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# MONEY MANAGEMENT STRATEGIES FOR FUTURES TRADERS

# 1

# Understanding the Money Management Process

In a sense, every successful trader employs money management principles in the course of futures trading, even if only unconsciously. The goal of this book is to facilitate a more conscious and rigorous adoption of these principles in everyday trading. This chapter outlines the money management process in terms of market selection, exposure control, trade-specific risk assessment, and the allocation of capital across competing opportunities. In doing so, it gives the reader a broad overview of the book.

A signal to buy or sell a commodity may be generated by a technical or chart-based study of historical data. Fundamental analysis, or a study of demand and supply forces influencing the price of a commodity, could also be used to generate trading signals. Important as signal generation is, it is not the focus of this book. The focus of this book is on the decision-making process that follows a signal.

## STEPS IN THE MONEY MANAGEMENT PROCESS

First, the trader must decide whether or not to proceed with the signal. This is a particularly serious problem when two or more commodities are vying for limited funds in the account. Next, for every signal accepted, the trader must decide on the fraction of the trading capital that he or she is willing to risk. The goal is to maximize profits while protecting the bankroll against undue loss and overexposure, to ensure participation in future major moves. An obvious choice is to risk a fixed dollar amount every time. More simply, the trader might elect to trade an equal number of contracts of every commodity traded. However, the resulting allocation of capital is likely to be suboptimal.

For each signal pursued, the trader must determine the price that unequivocally confirms that the trade is not measuring up to expectations. This price is known as the stop-loss price, or simply the stop *price*. The dollar value of the difference between the entry price and the stop price defines the maximum permissible risk per contract. The risk capital allocated to the trade divided by the maximum permissible risk per contract determines the number of contracts to be traded. Money management encompasses the following steps:

1. Ranking available opportunities against an objective yardstick of desirability
2. Deciding on the fraction of capital to be exposed to trading at any given time
3. Allocating risk capital across opportunities
4. Assessing the permissible level of loss for each opportunity accepted for trading
5. Deciding on the number of contracts of a commodity to be traded, using the information from steps 3 and 4

The following paragraphs outline the salient features of each of these steps.

## RANKING OF AVAILABLE OPPORTUNITIES

There are over 50 different futures contracts currently traded, making it difficult to concentrate on all commodities. Superimpose the practical constraint of limited funds, and selection assumes special significance. Ranking of competing opportunities against an objective yardstick of desirability seeks to alleviate the problem of virtually unlimited opportunities competing for limited funds.

The desirability of a trade is measured in terms of (a) its expected profits, (b) the risk associated with earning those profits, and (c) the investment required to initiate the trade. The higher the expected profit for a given level of risk, the more desirable the trade. Similarly, the lower the investment needed to initiate a trade, the more desirable the trade. In Chapter 3, we discuss chart-based approaches to estimating risk and reward. Chapter 5 discusses alternative approaches to commodity selection.



Having evaluated competing opportunities against an objective yardstick of desirability, the next step is to decide upon a cutoff point or benchmark level so as to short-list potential trades. Opportunities that fail to measure up to this cutoff point will not qualify for further consideration.

## CONTROLLING OVERALL EXPOSURE

Overall exposure refers to the fraction of total capital that is risked across all trading opportunities. Risking 100 percent of the balance in the account could be ruinous if every single trade ends up a loser. At the other extreme, risking only 1 percent of capital mitigates the risk of bankruptcy, but the resulting profits are likely to be inconsequential.

The fraction of capital to be exposed to trading is dependent upon the returns expected to accrue from a portfolio of commodities. In general, the higher the expected returns, the greater the recommended level of exposure. The optimal exposure fraction would maximize the overall expected return on a portfolio of commodities. In order to facilitate the analysis, data on completed trade returns may be used as a proxy for expected returns. This analysis is discussed at length in Chapter 7.

Another relevant factor is the correlation between commodity returns. Two commodities are said to be positively correlated if a change in one is accompanied by a similar change in the other. Conversely, two commodities are negatively correlated if a change in one is accompanied by an opposite change in the other. The strength of the correlation depends on the magnitude of the relative changes in the two commodities.

In general, the greater the positive correlation across commodities in a portfolio, the lower the theoretically safe overall exposure level. This safeguards against multiple losses on positively correlated commodities. By the same logic, the greater the negative correlation between commodities in a portfolio, the higher the recommended overall optimal exposure. Chapter 4 discusses the concept of correlations and their role in reducing overall portfolio risk.

The overall exposure could be a fixed fraction of available funds. Alternatively, the exposure fraction could fluctuate in line with changes in trading account balance. For example, an aggressive trader might want to increase overall exposure consequent upon a decrease in account balance. A defensive trader might disagree, choosing to increase overall exposure only after witnessing an increase in account balance. These issues are discussed in Chapter 7.

## ALLOCATING RISK CAPITAL

Once the trader has decided the total amount of capital to be risked to trading, the next step is to allocate this amount across competing trades. The easiest solution is to allocate an equal amount of risk capital to each commodity traded. This simplifying approach is particularly helpful when the trader is unable to estimate the reward and risk potential of a trade. However, the implicit assumption here is that all trades represent equally good investment opportunities. A trader who is uncomfortable with this assumption might pursue an allocation procedure that (a) identifies trade potential differences and (b) translates these differences into corresponding differences in exposure or risk capital allocation.

Differences in trade potential are measured in terms of (a) the probability of success and (b) the reward/risk ratio for the trade, arrived at by dividing the expected profit by the maximum permissible loss, or the payoff ratio, arrived at by dividing the average dollar profit earned on completed trades by the average dollar loss incurred. The higher the probability of success, and the higher the payoff ratio, the greater is the fraction that could justifiably be exposed to the trade in question. Arriving at optimal exposure is discussed in Chapter 7. Chapter 8 discusses the rules for increasing exposure during a trade's life, a technique commonly referred to as pyramiding.

## ASSESSING THE MAXIMUM PERMISSIBLE LOSS ON A TRADE

Risk in trading futures stems from the lack of perfect foresight. Unanticipated adverse price swings are endemic to trading; controlling the consequences of such adverse swings is the hallmark of a successful speculator. Inability or unwillingness to control losses can lead to ruin, as explained in Chapter 2.

Before initiating a trade, a trader should decide on the price action which would conclusively indicate that he or she is on the wrong side of the market. A trader who trades off a mechanical system would calculate the protective stop-loss price dictated by the system. This is explained in Chapter 9. If the trader is strictly a chartist, relying on chart patterns to make trading decisions, he or she must determine in advance the precise point at which the trade is not going the desired way, using the techniques outlined in Chapter 3.

It is always tempting to ignore risk by concentrating exclusively on reward, but a trader should not succumb to this temptation. There are no guarantees in futures trading, and a trading strategy based on hope rather than realism is apt to fail. Chapter 6 discusses alternative strategies for controlling unrealized losses.



## THE RISK EQUATION

Trade-specific risk is the product of the permissible dollar risk per contract multiplied by the number of contracts of the commodity to be traded. Overall trade exposure is the aggregation of trade-specific risk across all commodities traded concurrently. Overall exposure must be balanced by the trader's ability to lose and willingness to accept a loss. Essentially, each trader faces the following identity:

$$\text{Overall trade exposure} = \begin{array}{l}\text{Willingness to assume risk}\\ \text{backed by the ability to lose}\end{array}$$

The ability to lose is a function of capital available for trading: the greater the risk capital, the greater the ability to lose. However, the willingness to assume risk is influenced by the trader's comfort level for absorbing the "pain" associated with losses. An extremely risk-averse person may be unwilling to assume any risk, even though holding the requisite funds. At the other extreme, a risk lover may be willing to assume risks well beyond the available means.

For the purposes of discussion in this book, we will assume that a trader's willingness to assume risk is backed by the funds in the account. Our trader expects not to lose on a trade, but he or she is willing to accept a small loss, should one become inevitable.

## DECIDING THE NUMBER OF CONTRACTS TO BE TRADED: BALANCING THE RISK EQUATION

Since the trader's ability to lose and willingness to assume risk is determined largely by the availability of capital and the trader's attitudes toward risk, this side of the risk equation is unique to the trader who alone can define the overall exposure level with which he or she is truly comfortable. Having made this determination, he or she must balance this desired exposure level with the overall exposure associated with the trade or trades under consideration.

Assume for a moment that the overall risk exposure outweighs the trader's threshold level. Since exposure is the product of (a) the dollar risk per contract and (b) the number of contracts traded, a downward adjustment is necessary in either or both variables. However, manipulating the dollar risk per contract to an artificially low figure simply to suit one's pocketbook or threshold of pain is ill-advised, and tinkering with one's own estimate of what constitutes the permissible risk on a trade is an exercise in self-deception, which can lead to needless losses. The dollar risk per contract is a predefined constant. The trader, therefore, must necessarily adjust the number of contracts to be traded so as to bring the total risk in line with his or her ability and willingness to assume risk. If the capital risked to a trade is $1000, and the permissible risk per contract is $500, the trader would want to trade two contracts, margin considerations permitting. If the permissible risk per contract is $1000, the trader would want to trade only one contract.

## CONSEQUENCES OF TRADING AN UNBALANCED RISK EQUATION

An unbalanced risk equation arises when the dollar risk assessment for a trade is not equal to the trader's ability and willingness to assume risk. If the risk assessed on a trade is greater than that permitted by the trader's resources, we have a case of over-trading. Conversely, if the risk assessed on a trade is less than that permitted by the trader's resources, he or she is said to be under-trading.

Overtrading is particularly dangerous and should be avoided, as it threatens to rob a trader of precious trading capital. Overtrading typically stems from a trader's overconfidence about an impending move. When he is convinced that he is going to be proved right by subsequent events, no risk seems too big for his bankroll! However, this is a case of emotions winning over reason. Here speculation or reasonable risk taking can quickly degenerate into gambling, with disastrous consequences.

Undertrading is symptomatic of extreme caution. While it does not threaten to ruin a trader financially, it does put a damper on performance. When a trader fails to extend himself as much as he should, his performance falls short of optimal levels. This can and should be avoided.



## CONCLUSION

Although futures trading is rightly believed to be a risky endeavor, a defensive trader can, through a series of conscious decisions, ensure that the risks do not overwhelm him or her. First, a trader must rank competing opportunities according to their respective return potential, thereby determining which opportunities to trade and which ones to pass up. Next, the trader must decide on the fraction of the trading capital he or she is willing to risk to trading and how he or she wishes to allocate this amount across competing opportunities. Before entering into a trade, a trader must decide on the latitude he or she is willing to allow the market before admitting to be on the wrong side of the trade. This specifies the permissible dollar risk per contract. Finally, the risk capital allocated to a trade divided by the permissible dollar risk per contract defines the number of contracts to be traded, margin considerations permitting.

It ought to be remembered at all times that the futures market offers no guarantees. Consequently, never overexpose the bankroll to what might appear to be a "sure thing" trade. Before going ahead with a trade, the trader must assess the consequences of its going amiss. Will the loss resulting from a realization of the worst-case scenario in any way cripple the trader financially or affect his or her mental equilibrium? If the answer is in the affirmative, the trader must lighten up the exposure, either by reducing the number of contracts to be traded or by simply letting the trade pass by if the risk on a single contract is far too high for his or her resources.

Futures trading is a game where the winner is the one who can best control his or her losses. Mistakes of judgment are inevitable in trading; a successful trader simply prevents an error of judgment from turning into a devastating blunder.

# 2

# The Dynamics of Ruin

It is often said that the best way to avoid ruin is to have experienced it at least once. Hating experienced devastation, the trader knows firsthand what causes ruin and how to avoid similar debacles in future. However, this experience can be frightfully expensive, both financially and emotionally. In the absence of firsthand experience, the next best way to avoid ruin is to develop a keen awareness of what causes ruin. This chapter outlines the causes of ruin and quantifies the interrelationships between these causes into an overall probability of ruin.

Failure in the futures markets may be explained in terms of either (a) inaction or (b) incorrect action. Inaction or lack of action may be defined as either failure to enter a new trade or to exit out of an existing trade. Incorrect action results from entering into or liquidating a position either prematurely or after the move is all but over. The reasons for inaction and incorrect action are discussed here.

## INACTION

First, the behavior of the market could lull a trader into inaction. If the market is in a sideways or congestion pattern over several weeks, then a trader might well miss the move as soon as the market breaks out of its congestion. Alternatively, if the market has been moving very sharply in a particular direction and suddenly changes course, it is almost



impossible to accept the switch at face value. It is so much easier to do nothing, believing that the reversal is a minor correction to the existing trend rather than an actual change in the trend.

Second, the nature of the instrument traded may cause trader inaction. For example, purchasing an option on a futures contract is quite different from trading the underlying futures contract and could evoke markedly different responses. The purchaser of an option is under no obligation to close out the position, even if the market goes against the option buyer. Consequently, he or she is likely to be lulled into a false sense of complacency, figuring that a panic sale of the option is unwarranted, especially if the option premium has eroded dramatically.

Third, a trader may be numbed into inaction by fear of possible losses. This is especially true for a trader who has suffered a series of consecutive losses in the marketplace, losing self-confidence in the process. Such a trader can start second-guessing himself and the signals generated by his system, preferring to do nothing rather than risk sustaining yet another loss.

The fourth reason for not acting is an unwillingness to accept an error of judgment. A trader who already has a position may do everything possible to convince himself that the current price action does not merit liquidation of the trade. Not wanting to be confused by facts, the trader would ignore them in the hope that sooner or later the market will prove him right!

Finally, a trader may fail to act in a timely fashion simply because he has not done his homework to stay abreast of the markets. Obviously, the amount of homework a trader must do is directly related to the number of commodities followed. Inaction due to negligence most commonly occurs when a trader does not devote enough time and attention to each commodity he tracks.

## INCORRECT ACTION

Timing is important in any investment endeavor, but it is particularly crucial in the futures markets because of the daily adjustments in account balances to reflect current prices. A slight error in timing can result in serious financial trouble for the futures trader. Incorrect action stemming from imprecise timing will be discussed under the following broad categories: (a) premature entry, (b) delayed entry, (c) premature exit, and (d) delayed exit.

### Premature Entry

As the name suggests, premature entry results from initiating a new trade before getting a clear signal. Premature entry problems are typically the result of unsuccessfully trying to pick the top or bottom of a strongly trending market. Outguessing the market and trying to stay one step ahead of it can prove to be a painfully expensive experience. It is much safer to stay in step with the market, reacting to market moves as expeditiously as possible, rather than trying to forecast possible market behavior.

### Delayed Entry or Chasing the Market

This is the practice of initiating a trade long after the current trend has established itself. Admittedly, it is very difficult to spot a shift in the trend just after it occurs. It is so much easier to jump on board after the commodity in question has made an appreciably big move. However, the trouble with this is that a very strong move in a given direction is almost certain to be followed by some kind of pullback. A delayed entry into the market almost assures the trader of suffering through the pullback.

A conservative trader who believes in controlling risk will wait patiently for a pullback before plunging into a roaring bull or bear market. If there is no pullback, the move is completely missed, resulting in an opportunity forgone. However, the conservative trader attaches a greater premium to actual dollars lost than to profit opportunities forgone.

### Premature Exit

A new trader, or even an experienced trader shaken by a string of recent losses, might want to cash in an unrealized profit prematurely. Although understandable, this does not make for good trading. Premature exiting out of a trade is the natural reaction of someone who is short on confidence. Working under the assumption that some profits are better than no profits, a trader might be tempted to cash in a small profit now rather than agonize over a possibly bigger, but much more uncertain, profit in the future.



While it does make sense to lock in a part of unrealized profits and not expose everything to the vagaries of the marketplace, taking profits in a hurry is certainly not the most appropriate technique. It is good policy to continue with a trade until there is a definite signal to liquidate it. The futures market entails healthy risk taking on the part of speculators, and anyone uncomfortable with this fact ought not to trade.

Yet another reason for premature exiting out of a trade is setting arbitrary targets based on a percentage of return on investment. For example, a trader might decide to exit out of a trade when unrealized profits on the trade amount to 100 percent of the initial investment. The 100 percent return on investment is a good benchmark, but it may lead to a premature exit, since the market could move well beyond the point that yields the trader a 100 percent return on investment. Alternatively, the market could shift course before it meets the trader's target; in which case, he or she may well be faced with a delayed exit problem.

Premature liquidation of a trade at the first sign of a loss is very often a characteristic of a nervous trader. The market has a disconcerting habit of deviating at times from what seems to be a well-established trend. For example, it often happens that if a market closes sharply higher on a given day, it may well open lower on the following day. After meandering downwards in the initial hours of trading, during which time all nervous longs have been successfully gobbled up, the market will merrily waltz off to new highs!

### Delayed Exit

This includes a delayed exit out of a profitable trade or a delayed exit out of a losing trade. In either case, the delay is normally the result of hope or greed overruling a carefully thought-out plan of action. The successful trader is one who (a) can recognize when a trade is going against him and (b) has the courage to act based on such recognition. Being indecisive or relying on luck to bail out of a tight spot will most certainly result in greater than necessary losses.

## ASSESSING THE MAGNITUDE OF LOSS

The discussion so far has centered around the reasons for losing, without addressing their dollar consequences. The dollar consequence of a loss depends on the size of the bet or the fraction of capital exposed to trading. The greater the exposure, the greater the scope for profits, should prices unfold as expected, or losses, should the trade turn sour. An illustration will help dramatize the double-edged nature of the leverage sword.

It is August 1987. A trader with $100,000 in his account is convinced that the stock market is overvalued and is due for a major correction. He decides to use all the money in his account to short-sell futures contracts on the Standard and Poor's (S&P) 500 index, currently trading at 341.30. Given an initial margin requirement of $10,000 per contract, our trader decides to short 10 contracts of the December S&P 500 index on August 25, 1987, at 341.30. On October 19, 1987, in the wake of Black Monday, our trader covers his short positions at 201.30 for a profit of $70,000 per contract, or $700,000 on 10 contracts! This story has a wonderful ending, illustrating the power of leverage.

Now assume that our trader was correct in his assessment of an overvalued stock market but was slightly off on timing his entry. Specifically, let us assume that the S&P 500 index rallied 21 points to 362.30, crashing subsequently as anticipated. The unexpected rally would result in an unrealized loss of $10,500 per contract or $105,000 over 10 contracts. Given the twin features of daily adjustment of equity and the need to sustain the account at the maintenance margin level of $5,000 per contract, our trader would receive a margin call to replenish his account back to the initial level of $100,000. Assuming he cannot meet his margin call, he is forced out of his short position for a loss of $105,000, which exceeds the initial balance in his account. He ruefully watches the collapse of the S&P index as a ruined, helpless bystander! Leverage can be hurtful: in the extreme case, it can precipitate ruin.

## THE RISK OF RUIN

A trader is said to be ruined if his equity is depleted to the point where he is no longer able to trade. The risk of ruin is a probability estimate ranging between 0 and 1. A probability estimate of 0 suggests that ruin is impossible, whereas an estimate of 1 implies that ruin is ensured. The



risk of ruin is a function of the following:

1. The probability of success
2. The payoff ratio, or the ratio of the average trade win to the average trade loss
3. The fraction of capital exposed to trading

Whereas the probability of success and the payoff ratio are trading system-dependent, the fraction of capital exposed is determined by money management considerations.

Let us illustrate the concept of risk of ruin with the help of a simple example. Assume that we have $1 available for trading and that this entire amount is risked to trading. Further, let us assume that the average win, $1, equals the average loss, leading to a payoff ratio of 1. Finally, let us assume that past trading results indicate that we have 3 winners for every 5 trades, or a probability of success of 0.60. If the first trade is a loser, we end up losing our entire stake of $1 and cannot trade any more. Therefore, the probability of ruin at the end of the first trade is 2/5, or 0.40.

If the first trade were to result in a win, we would move to the next trade with an increased capital of $2. It is impossible to be ruined at the end of the second trade, given that the loss per trade is constrained to $1. We would now have to lose the next two consecutive trades in order to be ruined by the end of the third trade. The probability of this occurring is the product of the probability of winning on the first trade times the probability of losing on each of the next two trades. This works out to be 0.096 (0.60 x 0.40 x 0.40).

Therefore, the risk of ruin on or before the end of three trades may be expressed as the sum of the following:

1. The probability of ruin at the end of the first trade
2. The probability of ruin at the end of the third trade

The overall probability of these two possible routes to ruin by the end of the third trade works out to be 0.496, arrived at as follows:

$$0.40 + 0.096 = 0.496$$

Extending this logic a little further, there are two possible routes to ruin by the end of the fifth trade. First, if the first two trades are wins, the next three trades would have to be losers to ensure ruin. Alternatively, a more circuitous route to ruin would involve winning the first trade.

losing the second, winning the third, and finally losing the fourth and the fifth. The two routes are mutually exclusive, in that the occurrence of one precludes the other.

The probability of ruin by the end of five trades may therefore be computed as the sum of the following probabilities:

1. Ruin at the end of the first trade
2. Ruin at the end of the third trade, namely one win followed by two consecutive losses
3. One of two possible routes to ruin at the end of the fifth trade, namely (a) two wins followed by three consecutive losses, or (b) one win followed by a loss, a win, and finally two successive losses

Therefore, the probability of ruin by the end of the fifth trade works out to be 0.54208, arrived at as follows:

$$0.40 + 0.096 + 2 \times (0.02304) = 0.54208$$

Notice how the probability of ruin increases as the trading horizon expands. However, the probability is increasing at a decreasing rate, suggesting a leveling off in the risk of ruin as the number of trades increases.

In mathematical computations, the number of trades, $n$, is assumed to be very large so as to ensure an accurate estimate of the risk of ruin. Since the calculations get to be more tedious as $n$ increases, it would be desirable to work with a formula that calculates the risk of ruin for a given probability of success. In its most elementary form, the formula for computing risk of ruin makes two simplifying assumptions: (a) the payoff ratio is 1, and (b) the entire capital in the account is risked to trading.

Under these assumptions, William Feller’ states that a gambler's risk of ruin, $R$, is

$$R = \frac{(q/p)^a - (q/p)^k}{(q/p)^a \quad 1}$$

where the gambler has $k$ units of capital and his or her opponent has (a $-$ $k$) units of capital. The probability of success is given by $p$, and the complementary probability of failure is given by $q$, where $q = (I - p)$. As applied to futures trading, we can assume that the probability of winning, $p$, exceeds the probability of losing, $q$, leading to a fraction

[1] William Feller, *An Introduction to Probability Theory and its Applications*, Volume 1 (New York: John Wiley & Sons, 1950).



$(q/p)$ that is smaller than 1. Moreover, we can assume that the trader's opponent is the market as a whole, and that the overall market capitalization, a, is a very large number as compared to $k$. For practical purposes, therefore, the term $(q/p)$” tends to zero, and the probability of ruin is reduced to $(q/p)^k$.

Notice that the risk of ruin in the above formula is a function of (a) the probability of success and (b) the number of units of capital available for trading. The greater the probability of success, the lower the risk of ruin. Similarly, the lower the fraction of capital that is exposed to trading, the smaller the risk of ruin for a given probability of success.

For example, when the probability of success is 0.50 and an amount of $1 is risked out of an available $10, implying an exposure of 10 percent at any time, the risk of ruin for a payoff ratio of 1 works out to *be* $(0.50/0.50)^{10}$, or 1. Therefore, ruin is ensured with a system that has a 0.50 probability of success and promises a payoff ratio of 1. When the probability of success increases marginally to 0.55, with the same payoff ratio and exposure fraction, the probability of ruin drops dramatically to $(0.45/0.55)^{10}$ or 0.134! Therefore, it certainly does pay to invest in improving the odds of success for any given trading system.

When the average win does not equal the average loss, the risk-of-ruin calculations become more complicated. When the payoff ratio is 2, the risk of ruin can be reduced to a precise formula, as shown by Norman T. J. Bailey.[2]

Should the probability of losing equal or exceed twice the probability of winning, that is, if $q \geq 2p$, the risk of ruin, $R$, is certain or 1. Stated differently, if the probability of winning is less than one-half the probability of losing and the payoff ratio is 2, the risk of ruin is certain or 1. For example, if the probability of winning is less than or equal to 0.33, the risk of ruin is 1 for a payoff ratio of 2.

If the probability of losing is less than twice the probability of winning, that is, if $q < 2p$, the risk of ruin, $R$, for a payoff ratio equal to 2 is defined as

$$R = \left\{ \left(0.25 + \frac{q}{p}\right)^{0.5} - 0.5 \right\}^k$$

[2] Norman T. J. Bailey, *The Elements of Stochastic Processes with Applications to the Natural Sciences* (New York: John Wiley & Sons, 1964).

where $q$ = probability of loss

$p$ = probability of winning

$k$ = number of units of equal dollar amounts of capital available for trading

The proportion of capital risked to trading is a function of the number of units of available trading capital. If the entire equity in the account, $k$, were to be risked to trading, then the exposure would be 100 percent. However, if $k$ is 2 units, of which 1 is risked, the exposure is 50 percent. In general, if 1 unit of capital is risked out of an available $k$ units in the account, (100/k) percent is the percentage of capital at risk. The smaller the percentage of capital at risk, the smaller is the risk of ruin for a given probability of success and payoff ratio.

Using the above equation for a payoff ratio of 2, when the probability of winning is 0.60, and there are 2 units of capital, leading to a 50 percent exposure, the risk of ruin, $R$, is 0.209. With the same probability of success and payoff ratio, an increase in the number of total capital units to 5 (a reduction in the exposure level from 50 percent to 20 percent) leads to a reduction in the risk of ruin from 0.209 to 0.020! This highlights the importance of the fraction of capital exposed to trading in controlling the risk of ruin.

When the payoff ration exceeds 2, that is, when the average win is greater than twice the average loss, the differential equations associated with the risk of ruin calculations do not lend themselves to a precise or closed-form solution. Due to this mathematical difficulty, the next best alternative is to simulate the probability of ruin.

## SIMULATING THE RISK OF RUIN

In this section, we simulate the risk of ruin as a function of three inputs: (a) the probability of success, $p$, (b) the percentage of capital, $k$, risked to active trading, given by $(100/k)$ percent, and (c) the payoff ratio. For the purposes of the simulation, the probability of success ranges from 0.05 to 0.90 in increments of 0.05. Similarly, the payoff ratio ranges from 1 to 10 in increments of 1.

The simulation is based on the premise that a trader risks an amount of $1 in each round of trading. This represents $(100/k)$ percent of his



initial capital of $\$k$. For the simulation, the initial capital, $k$, ranges between $1, $2, $3, $4, $5 and $10, leading to risk exposure levels of 100%, 50%, 33%, 25%, 20%, and 10%, respectively,

### The logic of the Simulation Process

A fraction between 0 and 1 is selected at random by a random number generator. If the fraction lies between 0 and $(1-p)$, the trade is said to result in a loss of $1. Alternatively, if the fraction is greater than $(1-p)$ but less than 1, the trade is said to result in a win of $\$W$, which is added to the capital at the beginning of that round.

Trading continues in a given round until such time as either (a) the entire capital accumulated in that round of trading is lost or (b) the initial capital increases 100 times to $100k$, at which stage the risk of ruin is presumed to be negligible.

Exiting a trade for either reason marks the end of that round. The process is repeated 100,000 times, so as to arrive at the most likely estimate of the risk of ruin for a given set of parameters. To simplify the simulation analysis, we assume that there is no withdrawal of profits from the account. The risk of ruin is defined by the fraction of times a trader loses the entire trading capital over the course of 100,000 trials. The Turbo Pascal program to simulate the risk of ruin is outlined in Appendix A. Appendix B gives a BASIC program for the same problem. Both programs are designed to run on a personal computer.

### The Simulation Results and Their Significance

The results of the simulation are presented in Table 2.1. As expected, the risk of ruin is (a) directly related to the proportion of capital allocated to trading and (b) inversely related to the probability of success and the size of the payoff ratio. The risk of ruin is 1 for a payoff ratio of 2, regardless of capital exposure, up to a probability of success of 0.30. This supports Bailey's assertion that for a payoff ratio of 2, the risk of ruin is 1 as long as the probability of losing is twice as great as the probability of winning.

The risk of ruin drops as the probability of success increases, the magnitude of the drop depending on the fraction of capital at risk. The risk of ruin rapidly falls to zero when only 10 percent of available capital is exposed. Table 2.1 shows that for a probability of success of 0.35, a

**TABLE 2.1** Probability of Ruin Tables

Available Capital = $1; Capital Risked = $1 or 100%

| Probability of Success | Payoff Ratio 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.05 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.10 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.998 | 0.991 | 0.978 |
| 0.15 | 1.000 | 1.000 | 1.000 | 1.000 | 0.999 | 0.979 | 0.946 | 0.923 | 0.905 | 0.894 |
| 0.20 | 1.000 | 1.000 | 1.000 | 0.990 | 0.926 | 0.886 | 0.860 | 0.844 | 0.832 | 0.822 |
| 0.25 | 1.000 | 1.000 | 0.990 | 0.887 | 0.834 | 0.804 | 0.788 | 0.775 | 0.766 | 0.761 |
| 0.30 | 1.000 | 1.000 | 0.881 | 0.794 | 0.756 | 0.736 | 0.720 | 0.715 | 0.708 | 0.705 |
| 0.35 | 1.000 | 0.951 | 0.778 | 0.713 | 0.687 | 0.671 | 0.663 | 0.659 | 0.655 | 0.653 |
| 0.40 | 1.000 | 0.825 | 0.691 | 0.647 | 0.621 | 0.611 | 0.609 | 0.602 | 0.601 | 0.599 |
| 0.45 | 1.000 | 0.714 | 0.615 | 0.579 | 0.565 | 0.558 | 0.554 | 0.551 | 0.551 | 0.550 |
| 0.50 | 0.989 | 0.618 | 0.541 | 0.518 | 0.508 | 0.505 | 0.504 | 0.499 | 0.499 | 0.498 |
| 0.55 | 0.819 | 0.534 | 0.478 | 0.463 | 0.453 | 0.453 | 0.453 | 0.453 | 0.453 | 0.453 |
| 0.60 | 0.667 | 0.457 | 0.419 | 0.406 | 0.402 | 0.402 | 0.402 | 0.400 | 0.400 | 0.400 |
| 0.65 | 0.537 | 0.388 | 0.363 | 0.356 | 0.349 | 0.349 | 0.349 | 0.349 | 0.349 | 0.347 |
| 0.70 | 0.430 | 0.322 | 0.306 | 0.300 | 0.300 | 0.300 | 0.300 | 0.300 | 0.300 | 0.300 |
| 0.75 | 0.335 | 0.266 | 0.252 | 0.252 | 0.252 | 0.252 | 0.250 | 0.249 | 0.249 | 0.249 |
| 0.80 | 0.251 | 0.205 | 0.201 | 0.201 | 0.198 | 0.198 | 0.198 | 0.198 | 0.198 | 0.198 |
| 0.85 | 0.175 | 0.153 | 0.151 | 0.151 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 |
| 0.90 | 0.110 | 0.101 | 0.101 | 0.101 | 0.101 | 0.101 | 0.101 | 0.100 | 0.100 | 0.100 |

Available Capital = $2; Capital Risked = $1 or 50%

| Probability of Success | Payoff Ratio 1 | 2 | 3 | 4 | 5 | 6 | 7 | a | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.05 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.10 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.990 | 0.962 |
| 0.15 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.966 | 0.897 | 0.850 | 0.819 | 0.798 |
| 0.20 | 1.000 | 1.000 | 1.000 | 0.990 | 0.858 | 0.781 | 0.737 | 0.714 | 0.689 | 0.680 |
| 0.25 | 1.000 | 1.000 | 0.991 | 0.789 | 0.695 | 0.645 | 0.615 | 0.601 | 0.590 | 0.581 |
| 0.30 | 1.000 | 1.000 | 0.773 | 0.631 | 0.572 | 0.541 | 0.523 | 0.511 | 0.503 | 0.500 |
| 0.35 | 1.000 | 0.906 | 0.606 | 0.511 | 0.470 | 0.451 | 0.440 | 0.433 | 0.428 | 0.426 |
| 0.40 | 1.000 | 0.678 | 0.479 | 0.416 | 0.392 | 0.377 | 0.368 | 0.366 | 0.363 | 0.363 |
| 0.45 | 1.000 | 0.506 | 0.378 | 0.337 | 0.321 | 0.312 | 0.306 | 0.305 | 0.304 | 0.302 |
| 0.50 | 0.990 | 0.382 | 0.295 | 0.269 | 0.260 | 0.253 | 0.251 | 0.251 | 0.251 | 0.251 |
| 0.55 | 0.672 | 0.289 | 0.229 | 0.212 | 0.208 | 0.205 | 0.203 | 0.203 | 0.203 | 0.203 |
| 0.60 | 0.443 | 0.208 | 0.174 | 0.166 | 0.161 | 0.161 | 0.161 | 0.161 | 0.161 | 0.159 |
| 0.65 | 0.289 | 0.151 | 0.130 | 0.125 | 0.125 | 0.125 | 0.123 | 0.123 | 0.122 | 0.122 |
| 0.70 | 0.185 | 0.106 | 0.093 | 0.090 | 0.090 | 0.090 | 0.090 | 0.090 | 0.090 | 0.088 |
| 0.75 | 0.112 | 0.071 | 0.064 | 0.063 | 0.063 | 0.063 | 0.063 | 0.063 | 0.063 | 0.063 |
| 0.80 | 0.063 | 0.044 | 0.042 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.039 | 0.039 |
| 0.85 | 0.032 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.022 |
| 0.90 | 0.012 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 |



**Table 2.1** *continued*

Available Capital = $3; Capital Risked = $1 or 33.33%

| Probability of Success | Payoff Ratio 1 | 2 | 3 | 4 | 5 | 6 | 7 | a | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.05 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.10 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.990 | 0.942 |
| 0.15 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.951 | 0.852 | 0.782 | 0.744 | 0.714 |
| 0.20 | 1.000 | 1.000 | 1.000 | 0.990 | 0.796 | 0.692 | 0.635 | 0.599 | 0.576 | 0.560 |
| 0.25 | 1.000 | 1.000 | 0.991 | 0.699 | 0.581 | 0.518 | 0.485 | 0.467 | 0.455 | 0.441 |
| 0.30 | 1.000 | 1.000 | 0.680 | 0.501 | 0.428 | 0.395 | 0.374 | 0.367 | 0.357 | 0.352 |
| 0.35 | 1.000 | 0.862 | 0.474 | 0.365 | 0.324 | 0.303 | 0.292 | 0.284 | 0.281 | 0.278 |
| 0.40 | 1.000 | 0.559 | 0.332 | 0.269 | 0.243 | 0.232 | 0.226 | 0.220 | 0.219 | 0.219 |
| 0.45 | 1.000 | 0.364 | 0.230 | 0.195 | 0.179 | 0.173 | 0.171 | 0.168 | 0.168 | 0.168 |
| 0.50 | 0.990 | 0.236 | 0.161 | 0.139 | 0.133 | 0.127 | 0.127 | 0.126 | 0.126 | 0.126 |
| 0.55 | 0.551 | 0.151 | 0.110 | 0.100 | 0.096 | 0.092 | 0.092 | 0.092 | 0.092 | 0.092 |
| 0.60 | 0.297 | 0.095 | 0.072 | 0.068 | 0.064 | 0.064 | 0.064 | 0.063 | 0.063 | 0.063 |
| 0.65 | 0.155 | 0.058 | 0.047 | 0.044 | 0.044 | 0.042 | 0.042 | 0.042 | 0.042 | 0.042 |
| 0.70 | 0.079 | 0.035 | 0.029 | 0.028 | 0.028 | 0.028 | 0.027 | 0.027 | 0.027 | 0.025 |
| 0.75 | 0.037 | 0.019 | 0.017 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 |
| 0.80 | 0.016 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 |
| 0.85 | 0.006 | 0.004 | 0.004 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 |
| 0.90 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |

Available Capital = $4; Capital Risked = $1 or 25%

| Probability of Success | Payoff Ratio 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.05 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.10 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.990 | 0.926 |
| 0.15 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.936 | 0.805 | 0.727 | 0.673 | 0.638 |
| 0.20 | 1.000 | 1.000 | 1.000 | 0.990 | 0.736 | 0.612 | 0.546 | 0.503 | 0.477 | 0.459 |
| 0.25 | 1.000 | 1.000 | 0.991 | 0.620 | 0.487 | 0.422 | 0.383 | 0.358 | 0.346 | 0.337 |
| 0.30 | 1.000 | 1.000 | 0.599 | 0.399 | 0.327 | 0.290 | 0.271 | 0.260 | 0.254 | 0.250 |
| 0.35 | 1.000 | 0.820 | 0.366 | 0.264 | 0.222 | 0.201 | 0.194 | 0.187 | 0.185 | 0.180 |
| 0.40 | 1.000 | 0.458 | 0.229 | 0.174 | 0.152 | 0.142 | 0.135 | 0.133 | 0.132 | 0.130 |
| 0.45 | 1.000 | 0.259 | 0.142 | 0.111 | 0.102 | 0.097 | 0.094 | 0.092 | 0.092 | 0.092 |
| 0.50 | 0.990 | 0.147 | 0.086 | 0.072 | 0.067 | 0.064 | 0.063 | 0.063 | 0.062 | 0.062 |
| 0.55 | 0.447 | 0.082 | 0.052 | 0.045 | 0.044 | 0.043 | 0.042 | 0.042 | 0.041 | 0.041 |
| 0.60 | 0.195 | 0.043 | 0.030 | 0.027 | 0.027 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 |
| 0.65 | 0.083 | 0.023 | 0.016 | 0.016 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 |
| 0.70 | 0.036 | 0.011 | 0.009 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 |
| 0.75 | 0.013 | 0.005 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 |
| 0.80 | 0.004 | 0.002 | 0.0(2 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.001 |
| 0.85 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0,001 |
| 0.90 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

**Table 2.1** *continued*

Available Capital = $5; Capital Risked = $1 or 20%

| Prohabilitv of Success | Payoff Ratio 1 | 2 | 3 | 4 | 5 | 6 | | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.05 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.10 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.990 | 0.908 |
| 0.15 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.921 | 0.763 | 0.668 | 0.611 | 0.573 |
| 0.20 | 1.000 | 1.000 | 1.000 | 0.990 | 0.683 | 0.543 | 0.471 | 0.425 | 0.398 | 0.378 |
| 0.25 | 1.000 | 1.000 | 0.989 | 0.554 | 0.402 | 0.336 | 0.300 | 0.279 | 0.267 | 0.257 |
| 0.30 | 1.000 | 1.000 | 0.526 | 0.317 | 0.247 | 0.213 | 0.197 | 0.185 | 0.179 | 0.176 |
| 0.35 | 1.000 | 0.779 | 0.287 | 0.187 | 0.153 | 0.138 | 0.128 | 0.123 | 0.121 | 0.119 |
| 0.40 | 1.000 | 0.376 | 0.159 | 0.113 | 0.094 | 0.088 | 0.083 | 0.083 | 0.079 | 0.079 |
| 0.45 | 1.000 | 0.183 | 0.087 | 0.065 | 0.058 | 0.053 | 0.053 | 0.051 | 0.050 | 0.050 |
| 0.50 | 0.990 | 0.090 | 0.047 | 0.038 | 0.034 | 0.033 | 0.033 | 0.033 | 0.032 | 0.031 |
| 0.55 | 0.368 | 0.044 | 0.025 | 0.021 | 0.020 | 0.019 | 0.019 | 0.019 | 0.019 | 0.018 |
| 0.60 | 0.130 | 0.020 | 0.013 | 0.011 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 |
| 0.65 | 0.046 | 0.008 | 0.006 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 |
| 0.70 | 0.015 | 0.004 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.002 |
| 0.75 | 0.004 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| 0.80 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 0.85 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 0.90 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Available Capital = $10; Capital Risked = $1 or 10%

| Probability of Success | Payoff Ratio 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.05 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.10 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.990 | 0.822 |
| 0.15 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.849 | 0.579 | 0.449 | 0.371 | 0.325 |
| 0.20 | 1.000 | 1.000 | 1.000 | 0.990 | 0.467 | 0.297 | 0.220 | 0.178 | 0.159 | 0.144 |
| 0.25 | 1.000 | 1.000 | 0.990 | 0.303 | 0.162 | 0.113 | 0.090 | 0.078 | 0.069 | 0.067 |
| 0.30 | 1.000 | 1.000 | 0.277 | 0.102 | 0.060 | 0.045 | 0.039 | 0.034 | 0.033 | 0.031 |
| 0.35 | 1.000 | 0.608 | 0.082 | 0.036 | 0.023 | 0.018 | 0.016 | 0.015 | 0.014 | 0.014 |
| 0.40 | 1.000 | 0.143 | 0.025 | 0.013 | 0.008 | 0.008 | 0.007 | 0.007 | 0.006 | 0.006 |
| 0.45 | 1.000 | 0.033 | 0.008 | 0.004 | 0.003 | 0.003 | 0.003 | 0.002 | 0.002 | 0.002 |
| 0.50 | 0.990 | 0.008 | 0.002 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| 0.55 | 0.132 | 0.002 | 0.001 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 0.60 | 0.017 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 0.65 | 0.002 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 0.70 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 0.75 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 0.80 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 0.85 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 0.90 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |



payoff ratio of 2, and a capital exposure level of 10 percent, the risk of ruin is 0.608. The risk of ruin drops to 0.033 when the probability of success increases marginally to 0.45.

Working with estimates of the probability of success and the payoff ratio, the trader can use the simulation results in one of two ways. First, the trader can assess the risk of ruin for a given exposure level. Assume that the probability of success is 0.60 and the payoff ratio is 2. Assume further that the trader wishes to risk 50 percent of capital to open trades at any given time. Table 2.1 shows that the associated risk of ruin is 0.208.

Second, he or she can use the table to determine the exposure level that will translate into a prespecified risk of ruin. Continuing with our earlier example, assume our trader is not comfortable with a risk-of-ruin estimate of 0.208. Assume instead that he or she is comfortable with a risk of ruin equal to one-half that estimate, or 0.104. Working with the same probability of success and payoff ratio as before, Table 2.1 suggests that the trader should risk only 33.33 percent of his capital instead of the contemplated 50. This would give our trader a more acceptable risk-of-ruin estimate of 0.095.

## CONCLUSION

Losses are endemic to futures trading, and there is no reason to get despondent over them. It would be more appropriate to recognize the reasons behind the loss, with a view to preventing its recurrence. Is the loss due to any lapse on the part of the trader, or is it due to market conditions not particularly suited to his or her trading system or style of trading?

A lapse on the part of the trader may be due to inaction or incorrect action. If this is true, it is imperative that the trader understand exactly the nature of the error committed and take steps not to repeat it. Inaction or lack of action may result from (a) the behavior of the market, (b) the nature of the instrument traded, or (c) lack of discipline or inadequate homework on the part of the trader. Incorrect action may consist of (a) premature or delayed entry into a trade or (b) premature or delayed exit out of a trade. The magnitude of loss as a result of incorrect action depends upon the trader's exposure. A trader must ensure that losses do not overwhelm him to the extent that he cannot trade any further.

Ruin is defined as the inability to trade as a result of losses wiping out available capital. One obvious determinant of the risk of ruin is the probability of trading success: the higher the probability of success, the lower the risk of ruin. Similarly, the higher the ratio of the average dollar win to the average dollar loss-known as the payoff ratio- the lower the risk of ruin. Both these factors are trading system-dependent.

Yet another crucial component influencing the risk of ruin is the proportion of capital risked to trading. This is a money management consideration. If a trader risks everything he or she has to a single trade, and the trade does not materialize as expected, there is a high probability of being ruined. Alternatively, if the amount risked on a bad trade represents only a small proportion of a trader's capital, the'risk of ruin is mitigated.

All three factors interact to determine the risk of ruin. Table 2.1 gives the risk of ruin for a given probability of success, payoff ratio, and exposure fraction. Assume that the trader is aware of the probability of trading success and the payoff ratio for the trades he has effected. If the trader wishes to fix the risk of ruin at a certain level, he or she can estimate the proportion of capital to be risked to trading at any given time. This procedure allows the trader to control his or her risk of ruin.

# 3

# Estimating Risk and Reward

This chapter describes the estimation of reward and permissible risk on a trade, which gives the trader an idea of the potential payoffs associated with that trade. Technical trading is based on an analysis of historical price, volume, and open interest information. Signals could be generated either by (a) a visual examination of chart patterns or (b) a system of rules that essentially mechanizes the trading process. In this chapter we restrict ourselves to a discussion of the visual approach to signal generation.

## THE IMPORTANCE OF DEFINING RISK

Regardless of the technique adopted, the practice of predefining the maximum permissible risk on a trade is important, since it helps the trader think through a series of important related questions:

1. How significant is the risk in relation to available capital?
2. Does the potential reward justify the risk?
3. In the context of questions 1 and 2 and of other trading opportunities available concurrently, what proportion of capital, if any, should be risked to the commodity in question?

## THE IMPORTANCE OF ESTIMATING REWARD

Reward estimates are particularly useful in capital allocation decisions, when they are synthesized with margin requirements and permissible risk to determine the overall desirability of a trade. The higher the estimated reward for a given margin investment, the higher the potential return on investment. Similarly, the higher the estimated reward for a permissible dollar risk, the higher the reward/risk ratio.

## ESTIMATING RISK AND REWARD ON COMMONLY OBSERVED PATTERNS

Mechanical systems are generally trend-following in nature, reacting to shifts in the underlying trend instead of trying to predict where the market is headed. Therefore, they do not lend themselves easily to reward estimation. Accordingly, in this chapter we shall restrict ourselves to a chart-based approach to risk and reward estimation. The patterns outlined by Edwards and Magee[1] form the basis for our discussion. The measuring objectives and risk estimates for each pattern are based on the authors' premise that the market "goes right on repeating the same old movements in much the same old routine."[2] While the measuring objectives are good guides and have solid historical foundations to back them, they are by no means infallible. The actual reward may under- or overshoot the expected target.

With this qualifier, we begin an analysis of the most commonly observed reversal and continuation (or consolidation) patterns, illustrating how risk and reward can be estimated in each case. First, we will cover four major reversal patterns:

1. Head-and-shoulders formation
2. Double or triple tops and bottoms
3. Saucers or rounded tops and bottoms
4. V-formations, spikes, and island tops and bottoms

[1] Robert D. Edwards and John Magee, ***Technical Analysis of Stock Trends,*** 5th ed. (Boston: John Magee Inc., 1981).

[2] Edwards and Magee, ***Technical Analysis*** p. 1.



Next, we will focus on the three most commonly observed continuation or consolidation patterns:

1. Symmetrical and right-angle triangles
2. Wedges
3. Flags

## HEAD-AND-SHOULDERS FORMATION

Perhaps the most reliable of all reversal patterns, this formation can occur either as a head-and-shoulders top, signifying a market top, or as an inverted head-and-shoulders, signifying a market bottom. We shall concentrate on a head-and-shoulders top formation, with the understanding that the principles regarding risk and reward estimation are equally applicable to a head-and-shoulders bottom.

A theoretical head-and-shoulders top formation is described in Figure 3.1. The first clue of weakness in the uptrend is provided by prices reversing at 1 from their previous highs to form a left shoulder. A second rally at 2 causes prices to surpass their earlier highs established at 1, forming a head at 3. Ideally, the volume on the second rally to the head should be lower than the volume on the first rally to the left shoulder. A reaction from this rally takes prices lower, to a level near 2, but in any event to a level below the top of the left shoulder at 1. This is denoted by 4.

A third rally ensues, on decidedly lower volume than that accompanying the preceding two rallies, which helped form the left shoulder and the head. This rally fails to reach the height of the head before yet another pullback occurs, setting off a right shoulder formation. If the third rally takes prices above the head at 3, we have what is known as a broadening top formation rather than a head-and-shoulders reversal. Therefore, a chartist ought not to assume that a head-and-shoulders formation is in place simply because he observes what appears to be a left shoulder and a head. This is particularly important, since broadening top formations do not typically obey the same measuring objectives as do head-and-shoulders reversals.

### Minimum Measuring Objective

If the third rally fizzles out before reaching the head, and if prices on the third pullback close below an imaginary line connecting points

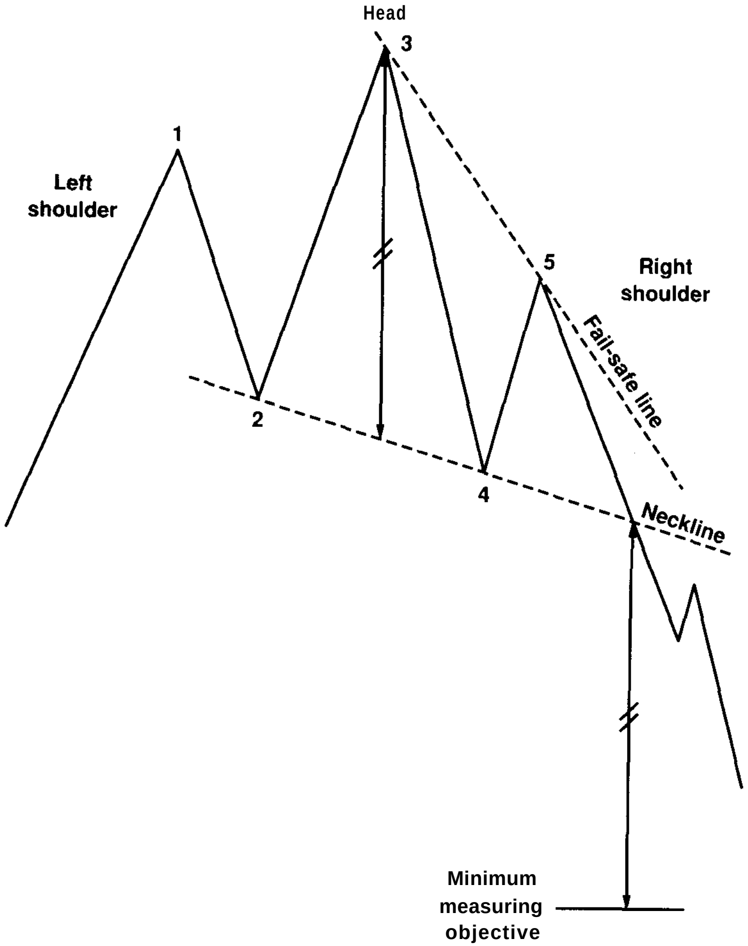



**Figure 3.1** Theoretical head-and-shoulders pattern.

2 and 4, known as the "neckline," on heavy volume and increasing open interest, a head-and-shoulders top is in place. If prices close below the neckline, they can be expected to fall from the point of penetration by a distance equal to that from the head to the neckline. This is a minimum measuring objective.

While it is possible that prices might continue to head downward, it is equally likely that a pullback might occur once the minimum measuring



objective has been met. Accordingly, at this point the trader might want to lighten the position if he or she is trading multiple contracts.

### Estimated Risk

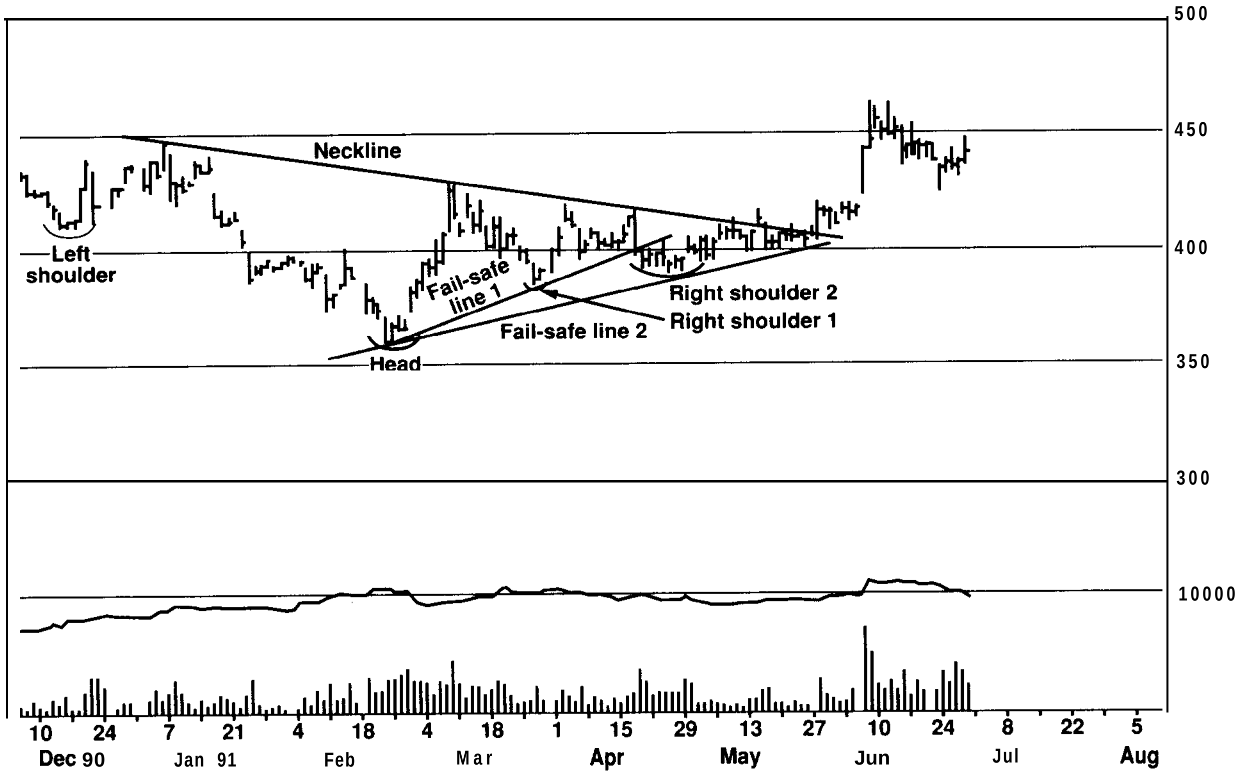
The trend line connecting the head and the right shoulder is called a "fail-safe line." Depending on the shape of the formation, either the neckline or the fail-safe line could be farther from the entry point. A protective stop-loss order should be placed just beyond the farther of the two trendlines, allowing for a minor retracement of prices without getting needlessly stopped out.

### Two Examples of Head-and-Shoulders Formations

Figure 3.2*a* gives an example of a head-and-shoulders bottom formation in July 1991 silver. Here we, have a downward-sloping neckline, with the distance from the head to the neckline approximately equal to 60 cents. Measured from a breakout at 418 cents, this gives a minimum measuring objective of 478 cents. The fail-safe line (termed fail-safe line 1 in Figure 3.2*a*) connecting the bottom of the head and the right shoulder (right shoulder 1) recommends a sell-stop at 399 cents. At the breakout of 418 cents, we have the possibility of earning 60 cents while assuming a 19-cent risk. This yields a reward/risk ratio of 3.16. The breakout does occur on April 18, but the trader is promptly stopped out the same day on a slump to 398 cents.

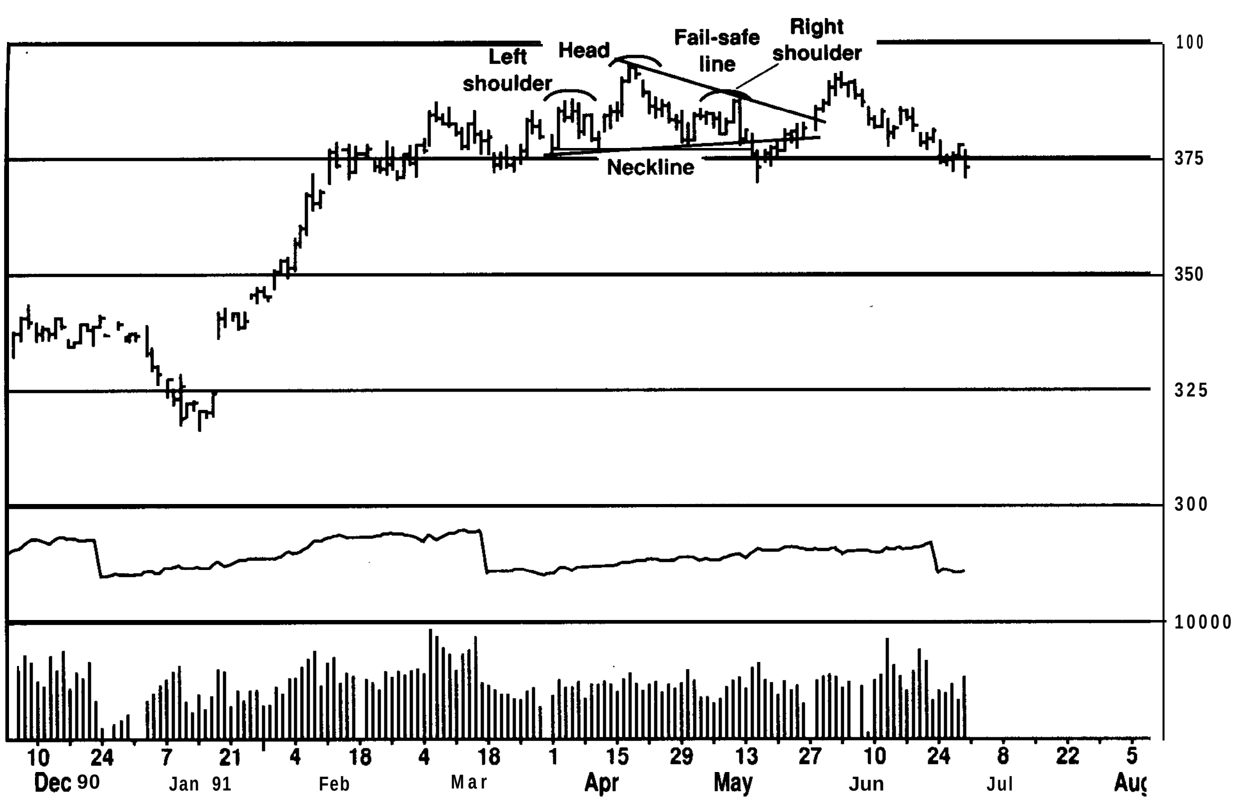
After the sharp plunge on April 18, prices stabilize around 390 cents, forming yet another right shoulder (right shoulder 2) between April 19 and May 6. Extending the earlier neckline, we have a new breakout point of 412 cents. The new fail-safe line (termed fail-safe line 2 in Figure 3.2*a*) recommends setting a sell-stop of 397 cents. At the breakout of 412 cents, we now have the possibility of earning 60 cents while assuming a 15-cent risk, for a reward/risk ratio of 4.00. In subsequent action, July silver rallies to 464 cents on July 7, almost meeting the target of the head-and-shoulders bottom.

In Figure 3.2*b*, we have an example, in the September 1991 S&P 500 Index futures, of a possible head-and-shoulders top formation that did not unfold as expected. The head was formed on April 17 at 396.20,




(*a*)

**Figure 3.2*a*** Head-and-shoulders formations: (*a*) bottom in July 1991 silver.




(*b*)

**Figure 3.2*b*** Head-and-shoulders formations: (*b*) possible top in September 1991 S&P 500 Index.

with a possible left shoulder formed at 387.75 on April 4 and the right shoulder formed on May 9 at 387.80. The head-and-shoulders top was set off on May 14 on a close below the neckline. However, prices broke through the fail-safe line connecting the head and the right shoulder on May 28, stopping out the short trade and negating the hypothesis of a head-and-shoulders top.

## DOUBLE TOPS AND BOTTOMS

A double top is formed by a pair of peaks at approximately the same price level. Further, prices must close below the low established between the two tops before a double top formation is activated. The retreat from the first peak to the valley is marked by light volume. Volume picks up on the ascent to the second peak but falls short of the volume accompanying the earlier ascent. Finally, we see a pickup in volume as prices decline for a second time. A double bottom is simply a double top turned upside down, with the foregoing rules, appropriately modified, equally applicable.

As a rule, a double top formation is an indication of bearishness, especially if the right half of the double top is lower than the left half. Similarly, a double bottom formation is bullish, particularly if the right half of the double bottom is higher than the left half. The market unsuccessfully attempted to test the previous peak (trough), signalling bearishness (bullishness).

### Minimum Measuring Objective

In the case of a double top, it is reasonable to expect that the decline will continue at least as far below the imaginary support line connecting the two tops as the distance from the higher of the twin peaks to the support line. Therefore, the greater the distance from peak to valley, the greater the potential for the impending reversal. Similarly, in the case of a double bottom, it is safe to assume that the upswing will continue at least as far up from the imaginary resistance line connecting the two bottoms as the height from the lower of the double bottoms to the resistance line. Once this minimum objective has been met, the trader might want to set a tight protective stop to lock in a significant portion of the unrealized profits.



### Estimated Risk

The imaginary line drawn as a tangent to the valley connecting two tops serves as a reliable support level. Similarly, the tangent to the peak connecting two bottoms serves as a reliable resistance level. Accordingly, a trader might want to set a stop-loss order just above the support level, in case of a double top, or just below the resistance level, in case of a double bottom. The goal is to avoid falling victim to minor retracements, while at the same time guarding against unanticipated shifts in the underlying trend.

If the closing price of the day that sets off the double top or bottom formation substantially overshoots the hypothetical support or resistance level, the potential reward on the trade might barely exceed the estimated risk. In such a situation, a trader might want to wait for a pullback before initiating the trade, in order to attain a better reward/risk ratio.

### Two Examples of a Double Top Formation

Consider the December 1990 soybean oil chart in Figure 3.3. We have a top at 25.46 cents formed on July 2, with yet another top formed on August 23 at 25.55. The valley high on July 23 was 23.39 cents, representing a distance of 2.16 cents from the peak of 25.55 on August 23. This distance of 2.16 cents measured from the valley high of 23.39 cents, represents the minimum measuring objective of 21.23 cents for the double top. The double top is set off on a close below 23.39 cents. This is accomplished on October 1 at 22.99. The buy stop for the trade is set at 23.51, just above the high on that day, for a risk of 0.52 cents.

The difference between the entry price, 22.99 cents, and the target price, 21.23 cents, gives a reward estimate of 1.76 cents for an associated risk of 0.52 cents. A reward/risk ratio of 3.38 suggests that this is a highly desirable trade. After the minimum reward target was met on November 6, prices continued to drift lower to 19.78 cents on November 20, giving the trader a bonus of 1.45 cents.

Although the comments for each pattern discussed here are illustrated with the help of daily price charts, they are equally applicable to weekly charts. Consider, for example, the weekly Standard & Poor's 500 (S&P 500) Index futures presented in Figure 3.4. We observe a double top formation between August 10 and October 5, 1987, labeled A and B in the figure. Notice that the left half of the double top, A, is higher than

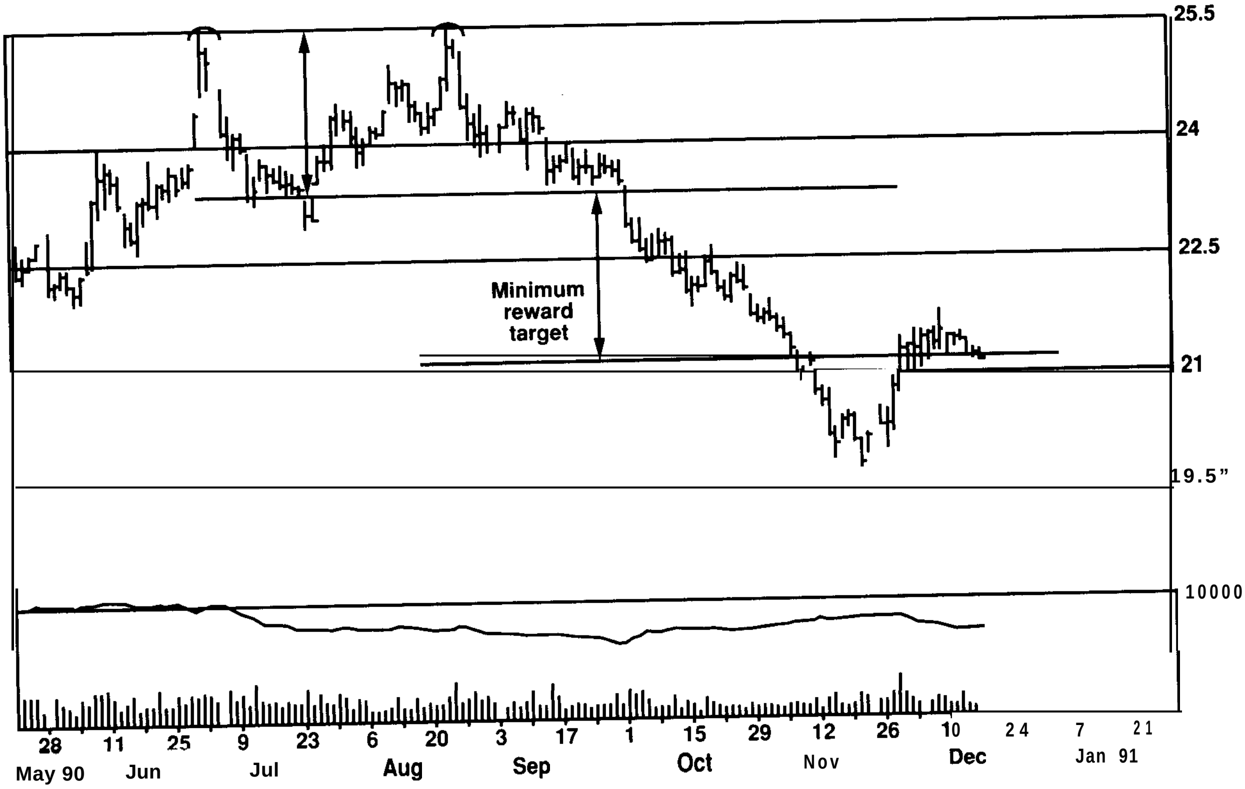



**Figure 3.3** Double top formation in December 1990 soybean oil.

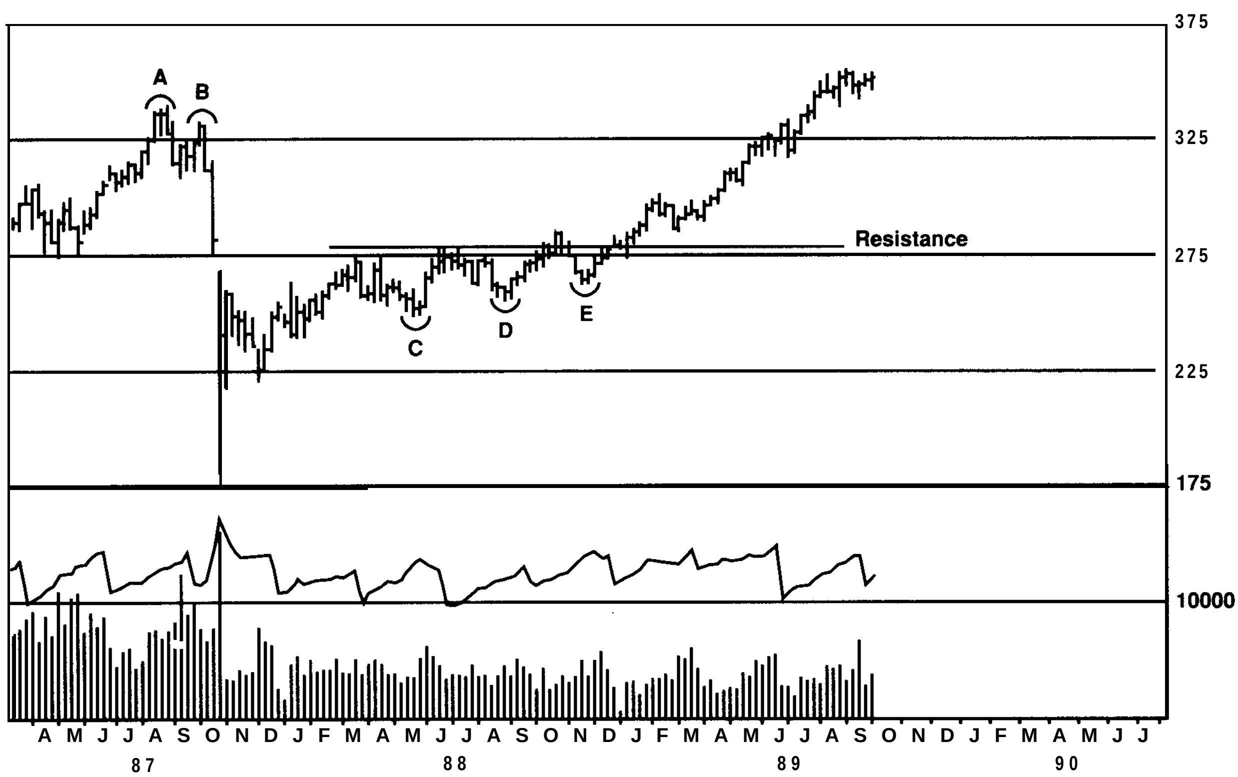



**Figure 3.4** Double top and triple bottom formation in weekly S&P 500 Index futures.

the right half, B. The failure to test the high of 339.45, achieved by A on August 24, 1987, is the first clue that the market has lost upside momentum. A bearish close for the week of October 5, just below the valley connecting the twin peaks, confirms the double top formation. The minimum measuring objective is given by the distance from peak A to valley, approximately 20 index points. Measured from the entry price of 312.20 on October 5, we have a reward target of 292.20. This objective was surpassed during the week of October 12, when the index closed at 282.25. Accordingly, the buy stop could be lowered to 292.20, locking in the minimum anticipated reward. The meltdown that ensued on October 19, Black Monday, was a major, albeit unexpected, bonus!

### Triple Tops and Bottoms

A triple top or bottom works along the same lines as a double top or bottom, the only difference being that we have three tops or bottoms instead of two. The three highs or lows need not be equally spaced, nor are there any specific guidelines as regards the time that ought to elapse between them. Volume is typically lower on the second rally or dip and even lower on the third. Triple tops are particularly powerful as indicators of impending bearishness if each successive top is lower than the preceding top. Similarly, triple bottoms are powerful indicators of impending bullishness if each successive bottom is higher than the preceding one.

In Figure 3.4, we see a classic triple bottom formation developing in the weekly S&P 500 Index futures between May and November 1988, marked C, D, and E. Notice how E is higher than D, and D higher than C, suggesting strength in the stock market. This is substantiated by the speed with which the market rallied from 280 to 360 index points, once the triple bottom was established at E and resistance was surmounted at 280.

## SAUCERS AND ROUNDED TOPS AND BOTTOMS

A saucer top or bottom is formed when prices seem to be stuck in a very narrow trading range over an extended period of time. Volume should gradually ebb to an extreme low at the peak of a saucer top or at the trough of a saucer bottom if the pattern is to be trusted. As the market seems to lack direction, a prudent trader would do well to stand



aside. As soon as a breakout occurs, the trader might want to enter a position. Saucers are not too commonly observed. Moreover, they are difficult to trade, because they develop at an agonizingly slow pace over an extended period of time.

### Minimum Measuring Objective and Permissible Risk

There are no precise measuring objectives for saucer tops and bottoms. However, clues may be found in the size of the previous trend and in the magnitude of retracement from previous support and resistance levels. The length of time over which the saucer develops is also important. Typically, the longer it takes to complete the rounding process, the more significant the subsequent move is likely to be. The risk for the trade is evaluated by measuring the distance between the entry price and the stop-loss price, set just below (above) the saucer bottom (top).

### An Example of a Saucer Bottom

Consider the October 1991 sugar futures chart in Figure 3.5. We have a saucer bottom developing between the beginning of April and the first week of June 1991, as prices hover around 7.50 cents. The breakout past 8.00 cents finally occurs in mid-June, at which time a long position could be established with a sell stop just below the life of contract lows at 7.45 cents. After two months of lethargic action, a rally finally ignited in early July, with prices testing 9.50 cents.

## V-FORMATIONS, SPIKES, AND ISLAND REVERSALS

As the name suggests, a V-formation represents a quick turnaround in the trend from bearish to bullish, just as an inverted V-formation signals a sharp reversal in the trend from bullish to bearish. As Figure 3.6 illustrates, a V-formation could be sharply defined as a spike, as in Figure 3.6*a*, or as an island reversal, as in Figure 3.6*b*. Alternatively, the formation may not be so sharply defined, taking time to develop over a number of trading sessions, as in Figure 3.6*c*.

The chief prerequisite for a V-formation is that the trend preceding it is very steep with few corrections along the way. The turn is characterized by a reversal day, a key reversal day, or an island reversal day on very heavy volume, as the V-formation causes prices to break through

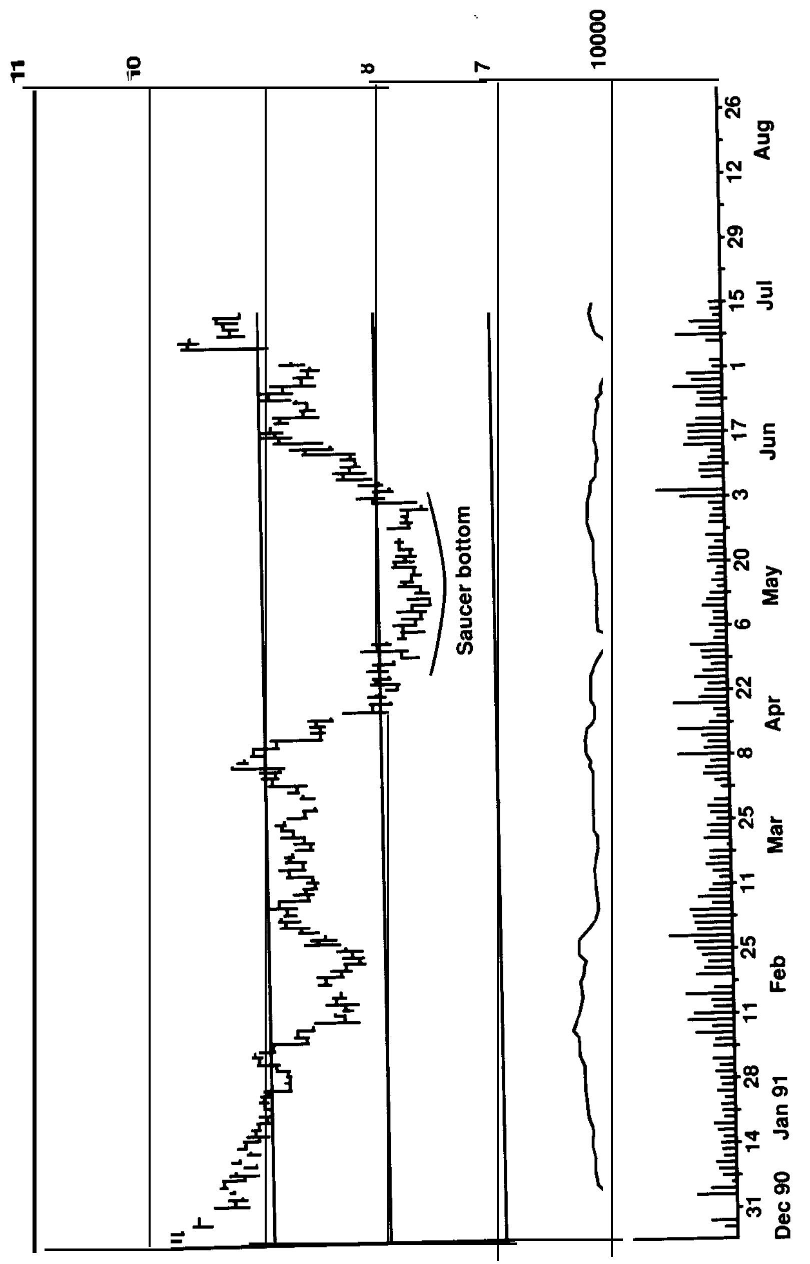



**Figure 3.5** Saucer bottom in October 1991 sugar.

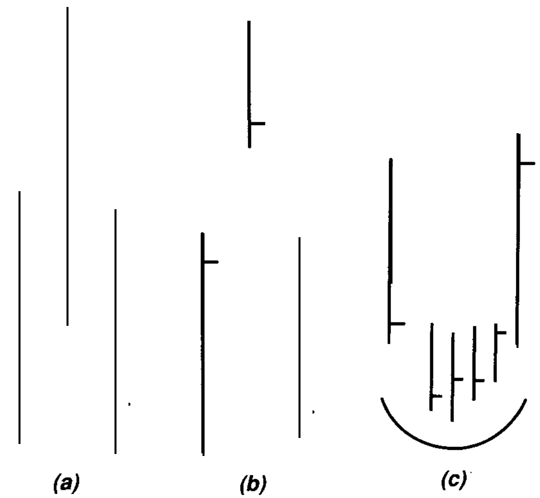



**Figure 3.6** Theoretical V-formations and island reversals: (a) spike formation; (b) island reversal; (c) gradual V-formation.

a steep trendline. A reversal day downward is defined as a day when prices reach new highs, only to settle lower than the previous day. Similarly, a reversal day upward is one where prices touch new lows, only to settle higher than the previous day. A key reversal day is one where prices establish new life-of-contract highs (lows), only to settle lower (or higher) than the previous day.

An island reversal, as is evident from Figure 3.6*b*, is so called because it is flanked by two gaps: an exhaustion gap to its left and a breakaway gap to its right. A gap occurs when there is no overlap in prices from one trading session to the next.

### Minimum Measuring Objective

The measuring objective for V-formations may be defined by reference to the previous trend. At a minimum, a V-formation should retrace anywhere between 38 percent and 62 percent of the move preceding the formation, with 50 percent commonly used as a minimum reward target. Once the minimum target is accomplished, it is quite likely that a congestion pattern will develop as traders begin to realize their profits.

**Estimated Risk**

In the case of a spike or a gradual V-formation, a reasonable place to set a protective stop would be just below the V-formation, for the start of an uptrend, or just above the inverted V-formation, for the start of a downtrend. The logic is that once a peak or trough defined by a V-formation is violated, the pattern no longer serves as a valid reversal signal.

In the case of an island reversal, a reasonable place to set a stop would be just above the low of the island day, in the case of an anticipated downtrend, or just below the high of the island day, in the case of an anticipated uptrend. The rationale is that once prices close the breakaway gap that created the island formation, the pattern is no longer a legitimate island and the trader must look for reversal clues afresh.

**Examples of V-formations, Spikes, and Island Reversals**

Figure 3.7 gives an example of V-formations in the March 1990 Treasury bond futures contract. A reasonable buy stop would be at 101 for a sell signal triggered by the inverted V-formation in July 1989, labeled A. Similarly, a reasonable sell stop would be just below 95 for the buy signal generated by the gradual V-formation, labeled B. In both cases, the reversal signals given by the V-formations are accurate.

However, if we continue further with the March 1990 Treasury bond chart, we come across another case of a bearish spike at C. A trader who decided to short Treasury bonds at 99-28 on December 15 with a protective buy stop at 100-07 would be stopped out the next day as the market touched 100-10. So much for the infallibility of spike days as reversal patterns! We have yet another bearish spike developing on December 20, denoted by D in the figure. Our trader might want to take yet another stab at shorting Treasury bonds at 100-05 with a buy stop at 100-21. The risk is 16 ticks or $500 a contract-a risk well assumed, as future events would demonstrate.

In Figure 3.8, we have two examples of an island reversal in July 1990 platinum futures. In November 1989, we have an island top. A short position could be initiated on November 27 at $547.1, with a protective stop just above $550.0, the low of the island top. This is denoted by point A in the figure. In January 1990, we have an island bottom, denoted by point B. A trader might want to buy platinum futures

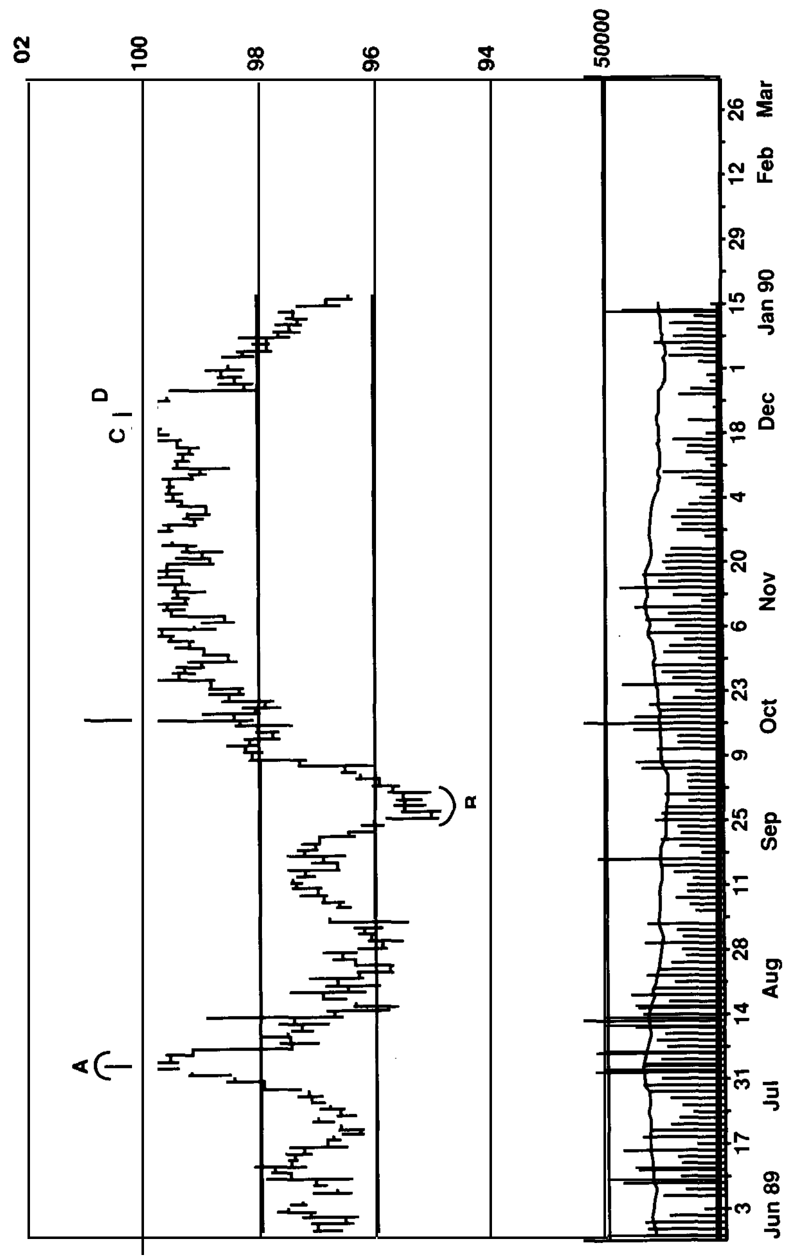



**Figure 3.7** V-formation in the March 1990 T-bond futures contract.

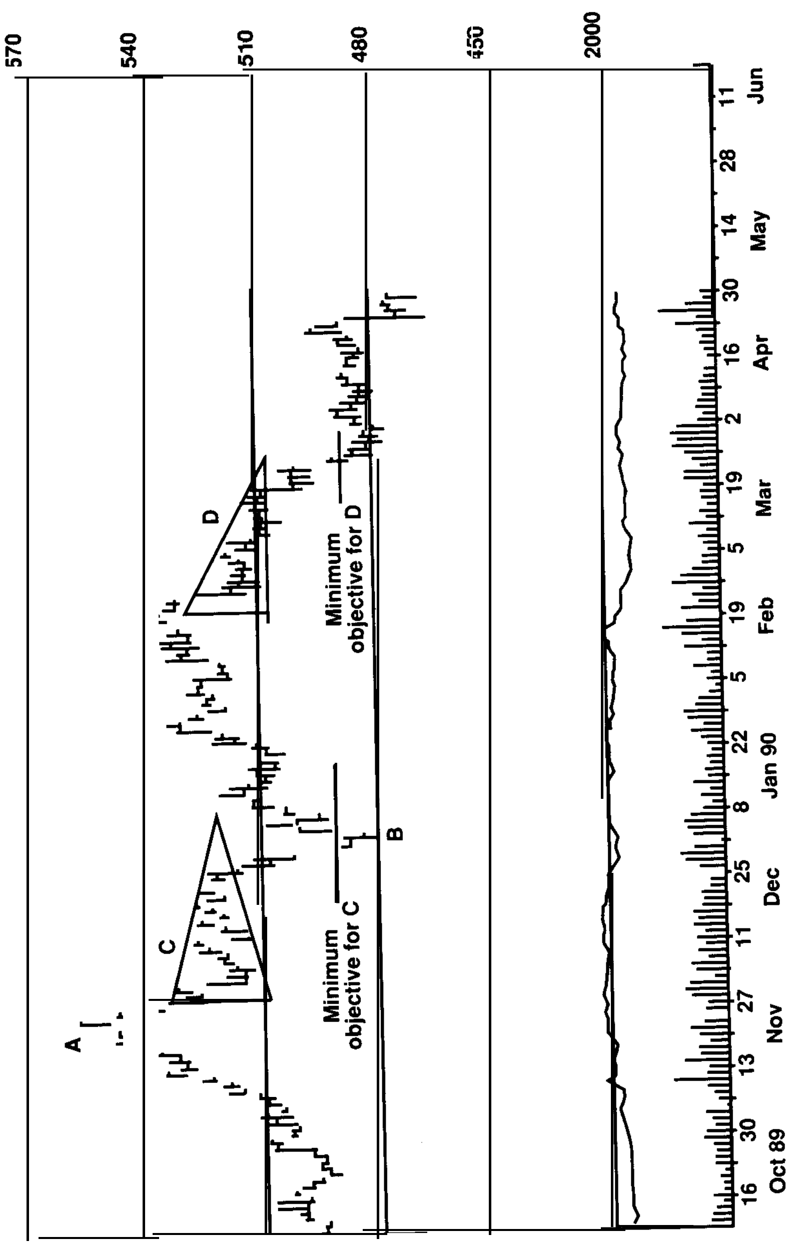



**Figure 3.8** Island reversals and triangles in July 1990 platinum

the following day at $499.9, with a stop just below $489.0, the high of the island reversal day. Notice that the island bottom is formed over a two-day period, disproving the notion that islands must necessarily be formed over a single trading session.

## SYMMETRICAL AND RIGHT-ANGLE TRIANGLES

A symmetrical triangle is formed by a series of price reversals, each of which is smaller than its predecessor. For a legitimate symmetrical triangle formation, we need to observe four reversals of the minor trend: two at the top and two at the bottom. Each minor top is lower than the top formed by the preceding rally, and each minor bottom is higher than the preceding bottom. Consequently, we have a downward-sloping trendline connecting the minor tops and an upward-sloping trendline connecting the minor bottoms. The two lines intersect at the apex of the triangle. Owing to its shape, this pattern is also referred to as a "coil." Decreasing volume characterizes the formation of a triangle, as if to affirm that the market is not clear about its future course.

Normally, a triangle represents a continuation pattern. In exceptional circumstances, it could represent a reversal pattern. While a continuation breakout in the direction of the existing trend is most likely, a reversal against the trend is possible. Consequently, avoid outguessing the market by initiating a trade in the direction of the trend until price action confirms a continuation of the trend by penetrating through the boundary line encompassing the triangle. Ideally, such a penetration should occur on heavy volume.

A right-angle triangle is formed when one of the boundary lines connecting the two minor peaks or valleys is flat or almost horizontal, while the other line slants towards it. If the top of the triangle is horizontal and the bottom converges upward to form an apex with the horizontal top, we have an ascending right-angle triangle, suggesting bullishness in the market. If the bottom is horizontal and the top of the triangle slants down to meet it at the apex, the triangle is a descending right-angle triangle, suggesting bearishness in the market.

Right-angle triangles are similar to symmetrical triangles but are simpler to trade, in that they do not keep the trader guessing about their intentions as do symmetrical triangles. Prices can be expected to ascend out of an ascending right-angle triangle, just as they can be expected to descend out of a descending right-angle triangle.

#### Minimum Measuring Objective

The distance prices may be expected to move once a breakout occurs from a triangle is a function of the size of the triangle pattern. For a symmetrical triangle, the maximum vertical distance between the two converging boundary lines represents the distance prices should move once they break out of the triangle.

The farther out prices drift into the apex of the triangle without bursting through the boundaries, the less powerful the triangle formation. The minimum measuring objective just stated will ensue with the highest probability if prices break out decisively at a point before three-quarters of the horizontal distance from the left-hand corner of the triangle to the apex.

The same measuring rule is applicable in the case of a right-angle triangle. However, an alternative method of arriving at measuring objectives is possible, and perhaps more convenient, in the case of right-angle triangles. Assuming we have an ascending right-angle triangle, draw a line sloping upward parallel to the bottom boundary from the top of the first rally that initiated the pattern. This line slopes upward to the right, forming an upward-sloping parallelogram. At a minimum, prices may be expected to climb until they reach the uppermost corner of the parallelogram.

In the case of a descending right-angle triangle, draw a line parallel to the top boundary from the bottom of the first dip. This line slopes downward to the right, forming a downward-sloping parallelogram. Prices may be expected to drop until they reach the lowermost corner of the parallelogram.

#### Estimated Risk

A logical place to set a protective stop-loss order would be just above the apex of the triangle for a breakout on the downside. Conversely, for a breakout on the upside, a protective stop-loss order may be set just below the apex of the triangle. The dollar value of the difference between the entry price and the stop price represents the permissible risk per contract.



#### An Example of a Triangle Formation

In Figure 3.8, we have an example of a symmetrical and a right-angle triangle formation in the July 1990 platinum futures, marked C and D, respectively. In both cases, the breakout is to the downside, and in both cases the minimum measuring objective is attained and surpassed. permissible risk per contract.

### WEDGES

A wedge is yet another continuation pattern in which price fluctuations are confined within a pair of converging lines. What distinguishes a wedge from a triangle is that both boundary lines of a wedge slope up or down together, without being strictly parallel. In the case of a triangle, it may be recalled that if one boundary line were upward-sloping, the other would necessarily be flat or downward-sloping.

In the case of a rising wedge, both boundary lines slope upward from left to right, but for the two lines to converge the lower line must necessarily be steeper than the upper line. In the case of a falling wedge, the two boundary lines slant downward from left to right, but the upper boundary line is steeper than the lower line.

A wedge normally takes between two and four weeks to form, during which time volume is gradually diminishing. Typically, a rising wedge is a bearish sign, particularly if it develops in a falling market. Conversely, a falling wedge is bullish, particularly if it develops in a rising market.

#### Minimum Measuring Objective

Once prices break out of a wedge, the expectation is that, at a minimum, they will retrace the distance to the point that initiated the wedge. In a falling wedge, the up move may be expected to take prices back to at least the uppermost point in the wedge. Similarly, in a rising wedge, the down move may be expected to take out the low point that first started the wedge formation. Care must be taken to ensure that a breakout from a wedge occurs on heavy volume. This is particularly important in the case of a price breakout on the upside out of a falling wedge.

### Estimated Risk

In the case of a rising wedge, a logical place to set a stop would be just above the highest point scaled prior to the downside breakout. The rationale is that if prices take out this high point, then the breakout is not genuine. Similarly, in the case of a falling wedge, a logical place to set a stop would be just below the lowest point touched prior to the upside breakout. Once again, if prices take out this point, then the wedge is negated.

### An Example of a Wedge

Figure 3.9 gives an example of a rising wedge in a falling September 1991 British pound futures market. The wedge was set off on May 17 when the pound settled at $1.68 16. On this date, the pound could have been short-sold with a buy stop just above the high point of the wedge, namely $1.7270, for a risk of $0.0454 per pound. The objective of this move is a retracement to the low of $1.6346 established on April 29. Accordingly, the estimated reward is $0.0470 per pound, representing the difference between the entry price of $1.68 16 and the target price of $1.6346. Given a permissible risk of $0.0454 per pound, we have a reward/risk ratio of 1.03.

Notice that the pound did not perform according to script over the next seven trading sessions, coming close to stopping out the trader on May 28, when it touched $1.7230. However, on May 29, the pound resumed its journey downwards, meeting and surpassing the objective of the rising wedge. A trader who had the courage to live through the trying period immediately following the short sale would have been amply rewarded, as the pound went on to make a new low at $1.5896 on June 18.

## FLAGS

A flag is a consolidation action whose chart, during an uptrend, has the shape of a flag: a compact parallelogram of price fluctuations, either horizontal or sloping against the trend during the course of an almost vertical move. In a downtrend, the formation is turned upside down. It is almost as though prices are taking a break before resuming their

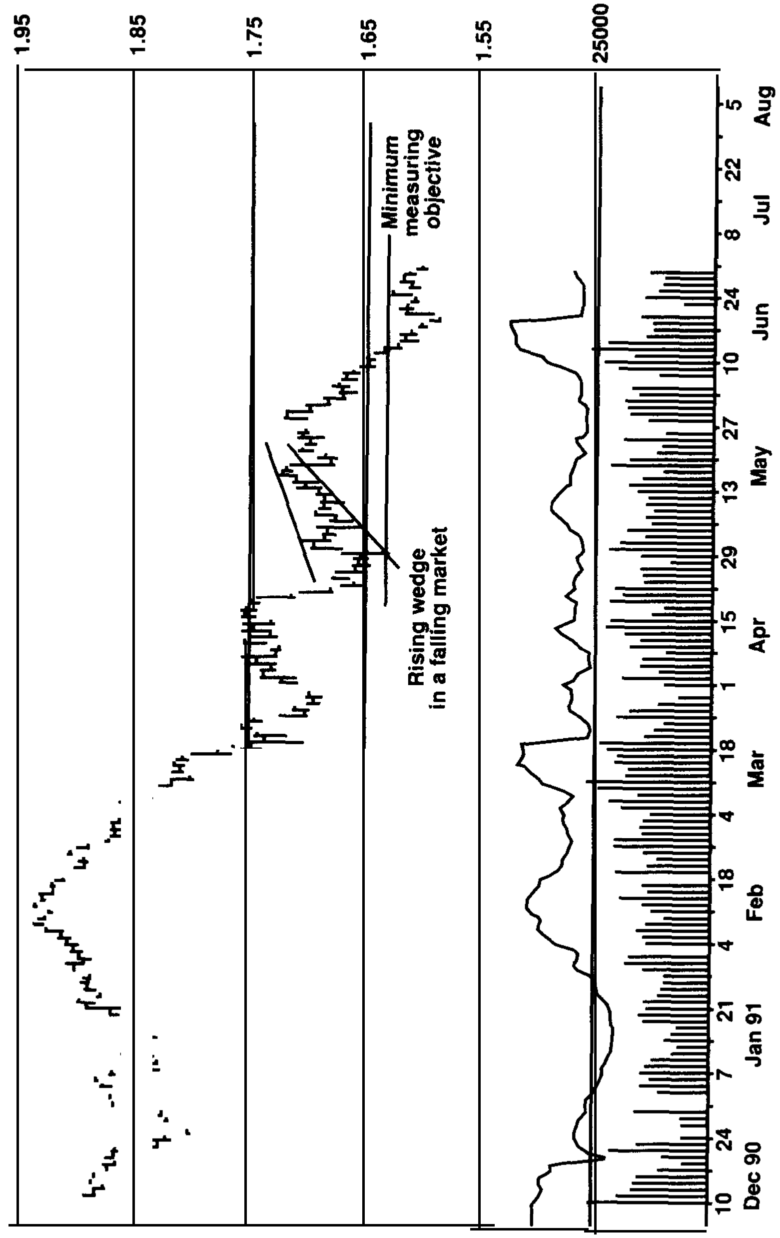



**Figure 3.9** Rising wedge formation in September 1991 British pound.

journey. Whereas the flag formation is characterized by low volume, the breakout from the flag is characterized by high volume. Seldom does a flag formation last more than five trading sessions; the trend resumes thereafter.

### Minimum Measuring Objective

In order to define the magnitude of the expected move, we need to measure the length of the "flagpole" immediately preceding the flag formation. To do this, we must first go back to the beginning of the immediately preceding move, be it a breakout from a previous consolidation or a reversal pattern. Having measured the distance from this breakout to the point at which the flag started to form, we then measure the same distance from the point at which prices penetrate the flag, moving in the direction of the breakout. This represents the minimum measuring objective for the flag formation.

### Estimated Risk

In the case of a flag in a bull market, a logical place to set a protective stop-loss order would be just below the lowest point of the flag formation. If prices were to retrace to this point, then we have a case of a false breakout. Similarly, in the case of a flag in a bear market, a logical place to set a protective stop-loss order would be just above the highest point of the flag formation. The risk for the trade is measured by the dollar value of the difference between the entry and stop-loss prices.

### An Example of a Flag Formation

In Figure 3.10, we have two examples of bear flags in the September 1991 wheat futures chart, denoted by A and B. Each of the flags represents a low-risk opportunity to short the market or to add to existing short positions. As is evident, each of the flags was a reliable indicator of the subsequent move, meeting the minimum measuring objective.

## REWARD ESTIMATION IN THE ABSENCE OF MEASURING RULES

Determining the maximum permissible risk on a trade is relatively straightforward, inasmuch as chart patterns have a way of signaling

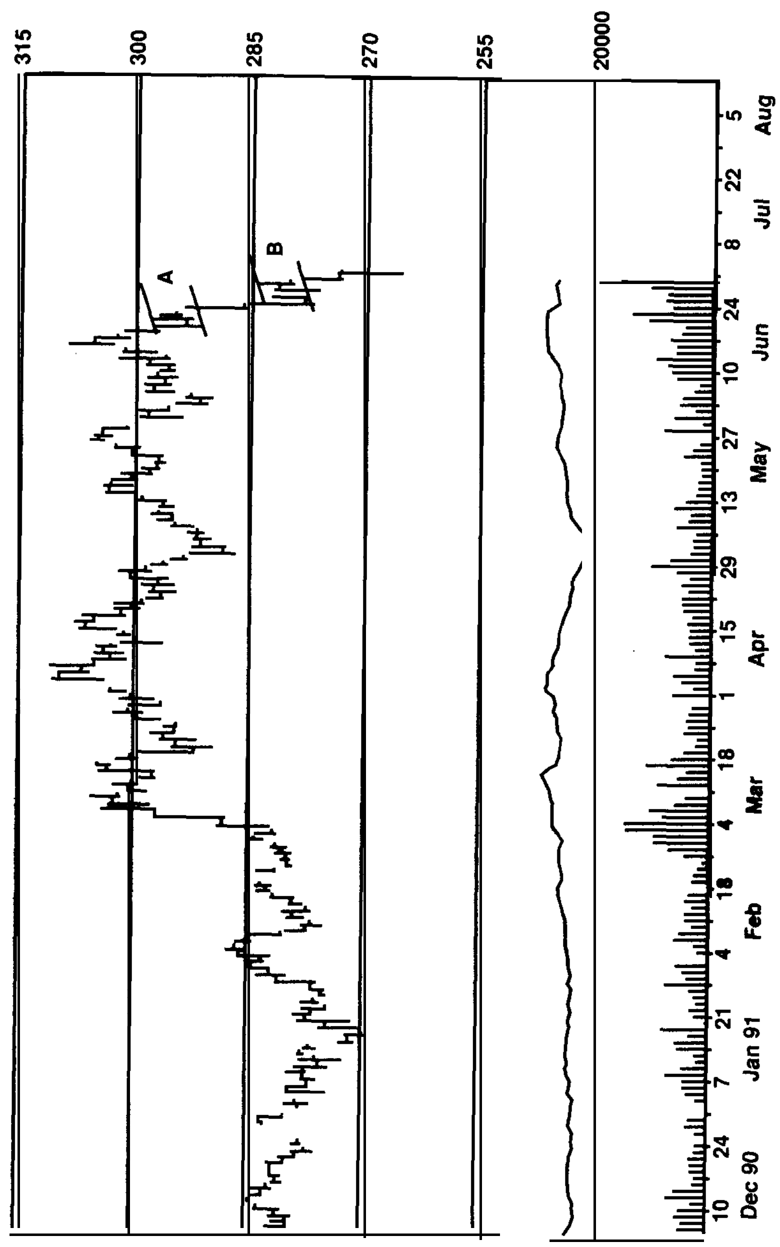



**Figure 3.10** Bear flag formations in September 1991 wheat.

the most reasonable place to set a stop-loss order. However, we do not always enjoy the same facility in terms of estimating the likely reward on a trade. This is especially true when a commodity is charting virgin territory, making new contract highs or lows. In this case, there is no prior support or resistance level to fall back on as a reference point.

Consider, for example, the February 1990 crude oil futures chart given in Figure 3.11. Notice the resistance around $20 a barrel between October and December 1989. Once prices break through this resistance level and make new contract highs, the trader is left with no means to estimate where prices are headed, primarily because prices are not obeying the dictates of any of the chart patterns discussed above.

One solution is to refer to a longer-term price chart, such as a weekly chart, to study longer-term support or resistance levels. Sometimes even longer-term charts are of little help, as prices touch record highs or record lows. A case in point is cocoa, which in 1991 fell below a 15-year low of $1200 a metric ton, leaving a trader guessing as to how much farther it would fall.

In such a situation, it would be worthwhile to analyze price action in terms of waves and retracements thereof. This information, coupled with Fibonacci ratios, could be used to estimate the magnitude of the subsequent wave. For example, Fibonacci theory says that a 38 percent retracement of an earlier move projects to a continuation wave 1.38 times the magnitude of the earlier move. Similarly, a 62 percent retracement of an earlier wave projects to a new wave 1.62 times the original wave. Prechter[3] provides a more detailed discussion on wave theory.

## Revising Risk Estimates

A risk estimate, once established, ought to be respected and never expanded. A trader who expanded the initial stop to accommodate adverse price action would be under no pressure to pull out of a bad trade. This could be a very costly lesson in how not to manage risk!

[3] Robert Prechter, *The Elliot Wave Principle,* 5th ed. (Gainesville, GA: New Classics Library, 1985).

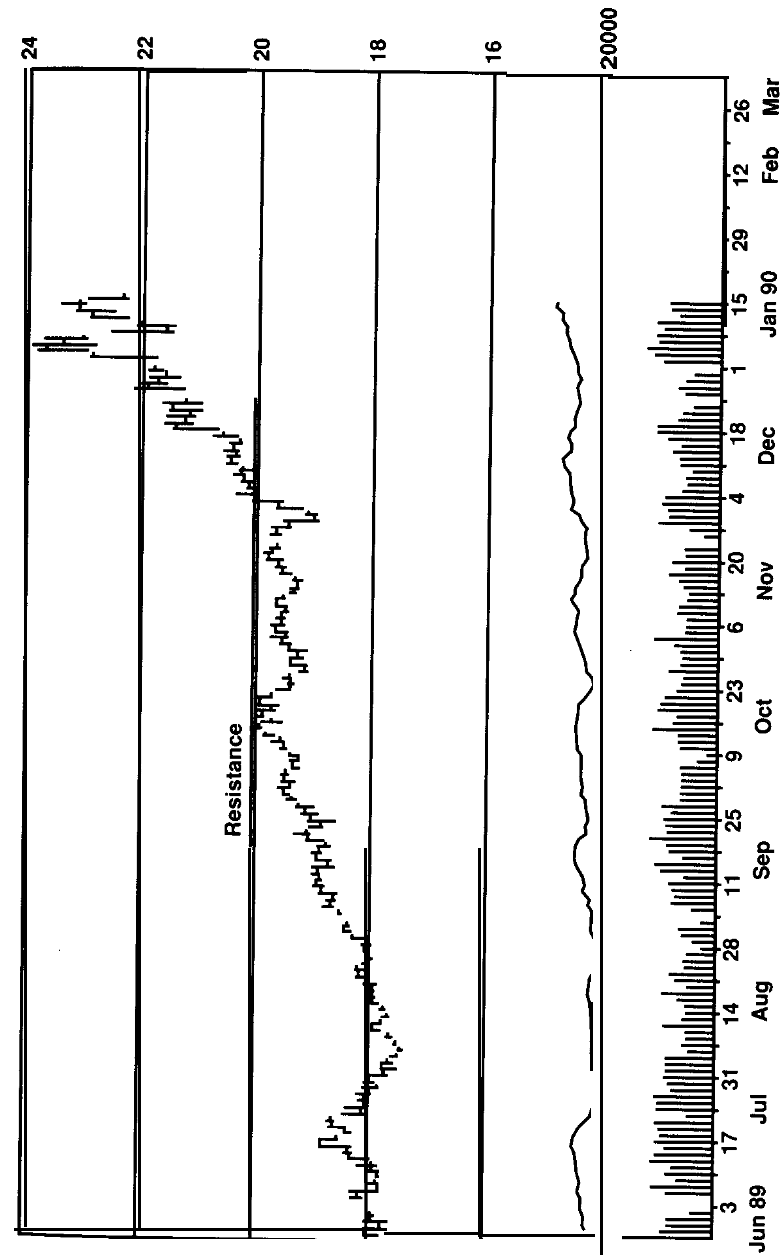



**Figure 3.11** Resistance level in February 1990 crude oil.

However, the rigidity of the initial risk estimates does not imply that the initial stop-loss price ought never to be moved in response to favorable price movements. On the contrary, if prices move as anticipated, the original stop-loss price should be moved in the direction of the move, locking in all or a part of the unrealized profits. Let us illustrate this with the help of a hypothetical example.

Assume for a moment that gold futures are trading at $400 an ounce. A trader who is bullish on gold anticipates prices will test $415 an ounce in the near future, with a possible correction to $395 on the way up. She figures that she will be wrong if gold futures close below $395 an ounce. Accordingly, she buys a contract of gold futures at $400 an ounce with a sell stop at $395. The estimated reward and risk on this trade are graphically displayed in Figure 3.12.

The estimated reward/risk ratio on the trade works out to be 3:1 to begin with. Assume that subsequent price action confirms the trader's expectations, with a rally to $410. If the earlier stop-loss price of $395 is left untouched, the payoff ratio now works out to be a lopsided 1:3! This is displayed in the adjacent block in Figure 3.12.

Although the initial risk assessment was appropriate when gold was trading at $400 an ounce, it needs updating based on the new price of

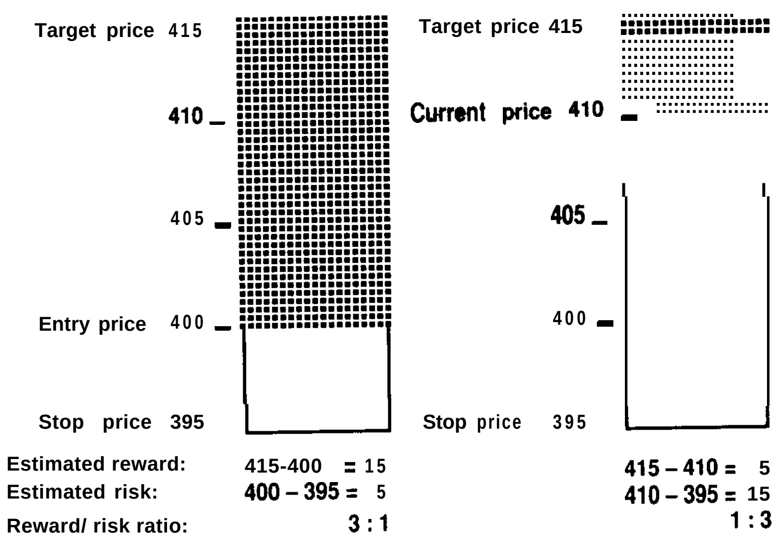



**Figure 3.12** The dynamic nature of risk and reward.



$410. Regardless of the precise location of the new stop price, it should be higher than the original stop price of $395, locking in a part of the favorable price move. If the scenario of rising gold prices were not to materialize, the trader should have no qualms about liquidating the trade at the predefined stop-loss price of $395. She ought not to move the stop downwards to, say, $390 simply to persist with the trade.

## SYNTHESIZING RISK AND REWARD

The objective of estimating reward and risk is to synthesize these two numbers into a ratio of expected reward per unit of risk assumed. The ratio of estimated reward to the permissible loss on a trade is defined as the reward/risk ratio. The higher this ratio, the more attractive the opportunity, disregarding margin considerations.

A reward/risk ratio less than 1 implies that the expected reward is lower than the expected risk, making the risk not worth assuming. Table 3.1 provides a checklist to help a trader assess the desirability of a trade.

**Table 3.1** Risk and Reward Estimation Sheet

Commodity/Contract ________________ Current Price ________________

1. (a) Where is the market headed? What is the probable price? ________________
   (b) Estimated reward:
   if long: target price – current price ______________
   if short: current price – target price ______________

2. (a) At what price must I pull out if the market does not go in the anticipated direction? ________________
   (b) Permissible risk:
   if long: current price – sell stop price ____________
   if short: buy stop price – current price ____________

3. What is the reward/risk ratio for the trade?
   Estimated reward/permissable risk ______________

## CONCLUSION

Risk and reward estimates are two important ingredients of any trade. As such, it would be shortsighted to neglect either or both of these estimates before plunging into a trade. Risk and reward could be viewed as weights resting on adjacent scales of the same weighing machine. If there is an imbalance and the risk outweighs the reward, the trade is not worth pursuing.

Obsession with the expected reward on a trade to the total exclusion of the permissible risk stems from greed. More often than not this is a road to disaster, as instant riches are more of an exception than the rule. The key to success is to survive, to forge ahead slowly but surely, and to look upon each trade as a small step in a long, at times frustrating, journey.

# 4

# Limiting Risk through Diversification

In Chapter 2, we observed that reducing exposure, or the proportion of capital risked to trading, was an effective means of reducing the risk of ruin. This chapter stresses diversification as yet another tool for risk reduction.

The concept of diversification is based on the premise that a trader's forecasting skills are fallible. Therefore, it is safer to bet on several dissimilar commodities simultaneously than to bet exclusively on a single commodity. The underlying rationale is that a prudent trader is not interested in maximizing returns per se but in maximizing returns for a given level of risk. This insightful fact was originally pointed out by Harry Markowitz.[1]

The key to trading success is to survive rather than be overwhelmed by the vicissitudes of the markets, even if this entails forgoing the chance of striking it exceedingly rich in a hurry. In addition to providing for dips in equity during the life of a trade, a trader also should be able to withstand a string of losses across a series of successive bad trades. There might be a temptation to shrug this away as a remote possibility. However, a trader who equates a remote possibility with a zero probability is unprepared both financially and emotionally to deal with this contingency should it arise.

[1] Harry Markowitz, *Portfolio Selection: Efficient Diversification of Investments* (New York: John Wiley, 1959).

When a trading system starts generating a series of bad signals, the typical response is to abandon the system in favor of another system. In the extreme case, the trader might want to give up on trading in general, if the losses suffered have cut deeply into available trading capital. It would be much wiser to recognize up front that the best trading systems will generate losing trades from time to time and to provide accordingly for the worst-case scenario. Here is where diversification can help.

Let us, for purposes of illustration, consider the hypothetical trading results for a commodity over a one-year period, shown in Table 4.1. Here we have a reasonably good trading system, given that the dollar

**Table 4.1** Results for a Commodity across 20 Trades

| Trade # | Change in Equity Profit (+)/Loss (−) | Cum. Value of Losing Trades |
|---|---|---|
| 1 | -500 | -500 |
| 2 | -300 | -800 |
| 3 | -100 | -900 |
| 4 | +200 | |
| 5 | +300 | |
| 6 | +1000 | |
| 7 | -600 | -600 |
| 8 | -500 | -1100 |
| 9 | -300 | -1400 |
| 10 | -400 | -1800 |
| 11 | +200 | |
| 12 | +2000 | |
| 13 | -200 | -200 |
| 14 | +500 | |
| 15 | -500 | -500 |
| 16 | +1000 | |
| 17 | -700 | -700 |
| 18 | +2500 | |
| 19 | +500 | |
| 20 | +800 | |

Summary of Results

| | # | $ |
|---|---|---|
| Winning trades | 10 | 9000 |
| Losing trades | 10 | 4100 |



value of winning trades ($9000) more than twice outweighs the dollar value of losing trades ($4100). The total number of profitable trades exactly equals the total number of losing trades, leading to a 50 percent probability of success. Nevertheless, there is no denying the fact that the system does suffer from runs of bad trades, and the cumulative effect of these runs is quite substantial. Unless the trader can withstand losses of this magnitude, he is unlikely to survive long enough to reap profits from the system.

A trader might convince himself that the string of losses will be financed by profits already generated by the system. However, this could turn out to be wishful thinking. There is no guarantee that the system will get off to a good start, helping build the requisite profit cushion. This is why it is essential to trade a diversified portfolio.

Assuming that a trader is simultaneously trading a group of unrelated commodities, it is unlikely that all the commodities will go through their lean spells at the same time. On the contrary, it is likely that the losses incurred on one or more of the commodities traded will be offset by profits earned concurrently on the other commodities. This, in a nutshell, is the rationale behind diversification.

In order to understand the concept of diversification, we must understand the risk of trading commodities (a) individually and (b) jointly as a portfolio. In Chapter 3, the risk on a trade was defined as the maximum dollar loss that a trader was willing to sustain on the trade. In this chapter, we define statistical risk in terms of the volatility of returns on futures trades. A logical starting point for the discussion on risk is a clear understanding of how returns are calculated on futures trades.

## MEASURING THE RETURN ON A FUTURES TRADE

Returns could be categorized as either (a) realized returns on completed trades or (b) anticipated returns on trades to be initiated. Realized returns are also termed historical returns, just as anticipated returns are commonly referred to as expected returns. In this section, we discuss the derivation of both historical and expected returns.

### Measuring Historical Returns

The historical or realized return on a futures trade is arrived at by summing the present value of all cash flows on a trade and dividing this sum by the initial margin investment. This ratio gives the return over the life of the trade, also known as the holding period return.

Technically, the cash flows on a futures trade would have to be computed on a daily basis, since prices are marked to market each day, and the difference, either positive or negative, is adjusted against the trader's account balance. If the equity on the trade falls below the maintenance margin level, the trader is required to deposit additional monies to bring the equity back to the initial margin level. This is known as a variation margin call. If the trade registers an unrealized profit, the trader is free to withdraw these profits or to use them for another trade.

However, in the interests of simplification, we assume that unrealized profits are inaccessible to the trader until the trade is liquidated. Therefore, the pertinent cash flows are the following:

1. The initial margin investment
2. Variation margin calls, if any, during the life of the trade
3. The profit or loss realized on the trade, given by the difference between the entry and liquidation prices
4. The release of initial and variation margins on trade liquidation

The initial margin represents a cash outflow on inception of the trade. Whereas cash flows (3) and (4) arise on liquidation of the trade, cash flow (2) can occur at any time during the life of the trade.

Since there is a mismatch in the timing of the various cash flows, we need to discount all cash flows back to the trade initiation date. Discounting future cash flows at a prespecified discount rate, $i$, gives the present value of these cash flows. The discount rate, $i$, is the opportunity cost of capital and is equal to the trader's cost of borrowing less any interest earned on idle funds in the account.

Care should be taken to align the rate, $i$, with the length of the trading interval. If the trading interval is measured in days, then $i$ should be expressed as a rate per day. If the trading interval is measured in weeks, then $i$ should be expressed as a rate per week.

The rate of return, $r$, for a purchase or a long trade initiated at time $t$ and liquidated at time $l$, with an intervening variation margin call at time v, is calculated as follows:

$$r = \frac{-IM - \dfrac{VM}{(1+i)^{v-t}} + \dfrac{(P_l - P_t)}{(1+i)^{l-t}} + \dfrac{(IM + VM)}{(1+i)^{l-t}}}{IM}$$



where $IM$ = the initial margin requirement per contract

$VM$ = the variation margin called upon at time v

$P_t$ = the dollar equivalent of the entry price

$P_l$ = the dollar equivalent of the liquidation price

All cash flows are calculated on a per-contract basis. Using the foregoing notation, the rate of return, $r$, for a short sale initiated at time $t$ and liquidated at time $l$ is given as follows:

$$r = \frac{-IM - \dfrac{VM}{(1+i)^{v-t}} - \dfrac{(P_l - P_t)}{(1+i)^{l-t}} + \dfrac{(IM + VM)}{(1+i)^{l-t}}}{IM}$$

For a profitable long trade, the liquidation price, $P_l$, would be greater than the entry price, $P_t$. Conversely, for a profitable short trade, the liquidation price, $P_l$, would be lower than the entry price, $P_t$. Hence we have a positive sign for the price difference term for a long trade and a negative sign for the same term for a short trade. The variation margin is a cash outflow, hence the negative sign up front. This money reverts back to the trader along with the initial margin when the trade is liquidated, representing a cash inflow.

The rate, $r$, represents the holding period return for $(l - t)$ days. When this is multiplied by $365/(l - t)$, we have an annualized return for the trade. Therefore, the annualized rate of return, $R$, is

$$R = r \times \frac{365}{l - t}$$

This facilitates comparison across trades of unequal duration.

Suppose a trader has bought a contract of the Deutsche mark at $0.5500 on August 1. The initial margin is $2500. On August 5, she is required to put up a further $1000 as variation margin as the mark drifts lower to $0.5400. On August 15, she liquidates her long position at $0.5600, for a profit of 100 ticks or $1250. Assuming that the annualized interest rate on Treasury bills is 6 percent, we have a daily interest rate, $i$, of 0.0164 percent or 0.000164. Using this information, the return, $r$, and the annualized return, $R$, on the trade works out to be

$$r = \frac{-2500 - \dfrac{1000}{(1.000164)s} + \dfrac{1250}{(1.000164)^{15}} + \dfrac{3500}{(1.000164)^{15}}}{2500}$$

$$= \frac{-2500 - 999.18 + 1246.93 + 3491.40}{2500}$$

$$= \frac{+\ 1239.15}{2500}$$

$$= 0.4957 \text{ or } 49.57\%$$

$$R = 49.57\% \times \frac{365}{15}$$

$$= 1206.10\%$$

### Measuring Expected Returns

The expected return on a trade is defined as the expected profit divided by the initial margin investment required to initiate the trade. The expected profit represents the difference between the entry price and the anticipated price on liquidation of the trade. Since there is no guarantee that a particular price forecast will prevail, it is customary to work with a set of alternative price forecasts, assigning a probability weight to each forecast. The weighted sum of the anticipated profits across all price forecasts gives the expected profit on the trade.

The anticipated profit resulting from each price forecast, divided by the required investment, gives the anticipated return on investment for that price forecast. The overall expected return is the summation across all outcomes of the product of (a) the anticipated return for each outcome and (b) the associated probability of occurrence of each outcome.

Assume that a trader is bullish on gold and is considering buying a contract of gold futures at the current price of $385 an ounce. The trader reckons that there is a 0.50 probability that prices will advance to $390 an ounce; a 0.20 probability of prices touching $395 an ounce; and a 0.30 probability that prices will fall to $380 an ounce. The margin for a contract of gold is $2000 a contract. The expected return is calculated in Table 4.2.



**Table 4.2** Expected Return on Long Gold Trade

| Probability | Price | Profit ($/contract) | Return | Probability x Return |
|---|---|---|---|---|
| 0.30 | 380 | -500 | -0.25 | -0.075 |
| 0.50 | 390 | +500 | +0.25 | +0.125 |
| 0.20 | 395 | +1000 | +0.50 | +0.100 |
| | | Overall Expected Return = | | +0.150 or 15% |

## MEASURING RISK ON INDIVIDUAL COMMODITIES

Statistical risk is measured in terms of the variability of either (a) historic returns realized on completed trades or (b) expected returns on trades to be initiated-the profit in respect of which is merely anticipated, not realized. Whereas the risk on completed trades is measured in terms of the volatility of historic returns, the projected risk on a trade not yet initiated is measured in terms of the volatility of expected returns.

### Measuring the Volatility of Historic Returns

The volatility or variance of historic returns is given by the sum of the squared deviations of completed trade returns around the arithmetic mean or average return, divided by the total number of trades in the sample less 1. Therefore, the formula for the variance of historic returns is

$$\text{Variance of historic returns} = \frac{\sum_{i=1}^{n} (\text{Return}_i - \text{Mean return})^2}{n-1}$$

where $n$ is the number of trades in the sample period.

The historic return on a trade is calculated according to the foregoing formula. The mean return is defined as the sum of the returns across all trades over the sample period, divided by the number of trades, $n$, considered in the sample.

The greater the volatility of returns about the mean or average return, the riskier the trade, as a trader can never be quite sure of the ultimate outcome. The lower the volatility of returns, the smaller the dispersion of returns around the arithmetic mean or average return, reducing the degree of risk.

To illustrate the concept of risk, Table 4.3 gives details of the historic returns earned on 10 completed trades for two commodities, gold ($X$) and silver ($Y$).

Whereas the average return for gold is slightly higher than that for silver, there is a much greater dispersion around the mean return in case of gold, leading to a much higher level of variance. Therefore, investing in gold is riskier than investing in silver.

The period over which historical volatility is to be calculated depends upon the number of trades generated by a given trading system. As a general rule, it would be desirable to work with at least 30 returns. The length of the sample period needs to be adjusted accordingly.

### Measuring the Volatility of Expected Returns

This measure of risk is used for calculating the dispersion of anticipated returns on trades not yet initiated. The variance of expected returns is defined as the summation across all possible outcomes of the product of the following:

1. The squared deviations of individual anticipated returns around the overall expected return
2. The probability of occurrence of each outcome

The formula for the variance of expected returns is therefore:

$$\text{Variance of expected returns} = \sum_{i=1}^{n} \left( \text{Anticipated return}_i - \text{Overall expected return} \right)^2 \times \text{Prob}_i$$

Continuing with our earlier example of the expected return on gold, the variance of such expected returns may be calculated as shown in Table 4.4.

The variance of expected returns works out to be 7.75%. Since assigning probabilities to forecasts of alternative price outcomes is difficult, calculating the variance of expected returns can be cumbersome. In order to simplify computations, the variance of historic returns is often used as a proxy for the variance of expected returns. The assumption is that expected returns will follow a variance pattern identical to that observed over a sample of historic returns.

**Table 4.3** Historic Returns on 10 Trades in Gold (X) and Silver (Y)

| $X_i$ | $(X_i - \overline{X})$ | $(X_i - \overline{X})^2$ | $Y_i$ | $(Y_i - \overline{Y})$ | $(Y_i - \overline{Y})^2$ | $(X_i - \overline{X}) \times (Y_i - \overline{Y})$ |
|---|---|---|---|---|---|---|
| 250 | 222 | 49, 284 | 125 | 100 | 10, 000 | 22, 200 |
| 50 | 22 | 484 | 75 | 50 | 2, 500 | 1, 100 |
| −150 | −178 | 31, 684 | −100 | −125 | 15, 625 | 22, 250 |
| −50 | −78 | 6, 084 | −25 | −50 | 2, 500 | 3, 900 |
| 100 | 72 | 5, 184 | 100 | 75 | 5, 625 | 5, 400 |
| 175 | 147 | 21, 609 | 90 | 65 | 4, 225 | 9, 555 |
| −100 | −128 | 16, 384 | −50 | −75 | 5, 625 | 9, 600 |
| 0 | −28 | 784 | 20 | −5 | 25 | 140 |
| 50 | 22 | 484 | 40 | 15 | 225 | 330 |
| −45 | −73 | 5, 329 | −25 | −50 | 2, 500 | 3, 650 |
| $\sum = 280$ | | $\sum = 137,310$ | $\sum = 250$ | | $\sum = 48,850$ | $\sum = 78,125$ |
| $\overline{X} = 28$ | | $\text{Var}_X = 15256.67$ | $\overline{Y} = 25$ | | $\text{Var}_Y = 5247.78$ | $\text{Cov}_{XY} = 8680.55$ |

**Table 4.4** Variance of Expected Return on Long Gold Trade

| Probability | Return | Return − Expected Return | (Return − Expected Return)$^2$ x Probability |
|---|---|---|---|
| 0.30 | -0.25 | -0.40 | 0.0480 |
| 0.50 | +0.25 | +0.10 | 0.0050 |
| 0.20 | +0.50 | +0.35 | 0.0245 |
| | | | Variance = 0.0775 or 7.75% |

## MEASURING RISK ACROSS COMMODITIES TRADED JOINTLY: THE CONCEPT OF CORRELATION BETWEEN COMMODITIES

The risk of trading two commodities jointly is given by the covariance of their returns. As the name suggests, the covariance between two variables measures their joint variability. Referring to the example of gold and silver given in Table 4.3, we observe that an increase in the return on gold is matched by an increase in the return on silver and vice versa. This leads to a positive covariance term between these two commodities.

The covariance between returns on gold and silver is measured as the sum of the product of their joint excess returns over their mean returns divided by the number of trades in the sample less 1. The formula for the covariance between the historic returns on X and Y is given as

Covariance between the historic returns $X_i$ and $Y_i$ on commodities X and Y

$$= \frac{\sum_{i=1}^{n}\left(\text{Return } X_i - \begin{matrix}\text{Mean return}\\ \text{on X}\end{matrix}\right)\left(\text{Return } Y_i - \begin{matrix}\text{Mean return}\\ \text{on Y}\end{matrix}\right)}{n-1}$$

where $n$ is the number of trades in the sample period.

The formula for the covariance between the expected returns on X and Y is similar to that for the covariance across historic returns. The exception is that each of the $i$ observations is assigned a weight equal to its individual probability of occurrence, Pi. Therefore, the formula



for the covariance between the expected returns on X and Y reads as follows:

Covariance between the expected returns $X_i$ and $Y_i$ on commodities X and Y

$$= \sum_{i=1}^{n}\left(\text{Return } X_i - \begin{matrix}\text{Exp. Return}\\ \text{on X}\end{matrix}\right)\left(\text{Return } Y_i - \begin{matrix}\text{Exp. Return}\\ \text{on Y}\end{matrix}\right)(P_i)$$

If there are two commodities under review, there is one covariance between the returns on them. If there are three commodities, X, Y, and Z, under review, there are three covariances to contend with: one between X and Y, the second between X and Z, and the third between Y and Z. If there are four commodities under review, there are six distinct covariances between the returns on them. In general, if there are $K$ commodities under review, there are $[K(K - 1)]/2$ distinct covariance terms between the returns on them.

In the foregoing example, the covariance between the returns on gold and silver works out to be 8680.55, suggesting a high degree of positive correlation between the two commodities. The correlation coefficient between two variables is calculated by dividing the covariance between them by the product of their individual standard deviations. The standard deviation of returns is the square root of the variance. The correlation coefficient assumes a value between + 1 and − 1. In the above example of gold and silver, the correlation works out to be $+0.95$, as shown as follows:

$$\begin{matrix}\text{Correlation betwen}\\ \text{gold and silver}\end{matrix} = \frac{\text{Covariance between returns on gold and silver}}{\text{(Std. dev. gold)(Std. dev. silver)}}$$

$$= \frac{8680.55}{123.52 \times 73.67}$$

$$= +0.95$$

Two commodities are said to exhibit perfect positive correlation if a change in the return of one is accompanied by an equal and similar change in the return of the other. Two commodities are said to exhibit Perfect negative correlation if a change in the return of one is accompanied by an equal and opposite change in the return of the other. Finally, two commodities are said to exhibit zero correlation if the return of one

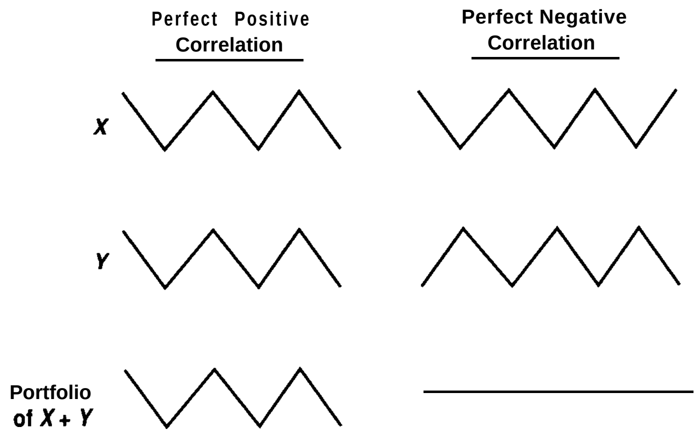



**Figure 4.1** Positive and negative correlations.

is unaffected by a change in the other's return. The concept of correlation is graphically illustrated in Figure 4.1.

In actual practice, examples of perfectly positively or negatively correlated commodities are rarely found. Ideally, the degree of association between two commodities is measured in terms of the correlation between their returns. For ease of exposition, however, it is assumed that prices parallel returns and that correlations based on prices serve as a good proxy for correlations based on returns.

## WHY DIVERSIFICATION WORKS

Diversification is worthwhile only if (a) the expected returns associated with diversification are comparable to the expected returns associated with the strategy of concentrating resources in one commodity and (b) the total risk of investing in two or more commodities is less than the risk associated with investing in any single commodity. Both these conditions are best satisfied when there is perfect negative correlation between the returns on two commodities. However, diversification will work even if there is less than perfect negative correlation between two commodities.

The returns associated with the strategy of concentrating all resources in a single commodity could be higher than the returns associated with diversification, especially if prices unfold as anticipated. However, the



risk or variability of such returns is much greater, given the higher probability of error in forecasting the movement of a single commodity. Given the lower variability of returns of a diversified portfolio, it makes sense to trade a diversified portfolio, especially if the expected return in trading a single commodity is no greater than the expected return from trading a diversified portfolio.

We can illustrate this idea by means of a simple example involving two perfectly negatively correlated commodities, X and Y. The distribution of expected returns is given in Table 4.5. Consider an investor who wishes to trade a futures contract of one or both of these commodities. If he invests his entire capital in either X or Y, he has a 0.50 chance of losing 50 percent and a 0.50 chance of making 100 percent. This results in an expected return of 25 percent and a variance of 5625 for both X and Y individually.

What will our investor earn, should he decide to split his investment equally between both X and Y? The probability of earning any given return jointly on X and Y is the product of the individual probabilities of achieving this return. For example, the joint probability that the return on both X and Y will be -50 percent is the product of the probabilities of achieving this return separately for X and Y. This is the product of 0.50 for X and 0.50 for Y, or 0.25. Similarly, there is a 0.25 chance of making + 100 percent on both X and Y simultaneously. Moreover, there

**Table 4.5** Expected Returns on Perfectly Negatively Correlated Commodities

| X | | | Y | | |
|---|---|---|---|---|---|
| Return | Probability | Prob. x Return | Return | Probability | Prob. x Return |
| (%) | | (%) | (%) | | (%) |
| −50 | .50 | −25 | +100 | .50 | +50 |
| +25 | 0 | 0 | 25 | 0 | 0 |
| +100 | 50 | +50 | −50 | .50 | −25 |
| Overall Expected Return | | for X = 25% | | | for Y = 25% |
| Variance of Exp. Returns | | for X = 5625 | | | for Y = 5625 |

is a 0.25 chance that X will lose 50 percent and Y will earn 100 percent, and another 0.25 chance that X will make 100 percent and Y will lose 50 percent. In both these cases, the expected return works out to be 25 percent, as

$$.50 \times (-50\%) + .50 \times (+100\%) = 25\%$$

Therefore, the probability of earning 25 percent on the portfolio of X and Y is the sum of the individual probabilities of the two mutually exclusive alternatives resulting in this outcome, namely 0.25 + 0.25, or 0.50.

Using this information, we come up with the probability distribution of returns for a portfolio which includes X and Y in equal proportions. The results are outlined in Table 4.6. Notice that the expected return of the portfolio of X and Y at 25 percent is the same as the expected return on either X or Y separately. However, the variance of the portfolio at 2812.5 is one-half of the earlier variance. The creation of the portfolio reduces the variability or dispersion of joint returns, primarily by reducing the probability of large losses and large gains. Assuming that our investor is risk-averse, he is happier as the variance of returns is reduced for a given level of expected return.

In the foregoing example, we have shown how diversification can help an investor when the returns on two commodities are perfectly negatively correlated. In practice, it is difficult to find perfectly negatively correlated returns. However, as long as the return distributions on two commodities are even mildly negatively correlated, the trader could stand to gain from the risk reduction properties of diversification. For

**Table 4.6** Joint Returns on a Portfolio of 50% X and 50% Y

| Return (%) | Probability | Probability × Return (%) |
|---|---|---|
| -50 | .25 | -12.5 |
| +25 | .50 | +12.5 |
| +100 | .25 | +25 |

Overall Expected Return for the Portfolio = **25%**
Variance of the portfolio = 2812.5



example, a portfolio comprising a long position in each of the negatively correlated crude oil and U.S. Treasury bonds is less risky than a long position in two contracts of either crude oil or Treasury bonds.

## AGGREGATION: THE FLIP SIDE TO DIVERSIFICATION

If a trader were to assume similar positions (either long or short) concurrently in two positively correlated commodities, the resulting portfolio risk would outweigh the risk of trading each commodity separately. Trading the same side of two or more positively correlated commodities concurrently is known as aggregation. Just as diversification helps reduce portfolio risk, aggregation increases it. An example would help to clarify this.

Given the high positive correlation between Deutsche marks and Swiss francs, a portfolio comprising a long position in both the Deutsche mark and the Swiss franc is more risky than investing in either the Deutsche mark or the Swiss franc exclusively. If the trader's forecast is proved wrong, he or she will be wrong on both the mark and the franc, suffering a loss on both long positions.

The first step to limiting the risk associated with concurrent exposure to positively correlated commodities is to categorize commodities according to the degree of correlation between them. This is done in Appendix C. Next, the trader must devise a set of rules which will prevent him or her from trading the same side of two or more positively correlated commodities simultaneously.

## CHECKING FOR SIGNIFICANT CORRELATIONS ACROSS COMMODITIES

Appendix C gives information on price correlations between pairs of 24 commodities between July 1983 and June 1988. Correlations have been worked out using the Dunn & Hargitt commodity futures prices database. The correlations are arranged commodity by commodity in descending order, beginning with the highest number and working down to the lowest number. For example, in the case of the S&P 500 stock index futures, correlations begin with a high of 0.999 (with the NYSE index) and gradually work their way down to a low of -0.862 (with corn).

As a rule of thumb, it is recommended that all commodity pairs with correlations that are (a) in excess of +0.80 or less than -0.80 and (b) statistically significant be classified as highly correlated commodities.

### Checking the Statistical Significance of Correlations

The most common test of significance checks whether a sample correlation coefficient could have come from a population with a correlation coefficient of 0. The null hypothesis, $H_0$, posits that the correlation coefficient, C, is 0. The alternative hypothesis, $H_1$, says that the population correlation coefficient is significantly different from 0. Since $H_1$ simply says that the correlation is significantly different from 0 without saying anything about the direction of the correlation, we use a two-tailed test of rejection of the null hypothesis. The null hypothesis is tested as a t-test with $(n - 2)$ degrees of freedom, where $n$ is the number of paired observations in the sample. Ideally, we would like to see at least 32 paired observations in our sample to ensure validity of the results. The value of $t$ is defined as follows:

$$t = \frac{C}{\sqrt{(1 - C^2)/(n - 2)}}$$

The value of $t$ thus calculated is compared with the theoretical or tabulated value of $t$ at a prespecified level of significance, typically 1 percent or 5 percent. A 1 percent level of significance implies that the theoretical $t$ value encompasses 99 percent of the distribution under the bell-shaped curve. The theoretical or tabulated $t$ value at a 1 percent level of significance for a two-tailed test with 250 degrees of freedom is $\pm 2.58$. Similarly, a 5 percent level of significance implies that the theoretical $t$ value encompasses 95 percent of the distribution under the bell-shaped curve. The corresponding tabulated $t$ value at a 5 percent level of significance for a two-tailed test with 250 degrees of freedom is $\pm 1.96$.

If the calculated $t$ value lies beyond the theoretical or tabulated value, there is reason to believe that the correlation is nonzero. Therefore, if the calculated $t$ value exceeds +2.58 (+ 1.96), or falls below -2.58 (- 1.96), the null hypothesis of zero correlation is rejected at the 1 percent (5 percent) level. However, if the calculated value falls between



$\pm$ 2.58 ($\pm$ 1.96), the null hypothesis of zero correlation cannot be rejected at the 1 percent (5 percent) level.

Continuing with our gold-silver example, the correlation between the two was found to be +0.95 across 10 sample returns. Is this statistically significant at a 1 percent level of significance? Using the foregoing formula,

$$t = \frac{0.95}{\sqrt{(1 \quad 0.9025)/(10 - 2)}} = 8.605$$

With eight degrees of freedom, the theoretical or table value of $t$ at a 1 percent level of significance is 3.355. Since the calculated $t$ value is well in excess of 3.355, we can conclude that our sample correlation between gold and silver is significantly different from zero.

In some cases the correlation numbers are meaningful and can be justified. For example, any change in stock prices is likely to have its impact felt equally on both the S&P 500 and the New York Stock Exchange (NYSE) futures index. Similarly, the Deutsche mark and the Swiss franc are likely to be evenly affected by any news influencing the foreign exchange markets.

However, some of the correlations are not meaningful, and too much weight should not be attached to them, notwithstanding the fact that they have a correlation in excess of 0.80 and the correlation is statistically significant. If two seemingly unrelated commodities have been trending in the same direction over any length of time, we would have a case of positively correlated commodities. Similarly, if two unrelated commodities have been trending in opposite directions for a long time, we would have a case of negative correlation. This is where statistics could be misleading. In the following section, we outline a procedure to guard against spurious correlations.

## A NONSTATISTICAL TEST OF SIGNIFICANCE OF CORRELATIONS

A good way of judging whether a correlation is genuine or otherwise is to rework the correlations over smaller subsample periods. For example, the period 1983-1988 may be broken down into subperiods, such as 1983-84, 1985-86, and 1987-88, and correlations obtained for each of these subperiods, to check for consistency of the results. Appendix C presents correlations over each of the three subperiods.

If the numbers are fairly consistent over each of the subperiods, we can conclude that the correlations are genuine. Alternatively, if the numbers differ substantially over time, we have reason to doubt the results. This process is likely to filter away any chance relationships, because there is little likelihood of a chance relationship persisting with a high correlation score across time.

Table 4.7 illustrates this by first reporting all positive correlations in excess of t-O.80 for the entire 1983-88 period and then reporting the corresponding numbers for the 1983-84, 1985-86, and 1987-88 subperiods.

Table 4.7 reveals the tenuous nature of some of the correlations. For example, the correlation between soybean oil and Kansas wheat is 0.876 between 1987 and 1988, whereas it is only 0.410 between 1983 and 1984. Similarly, the correlation between corn and crude oil ranges from a low of -0.423 in 1987-88 to a high of 0.735 between 1983 and 1984. Perhaps more revealing is the correlation between the S&P 500 and the Japanese yen, ranging from a low of -0.644 to a high of 0.949! Obviously it would not make sense to attach too much significance to high positive or negative correlation numbers in any one period, unless the strength of the correlations persists across time.

If the high correlations do not persist over time, these commodities ought not to be thought of as being interrelated for purposes of diversification. Therefore, a trader should not have any qualms about buying (or selling) corn and crude oil simultaneously. Only those commodities that display a consistently high degree of positive correlation should be treated as being alike and ought not to be bought (or sold) simultaneously.

## MATRIX FOR TRADING RELATED COMMODITIES

The matrix in Figure 4.2 summarizes graphically the impact of holding positions concurrently in two or more related commodities. If two commodities are positively correlated and a trader were to hold similar positions (either long or short) in each of them concurrently, the resulting aggregation would result in the creation of a high-risk portfolio.

Table 4.7 Positive Correlations in Excess of 0.80 during 1983-88 Period

| Commodity pair | Correlation between commodities | | | |
|---|---|---|---|---|
| | **1983-88** | **1983-84** | **1985-86** | **1987-88** |
| S&P 500/NYSE indices | 0.999 | 0.991 | 1.000 | 0.997 |
| D. Mark/Swiss Franc | 0.998 | 0.966 | 0.997 | 0.991 |
| T-Bonds/T-Notes | 0.996 | 0.996 | 0.993 | 0.996 |
| Eurodollar/F-Bills | 0.989 | 0.976 | 0.995 | 0.909 |
| D. Mark/Yen | 0.983 | 0.642 | 0.981 | 0.933 |
| Swiss Franc/Yen | 0.981 | 0.613 | 0.983 | 0.925 |
| Chgo. Wheat/Kans. Wheat | 0.964 | 0.817 | 0.954 | 0.950 |
| T-Bills/T-Notes | 0.955 | 0.879 | 0.953 | 0.822 |
| Eurodollar/T-Notes | 0.953 | 0.937 | 0.946 | 0.945 |
| T-Bills/T-Bonds | 0.942 | 0.876 | 0.928 | 0.842 |
| Eurodollar/T-Bonds | 0.937 | 0.933 | 0.919 | 0.948 |
| British Pound/Swiss Franc | 0.901 | 0.973 | 0.809 | 0.913 |
| Corn/Kansas Wheat | 0.891 | 0.440 | 0.825 | 0.803 |
| British Pound/D. Mark | 0.889 | 0.947 | 0.800 | 0.928 |
| Corn/Soybean oil | 0.886 | 0.573 | 0.871 | 0.848 |
| Soybean oil/Kansas Wheat | 0.868 | 0.410 | 0.804 | 0.876 |
| S&P 500iYen | 0.864 | -0.363 | 0.949 | -0.644 |
| S&P 500/D. Mark | 0.857 | -0.195 | 0.933 | -0.766 |
| Gold/Swiss Franc | 0.855 | 0.916 | 0.879 | 0.627 |
| NYSE/Yen | 0.855 | -0.350 | 0.945 | -0.676 |
| British Pound/Yen | 0.854 | 0.479 | 0.779 | 0.974 |
| Gold/British Pound | 0.853 | 0.943 | 0.565 | 0.596 |
| NYSE/D. Mark | 0.846 | -0.170 | 0.928 | -0.796 |
| Corn/Chicago Wheat | 0.844 | 0.426 | 0.769 | 0.692 |
| Crude oil/Kansas Wheat | 0.843 | 0.423 | 0.818 | -0.671 |
| Gold/D. Mark | 0.841 | 0.893 | 0.875 | 0.561 |
| S&P 500/Swiss Franc | 0.840 | -0.045 | 0.922 | -0.741 |
| Soybean oil/Chicago Wheat | 0.837 | 0.420 | 0.727 | 0.838 |
| NYSE/T-Bonds | 0.832 | 0.748 | 0.976 | 0.044 |
| NYSE/Swiss Franc | 0.828 | -0.022 | 0.917. | -0.776 |
| Corn/Soybeans | 0.826 | 0.925 | 0.875 | 0.912 |
| NYSE/T-Notes | 0.825 | 0.733 | 0.970 | 0.061 |
| S&P 500/T-Bonds | 0.818 | 0.747 | 0.975 | -0.004 |
| NYSE/T-Bills | 0.816 | 0.533 | 0.892 | -0.257 |
| Soybeans/Soymeal | 0.811 | 0.919 | -0.443 | 0.886 |
| S&P 500/T-Notes | 0.811 | 0.731 | 0.971 | 0.010 |
| Corn/Crude oil | 0.808 | 0.735 | 0.645 | -0.423 |
| S&P 500/T-Bills | 0.804 | 0.530 | 0.894 | -0.286 |

**Positions in X and Y**

| Correlation between X and Y | | Similar (long, long or short, short) | Opposing (long, short or short, long) |
|---|---|---|---|
| | + | high risk | low risk |
| | | low risk | high risk |

**Figure 4.2** Matrix for trading related commodities

Typically, a trend-following system would have us gravitate towards the higher-risk strategies, given the strong correlation between certain commodities. For example, an uptrend in soybeans is likely to be accompanied by an uptrend in soymeal and soybean oil. A trend-following system would recommend the simultaneous. purchase of soybeans, soymeal, and soybean oil. This simultaneous purchase ignores the overall riskiness of the portfolio should some bearish news hit the soybean market. It is here that the diversification skills of a trader are tested. He or she must select the most promising commodity out of two or more positively correlated commodities, ignoring all others in the group.

## SYNERGISTIC TRADING

Synergistic trading is the practice of assuming positions concurrently in two or more positively or negatively correlated commodities in the hope that a specified scenario will unfold. Often the positions are held in direct violation of diversification theory. For example, the unfolding of a scenario might require that a trader assume similar positions



in two or more positively correlated commodities. Alternatively, opposing positions could be assumed in two or more negatively correlated commodities. If the scenario were to materialize as anticipated, each of the trades could result in a profit. However, if the scenario were not to materialize, the domino effect could be devastating, underscoring the inherent danger of this strategy.

For example, believing that lower inflation is likely to lead to lower interest rates and lower silver prices, a trader might want to buy a contract of Eurodollar futures and sell a contract of silver futures. This portfolio could result in profits on both positions if the scenario were to materialize. However, if inflation were to pick up instead of abating, leading to higher silver prices and lower Eurodollar prices, losses would be incurred on both positions, because of the strong negative correlation between silver and Eurodollars.

## SPREAD TRADING

One way of reducing risk is to hold opposing positions in two positively correlated commodities. This is commonly termed spread trading. The objective of spread trading is to profit from differences in the relative speeds of adjustment of two positively correlated commodities. For example, a trader who is convinced of an impending upward move in the currencies and who believes that the yen will move up faster than the Deutsche mark, might want to buy one contract of the yen and simultaneously short-sell one contract of the Deutsche mark for the same contract period.

In technical parlance, this is called an intercommodity spread. A spread trade such as this helps to reduce risk inasmuch as it reduces the impact of a forecast error. To continue our example, if our trader is wrong about the strength of the yen relative to the mark, he or she could incur a loss on the long yen position. However, assuming that the mark falls, a portion of the loss on the yen will be cushioned by the profits earned on the short Deutsche mark position. The net profit or loss picture will be determined by the relative speeds of adjustment of the yen against the Deutsche mark.

In the unlikely event that two positively correlated commodities were to move in opposite directions, the trader could be left with a loss on both legs of the spread. To continue with our example, if the yen were to fall as the mark rallied, the trader would be left with a loss on both the long yen and the short mark positions. In this exceptional case, a spread trade could actually turn out to be riskier than an outright position trade, negating the premise that spread trades are theoretically less risky than outright positions. After all, it is this theoretical premise that is responsible for lower margins on spread trades as compared to outright position trades.

## LIMITATIONS OF DIVERSIFICATION

Diversification can help to reduce the risk associated with trading, but it cannot eliminate risk completely. Even if a trader were to increase the number of commodities in the portfolio indefinitely, he or she would still have to contend with some risk. This is illustrated graphically in Figure 4.3.

Notice that the gains from diversification in terms of reduced portfolio risk are very apparent as the number of commodities increases from 1 to 5. However, the gains quickly taper off, as portfolio risk can no longer be diversified away. This is represented by the risk line becoming parallel

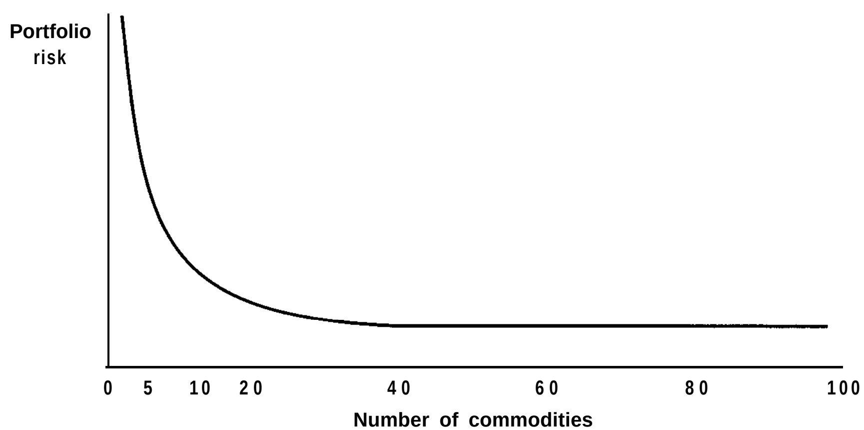



**Figure 4.3** Graph illustrating the benefits and limitations of diversification.



to the horizontal axis. There is a certain level of risk inherent in trading commodities, and this minimum level of risk cannot be eliminated even if the number of commodities were to be increased indefinitely.

## CONCLUSION

Whereas volatility in the futures markets opens up opportunities for enormous financial gains, it also adds to the dangers of trading. Traders who tend to get carried away by the prospects of large gains sometimes deliberately overlook the fact that leverage is a double-edged sword. This leads to unhealthy trading habits.

Typically, diversification is one of the first casualties, as traders tend to place all their eggs in one basket, hoping to maximize leverage for their investment dollars. If there were such a thing as perfect foresight, it would make sense to bet everything on a given trade. However, in the absence of perfect foresight, concentrating all one's money on a single trade or on the same side of two or more positively correlated commodities could prove to be disastrous.

Diversification helps reduce risk, as measured by the variability of overall trading returns. Ideally, this is accomplished by assuming similar positions across two unrelated or negatively correlated commodities. Diversification could also be accomplished by assuming opposing positions in two positively correlated commodities, a practice known as spread trading.

Finally, a trader might assume that the unfolding of a certain scenario will affect related commodities in a certain fashion. Accordingly, he or she would hold similar positions in two positively correlated commodities and opposing positions in two or more negatively correlated commodities. This is known as synergistic trading. Synergistic trading is a risky strategy, because nonrealization of the forecast scenario could lead to losses on all positions.

# 5

# Commodity Selection

The case for commodity selection is best presented by J. Welles Wilder, Jr.[1] Wilder observes that "most technical systems are trend-following systems; however, most commodities are in a good trending mode (high directional movement) only about 30 percent of the time. If the trader follows the same commodities or stocks all of the time, then his system has to be good enough to make more money 30 percent of the time than it will give back 70 percent of the time. Compare that approach to trading only the top five or six commodities on the CSI [Commodity Selection Index] scale. This is the underlying concept.. ."[2]

Currently, there are over 50 futures contracts being traded on the exchanges in the United States. The premise behind the selection process is that not all 50 contracts offer trading opportunities that are equally attractive. The goal is to enable the trader to identify the most promising opportunities, allowing him or her to concentrate on these trades instead of chasing every opportunity that presents itself. By ranking commodities on a desirability scale, commodity selection creates a short list of opportunities, thereby helping to allocate limited resources more effectively.

[1] J. Welles Wilder, Jr., ***New Concepts in Technical Trading Systems*** (Greensboro, NC: Trend Research, 1978).

[2] Wilder, New ***Concepts,*** p. 115.





## MUTUALLY EXCLUSIVE VERSUS INDEPENDENT OPPORTUNITIES

Opportunities across commodities can be categorized as being either mutually exclusive or independent. Two opportunities are mutually exclusive if the selection of one precludes the selection of the other. Two opportunities are said to be independent if the selection of one has no impact on the selection of the other.

Accordingly, if two commodities are highly positively correlated, as, for example, the Deutsche mark and the Swiss franc, a trader would want to trade either the mark or the franc. Diversification theory dictates that one should not hold identical positions in both currencies simultaneously. Hence, selection of one currency precludes selection of the other, rendering an objective evaluation of both opportunities that much more important. In the case of mutually exclusive commodities, the aim is to trade the commodity that offers the greatest reward potential for a given level of risk and investment.

In the case of independent opportunities, as, for example, gold and corn, the trader is free to trade both simultaneously, provided they are both short-listed on a desirability scale. However, if resources do not permit trading both commodities concurrently, the trader would select the commodity that ranks higher on his or her desirability scale.

Although selection is especially important when tracking two or more commodities simultaneously, it can also be justified when only one commodity is traded. By comparing the potential of a trade against a prespecified benchmark or cutoff rate, a trader can decide whether he or she wishes to pursue or forgo a given signal.

## THE COMMODITY SELECTION PROCESS

Commodity selection is the process of evaluating alternative opportunities that may emerge at any given time. The objective is to rank each of the opportunities in order of desirability. Of primary importance, therefore, is the creation of a yardstick that facilitates objective comparison of competing opportunities across an attribute or attributes of desirability.

Having created the yardstick, the next step is to specify a benchmark measure below which opportunities fail to qualify for consideration. The decision regarding a cutoff level is a subjective one, depending on the trader's attitudes towards risk and the funds available for trading. The more risk-averse the trader, the more selective he or she is, and this is reflected in a higher cutoff level. Similarly, the smaller the size of the account, the more restricted the alternatives available to the trader, leading to a higher cutoff level. In this chapter, we shall restrict ourselves to a discussion of the construction of objective measures of assessing trade desirability.

Typically, the desirability of a trade is measured in terms of (a) its expected profitability, (b) the risk associated with earning those profits, and (c) the investment required to initiate the trade. The higher the expected profit, the more desirable a trade. The lower the investment required to initiate the trade, the higher the expected return on investment, and the greater its desirability. Finally, the lower the risk associated with earning a projected return on investment, the more desirable the trade.

A commodity selection yardstick is designed to synthesize all of these attributes of desirability in order to arrive at an objective measure for comparing opportunities. We now present four plausible approaches to commodity selection:

1. The Sharpe ratio approach, which measures the return on investment per unit risk
2. Wilder's commodity selection index
3. The price movement index
4. The adjusted payoff ratio index

## THE SHARPE RATIO

In a study of mutual fund performance, William Sharpe[3] emphasized that risk-adjusted returns, rather than returns per se, were a reliable measure of comparative performance. Accordingly, he studied the returns on individual mutual funds in excess of the risk-free rate as a ratio of the riskiness of such returns, measured by their standard deviation. This

3 William Sharpe, "Mutual Fund Performance," *Journal of Business* (January 1966), pp. 119-138.



ratio has since come to be known as the Sharpe ratio. The Sharpe ratio is computed as follows:

$$\text{Sharpe ratio} = \frac{\text{Return} - \text{Risk-free Interest Rate}}{\text{Standard Deviation of Return}}$$

The higher the Sharpe ratio, the greater the excess return per unit of risk, enhancing the desirability of the investment under review.

The Sharpe ratio may be defined in terms of the expected return on a trade and the associated standard deviation. Alternatively, a trader who is working with a mechanical system, which is incapable of estimating future returns, might want to use the average historic return as the best estimator of the future expected return. In this case, the relevant measure of risk is the standard deviation of historic returns. The formulas for calculating historic and expected trade returns and their standard deviations are given in Chapter 4.

Care should be taken to annualize trade returns so as to facilitate comparison across trades. This is accomplished by multiplying the raw return'by a factor of 365/n, where *n* is the estimated or observed life of the trade in question. Deducting the annualized risk-free interest rate from the annualized trade return gives an estimate of the incremental or excess return from futures trading. A negative excess return implies that the trader would be better off not trading. The risk-free rate is given by the prevailing interest rate on Treasury bills. This is the rate the trader could have earned had he or she invested the capital in Treasury bills rather than trading the market.

Assume that a trader is evaluating opportunities in crude oil, Deutsche marks, and world sugar, with the expected trade returns, the risk-free return, and standard deviation of expected returns as given in Table 5.1.

**Table 5.1** Calculating Sharpe Ratios across Three Commodities

| Commodity | Expected Return (2) | Risk-free Return (3) | Excess Returns (4) = (2) − (3) | Standard Deviation (5) | Sharpe Ratio (6) = (4)/(5) |
|---|---|---|---|---|---|
| Crude Oil | 0.46 | 0.06 | 0.40 | 0.80 | 0.50 |
| D. mark | 0.36 | 0.06 | 0.30 | 0.50 | 0.60 |
| Sugar | 0.26 | 0.06 | 0.20 | 0.30 | 0.67 |

**Notice that** whereas the expected excess return on crude oil is the highest at 0.40, the corresponding Sharpe ratio is the lowest at 0.50. The converse is true for sugar. This is because the variability of returns on crude oil is more than twice that for sugar, rendering crude oil a much riskier proposition as compared to sugar. Since the Sharpe ratio measures return per unit of risk rather than return per se, sugar outperforms crude oil.

A benchmark Sharpe ratio could be set separately for each commodity, based on past data for the commodity in question. Alternatively, an overall benchmark Sharpe ratio could be set across all commodities. Consequently, comparisons of the Sharpe ratio may be effected across time for a given commodity, or across commodities at a given time.

## WILDER'S COMMODITY SELECTION INDEX

Wilder's commodity selection index is particularly suited for use alongside conventional mechanical trading systems, which signal the beginning of a trend but are silent as regards the magnitude of the projected move. Wilder analyzes price action in terms of its (a) directional movement and (b) volatility, observing that "volatility is always accompanied by movement, but movement is not always accompanied by volatility."[4]

The commodity selection index for a given commodity is based on (a) Wilder's average directional movement index rating, (b) volatility as measured by the 14-day average true range, (c) the margin requirement in dollars, and (d) the commission in dollars. The higher the average directional movement index rating for a commodity and the greater its volatility, the higher is its selection index value. Similarly, the lower the margin required for a commodity, the higher the selection index value. Let us begin with a discussion of Wilder's average directional movement index rating.

### Directional Movement

Wilder defines directional movement (DM) as the largest portion of the current day's trading range that lies outside the preceding day's range. In

[4] Wilder, New Concepts, p. 11 I



the case of an up move today, this would represent positive directional movement, representing the difference between today's high and yesterday's high. Conversely, for a move downwards, we would have negative directional movement, representing the difference between today's low and yesterday's low.

In the case of an outside range day, where the current day's range includes and surpasses yesterday's range, we have simultaneous occurrence of both positive and negative directional movement. Here, Wilder defines the directional movement to be the greater of positive and negative movements. In the case of an inside day, where the range for the current day is contained within the range for the preceding day, the directional movement is assumed to be zero.

When prices are locked limit-up, the directional movement is positive and represents the difference between the locked-limit price and yesterday's high. Similarly, when prices are locked limit-down, the directional movement is negative, representing the difference between yesterday's low and the locked-limit price. Negative directional movement is simply a description of downward movement: it is not considered as a negative number but rather an absolute value for calculation purposes.

### The Directional Indicator

Next, Wilder divides the directional movement number for any given day by the true range for that day to arrive at the directional indicator (DI) for that day. The true range is a positive number and represents the largest of (a) the difference between the current day's high and low, (b) the difference between today's high and yesterday's close, and (c) the difference between yesterday's close and today's low.

Summing the positive directional movement over the past 14 days and dividing by the true range over the same period, we arrive at a positive directional indicator over the past 14 days. Similarly, summing the absolute value of the negative directional movement over the past 14 days and dividing by the true range over the same period, we arrive at a negative directional indicator over the past 14 days.

### The Average Directional Movement index Rating

The net directional movement is the difference between the 14-day positive and negative directional indicators. This difference, when divided by the sum of the 14-day positive and negative directional indicators, gives the directional movement index (DX).

Therefore,

$$DX = \frac{+DI_{14} - -DI_{14}}{+DI_{14} + -DI_{14}}$$

The average directional movement index (ADX) is the 14-day average of the directional movement index. The average directional movement index rating (ADXR) is the average of the ADX value today and the ADX value 14 days ago. Therefore,

$$ADXR = \frac{ADX_{\text{today}} + ADX_{\text{14 days ago}}}{2}$$

Mathematically, the commodity selection index (CSI) may be defined as:

$$CSI = ADXR \times ATR_{14} \times \left[ \frac{V}{\sqrt{M}} \times \frac{1}{150 + c} \right] \times 100$$

where ADXR = average directional movement index rating

$ATR_{14}$ = 14-day average true range

v = dollar value of a unit move in ATR

$\sqrt{M}$ = square root of the margin requirement in dollars

C = per-trade commission in dollars

An example will help clarify the formula. Assume once again that a trader is evaluating opportunities in crude oil, Deutsche marks, and sugar. Details of the average directional movement index rating (ADXR), the 14-day average true range (ATR), the dollar value (V) of a unit move in the average true range, and the margin investment (M) are given in Table 5.2. Assume further that the commission for each of the three commodities is $50.

Notice that the Deutsche mark has the highest index value, primarily because of its high directional index movement rating and moderate margin requirement. Crude oil, on the other hand, has a low directional index movement rating and a high margin requirement, both of which have an adverse impact upon its selection index. Sugar has a low margin requirement but suffers from low volatility, moderating the value of its selection index.



**Table 5.2** Calculating the Commodity Selection Index across Commodities

| Commodity | ADXR | ATR | V<br>$/ATR | M | CSI |
|---|---|---|---|---|---|
| Crude Oil | 40 | 1.50 | 1000 | 5000 | 424.26 |
| D. mark | 80 | 75.00 | 12.50 | 2500 | 750.00 |
| Sugar | 60 | 0.50 | 1120 | 1000 | 531.26 |

## THE PRICE MOVEMENT INDEX

The price movement index is an adaptation of Wilder's commodity selection index, designed to simplify the arithmetic of the calculations. Whereas Wilder's index segregates price movement according to its directional and volatility components, the price movement index does not attempt such a breakdown. The price movement index is based on the premise that once a price move has begun, it can be expected to continue for some time to come. The greater the dollar value of a price move for a given margin investment, the more appealing the trade.

As is the case with Wilder's commodity selection index, the price movement index is most useful when precise estimation of reward is infeasible. This is particularly true of mechanical trading systems, which signal precise entry points without giving a clue as to the potential magnitude of the move.

As the name suggests, the price movement index measures the dollar value of price movement for a commodity over a historical time period. This number is divided by the initial margin investment required for that commodity, multiplying the answer by 100 percent to express it as a percentage. Mathematically, the price movement index for commodity **X** may be defined as

$$\text{Index for X} = \frac{\text{Dollar value of price move over } n \text{ sessions}}{\text{Margin investment for commodity X}} \times 100$$

where $n$ is a predefined number of trading sessions, expressed in days or weeks, over which price movement is measured.

**Table 5.3** Calculating the Price Movement Index Across Commodities

| Commodity | Price Move (ticks) | $ Value of 1 tick | $ Value of Price Move | Margin Investment | Price Movement Index (%) |
|---|---|---|---|---|---|
| Crude oil | 250 | 10 | 2500 | 5000 | 50 |
| D. mark | 150 | 12.5 | 1875 | 2500 | 75 |
| Sugar | 60 | 11.2 | 672 | 1000 | 67.2 |

Price movement represents the difference between the maximum and minimum prices recorded by the commodity in question over the past *n* trading sessions. If *n* were 14, calculate the difference between the maximum (or highest high) and minimum (or lowest low) prices for the commodity over the past 14 days.

For example, if the maximum price registered by the Deutsche mark were $0.5800 and the minimum price were $0.5500, the difference would be 300 ticks. Given that each tick in the Deutsche mark futures is worth $12.50, the dollar value of 300 ticks is $3750. Assuming an initial margin investment of $2500, the price movement index works out to be 150 percent. If this happens to fall short of the trader's cutoff level, he would not pursue the mark trade. Alternatively, if it surpasses his cutoff level, he would be interested in trading the mark.

Assume once again that a trader is evaluating opportunities in crude oil, Deutsche marks, and sugar, with the respective n-day historical price movements and margin investments as given in Table 5.3.

If the trader did not wish to trade any commodity with a price movement index less than 60, he would ignore crude oil. Notice that the rankings given by Wilder's commodity selection index match those given by the price movement index. Although this is coincidental, it could be argued that the similarity in the construction of the two indices could account for a similarity in the two sets of rankings.

## THE ADJUSTED PAYOFF RATIO INDEX

The payoff or reward/risk ratio is arrived at by dividing the potential dollar reward by the permissible dollar risk on a trade under consideration.



Therefore, if the potential reward on a trade is $1000 and the permissible risk is $250, the payoff ratio is 4. The higher the payoff ratio, the more promising the trade.

Notice that the payoff ratio says nothing about the investment required for initiating a trade, thereby limiting its usefulness as a yardstick for comparison. Given that investment requirements are dissimilar across commodities, it would be necessary to factor such differences into the payoff ratio.

One way of doing this is to divide the payoff ratio by the relative investment required for a given commodity. This is known as the adjusted payoff ratio. Therefore, the adjusted payoff ratio for commodity X is

$$\text{Adjusted payoff ratio for X} = \frac{\text{Payoff ratio for X}}{\text{Relative investment for X}}$$

The relative investment for a given commodity is arrived at by dividing the investment required for that commodity by the maximum investment across all commodities:

$$\text{Relative investment for X} = \frac{\text{Investment required for commodity X}}{\text{Maximum investment across all commodities}}$$

Let us assume that the margin for a Standard & Poor's 500 index futures contract, say $25,000, represents the maximum investment across all commodities. If the investment required for a contract of gold futures is $1250, the relative investment in gold represents $1250/$25,000, which is 0.05 or 5 percent of the maximum investment.

The relative investment ratio ranges between 0 and 1; the lower the relative investment, the higher the adjusted payoff ratio. In turn, the higher the adjusted payoff ratio, the more attractive the trade. For example, assuming the payoff ratio for the proposed gold trade is 3, the adjusted payoff ratio works out to be 3/0.05 or 60. If, on the other hand, the investment needed for a contract of gold were $20,000, the relative investment would be $20,000/$25,000 or 0.80. In this case, the adjusted Payoff ratio would work out to 3/0. 80 or 3.75, significantly lower than the earlier adjusted payoff ratio of 60.

An example would help clarify the process. Assume that a trader is evaluating opportunities in crude oil, Deutsche marks, and sugar with the respective payoff ratios and investments as given in Table 5.4. Assume further that the maximum investment across all commodities is $25,000. Therefore, the relative investment for a given commodity is arrived

**Table 5.4** Calculating the Adjusted Payoff Ratio across Commodities

| Commodity | Payoff ratio | Margin Investment | Relative Investment | Adjusted Payoff ratio |
|---|---|---|---|---|
| Crude oil | 5 | 5000 | 0.20 | 25 |
| D. mark | 3 | 2500 | 0.10 | 30 |
| Sugar | 2 | 1000 | 0.04 | 50 |

at by dividing the investment required for the commodity by **$25,000.**

Notice that the payoff ratio is the highest for crude oil, more than twice as large the payoff ratio for sugar. However, the investment needed for a contract of crude oil at $5000 is five times as large as the investment of $1000 for sugar. Consequently, the adjusted payoff ratio for sugar is higher than that for crude oil, implying that sugar is relatively more attractive. If, as a matter of policy, trades with an adjusted payoff ratio of less than 30 were disregarded, the crude oil trade would not qualify for consideration.

## CONCLUSION

The selection process is based on the premise that all trading opportunities are not equally desirable. Whereas some trades may justifiably be forgone, others might present a compelling case for a greater than average allocation. These decisions can only be made if the trader has an objective yardstick for measuring the desirability of trades.

Four alternative approaches to commodity selection have been suggested. It is conceivable that the trade rankings could vary across different approaches. However, as long as the trader uses a particular approach consistently to evaluate all opportunities, the differences in rankings are largely academic.

The selection techniques outlined above allow the trader to sift through a maze of opportunities, arriving at a short list of those trades that satisfy his criteria of desirability. Now that the trader has a clear idea of the commodities he wishes to trade, the next step is to allocate risk capital across them. This is the subject matter of our discussion in Chapter 8.

# 6

# Managing Unrealized Profits and losses

The goal of risk management is conservation of capital. This implies getting out of a trade without (a) giving up too much of the unrealized profits earned or (b) incurring too much of an unrealized loss. The purpose of this chapter is to define how much is "too much." An unrealized profit or loss arises during the life of a trade, reflecting the difference between the current price and the entry price. As soon as the trade is liquidated, the unrealized profit or loss is converted into a realized profit or loss.

An equity reduction or "drawdown" results from a reduction in the unrealized profit or an increase in the unrealized loss on a trade. When confronted with an equity drawdown on a trade in progress, a trader must choose between two conflicting courses of action: (a) liquidating the trade with a view to conserving capital or (b) continuing with it in the hope of making good on the drawdown.

Liquidating a profitable trade at the slightest sign of a drawdown will Prevent further evaporation of unrealized profits. However, by exiting the trade, the trader is forgoing the opportunity to earn any additional profits on the trade. Similarly, an unrealized loss might possibly be recouped by continuing with the trade, instead of being converted into a realized loss upon liquidation. However, if the trade continues to deteriorate, the unrealized loss could multiply.

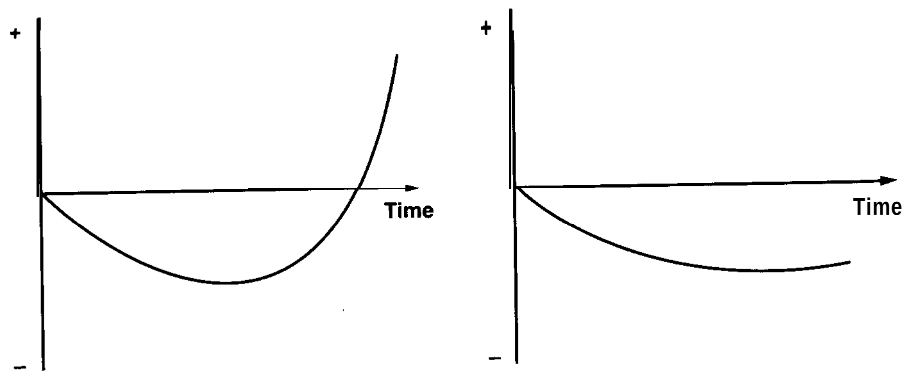
The aim is to be mindful of equity drawdowns while simultaneously minimizing the probability of erroneously short-circuiting a trade. Obviously, a trader does not have the luxury of hindsight to help decide whether an exit is timely or premature. While there are no cut-and-dried formulas to resolve the problem, we will present a series of plausible solutions. We begin by discussing the treatment of unrealized losses. Subsequently, we focus on unrealized profits.

## DRAWING THE LINE ON UNREALIZED LOSSES

Consider the life cycles of two trades, represented by Figures 6. la and 6.1b. In Figure 6.1a, the trade starts out with an unrealized loss, only to recover and end on a profitable note. In Figure 6.1 b, the trade starts out as a loser and never recovers.

The trader must decide upon an unrealized loss level beyond which it is highly unlikely that a losing trade will turn around. This cutoff price, or stop-loss price, defines the maximum permissible dollar risk per contract. Setting a stop-loss order shows that a trader has thought through the risk on a trade and made a determination of the price at which he wishes to dissociate himself from the trade. Ideally, this determination will be made before the trade is initiated, so as to avoid needless second-guessing when it comes time to act.

If the stop-loss price is too far from the entry price, it is less likely that a trader will be forced out of his position when he would rather continue with it. However, if his stop is hit, the magnitude of the dollar




(*a*) (*b*)

**Figure 6.1** The profit life cycles of two potentially losing trades.



loss is relatively more painful. A stop-loss price closer to the entry price minimizes the size of the loss, but there is a greater likelihood that random price action will force a trader out of his position needlessly.

In this chapter, we discuss five approaches to setting stop-loss orders:

1. A visual approach to setting stops
2. Volatility stops
3. Time stops
4. Dollar-value stops
5. Probability stops, based on an analysis of the unrealized loss patterns on completed profitable trades

## THE VISUAL APPROACH TO SETTING STOPS

One way of deciding on a stop-loss point for a trade is to be mindful of clues offered by the commodity price chart in question. As discussed in Chapter 3, a chart pattern that signals a reversal formation will also let the trader know precisely when the pattern is no longer valid.

Another commonly used technique is to set a buy stop to liquidate a short sale just above an area of price resistance. Similarly, a sell stop to liquidate a long trade could be set below an area of price support. Prices are said to encounter resistance if they cannot overcome a previous high. By the same token, prices are said to find support if they have difficulty falling below a previous low. Support or resistance is that much stronger if prices fail to take out a previous high or low on repeated tries.

Consider, for example, the price chart for the British pound June 1990 futures contract given in Figure 6.2a. Notice the contract high of $1.6826 established on February 19. Subsequently, the pound retreated to a low of $1.5700 in March, before staging a gradual recovery. On May 15, the pound closed sharply lower, after making a higher high. Anticipating a double top formation, a trader might be tempted to short the pound on the close on May 15 at $1.6630, with a buy stop at $1.6830, just above the high of February 19.

As is evident from Figure 6.2b, our trader was stopped out on May 17 when the pound broke past the earlier high. The breakout on the upside negated the double top hypothesis, proving once again that anticipating a Pattern before it is set off can be expensive. Be that as it may, liquidating the trade with a small loss saved the trader from a much bigger loss had

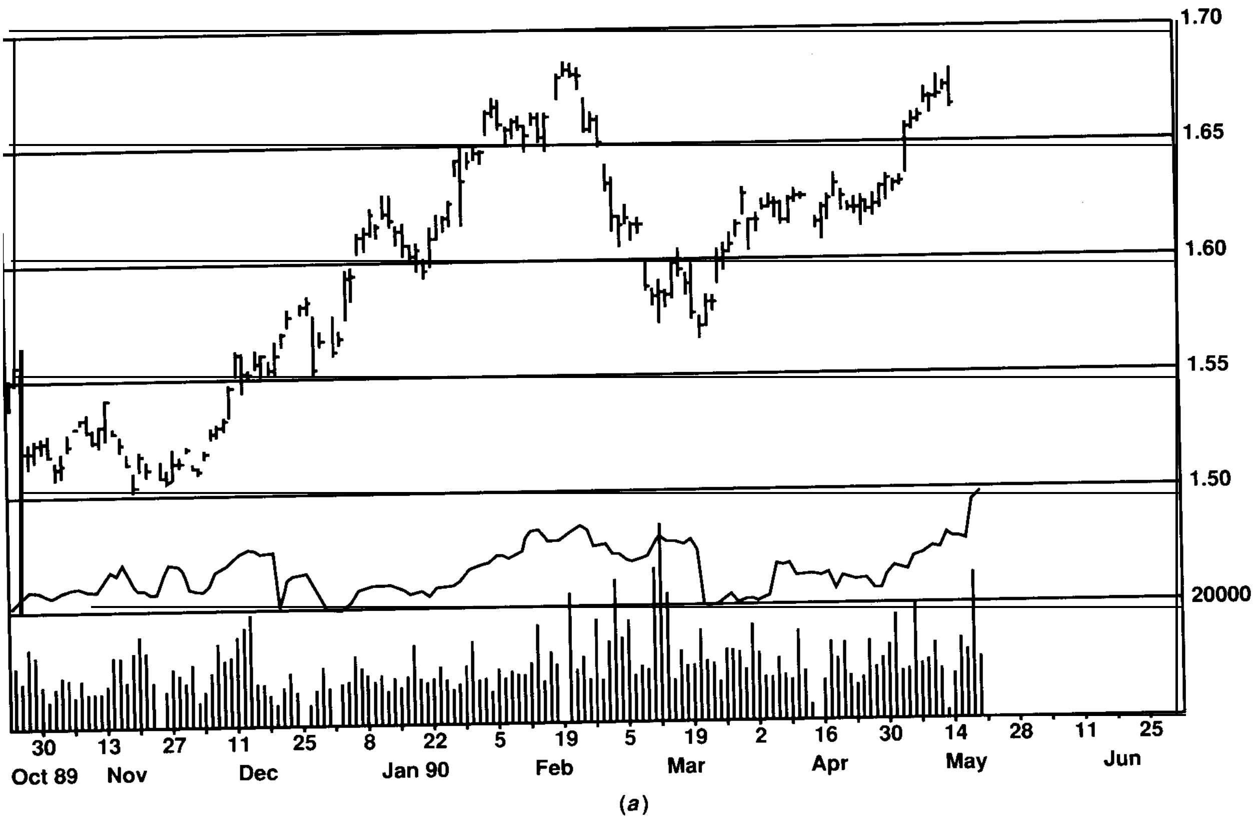



**Figure 6.2a** Setting stops: June 1990 British pound.

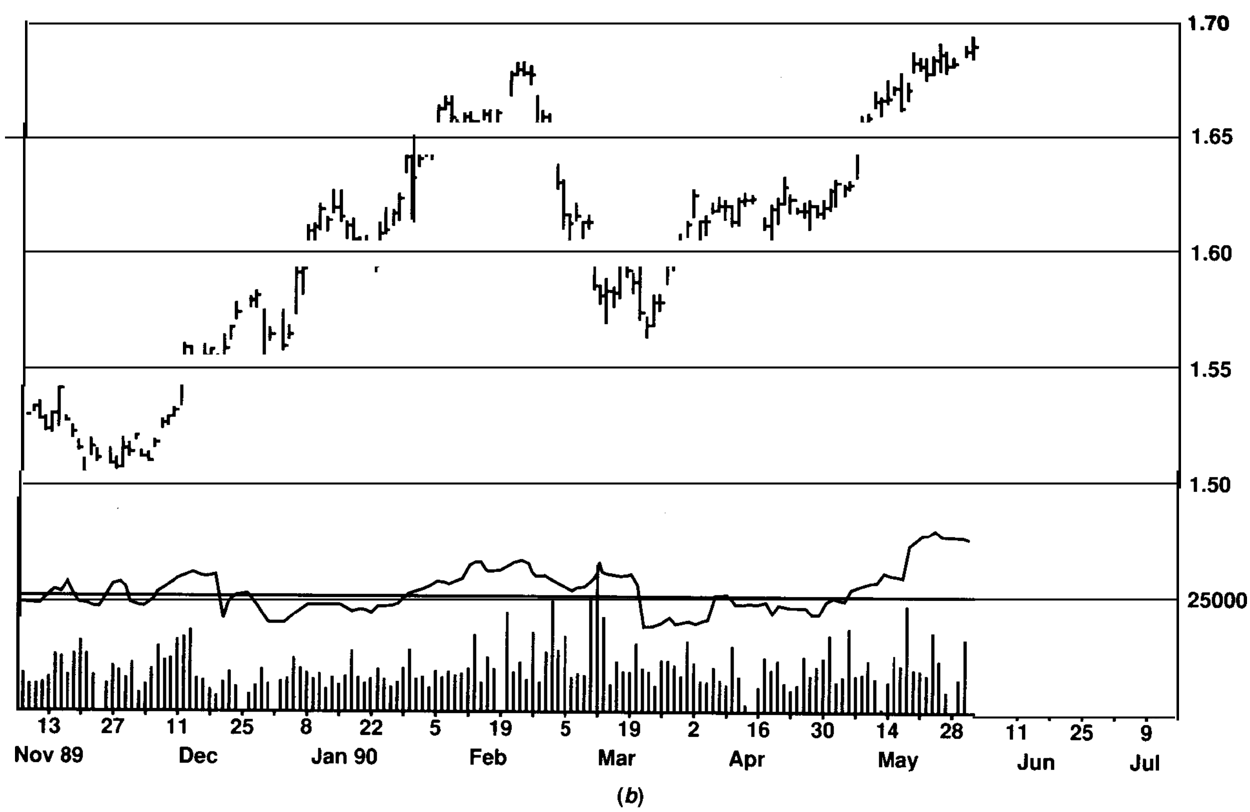



**Figure 6.2b** Setting stops: June 1990 British pound, continued.

he or she continued with the trade: the June futures rallied to $1.6996 on May 30!

Chart patterns offer a simple yet effective, tool for setting stop-loss orders. However, the reader must be cautioned against placing a stop-loss order exactly at or very close to the support or resistance point. This is because support and resistance prices are quite apparent, and a large number of stop-loss orders could possibly be set off at these levels. Consequently, one might be needlessly stopped out of a good trade.

Critics of this approach discount it as being subjective and open to the chartist's interpretation. However, it is worth noting that speculation entails forecasting, and in principle all forecasting is subjective. Subjectivity can hurt only when it creates a smoke screen around the trader, making an objective assessment of market reality difficult. As long as the trader has the discipline to abide by his stop-loss price, the methodology used for setting stops is of little consequence.

## VOLATILITY STOPS

The volatility stop acknowledges the fact that there is a great deal of randomness in price behavior, notwithstanding the fact that the market may be trending in a particular direction. Essentially, volatility stops seek to distinguish between inconsequential or random fluctuations and a fundamental shift in the trend. In this section, we discuss some of the more commonly used techniques that seek to make this distinction.

Ideally, a trader would want to know the future volatility of a commodity so as to distinguish accurately between random and nonrandom price movements. However, since it is impossible to know the future volatility, this number must be estimated. Historic volatility is often used as an estimate of the future, especially when the future is not expected to vary significantly from the past.

However, if significant changes in market conditions are anticipated, the trader might be uncomfortable using historic volatility. One commonly used alternative is to derive the theoretical futures volatility from the price currently quoted on an associated option, assuming that the option is fairly valued. This estimate of volatility is also known as the implied volatility, since it is the value implicit in the current option premium. In this section, we discuss both approaches to computing volatility.



### Using Standard Deviations to Measure Historical Volatility

Historical volatility, in a strictly statistical sense, is a one-standard-deviation price change, expressed in percentage terms, over a calendar year. The assumption is that the percent changes in a commodity's prices, as opposed to absolute dollar changes, are normally distributed. The assumption of normality implies that the percentage price change distribution is bell-shaped, with the current price representing the mean of the distribution at the center of the bell. A normal distribution is symmetrical around the mean, enabling us to arrive at probability estimates of the future price of the commodity.

For example, if cocoa is currently trading at $1000 a metric ton and the historic volatility is 25 percent, cocoa could be trading anywhere between $750 and $1250 ($1000 ± 1 × 25 percent × $1000) a year from today approximately 68 percent of the time. More broadly, cocoa could be trading between $250 and $1750 ($1000 ± 3 × 25 percent × $1000) one year from now approximately 99 percent of the time.

In order to compute the historic volatility, the trader must decide on how far back in time he wishes to go. He or she would want to go as far back as is necessary to get an accurate picture of future market conditions. Accordingly, the period might vary from two weeks to, say, 12 months. Typically, daily close price changes are used for computing volatility estimates.

Since a trader's horizon is likely to be shorter than one year, the annualized volatility estimate must be modified to acknowledge this fact. Assume that there are 250 trading days in a year and that a trader wishes to estimate the volatility over the next $n$ days. In order to do this, the trader would divide the annualized volatility estimate by the squareroot of 250/n.

Continuing with our cocoa example, assume that the trader were interested in estimating the volatility over the next week or five trading days. In this case, $n$ is 5, and the volatility discount factor would be computed as follows:

$$\text{Discount Factor} = \sqrt{\frac{250}{5}} = 7.07$$

$$\text{Volatility over next 5 days} = \frac{0.25}{7.07} = 0.03536 \text{ or } 3.536\%$$

The dollar equivalent of this one-standard-deviation percentage price change over the next five days is simply the product of the current price of cocoa times the percentage. Therefore, the dollar value of the volatility expected over the next five days is

$1000 x 0.03536 = $35.36

Consequently, there is a 68 percent chance that prices could fluctuate between $1035.36 and $964.64 ($1000 ± 1 x $35.36) over the next five days. There is a 99 percent chance that prices could fluctuate between $1106.08 and $893.92 ($1000 ± 3 x $35.36) within the same period.

The definition of price used in the foregoing calculations needs to be clarified for certain interest rate futures, as for example Eurodollars and Treasury bills, which are quoted as a percentage of a base value of 100. The interest rate on Treasury bills is arrived at by deducting the currently quoted price from 100. Therefore, if Treasury bills futures were currently quoted at 94.45, the corresponding interest rate would be 5.55 percent (100 – 94.45). Volatility calculations will be carried out using this value of the interest rate rather than on the futures price of 94.45.

### Using The True Range as a Measure of Historical Volatility

A nontechnical measure of historical volatility is given by the range of prices during the course of a trading interval, typically a day or a week. The range of prices represents the difference between the high and the low for a given trading interval. Should the range of the current day lie beyond the range of the previous day (a phenomenon referred to as a "gap day") the current day's range must include the distance between today's range and yesterday's close. This is commonly referred to as the true range. The true range for a gap-down day is the difference between the previous day's settlement price and today's low. Similarly, the true range for a gap-up day is the difference between today's high and the previous day's settlement price.

A percentile distribution of daily and weekly true ranges in ticks is given for 24 commodities in Appendix D. A tick is the smallest increment by which prices can move in a given futures market. Appendix D also translates a tick value stop into the equivalent dollar exposure resulting from trading one through 10 contracts of the commodity. A tick value corresponding to 10 percent signifies that only 10 percent of all observations in our sample had a range equal to or less than this number. In other words, the true range exceeded this number for 90 percent of the observations studied. Similarly, a value corresponding to 90 percent



implies that the range exceeded this value only 10 percent of the time. Therefore, a stop equal to the 10 percent range value is far more likely to be hit by random price action than is a stop equal to the 90 percent value.

Reference to Appendix D for British pound data shows that 90 percent of all observations between 1980 and 1988 had a daily true range equal to or less than 117 ticks. Therefore, a trader who was long the pound, might want to set a protective sell stop 117 ticks below the previous day's close. The chances of being incorrectly stopped out of the long trade are 1 in 10. Similarly, a trader who had short-sold the pound might want to set a buy stop 117 ticks above the preceding day's close. The dollar value of this stop is $1462.50, or $1463 as rounded off in Appendix D, per contract.

Instead of concentrating on the true range for a day or a week, a trader might be more comfortable working with the average true range over the past *n* trading sessions, where *n* is any number found to be most effective through back-testing. The belief is that the range for the past *n* periods is a more reliable indicator of volatility as compared to the range for the immediately preceding trading session. An example would be to calculate the average range over the past 15 trading sessions and to use this estimate for setting stop prices.

A slightly modified approach recommends working with a fraction or multiple of the volatility estimate. For example, a trader might want to set his stop equal to 150 percent of the average true range for the past *n* trading sessions. The supposition is that the fraction or multiple enhances the effectiveness of the stop.

### Implied Volatility

The implied volatility of a futures contract is the volatility derived from the price of an associated option. Implied volatility estimates are particularly useful in turbulent markets, when historical volatility measures are inaccurate reflectors of the future. The theoretical price of an option is given by an options pricing model, as, for example, the Black-Scholes model. The theoretical price of an option on a futures contract is determined by the following five data items:

1. The current futures price
2. The strike or exercise price of the option
3. The time to expiration

4. The prevailing risk-free interest rate, and
5. The volatility of the underlying futures contract.

Assuming that options are fairly valued, we can say that the current option price matches its theoretical value given by the options pricing model. Using the current price of the option as a given and plugging in values for items 1 to 4 in the theoretical options pricing model, we can solve backwards for item 5, the volatility of the futures contract. This is the implied volatility, or the volatility implicit in the current price of the option.

The implied volatility estimate is expressed as a percentage and represents a one-standard-deviation price change over a calendar year. The trader can use the procedure just outlined for historical volatility computations, to derive the likely variability in prices over an interval of time shorter than a year.

## TIME STOPS

Instead of working with a volatility stop, a trader might want to base stops on price action over a fixed interval of time. A trader who has bought a commodity would want to set a sell stop below the low of the past *n* trading sessions, where *n* is the number found most effective in back-testing over a historical time period. A trader who has short-sold the commodity would set a buy stop above the high of the past *n* trading sessions. For example, a 10–day rule would specify that a sell-stop be set just under the low of the preceding 10 days and that a buy stop would be set just above the high of the preceding 10 days. The logic is that if a commodity has not traded beyond a certain price over the past *n* days, there is little likelihood it will do so now, barring a change in the trend. The value of *n* may be determined by a visual examination of price charts or through back-testing of data.

Bruce Babcock, Jr. presents a slight variation for setting time stops, which he terms a "prove-it-or-lose-it" stop.[1] This stop recommends liquidation of a trade that is not profitable after a certain number of days, *n*, to be prespecified by the trader. The idea is that if a trade is going to be profitable, it should "prove" itself over the first *n* days. If it stagnates within this time frame, the trader would be well advised to look for alternative opportunities.

[1] Bruce Babcock, Jr., ***The Dow Jones-Irwin Guide to Trading Systems*** (Homewood, IL: Dow Jones-Irwin, 1989).



Clearly, there should be a mechanism to safeguard against undue losses in the interim period while the trade is left to prove itself. The "prove-it-or-lose-it" stop, therefore, is best used in conjunction with another stop designed to prevent losses from getting out of control.

## DOLLAR-VALUE MONEY MANAGEMENT STOPS

Some traders prefer to set stops in terms of the dollar amount they are willing to risk on a trade. Often, this dollar risk is arrived at as a percentage of available trading capital or the initial margin required for the commodity. If the permissible risk is expressed as a percentage of capital, this would entail using the same money management stop across all commodities. This may not be appropriate if the volatility of the markets traded is vastly different. For example, a $500 stop would allow for an adverse move of 10 cents in corn, whereas it would only allow for a l-index-point adverse move in the S&P 500 index futures. The stop for corn is reasonable, inasmuch as it allows for normally expected random fluctuations. However, the stop for the S&P 500 is simply too tight. This is the problem with money management stops fixed as a percentage of capital. In order to overcome this problem, the money management stop is often set as a percentage of the initial margin for the commodity. The logic is that the higher the volatility, the greater the required margin for the commodity. This translates into a larger dollar stop for the more volatile commodities.

The dollar amount of the money management stop is translated into a stop-loss price using the following formula:

Stop-loss price =
Entry price ± Tick value of permissible dollar loss

where

$$\text{Tick value of permissible dollar loss} = \frac{\text{Permissible dollar loss}}{\text{\$ value of a tick}}$$

Assume that the margin for soybeans is $1000 and that the trader Wishes to risk a maximum of 50 percent of the initial margin, or $500 per contract. This translates into a stop-loss price 40 ticks or 10 cents from the entry price, given that each soybean tick is worth $\frac{1}{4}$ cent per bushel. For two contracts, the dollar risk under this rule translates into $1000; for five contracts, the risk is $2500; for 10 contracts, the risk escalates to $5000.

Appendix D defines the dollar equivalent of a specified risk exposure in ticks for up to 10 contracts of each of 24 commodities. A percentile distribution of daily and weekly true ranges in ticks helps the trader place the money management stop in perspective. For example, the daily analysis for soybeans reveals that 60 percent of the days had a true range less than or equal to 42 ticks. Therefore, there is approximately a 40 percent chance of the daily true range exceeding a 40-tick money management stop.

## ANALYZING UNREALIZED LOSS PATTERNS ON PROFITABLE TRADES

A trader could undertake an analysis of the maximum unrealized loss or equity drawdown suffered during the course of each profitable trade completed over a historical time period, with a view to identifying distinctive patterns. If a pattern does exist, it could be used to formulate appropriate drawdown cutoff rules for future trades. This approach assumes that the larger the unrealized loss, the lower the likelihood of the trade ending on a profitable note. A hypothetical analysis of unrealized losses incurred on all profitable trades over a given time period may look as shown in Table 6.1.

Armed with this information, the trader can estimate a cutoff value, beyond which it is highly unlikely that the unrealized loss will be recouped and the trade will end profitably. In the example given in Table 6.1, it is a good idea to pull out of a trade when unrealized losses equal or

**Table 6.1** Unrealized Loss Patterns on Profitable Trades

| $ Value of Unrealized Loss | # of Profitable Trades | Cumulative # of Profitable Trades | Cumulative % |
|---|---|---|---|
| 100 | 4 | 4 | 40% |
| 200 | 3 | 7 | 70% |
| 500 | 2 | 9 | 90% |
| 1000 | 0 | 9 | 90% |
| 1500 | 1 | 10 | 100% |



exceed $501. This is because only 10 percent of all profitable trades suffer an unrealized loss of greater than $500, mitigating the odds of prematurely pulling out of a profitable trade.

Instead of discussing the hypothetical, let us evaluate the unrealized loss patterns for Swiss francs, the Standard & Poor's (S&P) 500 Index futures, and Eurodollars, using a dual-moving-average crossover rule. A buy signal is generated when the shorter of two moving averages exceeds the longer one; a sell signal is generated when the shorter moving average falls below the longer moving average. Four sets of daily moving average crossover rules have been selected randomly for the analysis.

The time period considered is January 1983 to December 1986, divided into two equal subperiods: January 1983 to December 1984 and January 1985 to December 1986. Optimal drawdown cutoff rules have been arrived at by analyzing drawdown patterns over the 1983-84 subperiod. These drawdown cutoff rules are then applied to data for 1985-86, and a comparison effected against the conventional no-stop moving-average rule for the same period.

The optimal unrealized loss cutoff levels for each of the three commodities, across all four crossover rules, using daily data for January 1983 to December 1984, are summarized in Table 6.2. The optimal loss drawdown cutoff is set at a level equal to the maximum unrealized loss registered on 90 percent of all winning trades.

Once stopped out of a trade, the system stays neutral until a reversal signal is generated. Therefore, the total number of trades generated for each commodity remains unaffected by the stop rule, although the split between winners and losers does change.

The results are summarized in Tables 6.3 to 6.5. Notice from the tables that in the no-stop case, as the unrealized loss drawdown increases, the

**Table 6.2** Optimal Unrealized Loss Stop on Winning Trades

| Crossover rule | Eurodollars | | S&P 500 | | Swiss francs | |
|---|---|---|---|---|---|---|
| | ticks | $ | ticks | $ | ticks | $ |
| 6- & 27-day | 15 | 375 | 19 | 475 | 81 | 1013 |
| 9- & 33-day | 24 | 600 | 52 | 1300 | 63 | 788 |
| 12- & 39-day | 30 | 750 | 51 | 1275 | 80 | 1000 |
| 15- & 45-day | 40 | 1000 | 46 | 1150 | 72 | 900 |

**Table 6.3** Analysis of Unrealized Loss Drawdowns on Eurodollars during 1985-86 using stops based on 1983-84 data

| | Without Stops | | Using Drawdown Stops | |
|---|---|---|---|---|
| | Winners | Losers | Winners | Losers |
| 6- & 27-day Crossover | | | | |
| 0-8 | 5 | 0 | 4 | 0 |
| 9-16 | 2 | 3 | 2 | 20 |
| 17-24 | 1 | 5 | 0 | 1 |
| >24 | 1 | 11 | 0 | 1 |
| Total Trades | 9 | 19 | 6 | 22 |
| Profit/(Loss) without stops: | ($2,600) | | | |
| Profit/(Loss) using 1 5-tick stop: | ($3,600) | | | |
| 9- & 33-day Crossover | | | | |
| 0-7 | 2 | 0 | 2 | 0 |
| 8-21 | 3 | 5 | 3 | 5 |
| 22-28 | 1 | 2 | 0 | 11 |
| >28 | 0 | 9 | 0 | 1 |
| Total Trades | 6 | 16 | 5 | 17 |
| Profit/(Loss) without stops: | ($900) | | | |
| Profit/(Loss) using 24-tick stop: | ($175) | | | |
| 12- & 39-day Crossover | | | | |
| 0-8 | 6 | 0 | 6 | 0 |
| 9-24 | 3 | 2 | 3 | 2 |
| 25-40 | 0 | 4 | 0 | 9 |
| >40 | 0 | 5 | 0 | 0 |
| Total Trades | 9 | 11 | 9 | ii |
| Profit/(Loss) without stops: | $2,250 | | | |
| Profit/(Loss) using 30-tick stop: | $4,025 | | | |
| 15- & 45-day Crossover | | | | |
| 0-8 | 5 | 0 | 5 | 0 |
| 9-24 | 1 | 2 | 1 | 8 |
| 25-40 | 0 | 1 | 0 | 0 |
| >40 | 0 | 5 | 0 | 0 |
| Total Trades | 6 | 8 | 6 | 8 |
| Profit/(Loss) without stops: | ($1,300) | | | |
| Profit/(Loss) using 40 tick stop: | $1,575 | | | |

**Table 6.4** Analysis of Unrealized Loss Drawdowns on Swiss Francs during 1985-86 using stops based on 1983-84 data

| | Without Stops | | Using Drawdown Stops | |
|---|---|---|---|---|
| | Winners | Losers | Winners | Losers |
| 6- & 27-day Crossover | | | | |
| 0-30 | 4 | 0 | 4 | 0 |
| 31-60 | 2 | 0 | 2 | 0 |
| 61-120 | 1 | 5 | 0 | 13 |
| > 121 | 1 | 7 | 0 | 1 |
| Total Trades | 8 | i-5 | 6 | 14 |
| Profit/(Loss) without stops: | $1,188 | | | |
| Profit/(Loss) using 81 -tick stop: | ($1,613) | | | |
| 9- & 33-day Crossover | | | | |
| 0-46 | 3 | 0 | 3 | 0 |
| 47-92 | 2 | 1 | 0 | 14 |
| 93-184 | 1 | 4 | 0 | 1 |
| > 185 | 0 | 7 | 0 | 0 |
| Total Trades | 6 | 12 | 3 | 15 |
| Profit/(Loss) without stops: | ($10,713) | | | |
| Profit/(Loss) using 63-tick stop: | ($ 8,987) | | | |
| 12- & 39-day Crossover | | | | |
| 0-48 | 5 | 0 | 5 | 0 |
| 49-144 | 5 | 2 | 2 | 9 |
| 145-240 | 0 | 0 | 0 | 0 |
| > 241 | 0 | 4 | 0 | 0 |
| Total Trades | 10 | 6 | 7 | 9 |
| Profit/(Loss) without stops: | $5,012 | | | |
| Profit/(Loss) using 80-tick stop: | $6,700 | | | |
| 15- & 45-day Crossover | | | | |
| 0-43 | 5 | 2 | 5 | 2 |
| 44-129 | 2 | 1 | 2 | 7 |
| 130-258 | 1 | 1 | 0 | 0 |
| > 259 | 0 | 4 | 0 | 0 |
| Total Trades | 8 | 8 | 7 | 9 |
| Profit/(Loss) without stops: | $ 7,863 | | | |
| Profit/(Loss) using 72-tick stop: | $13,838 | | | |

**Table 6.5** Analysis of Unrealized Loss Drawdowns on S&P 500 Index Futures during 1985-86 using stops based on 1983-84 data

| | Without Stops | | Using Drawdown Stops | |
|---|---|---|---|---|
| | Winners | Losers | Winners | Losers |
| 6- & 27-day Crossover | | | | |
| 0-35 | 7 | 0 | 3 | 19 |
| 36-105 | 2 | 5 | 0 | 0 |
| 106-175 | 0 | 6 | 0 | 0 |
| >175 | 0 | 2 | 0 | 0 |
| Total Trades | 9 | 13 | 3 | 19 |
| Profit/(Loss) without stops: | | | $ 800 | |
| Profit/(Loss) using 19-tick (0.95 index point) stop: | | | $ 4,500 | |
| 9- & 33-day Crossover | | | | |
| 0-40 | 8 | 0 | 8 | 0 |
| 41-82 | 0 | 1 | 0 | 8 |
| 83-165 | 0 | 2 | 0 | 0 |
| > 165 | 0 | 5 | 0 | 0 |
| Total Trades | 8 | 8 | 8 | 8 |
| Profit/(Loss) without stops: | | | $ 6,400 | |
| Profit/(Loss) using 52-tick (2.60 index points) stop: | | | $30,525 | |
| 12- & 39-day Crossover | | | | |
| 0-40 | 9 | 0 | 9 | 0 |
| 41-81 | 1 | 1 | 0 | 9 |
| 82-161 | 0 | 1 | 0 | 0 |
| > 161 | 0 | 6 | 0 | 0 |
| Total Trades | 10 | 8 | 9 | 9 |
| Profit/(Loss) without stops: | | | ($7,800) | |
| Profit/(Loss) using 51-tick ( 2.55 index points) stop: | | | $21,225 | |
| 15- & 45-day Crossover | | | | |
| 0-46 | 4 | 0 | 4 | 11 |
| 47-94 | 1 | 1 | 0 | 0 |
| 95-188 | 0 | 3 | 0 | 0 |
| > 188 | 0 | 6 | 0 | 0 |
| Total Trades | 5 | 10 | 4 | 11 |
| Profit/(Loss) without stops: | | | ($18,250) | |
| Profit/(Loss) using 46-tick (2.30 index points) stop: | | | $16,600 | |



number of profitable trades declines sharply, both in absolute numbers and as a percentage of total trades. In other words, the larger the loss drawdown, the smaller is the probability of the trade ending up a winner. Consequently, as the unrealized loss increases, losing trades outnumber winning trades. Significantly, this conclusion holds consistently across each of the three commodities and four crossover rules, supporting the belief that unrealized loss cutoff rules could help short-circuit losing trades without prematurely liquidating profitable trades.

In general, using drawdown stops based on 1983-84 data tends to stem the drawdown on losing trades. This is true for all commodities and crossover rules. Gap openings through the stipulated stop price at times result in unrealized losses exceeding the level stipulated by our optimal drawdown cutoff rule. This is particularly true of the Swiss franc.

There is a significant increase in profits in case of the S&P 500 Index futures as a result of using stops. In the case of the Swiss franc and Eurodollars, the increase in profits is most noticeable in case of the slow-reacting, longer-term moving-average crossover rules.

As a note of caution, it must be pointed out that optimal drawdown cutoff rules are likely to be sensitive to changes in market conditions. A significant shift in market conditions could result in a dramatic change in the unrealized loss pattern on both winning and losing trades. In view of this, the optimal drawdown cutoff rule for a given period should be based on the results of a drawdown analysis for profitable trades effected in the immediately preceding period.

## BULL AND BEAR TRAPS

We now digress into a discussion of bull and bear traps and how not to fall prey to them. Bull and bear traps typically result from chasing a market that is perceived to be extremely bullish or bearish, as the case may be. Bullish expectations are reinforced by a sharply higher or "gap-up" opening, just as bearish expectations are supported by a sharply lower or "gap-down" opening. The trader enters the market at the opening price, hoping that the market will continue to move in the direction signaled by the opening price.

A bull trap occurs as a result of prices retreating from a sharply higher or gap-up opening. The pullback occurs during the same trading session that witnessed the strong opening, belying hints of a major rally.

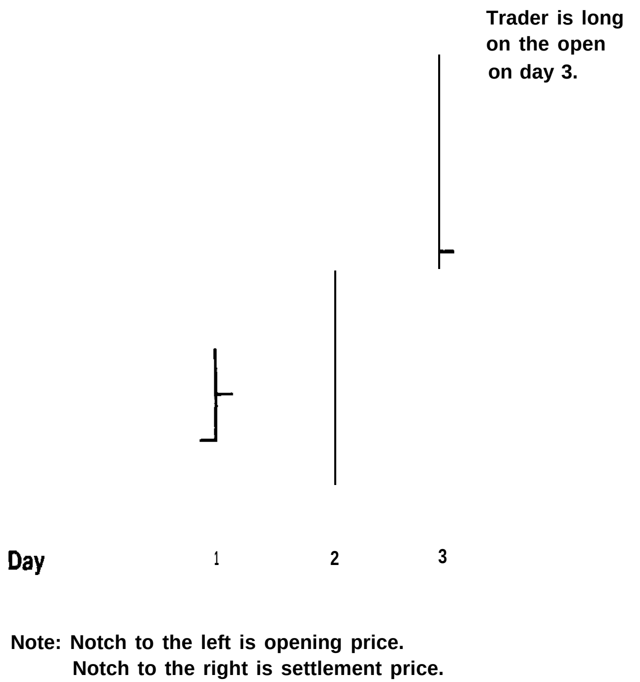



**Figure 6.3** A hypothetical example of a bull trap.

Consequently, an unsuspecting bull who bought the commodity at the opening price is left with an unrealized loss. The fact that prices might actually settle marginally higher than the preceding session offers little consolation to our harried trader, who has already fallen victim to a bull trap. Figure 6.3 illustrates the working of a bull trap.

A bear trap occurs as a result of prices recovering from a sharply lower or gap-down opening. The retracement occurs during the same trading session that witnessed the depressed opening, confounding expectations of an outright collapse. The retracement results in an unrealized loss for a gullible bear who sold the commodity at the gap-down opening price or shortly thereafter. Figure 6.4 illustrates a bear trap.

## AVOIDING BULL AND BEAR TRAPS

The trauma arising out of bull and bear traps is not inevitable and should be avoided by means of an appropriate stop-loss order. Since a bull or



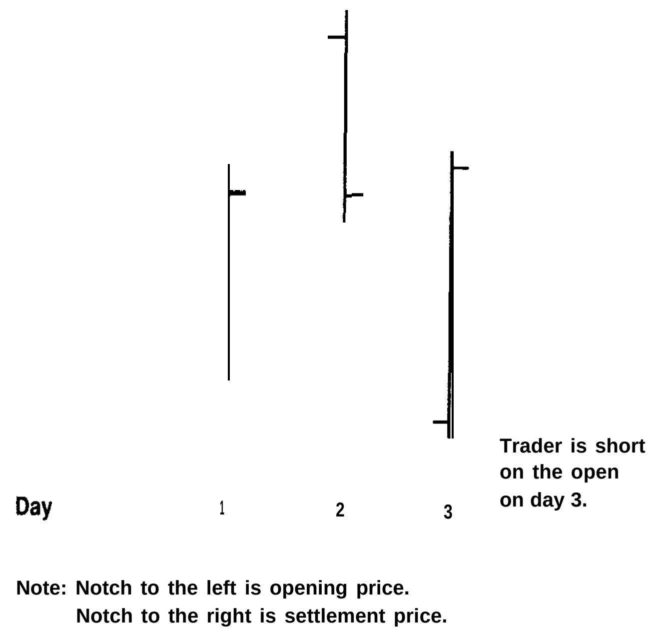



**Figure 6.4** A hypothetical example of a bear trap.

bear trap develops as a result of entering the market at or soon after the opening on any given day, a stop-loss order should be set with reference to the opening price. In the following section, we analyze the location of the opening price in relation to the high and low ends of the daily (or weekly) trading range over a historical time period.

### Analyzing Historical Opening Price Behavior

It is common knowledge that when prices are trending upwards, the opening price for any given period lies near the low end of the day's range and the settlement price lies above the opening price. Similarly, when prices are trending downwards, the opening price for any given Period lies near the high end of the day's range and the settlement price lies below the opening price. As a result, we observe a narrow spread between the opening price and the day's low when prices are trending upwards. Conversely, we observe a narrow spread between the daily high and the opening price when prices are trending downwards. In some cases, we find the opening price to be exactly equal to the high of a down day or the low of an up day, leading to a zero spread.

For purposes of this analysis, an "up" period, either day or week, is defined as a trading period at the end of which the settlement price is higher than the opening price. Similarly, a "down" period is defined as a trading period at the end of which the settlement price is lower than the opening price.

Using this definition of up and down periods, we analyze the percentile distribution of the spread between the opening price and the high (low) for down (up) periods. Appendix E tabulates the findings separately for both up and down periods for 24 commodities and gives a percentage distribution of the spread. The results are based on data from January 1980 through June 1988.

Consider, for example, the 10 percent value of 2 ticks for up days in the British pound. This suggests that 10 percent of all up days in our sample have an opening price within 2 ticks of the day's low. Similarly, the 90 percent value of 32 ticks for down days implies that in 90 percent of the down days surveyed in our sample, the opening price is within 32 ticks of the day's high.

## USING OPENING PRICE BEHAVIOR INFORMATION TO SET PROTECTIVE STOPS

The information given in Appendix E can be used by a trader who (a) has a definite opinion about the future direction of the market, (b) observes a gap opening in the direction he believes the market is headed, and (c) wishes to participate in the move without getting snared in a costly bull or bear trap. A bullish trader who enters a long position at a gap-up opening on a given day would want to set a stop-loss order *n* ticks below the opening price of that day. A bearish trader who enters a short position at a gap-down opening on a given day, would want to set a stop-loss order *n* ticks above the opening price of that day.

The value of *n* is based on the information given in Appendix E and corresponds to the percentile value of the spread between the open and the high (or the low) the trader is most comfortable with. A conservative approach would be to set the stop-loss order based on the 90 percent value of the distance in ticks between the open and the high price for an anticipated move downwards, or between the open and the low price, for an anticipated move upwards.



Suppose a trader is bearish on the Deutsche mark futures. Assume further that the Deutsche mark futures contract has a gap-down opening at $0.5980 just as our trader wishes to initiate a short position. In order to avoid falling into a bear trap, he would be advised to set a protective buy stop 17 ticks above the opening price, or at $0.5997. This is because our analysis reveals that the opening price lies within 17 ticks of the day's high in 90 percent of the down days for the Deutsche mark. The likelihood of getting stopped out of the trade erroneously is 10 percent. This implies that there is a 1 in 10 chance of the daily high being farther than 17 ticks from the opening price, with the day still ending up as a down day.

## SURVIVING LOCKED-LIMIT MARKETS

A market is said to be "locked-limit" when trading is suspended consequent upon prices moving the exchange-stipulated daily limit. This section discusses strategies aimed at surviving a market that is "locked-limit" against the trader. Prices have moved against the trader, perhaps even through the stop-loss price. However, since trading is suspended, the position cannot be liquidated. What is particularly worrisome is the uncertainty surrounding the exit price, since there is no telling when normal trading will resume.

When caught in a market that is trading locked-limit, the primary concern is to contain the loss as best as is possible. In this section, we examine some of the alternatives available to help a trader cope with a locked-limit market.

### Using Options to Create Synthetic Futures

In certain futures markets, options on futures are not affected by limit moves in the underlying futures. In such a case, the trader is free to use options to create a synthetic futures position that neutralizes the trader's existing futures position. For example, if she is long pork belly futures and the market is locked-limit against her, she might want to create a synthetic short futures position by simultaneously buying a put option and selling a call option for the same strike or exercise price on pork belly futures. Similarly, if she is short pork belly futures, and is caught in a limit-up market, she might create a synthetic long futures position by buying a call option and selling a put option for the same strike or exercise price on pork belly futures.

Since the synthetic futures position offsets the original futures position, the trader need not fret over her inability to exit the futures market. She has locked in a loss, as any loss suffered in subsequent locked-limit sessions in the futures market will be offset by an equal profit in the options market.

### Using Options to Create a Hedge Against the Underlying Futures

If the trader is of the opinion that the locked-limit move represents a temporary aberration rather than a shift in the underlying trend, he might want to use options to protect or hedge rather than to liquidate his futures position. For example, if a trader is short pork belly futures, he might want to hedge himself by buying call options. Alternatively, if he is long pork belly futures, and believes that the limit move against him is a temporary setback, he might want to hedge himself by buying put options. When the market resumes its journey upwards after the temporary detour, the hedge may be liquidated by selling the option in question.

The protection offered by the hedge depends on the nature of the hedge. An in-the-money option has intrinsic value, which makes it a better hedge than an at-the-money option. In turn, an at-the-money option, with a strike or exercise price exactly equal to the current futures price, provides a better hedge than an out-of-the-money option with no intrinsic value. This is because an in-the-money option replicates the underlying futures contract more closely than an at-the-money option and much more so than an out-of-the-money option.

Whereas hedging a futures position with options does help ease the pain of loss, the magnitude of relief depends on the nature of the hedge. If the hedge is not perfect, or "delta neutral" in options parlance, the trader is still exposed to adverse futures price action and his loss might continue to grow.

### Switching Out of a Locked-Limit Market

A switch is a two-step strategy that is available when at least one contract month in a given commodity has no trading limit. The rules as to when



a switch is available vary from commodity to commodity and from exchange to exchange.

For example, during the month of July, July soybeans have no limit, whereas all other contract months have price limits. Accordingly, if a trader is long January 1992 soybeans and the market for January soybeans opens locked-limit down sometime in July 1991, the trader might wish to exit the January position through the following set of orders:

1. A spread order to buy a contract of July soybeans at the market, simultaneously selling a contract of January soybeans
2. A second order to sell a contract of July soybeans at the market, entered when order 1 is filled

Whereas the first order switches the trader from long January soybeans to long July soybeans, the second order offsets the July position. This is a circuitous but effective way of liquidating the January position. It may be noted that as long as one contract month is trading, the spread is usually available. However, owing to the extreme volatility of a market that is trading at locked-limit levels, the spreads tend to be extremely volatile. Care must be taken to ensure that the switch is carried out in the order here described.

### Exchange for the Physical Commodity

As the name suggests, this strategy involves liquidating a locked-limit futures position by initiating an offsetting trade in the cash market. The cash market is not affected by the suspension of trading in the futures market, making the exchange a viable strategy. Notice that this strategy involves a single transaction and is therefore easier to implement than some of the multistep strategies just outlined.

## MANAGING UNREALIZED PROFITS

Since losing trades typically outnumber winning trades, a trader has ample opportunity to master the art of controlling losses. As profitable trades are fewer in number, expertise in managing unrealized profits is that much harder to develop. The objective is to continue with a Profitable trade as long as it promises even greater profits, while at the same time not exposing all the profits already earned on the trade.

When a trade is initiated, a protective stop-loss order should be placed to prevent unrealized losses from getting out of control. If prices move as anticipated, the protective stop-loss price should be updated so as to reflect the favorable price action, reducing exposure on the trade. At some stage, this process of updating stop-loss prices will result in a break-even trade. It is only after a break-even trade is assured that a profit conservation stop will take effect. In this section, we discuss strategies for setting profit conservation stops.

### limit Orders to Exit a Position

Often, an exit price is set so as to achieve a given profit target. For example, if a trader is long a commodity, he would set his exit price somewhere above the current market price. Similarly, if he were short, he would set his exit price somewhere below the current market price. These orders are termed limit orders. Once a limit order based on a profit target is hit, a trader ends up observing the rally, as a helpless spectator, instead of participating in it! Alternatively, if the profit target is not hit, the trader might feel pressured to continue with the trade, hoping to achieve his elusive profit target. This could be dangerous, especially if the trader is adamant about his view of the market and decides to wait it out to prove himself right.

Instead of using profit targets to exit the market, it would be more advisable to use stops as a means of protecting unrealized profits. This section offers two different approaches for setting unrealized profit conservation stops using

1. Chart-based support and resistance levels
2. Volatility-based trailing stops

### Using Price Charts to Manage Unrealized Profits

Price charts provide a simple but effective means of setting profit conservation stops. A trader who anticipates a continuation of the current trend must decide how much of a retracement the market is capable of making without in any way disturbing the current trend. An example will help clarify this approach.

Consider the Deutsche mark futures price chart for the March 1990 contract given in Figure 6.5. Notice the 100-tick gap between the high of $0.5172 on September 22 and the low of $0.5272 on September 25.

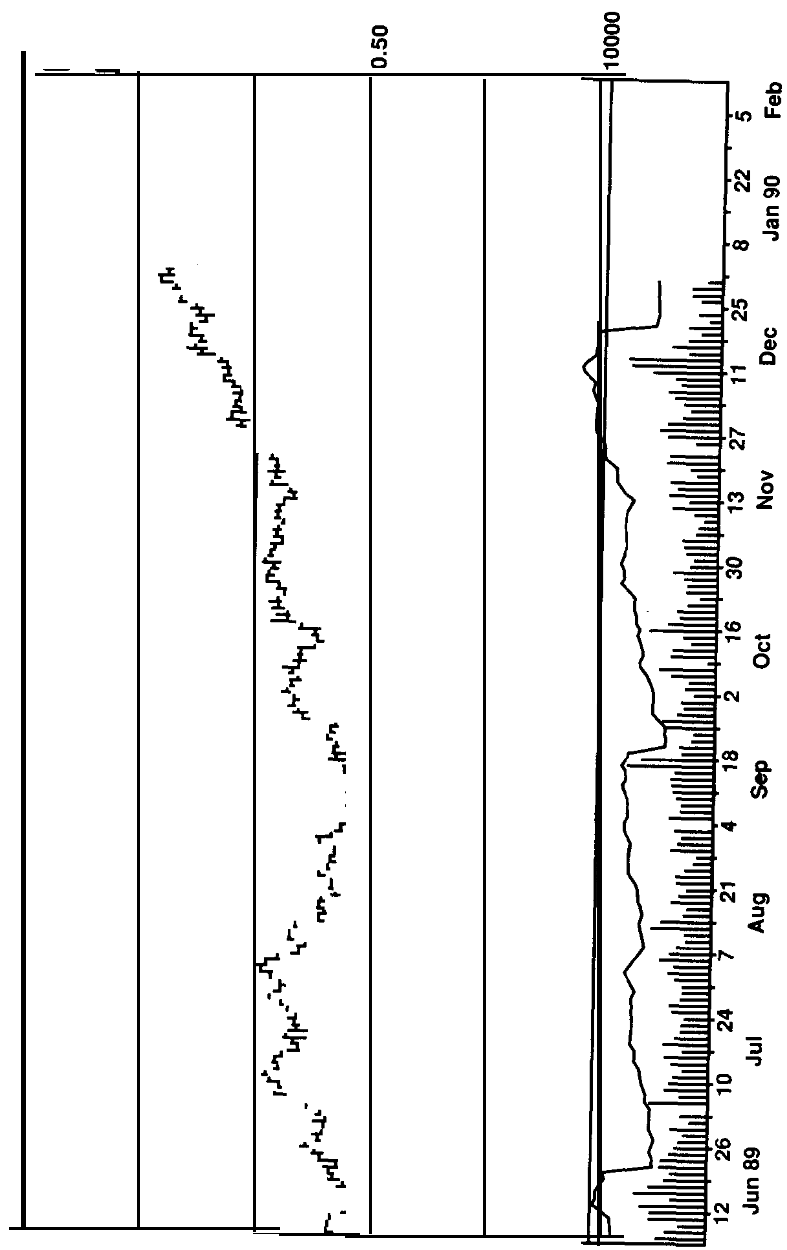



**Figure 6.5** Profit conservation stops: March 1990 Deutsche mark.

This was the market's response to the weekend meeting of the leaders of seven industrialized nations. Consequently, a trader who was long the Deutsche mark coming into September 25 started the week with a windfall profit of over 100 ticks or $1250. Fearing that the market would fill the gap it had just created, he or she might want to set a sell stop just below $0.5272, the low of September 25, locking in the additional windfall profit of 100 ticks.

However, if the trader were not keen on getting stopped out, he or she would allow for a greater price retracement, setting a looser stop anywhere between $0.5 172 and $0.5272. The unfolding of subsequent price action confirms that a trader would have been stopped out if the sell stop were set just below $0.5272. On the other hand, if the stop were set at or below $0.5200, the long position would be untouched by the retracement .

### Using Volatility-Based Trailing Stops

The trader might want to set his or her profit conservation stop *n* ticks below the peak unrealized profit level registered on the trade. The number *n* could be based on the volatility for a single trading period, either a day or a week, or it could be the average volatility over a number of trading periods. If the trader so desires, he could work off some multiple or fraction of the volatility he proposes to use.

If the trader is not confident about the future course of the market, he might wish to lock in most of his profits. Consequently, he might want to set a tight volatility stop. Alternatively, if he is reasonably confident about the future trend, he might wish to work with a loose trailing stop, locking in only a fraction of his unrealized profits.

## CONCLUSION

Setting no stops, although an easy way out, is not a viable alternative to setting reasonable stops to safeguard against unrealized losses. However, the definition of a reasonable stop is not etched in stone, and it is very much dependent on prevailing market conditions and the trading technique adopted by the trader.

A stop-loss order is designed to control the maximum amount that can be lost on a trade. Stop-loss orders may be set by reference to price



charts or by reference to historical price action, typified by time and volatility stops. Alternatively, the trader might wish to set dollar value stops based on a predetermined amount he is willing to lose on a trade. Finally, the trader might analyze the unrealized loss pattern on completed profitable trades, using a given system to arrive at probability stops.

As and when the market moves in favor of the trader's position, the initial stop-loss price should be moved to lock in a part of the unrealized profits. A profit conservation stop replaces the initial stop-loss price. The amount of profits to be locked in depends upon an analysis of price charts or an analysis of historical price volatility of the commodity in question.

# 7

# Managing the Bankroll: Controlling Exposure

The fraction of available funds exposed to potential trading loss is termed "risk capital." The higher this fraction, the higher the exposure and the greater the risk of loss. This chapter presents several approaches to determining the dollar amount to be risked to trading. Although the magnitude of this fraction depends upon the approach adopted, the following factors are relevant regardless of approach: (a) the size of the bankroll, (b) the probability of success, and (c) the payoff ratio- the ratio of the average win to the average loss.

Each approach is judged against the following yardsticks: (a) its reward potential, both in dollar terms and in terms of the time it takes to achieve a given target; (b) the associated risk of ruin; and (c) the practicality of the strategy. The optimal strategy is one that offers the greatest reward potential for a given level of risk and lends itself to easy implementation.

## EQUAL DOLLAR EXPOSURE PER TRADE

True to its name, the equal-dollar-exposure approach recommends that a fixed dollar amount be risked per trade. The greatest appeal of this system is its simplicity. The dollar amount is independent of changes in





the original bankroll, thus necessitating no further calculations. However, the equal-dollar-exposure strategy is surpassed by other strategies that offer greater potential for growth of the bankroll for the same level of risk.

## FIXED FRACTION EXPOSURE

A fixed-proportional-exposure system recommends that a trader always risk a fixed proportion of the current bankroll. Should the trader's bankroll decrease, the bet size decreases proportionately; as the bankroll increases, the trader bets more. The fixed-fraction system in its most simplistic sense is based strictly on the probability of trading success. The implicit assumption is that the average win is exactly equal to the average loss, leading to a payoff ratio of 1.

The probability of success is given by the ratio of the number of profitable trades to the total number of trades signaled by a trading system over a given time period. For example, if a system has generated 10 trades over the past year and six of these trades were profitable, the probability of success of that system is 0.60. The fixed fraction, f, of the current bankroll is given by the formula

$$f = [P - (1 - P)]$$

where p is the probability of winning using a given trading system, and $1 - p$ is the complementary probability of losing. If, for example, the trading system is found historically to generate 5.5 percent winners on average, then the formula would recommend risking $[0.55 - (1 - 0.55)]$ or 10 percent of available capital.

With a slightly higher success rate of 60 percent, the formula would suggest an allocation of $[0.60 - (1 - 0.60)]$ or 20 percent. Intuitively, it makes sense to risk a larger fraction of trading capital when confidence in signals generated by a given trading system runs high. If a system is not very reliable, it is only prudent to be wary about risking money on the basis of such a system.

This method of allocation presupposes that the probability of success for any given trading system is at least 5 1 percent. If a system cannot satisfy this benchmark criterion, then a trader ought not to rely on it in trading the futures markets. With a success rate of 50 percent, the probability of winning is exactly offset by the probability of losing, reducing the proportion of capital to be risked to [0.50 - (1 - 0.50)] or 0.

Assume that the initizl capital is equal to $20,000, and our trader uses a system which has a 55 percent probability of success. Hence, the trader decides to risk 10 percent of $20,000, or $2000, toward active trading. Assume further that every successful trade results in a profit exactly equal to the initial amount invested. For ease of illustration, let us also assume that every unsuccessful trade results in a loss equal to the initial amount invested.

Therefore, an investment of $2000 could result in a profit of $2000 or a loss of $2000. If the first trade turns out to be successful, the total trading capital will grow to 110 percent of the initial amount, or $22,000 ($20,000 x 1.10). The next time around, therefore, the trader should consider risking 10 percent of $22,000, or $2200, toward active trading. If the second trade happens to be a winner as well and results in a 100 percent return on investment, the balance will now grow to $24,200 ($22,000 x 1.10). The trader now can risk $2420 toward the third trade. However, if the first trade results in a loss, the trader now has only $18,000 ($20,000 x .90) available, and the amount that can be allocated toward the second trade will now shrink to 10 percent of $18,000, or $1800. If the second trade again results in a loss, the trader is now left with $16,200 ($18,000 x .90), or $1620, toward the third trade.

Notice that this system gradually increases or decreases the amount applied to active trading, depending on the results of prior trades. The system is particularly good at controlling the risk of ruin. Even if a trader continues to suffer a series of consecutive losses, the fixed-fraction system ensures that there is something left over for yet another trade.

#### Introducing Payoffs into the Formula

The implicit assumption in the discussion so far is that the dollar value of a profitable trade on average equals the dollar value of a losing trade. However, this is hardly ever true in futures trading. The principle of cutting losses in a hurry and letting profits ride, if faithfully followed, should result in the average profitable trade outweighing the average losing trade.

In other words, the payoff ratio, which compares the average dollar profit to the average dollar loss, is likely to be greater than 1. A payoff ratio of 2, for example, would mean that the dollar value of an average winning trade is twice as large as the dollar value of an average losing trade. The greater the payoff ratio, the more desirable the trading system. A successful trader could have just under 50 percent of trades as winners and come out ahead simply because the average winner is more than twice the average loser. Clearly, a method of exposure determination with no regard to the payoff ratio would be inaccurate at best.



In order to rectify this anomaly, Thorp[1] modified the fixed-fraction formula to account for the average payoff ratio, $A$, in addition to the average probability of success, $p$. The formula was originally developed by Kelly and is therefore sometimes referred to as the Kelly system.[2] Thorp also refers to the formula as the "optimal geometric growth portfolio" strategy, because it maximizes the long-term rate of growth of one's bankroll. The optimal fraction, f, of capital to be risked to trading may be defined as

$$f = \frac{[(A+1)p] - 1}{A}$$

The numerator of this fraction is the expected profit on a one-dollar trade that is anticipated to yield either of two outcomes: (a) a profit of $\$A$ with a probability $p$, or (b) a loss of $1 with a probability of $(1-p)$. The expected profit on this trade is the net amount likely to be earned, arrived at as follows:

$$\begin{aligned} A(p) - (1(1-p)) &= A(p) + p - 1 \\ &= [(A+1)p] - 1 \end{aligned}$$

The probability-based fixed-fraction allocation formula, discussed earlier, is a special case of the current formula where the payoff ratio is assumed to be 1. To verify this, let us substitute a value of 1 for the payoff ratio, $A$, in the Kelly formula. Then

$$f = \frac{[(1+1)p] - 1}{1} = \frac{2p - 1}{1} = [p - (1-p)]$$

Recall that in terms of the strict probability-based approach discussed Previously, we had advised against trading a system that has a probability of success less than 0.5 1. However, with the introduction of the payoff

[1] Edward 0. Thorp, *The Mathematics of Gambling* (Van Nuys, CA: Gambling Times Press, 1984).

[2] J. L. Kelly, "A Nkw Interpretation of Information Rate," *Bell System Technical Journal,* Vol. 35, July 1956, pp. 917-926.

ratio into the equation, this is no longer true. The more generalized approach is not only more accurate but also more representative of reality. For example, if the probability of success is 0.33, and the payoff ratio is 5, the trader should risk 20 percent of trading capital toward a given trade, as given by

$$f = \frac{[(5+1)(.33)] - 1}{5} = \frac{2-1}{5} = \frac{1}{5} = 0.20$$

The above discussion is based on the probability of success and the payoff ratio over a historical time period. The average probability of success is simply the ratio of the number of winning trades to the total number of trades over a historical time period. Similarly, the average payoff ratio is the ratio of the dollars earned on average across all winning trades to the dollars lost on average across all losing trades over a historical time period.

The major shortcoming of the Kelly approach just discussed is that it assumes that performance measures based on historical results are reliable predictors of the future. In real-life trading it is unlikely that the payoff ratio on a trade or its probability of success will coincide with the historical average. Chapter 9 provides empirical evidence in support of the instability of performance measures across time. In view of this, we need an approach that recognizes that each trade is unique. Average performance measures derived from a historical analysis of completed trades will not yield the optimal exposure fraction.

## THE OPTIMAL FIXED FRACTION USING THE MODIFIED KELLY SYSTEM

The modified approach relies on the original Kelly formula but uses trade-specific performance measures instead of historical averages to arrive at the optimal *f*. The modified Kelly system assumes that the probability of success and the payoff ratio are likely to vary across trades. Consequently, it reckons the optimal *f* for a trade based on the performance measures unique to that trade.

Ziemba simulates the performance of several betting systems and finds the modified Kelly system has the highest growth for a given level of risk. Ziemba concludes that "the other strategies either bet too little, and hence have too little growth, or bet too much and have high risk including many tapouts."[3]



## ARRIVING AT TRADE-SPECIFIC OPTIMAL EXPOSURE

Trade-specific optimal exposure may be calculated using either (a) projected risk and reward estimates or (b) historic return data. The projected-risk-and-reward approach arrives at the optimal fraction, *f*, by calculating the payoff ratio and estimating the probability of success associated with a trade. The historic-return approach uses an iterative technique to arrive at the optimal value of *f*.

### The Projected-Risk-and-Reward Approach

The projected-risk-and-reward approach assumes that the trader knows the likely reward and the permissible risk on a trade before its initiation. Based on past experience, the trader can estimate the probability of success. Assume, for example, that a trader is considering buying a contract of soybeans and is willing to risk 8 cents in the hope of earning 20 cents on the trade. Based on past performance, the probability of success is expected to be 0.45. Using this information, we calculate the payoff ratio, A, on the trade as follows:

$$\text{Payoff ratio, } A = \frac{\text{Expected win}}{\text{Permissible loss}} = \frac{20}{8} = 2.50$$

Next, calculate the expected value of the payoff ratio as under:

$$\begin{aligned}\text{Expected Value of Payoff ratio} &= \begin{pmatrix}\text{Probability * Payoff} \\ \text{of winning} \quad \text{ratio}\end{pmatrix} - \begin{pmatrix}\text{Probability * 1} \\ \text{of losing}\end{pmatrix} \\ &= (0.45 * 2.50) - (0.55 * 1) \\ &= 1.125 - 0.550 \\ &= 0.575\end{aligned}$$

[3] William T. Ziemba, "A Betting Simulation: The Mathematics of Gambling and Investment," *Gambling Times,* June 1987.

Using this information, the optimal exposure fraction, $f$, for the soybean trade in question works out to be

$$f = \frac{[(2.50 + 1)0.45 - 1]}{2.50} = \frac{0.575}{2.500} = 0.23 \text{ or } 23\%$$

Hence the trader could risk 23 percent of the current bankroll on the soybean trade.

### The Historic-Returns Approach

The historic-returns approach uses an iterative approach to arrive at a value off that would have maximized the terminal wealth of a trader for a given set of historical trade returns. This is the optimal fraction of funds to be risked. As is true of all historical analyses, this approach makes the assumption that the fraction that was optimal over the recent past will continue to be optimal for the next trade. In the absence of precise risk and reward estimates, we have to live with this assumption.

This method has been developed by Vince[4]. Consider a sample of completed trades that includes at least one losing trade. The raw historical returns for each trade within the sample are divided by the return on the biggest losing trade. Next, the negative of this ratio is multiplied by a factor, $f$, and added to 1 to arrive at a weighted holding-period return. As a result, the weighted holding-period return (HPR) is defined as

$$\text{HPR on trade } i = 1 + \left[f \times \left(\frac{\text{(-Return on trade } i)}{\text{Return on worst losing trade}}\right)\right]$$

The terminal wealth relative (TWR) is the product of the weighted holding-period returns generated for a commodity across all trades over the sample period. Therefore, the terminal wealth relative (TWR) across $n$ returns is

$$\text{TWR} = [(\text{HPR}_1) \times (\text{HPR}_2) \times (\text{HPR}_3) \times \cdots \times (\text{HPR}_n)]$$

By testing a number of values off between 0.01 and 1, we arrive at the value off that maximizes the TWR. This value represents the optimal fraction of funds to be allocated to the commodity in the next round of trading.

[4] Ralph Vince, ***Portfolio Management Formulas*** (New York: John Wiley and Sons, 1990).



**Table 7.1** Calculating the Weighted Holding-Period Return on Five Trades of X

| Trade | Holding-Period Return |
|---|---|
| 1 | $1 + f\left(-\frac{+0.25}{-0.35}\right) = 1 + f(+0.71428)$ |
| 2 | $1 + f\left(-\frac{-0.35}{-0.35}\right) = 1 + f(-1.00000)$ |
| 3 | $1 + f\left(-\frac{+0.40}{-0.35}\right) = 1 + f(+1.14286)$ |
| 4 | $1 + f\left(-\frac{-0.10}{-0.35}\right) = 1 + f(-0.28571)$ |
| 5 | $1 + f\left(-\frac{+0.30}{-0.35}\right) = 1 + f(+0.85714)$ |

For example, let us consider the following sequence of trade returns for a commodity X:

+0.25 -0.35 +0.40 -0.10 +0.30

The worst losing trade yields a return of -0.35. Each return is divided by this value, and the resulting holding period returns are given in Table 7.1. Using the information in that table, we calculate the TWR for $f$ values equal to 0.10, 0.25, 0.35, 0.40, and 0.45, as shown in Table 7.2. Since the TWR is maximized when $f$ = 0.40, this is the optimal fraction, $f^*$, of funds to be allocated to the next trade in X.

**Table 7.2** Calculating the TWR for X for Different Values of $f$

| | Holding-Period Return (HPR) | | | | |
|---|---|---|---|---|---|
| Trade | $f = 0.10$ | $f = 0.25$ | $f = 0.35$ | $f = 0.40$ | $f = 0.45$ |
| 1 | 1.07143 | 1.17857 | 1.25000 | 1.28571 | 1.32143 |
| 2 | 0.90000 | 0.75000 | 0.65000 | 0.60000 | 0.55000 |
| 4 | 1.11428 | 1.28571 | 1.40000 | 1.45714 | 1.51429 |
| 5 | 0.97143 | 0.92857 | 0.90000 | 0.88572 | 0.87143 |
| | 1.08571 | 1.21429 | 1.30000 | 1.34286 | 1.38571 |
| TWR = | 1.13325 | 1.28144 | 1.33087 | 1.33697 | 1.32899 |

## MARTINGALE VERSUS ANTI-MARTINGALE BETTING STRATEGIES

The discussion so far has concentrated exclusively on the projected performance of a trade in determining the optimal exposure fraction. Changes in available capital are considered, but only indirectly. For example, a 10 percent optimal exposure fraction on available capital of $10,000 would entail risking $1000. If the capital in the account grew to $12,000, a 10 percent exposure would now amount to $1200, an increase of $200. However, if the capital were to shrink to $7500, a 10 percent exposure would amount to $750, a decrease of $250.

Critics of performance-based approaches would like to see a more direct linkage between the exposure fraction and changes in available capital. An aggressive trader, it is argued, might use adversity as a spur to even greater risks. After all, such a trader is interested in recouping losses in the shortest possible time. A risk-averse trader, when faced with similar misfortune, might be inclined to scale down the exposure. Assuming a trader were interested in a more direct linkage between the exposure fraction and changes in available capital, what are the options available and what are their relative merits?

This section examines two strategies that incorporate the outcome of closed-out trades and consequential changes in the bankroll into the calculation of the exposure fraction. The exposure fraction either increases or decreases, depending on the trader's risk threshold. A strategy that doubles the size of the bet after a loss is termed a Martingale strategy. The word Martingale is derived from a village named Martigues in the Provence district of southern France, whose residents were noted for their bizarre behavior. An example of such behavior was doubling up on losing bets. Consequently, the doubling up system was dubbed as gambling "à la Martigals," or "in the Martigues manner." Conversely, a strategy that doubles bet size after each win is referred to as an anti-Martingale strategy.

### The Martingale Strategy

The Martingale strategy proposes that a trader bet one unit to begin with, double the bet on each loss, and revert to one unit after each win. The attraction of this technique is that when the trader finally does win, it allows him or her to recover all prior losses. In fact, a win always sets the trader ahead by one betting unit.

However, because the bet size increases rapidly during a sequence of losses, it is quite likely that the trader will run out of capital before recovering the losses! More importantly, in order to prevent heavily capitalized gamblers from implementing this strategy successfully, most casinos impose limits on the size of permissible bets. Similar restrictions are imposed by exchanges on the size of positions that may be assumed by speculators.



### The Anti-Martingale Strategy

As the name suggests, the anti-Martingale strategy recommends a starting bet of one unit; the bet doubles after each win and reverts to one unit after each loss. Since the increased bet size is financed by winnings in the market, the trader's capital is secure. The shortcoming of this approach is that since there is no way of predicting the outcome of a trade, the largest bet might well be placed on a losing trade immediately following a successful trade.

### Evaluation of the Alternative Strategies

Bruce Babcock[5] provides a comparative study of the two strategies, using a neutral strategy as a benchmark for comparison. The neutral strategy recommends trading an equal number of contracts at all times regardless of wins or losses. The Martingale strategy turns in the largest percentage of winning streaks, regardless of trading system used. However, the high risk of the strategy, given by the magnitude of the worst loss, makes it unsuitable for commodities trading. Moreover, the capital required to carry a trader through periods of adversity makes the strategy impractical.

The anti-Martingale strategy incurs lower risk while affording the highest profit potential. The average profits under the neutral strategy are the lowest, with the worst loss being no greater than under the anti-Martingale strategy. Clearly, the strategy of working with a constant number of contracts was overshadowed by the anti-Martingale strategy.

[5] Bruce Babcock, Jr., *The Dow Jones-Irwin Guide to Trading Systems* (Homewood, IL: Dow Jones-Irwin, 1989).

In Babcock's study the anti-Martingale strategy increased performance appreciably, without any appreciable increase in total risk. This should inspire small, one-contract traders to build steadily on their wins. Babcock's findings confirm that a trader may double exposure after a win, but doubling up after a loss in the hope of recouping the loss could prove to be a risky and financially draining strategy.

As a word of caution, it should be pointed out that the advantage of the anti-Martingale strategy is contingent upon using a winning system—that is, a system with a positive mathematical expectation of reward. As Babcock rightly concludes, "In the long run, no trade management strategy can turn a losing system into a winner."[6]

## TRADE-SPECIFIC VERSUS AGGREGATE EXPOSURE

The discussion so far has revolved around the optimal exposure fraction for a trade. Assuming that multiple commodities are traded simultaneously, what should the optimal exposure, $F$, be across all trades? An obvious answer is to sum the optimal exposure fractions, $f$, across the individual commodities traded. However, the simple aggregation approach suffers on two counts.

First, it assumes zero correlation between commodity returns. This may not always be true and could lead to inaccurate answers. For example, if the returns on two commodities are positively correlated, the aggregate optimal exposure across both commodities would be lower than the optimal exposure on the commodities individually. Conversely, if the returns are negatively correlated, the aggregate optimal exposure would be higher than the sum of the optimal exposure on the individual commodities.

For ease of analysis, we could assume that (a) positively correlated commodities will not be traded concurrently and (b) negative correlations between commodities may be ignored. Since strong negative correlations between commodities are uncommon, the theoretical invalidity of assumption (b) is not as worrisome as it appears.

The more serious problem with the simple aggregation technique is that it does not guard against an aggregate exposure fraction greater

[6] Babcock, ***Guide to Trading Systems,*** p. *25.*



than 1. This is clearly unacceptable, since risking an amount in excess of one's bankroll is practically infeasible! Here is where the simple aggregation technique breaks down, necessitating an alternative approach to defining $F$.

The approach presented here is an iterative procedure similar to the Vince technique previously discussed for the one-commodity case. This approach assumes that the mix of traded commodities analyzed will be identical to the mix to be traded in the next period. It further assumes stability of the correlations between returns. Finally, it assumes that the sample of joint returns will include at least one losing trade with a negative return.

### Calculating Joint Returns across Commodities

The joint return for trade, $i$, across a set of commodities is the geometric average of the individual commodity returns for that trade. The geometric average gives equal weight to each trade, regardless of the magnitude of the trade return. Therefore, it is not unduly affected by extreme values. The geometric average return, $R_i$, for trade $i$ across $n$ commodities is worked out as follows:

$$R_i = [(1 + R_{i1}) \times (1 + R_{i2}) \times (1 + R_{i3}) \times \cdots \times (1 + R_{in})]^{1/n} - 1$$

where $R_{ij}$ = realized return on trade $i$ for commodity $j$.

Assume that a trader has traded three commodities, A, B, and C, over the past year. Assume further that over this period seven trades were executed for A, four for B, and two for C. The returns on the individual trades and the joint returns across commodities were as shown in Table 7.3. Notice that the number of joint returns equals the maximum number of trades for any single commodity in the portfolio. In our example, we have seven joint returns to accommodate the maximum number of trades for commodity A. For trades 5, 6, and 7, the joint returns are essentially the returns on commodity A, since there are no matching trades for B and C.

The negative return on the worst losing trade is -0.25. Each joint return is divided by this value. The negative of this ratio is multiplied by a factor, $F$, and added to 1 to arrive at an aggregate weighted holding-period return (HPR) for a trade $i$. Therefore,

$$\text{HPR}_i = 1 + \left[F \times \left(\frac{\text{-Return on trade } i}{\text{Return on worst losing trade}}\right)\right]$$

Table 7.3 Computing Joint Returns across a Portfolio of Commodities

| | Return Realized on | | | Geometric Joint Return |
|---|---|---|---|---|
| Trade # | A | B | C | on A, B and C |
| 1 | -0.20 | -0.35 | 0.50 | $[(0.80)(0.65)(1.50)]^{1/3} - 1 = -0.079$ |
| 2 | 0.25 | 0.15 | -0.25 | $[(1.25)(1.15)(0.75)]^{1/3} - 1 = 0.025$ |
| 3 | -0.50 | 0.75 | | $[(0.50)(1.75)]^{1/2} - 1 = -0.065$ |
| 4 | 0.75 | -0.10 | | $[(1.75)(0.90)]^{1/2} - 1 = 0.255$ |
| 5 | 0.35 | | | = 0.350 |
| 6 | -0.25 | | | = -0.250 |
| 7 | 0.10 | | | = 0.100 |

In the foregoing example, the weighted holding-period return for each of the 7 trades may be calculated as shown in Table 7.4.

The terminal wealth relative (TWR) is the product of the weighted joint holding-period returns generated across trades over a given time period, using a predefined *F* value. Therefore, the TWR across *n* trades

Table 7.4 Calculating the Aggregate Weighted Holding-Period Return

| Trade | Holding-Period Return |
|---|---|
| 1 | $1 + F\left(-\frac{-0.079}{-0.250}\right) = 1 + F(-0.316)$ |
| 2 | $1 + F\left(-\frac{+0.025}{-0.250}\right) = 1 + F(+0.100)$ |
| 3 | $1 + F\left(-\frac{-0.065}{-0.250}\right) = 1 + F(-0.260)$ |
| 4 | $1 + F\left(-\frac{+0.255}{-0.250}\right) = 1 + F(+1.020)$ |
| 5 | $1 + F\left(-\frac{+0.350}{-0.250}\right) = 1 + F(+1.400)$ |
| 6 | $1 + F\left(-\frac{-0.250}{-0.250}\right) = 1 + F(-1.000)$ |
| 7 | $1 + F\left(-\frac{+0.100}{-0.250}\right) = 1 + F(+0.400)$ |



Table 7.5 Calculating the Aggregate TWR for Different Values of *F*

| | Holding-Period Return (HPR) | | | | |
|---|---|---|---|---|---|
| Trade | F = 0.25 | F = 0.30 | F = 0.35 | F = 0.40 | F = 0.45 |
| 1 | 0.921 | 0.905 | 0.889 | 0.874 | 0.858 |
| 2 | 1.025 | 1.030 | 1.035 | 1.040 | 1.045 |
| 3 | 0.935 | 0.922 | 0.909 | 0.896 | 0.883 |
| 4 | 1.255 | 1.306 | 1.357 | 1.408 | 1.459 |
| 5 | 1.350 | 1.420 | 1.490 | 1.560 | 1.630 |
| 6 | 0.750 | 0.700 | 0.650 | 0.600 | 0.550 |
| 7 | 1.100 | 1.120 | 1.140 | 1.160 | 1.180 |
| TWR = | 1.2337 | 1.2496 | 1.2531 | 1.2450 | 1.2219 |

is defined as

$$\text{TWR} = [(\text{HPR}_1) \times (\text{HPR}_2) \times (\text{HPR}_3) \times \ldots \times (\text{HPR}_n)]$$

where $\text{HPR}_i$ represents the joint return for trade $i$.

By testing a number of values of *F* between 0.01 and 1, we can arrive at the value of *F* that maximizes TWR. This value, $F^*$, represents the optimal fraction of funds to be risked across all commodities during the next round of trading. Continuing with our example, we calculate the TWR for *F* values equal to 0.25, 0.30, 0.35, 0.40, and 0.45, as shown in Table 7.5. Since the TWR is maximized when *F* = 0.35, this is the optimal fraction, $F^*$, of funds to be allocated to the next round of trading. More accurately, the TWR is maximized at 1.2539 when *F* = 0.34, suggesting that 34 percent of the available capital should be risked to trading.

## CONCLUSION

The allocation of capital across commodities is at the heart of any trading program. If a trader were to risk the entire bankroll to active trading, chances are that all the trades could go against the trader, who could end up losing everything in the account. In view of this, it is recommended that a trader risk only a fraction of his or her total capital to active trading. This fraction is a function of the probability of trading success and the payoff ratio. The fraction of available capital exposed to active trading is termed "risk capital."

The exposure fraction could be a fixed proportion of the trader's current bankroll, or it could vary as a function of changes in the bankroll. A loss results in a depletion of capital, and a trader might want to recoup this loss by increasing exposure. This is referred to as the Martingale strategy. The converse strategy of reducing the size of the bet consequent upon a loss is referred to as the anti-Martingale strategy. The anti-Martingale strategy is a more practical and conservative approach to trading than the Martingale strategy.

# 8

# Managing the Bankroll: Allocating Capital

The previous chapter concentrated on exposure determination for a single commodity as well as across multiple commodities. In this chapter, we present various approaches to risk capital allocation across commodities. Following this discussion, we turn to strategies designed to increase the risk capital allocated to a trade during its life. This is commonly referred to as pyramiding.

## ALLOCATING RISK CAPITAL ACROSS COMMODITIES

If all opportunities are assumed to be equally attractive in terms of both their risk and their reward potential, a trader would be best off trading an equal number of contracts of each of the commodities under consideration. For example, a trader might want to trade one contract or, if he or she is better capitalized or more of a risk seeker, more than one contract of each commodity, always keeping the number constant across all commodities traded.

The equal-number-of-contracts technique is particularly easy to implement when a trader is unclear about both the risk and the reward potential associated with a trade. Whereas the simplicity of this technique is its chief virtue, it does not necessarily result in optimal performance. The allocation techniques discussed here assume that (a) some opportunities are more promising than others in terms of higher reward potential or lower risk and (b) there exists a mechanism to identify these differences.

We begin with a discussion of risk capital allocation within the context of a single-commodity portfolio. In subsequent sections, we discuss allocation techniques when more than one commodity is traded simultaneously.

## ALLOCATION WITHIN THE CONTEXT OF A SINGLE-COMMODITY PORTFOLIO

When a portfolio is comprised of a single commodity, the optimal exposure fraction, $f$, for that commodity may be used as the basis for the risk capital allocated to it. Multiplying the optimal fraction, $f$, by the current bankroll gives the risk capital allocation for the commodity in question. Therefore,

$$\text{Risk capital allocation for a commodity} = f \times \text{Current bankroll}$$

For example, if the current bankroll were \$10,000, and the optimal $f$ for a commodity were 14 percent, the risk capital allocation would be \$1400. However, if the trader wished to set a cap on the maximum amount he or she were willing to risk to a particular trade, such a cap would override the percentage recommended by the optimal $f$. For example, if the maximum exposure on a single commodity were restricted to 5 percent, this restriction would override the optimal $f$ allocation of 14 percent.

## ALLOCATION WITHIN THE CONTEXT OF A MULTI-COMMODITY PORTFOLIO

Risk capital allocation is especially important when more than one commodity is traded simultaneously. This section discusses three alternative techniques for allocating risk capital across a portfolio of commodities:

1. Equal-dollar risk capital allocation
2. Optimal allocation following modern portfolio theory
3. Individual trade allocation based on the optimal $f$ for each commodity.



## EQUAL-DOLLAR RISK CAPITAL ALLOCATION

Once the aggregate exposure fraction, $F$, has been determined, the equal-dollar approach recommends an equal allocation of risk capital across each commodity traded. The exact allocation is a function of (a) the aggregrate exposure and (b) the number of commodities realistically expected to be traded concurrently. This technique is based on the assumption that a trader can quantify the dollar risk for a given trade but is unsure about the associated reward potential. The approach also assumes the existence of negligible correlation between commodity returns.

The dollar allocation for each commodity is arrived at by dividing the total risk capital allocation by the number of commodities expected to be traded concurrently. Assume, for example, that the aggregate risk capital fraction, $F$, is 20 percent of \$25,000, or \$5000, and the trader expects to trade a maximum of five commodities concurrently. The risk capital allocation for each commodity would be \$1000. However, if the trader expects to trade only two commodities simultaneously, the risk capital allocation works out to be \$2500 for each commodity. Therefore,

$$\text{Risk capital per commodity} = \frac{\text{Aggregrate exposure across commodities}}{\text{number of commodities traded}}$$

Like the equal-number-of-contracts approach, the equal-dollar risk capital allocation approach is easy to implement. However, it would be naive to expect it to yield optimal allocations, because reward potentials and correlations between commodity returns are disregarded.

## OPTIMAL CAPITAL ALLOCATION: ENTER MODERN PORTFOLIO THEORY

The optimal-allocation strategy recommends differential capital allocation and is based on the premise that no two opportunities share the same risk and reward characteristics. Modem portfolio theory is based on the premise that there is a definite relationship between reward and risk. The higher the risk, the greater the reward required to induce an investor to assume such risk.

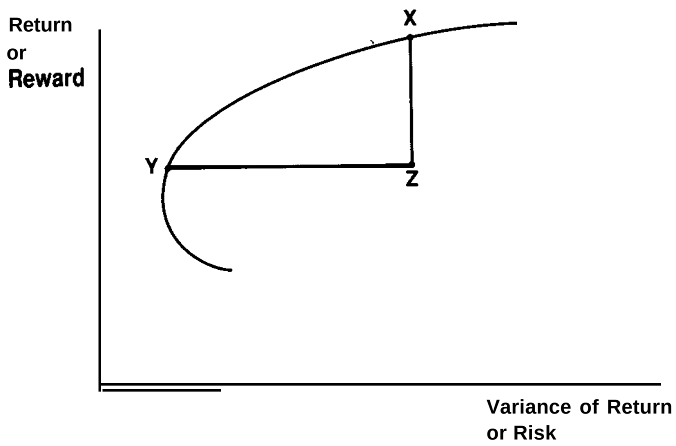



**Figure 8.1** Relationship between reward and risk: tracing the efficient frontier.

Harry Markowitz was the first to formalize the relationship between risk and reward.[1] Markowitz argued that investors, given a choice, would like to invest in a portfolio of stocks that offered a return higher than that yielded by their current portfolio but was no more risky. Alternatively, they would like to invest in a portfolio of stocks that would lower the overall risk of investing while holding reward constant. Risk is measured in terms of the variability of portfolio returns. The higher the variability, the greater the risk associated with investing.

The theoretical relationship between reward and risk is graphically demonstrated in Figure 8.1. The curve connecting the various reward and risk coordinates is termed the "efficient frontier." A portfolio that lies below the efficient frontier is an inefficient portfolio inasmuch as it is outperformed by corresponding portfolios on the efficient frontier.

For example, consider the case of portfolio Z in Figure 8.1, which lies vertically below portfolio X and laterally to the right of Y. Portfolio Z is outperformed by both X and Y, insofar as X offers a higher return for the same risk and Y offers a lower risk for the same return. Therefore, the investor would be better off investing in either X or Y, depending on whether he or she wishes to improve portfolio return or to reduce portfolio risk. This, in turn, is a function of the investor's risk preference.

[1] Harry Markowitz: *Portfolio Selection: Efficient Diversification **of Investments*** (New York: John Wiley and Sons, 1959).



In this section, we construct an optimal futures portfolio that lies on the efficient frontier. This is a portfolio that minimizes the variance of portfolio returns while achieving the target return specified by the trader. The problem seeks to minimize overall portfolio variance while satisfying the following constraints:

1. The expected return on the portfolio must be equal to a prespecified target.
2. The portfolio weights across all trades must sum to 1, signifying that the sum of the allocations across trades cannot exceed the overall risk capital allocation.
3. The individual portfolio weights must equal or exceed 0.

Appendix F defines this as a problem in constrained optimization, to be solved using standard quadratic programming techniques. The solution to the optimization problem is defined in terms of a set of optimal weights, $w_i$, representing the fraction of risk capital to be exposed to trading commodity $i$.

### Inputs for the Optimization Technique

The inputs for the optimization technique are (a) the expected returns on individual trades, (b) the variance of individual trade returns and the covariances between returns on all possible pairs of commodities in the opportunity set, and (c) the overall portfolio return target. Each of these inputs is discussed in detail here.

### The Rate of Return on Individual Trades and the Portfolio

As discussed in Chapter 4, the rate of return, $r$, on a futures trade is measured as the sum of the present values of all cash flows generated during the life of the trade, divided by the initial margin investment.

Ideally, the portfolio selection model requires that we work with the expected returns on trades under consideration. In order to implement the model, therefore, the trader would need to know the estimated reward on the trade. This could be computed using the reward estimation techniques discussed in Chapter 3. Additionally, the trader would need to estimate the approximate time it would take to reach the target price. Since every trade is expected to be profitable at the outset, the variation margin term could be ignored in the return calculations.

If the trader uses a mechanical system that is silent as regards the estimated reward on a trade, the return cannot be forecast. In such a case, the trader could use the historical average realized return on completed trades for a commodity as a proxy for expected returns on future trades. The historic average is the arithmetic average of returns on completed trades.

The arithmetic average return, X, on $n$ trades with a return $X_i$ on trade $i$ is the sum of the $n$ returns divided by $n$ and is given by the following formula:

$$x = (X_1 + X_2 + X_3 + \ldots + X_n)/n$$

The greater the number of trades in the sample, the more robust the average. Ideally, the arithmetic average should be computed based on a sample of at least 30 realized returns.

The weighted portfolio expected return is calculated by multiplying each commodity's expected return by the corresponding fraction of risk capital allocated to that trade. The overall portfolio return is fixed at a prespecified target, $T$, to be decided by the trader. The overall portfolio target should be realistic and be in line with the returns expected on the individual commodities. If the return target is set at an unrealistically high level, the optimization program will yield an infeasible solution.

### Variance and Covariance of Returns

The riskiness of commodity returns is measured by the variance of such returns about their mean. The covariance between returns seeks to capture interdependencies between pairs of commodity returns. The existence of negative covariances between commodity returns could lead to an overall portfolio variance lower than the sum of the variances on the individual commodities. Similarly, the existence of positive covariances between commodity returns could lead to an overall portfolio variance higher than the sum of the variances on the individual commodities.

To recapitulate, the variance, $s_X{}^2$, of $n$ historical returns for commodity X, with an arithmetic average return $\overline{X}$, is calculated as follows:

$$s_X{}^2 = \frac{\sum_i (X_i - \overline{X})^2}{n-1}$$

The covariance, $s_{XY}$, between $n$ historical returns for X and $Y$, with arithmetic average returns $\overline{X}$ and $\overline{Y}$, respectively, is



$$s_{XY} = \frac{\sum_i (X_i - \overline{X})(Y_i - \overline{Y})}{n-1}$$

If there are $K$ commodities under consideration, there will be $K$ variance terms and $[K(K-1)]/2$ covariance terms to be estimated. For example, if there are 3 commodities under review, X, Y, and Z, we need the covariance between returns for (a) X and Y, (b) X and Z, and (c) Y and Z. Typically, the variance-covariance matrix is estimated using historical data on a pair of commodities. The assumption is that the past is a good reflector of the future. Given the disparate nature of trade lives, we could well observe an unequal number of trades for two or more commodities over a fixed historical time period, making it impossible to calculate the resulting covariances between their returns. To remedy this problem, historical price data is often used as a proxy for trade returns.

Assuming portfolio returns are normally distributed, a distance of $\pm$ 1.96 standard deviations around the mean portfolio return captures approximately 95 percent of the fluctuations in returns. The lower the specified portfolio variance, the tighter the spread around the mean portfolio return. The assumption of normality of portfolio returns has been empirically validated by Lukac and Brorsen.[2] Their study revealed that whereas portfolio returns are normally distributed, returns on individual commodities tend to be positively skewed, underscoring the fact that most trading systems are designed to cut losses quickly and let profits ride.

### limitations of the Optimal-Allocation Approach

The optimal-allocation approach discussed above is based on a comparison of competing opportunities and is reminiscent of stock portfolio construction. Implicit in this approach is the assumption that there will be no addition to or deletion from the opportunities currently under review. This is well suited to stock investing, where the investment horizon is fairly long-term and the opportunity set is not subject to frequent changes.

Changes in the opportunity set would result in corresponding changes in the relative weights assigned to individual opportunities. Such changes

[2] Louis P. Lukac and R. Wade Brorsen, "A Comprehensive Test of Futures Market Disequilibrium," *The Financial Review*, Vol. 25, No. 4 (November 1990), pp. 593-622.

could result in premature liquidation of trades and would detract from the efficacy of the optimal-allocation exercise. As a result, the optimal-allocation approach would be useful to a position trader with a longer-term perspective. However, it could prove inconvenient for a trader with an extremely short-term view of the markets, who sees the menu of opportunities changing almost every trading day.

A more serious handicap is that the optimal fraction of risk capital allocated to a trade could lie anywhere between 0 and 1. A fraction of 0 implies no position in the commodity, whereas a fraction of 1 implies that the the entire risk capital is allocated to a single trade. If such a concentration of resources were unacceptable, the trader might want to set a cap on the funds to be allocated to a single commodity. However, such a cap would have to be imposed by the trader as a sequel to the results obtained from the optimization program, as the program does not allow for caps to be superimposed on the individual weights.

### An Illustration of Optimal Portfolio Construction

Consider Table 8.1, which presents the historical returns on two commodities, A and B. Using historical average returns as estimators of

**Table 8.1** Historical Returns on A and B

| Trade | % Return on A | % Return on B |
|---|---|---|
| 1 | 100 | 50 |
| 2 | -45 | -20 |
| 3 | 40 | -10 |
| 4 | -25 | 55 |
| 5 | -35 | 100 |
| 6 | 50 | -60 |
| 7 | -10 | 50 |
| 8 | 50 | -45 |
| 9 | 75 | -50 |
| 10 | 50 | 130 |
| Arithmetic Average Return: | 25 | 20 |
| Variance of Returns: | 2494 | 4394 |
| Standard Deviation: | 49.94 | 66.29 |
| Covariance of Returns: | | -819.44 |
| Correlation between A and B: | | -0.2475 |



**Table 8.2** Tracing the Efficient Frontier for Portfolios of A and B

| Portfolio Number | % weight in A | % weight in B | Portfolio Return | Portfolio Variance |
|---|---|---|---|---|
| 1 | 61.20 | 38.80 | 23.06 | 1206.67 |
| 2 | 78.60 | 21.40 | 23.93 | 1466.64 |
| 3 | 81.00 | 19.00 | 24.05 | 1543.02 |
| 4 | 84.20 | 15.80 | 24.21 | 1660.14 |
| 5 | 88.80 | 11.20 | 24.44 | 1859.11 |
| 6 | 95.60 | 4.40 | 24.78 | 2219.33 |

future expected returns, we could construct an optimal portfolio of A and B that would minimize variance for a specified target level of portfolio returns. To illustrate the dynamics of this process, Table 8.2 traces the efficient frontier for portfolios of A and B, giving the optimal weights for different levels of portfolio variance and the return associated with each variance level.

Notice that a rise in the portfolio return is accompanied by a corresponding rise in portfolio variance. The trader must specify the portfolio return he or she seeks to achieve. For example, if the trader wishes to earn an overall portfolio return of 23 percent, the optimal portfolio is 1, with weights of 61.20 percent and 38.80 percent for A and B respectively. The variance for this optimal portfolio is 1206.67. If the target return is set slightly higher, at 24 percent, the optimal portfolio is 3, with weights of 81.00 percent and 19.00 percent for A and B respectively. The variance for this portfolio is higher at 1543.02. If the target return were set greater than 25 percent, the optimization program would yield an infeasible solution. This is because the highest return that could be earned by allocating 100 percent of risk capital to the higher return asset, A, would be just 25 percent.

## USING THE OPTIMAL $f$ AS A BASIS FOR ALLOCATION

This approach uses the optimal exposure fraction, $f$, for a commodity as the basis for the capital allocated to it. For simplicity, the approach assumes that (a) the trader will not trade positively correlated commodities concurrently and (b) negative correlations between commodities may be ignored. Consequently, each opportunity is judged independently rather than as part of a portfolio of concurrently traded commodities.

Multiplying the optimal fraction, $f$, for a commodity by the current bankroll gives the risk capital allocation for that commodity. The trader might want to set a cap on the maximum percentage of total capital he or she is willing to risk on any given trade. If such a cap were in existence, it would override the percentage recommended by the optimalf. If, for example, the maximum exposure on a single commodity were restricted to 5 percent, this restriction would override an optimal $f$ allocation greater than 5 percent.

The trader must ensure that the total exposure across all commodities at any time does not exceed the overall optimal exposure fraction, $F$. The problem of overshooting is most likely to arise (a) when positions are assumed in all or a majority of the commodities traded or (b) if one commodity receives a disproportionately large allocation. Complying with the aggregate exposure fraction on an overall basis might necessitate forgoing some opportunities. This is a judgment call the trader must make, not merely to contain the risk of ruin but also to ensure that he or she stays within the confines of the available capital. This brings us to the related issue of the relationship between risk capital and funds available for trading. The following section discusses the linkage.

## LINKAGE BETWEEN RISK CAPITAL AND AVAILABLE CAPITAL

Assume that the aggregate exposure fraction across all commodities is given by $F$. The reciprocal of $F$, given by l/F, represents the multiple of funds available for each dollar at risk. For example, if $F$ is 10 percent or 0.10, we have 1/0.10, or \$10, backing every \$1 of capital risked to a trade.

Although this multiple is based on the overall relationship between risk capital and the current bankroll, it could be used to determine the proportion of the bankroll to be set aside for individual trades. Assume that the aggregate risk exposure fraction, $F$, is 10 percent across all commodities. Assume further that the trader wishes to allocate 4 percent of the risk capital to commodity A, and 2 percent to commodity B. The trader does not wish to pursue any other opportunities at the moment. Given a multiple of l/O. 10 or 10, commodity A qualifies for an allocation of4 percent × 10, or 40 percent, of the funds in the account. Commodity B qualifies for a capital allocation of 2 percent x 10, or 20 percent. This will result in a 60 percent utilization of available capital, leaving 40 percent available for future opportunities.



## DETERMINING THE NUMBER OF CONTRACTS TO BE TRADED

The number of contracts of a commodity to be traded is a function of (a) the risk capital allocation, in relation to the permissible risk per contract, and (b) the funds allocated to a commodity, in relation to the initial margin required per contract.

The available capital allocated to the commodity, divided by the initial margin requirement per contract, gives a margin-based estimate of the number of contracts to be traded. Similarly, the risk capital allocated to a commodity, divided by the permissible risk per contract, gives a risk-based estimate of the number of contracts to be traded. Therefore,

$$\text{Margin-based estimate of the number of contracts to be traded} = \frac{\text{Available capital allocation}}{\text{Initial margin per contract}}$$

$$\text{Risk-based estimate of the number of contracts to be traded} = \frac{\text{Risk capital allocation}}{\text{Permissible risk per contract}}$$

When the risk-based estimate differs from the margin-based estimate, the trader has a conflict. To resolve this conflict, select the approach that yields the lower of the two estimates, so as to comply with both risk and margin constraints. An example will help illustrate the potential conflict between the two approaches, and its resolution. Assume that the aggregate exposure fraction, $F$, recommends a risk capital allocation of 10 percent of total capital of \$100,000, or \$10,000. Assume further that a trader wishes to trade three commodities *A, B,* and C concurrently, with risk capital allocations of 6 percent, 3 percent, and 1 percent, respectively.

Table 8.3 defines the permissible risk per contract of each of the three commodities along with their initial margin requirements. It also calculates the number of contracts to be traded, based on both the risk and margin criteria.

**Table 8.3** Determining the Number of Contracts to be Traded

| Commodity | Capital Allocation Risk | Capital Allocation Total | Per Contract Risk | Per Contract Margin | Risk/ Margin | Number of Contracts by Risk | Number of Contracts by Margin |
|---|---|---|---|---|---|---|---|
| A | 6,000 | 60,000 | 1,000 | 20,000 | 0.05 | 6 | 3 |
| B | 3,000 | 30,000 | 500 | 2,500 | 0.20 | 6 | 12 |
| C | 1,000 | 10,000 | 2,000 | 20,000 | 0.10 | 0.5 | 0.5 |

Notice that in the case of commodity ***A,*** the margin constraint prescribes three contracts, whereas the risk constraint recommends six contracts. The margin constraint prevails over the risk constraint, since the trader simply does not have the margin needed to trade six contracts. In the case of commodity ***B,*** the risk constraint recommends six contracts, whereas the margin constraint recommends 12 contracts. In this case the capital allocation is adequate to meet the margin required for 12 contracts; however, the risk capital allocation falls short. Therefore, the risk constraint prevails over the margin constraint. Finally, in the case of commodity C, both risk and margin approaches are unanimous in recommending 0.5 contracts, avoiding the choice problems which arose in cases ***A*** and ***B.***

A closer look at the data in Table 8.3 reveals an interesting relationship between the aggregate exposure fraction, $F$, and the ratio of permissible risk to the initial margin required for each of the three commodities. The aggregate exposure fraction, 10 percent in our example, represents a ratio of overall risk exposure to total capital available for trading. Whereas the ratio of permissible risk/margin is lower, at 5 percent, than the aggregate exposure fraction for ***A,*** it is higher for ***B*** at 20 percent, and is exactly equal for C.

Consequently, if the permissible risk/margin ratio for a given commodity is greater than the aggregate exposure fraction, $F$, the permissible risk rather than the margin requirement determines the number of contracts to be traded. Similarly, if the permissible risk/margin ratio for a commodity is lower than the aggregate exposure fraction, $F$, it is the margin requirement rather than the permissible risk, that determines the number of contracts traded. If the permissible risk/margin ratio for a commodity is exactly equal to the aggregate exposure fraction, ***F,*** then both risk and margin constraints yield identical results.



## THE ROLE OF OPTIONS IN DEALING WITH FRACTIONAL CONTRACTS

If the allocation strategy just outlined recommends fractional contracts, a conservative rule would be to ignore fractions and to work with the smallest whole number of contracts. For example, if 2.4 contracts of a commodity were recommended, the conservative trader would initiate a position in two rather than three contracts of the commodity. By doing so, the trader ensures that he or she stays within the risk and total capital allocation constraints.

However, this strategy fails when the recommended optimal solution recommends less than one contract, as, for example, commodity C (0.5 contracts) in the preceding illustration. Since the trader is advised against rounding off to the next higher whole number, he or she would have to forgo the trade. This problem is likely to arise in the case of commodities with large margin requirements, as, for example, the Standard & Poor's (S&P) 500 Index futures. A trader who is keen on pursuing opportunities in the S&P 500 futures without compromising on risk control must look for alternatives to outright futures positions. Options on futures contracts offer one such alternative.

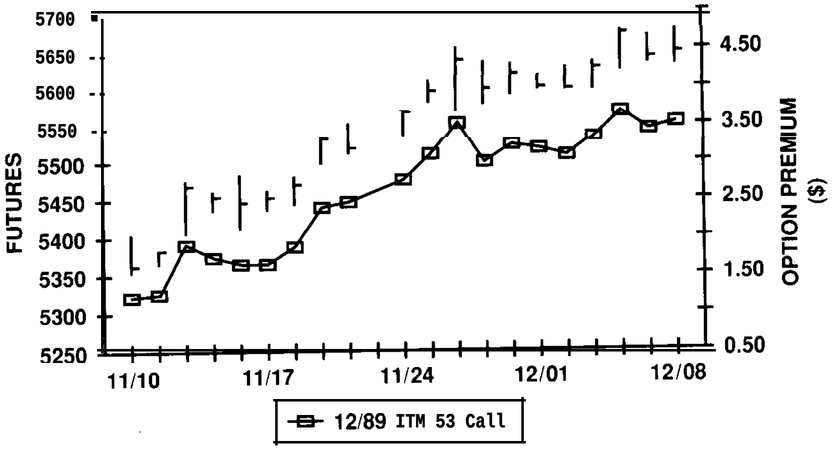
A trader would buy a call option if the underlying futures price were expected to increase. Conversely, the trader would buy a put option if he or she expected the underlying futures price to decrease. Buying an options contract enables the options buyer to replicate futures price action while limiting the risk of loss to the initial premium payment.

The extent to which the options premium mirrors movement in the underlying futures price depends on the proximity of the strike or exercise price of the option to the current futures price. The delta of an option measures its responsiveness to shifts in futures prices. A delta close to I suggests high responsiveness of the option premium to changes in the underlying futures price, whereas a delta close to 0 suggests minimal responsiveness.

The intrinsic value inherent in an in-the-money option makes it mirror futures price changes more closely, giving it a delta closer to 1. An out-of-the-money option with no intrinsic value has a delta closer to 0, whereas an at-the-money option with a strike price approximately equal to the current futures price has a delta close to 0.50.

The delta of a futures contract is, by definition 1, leading to the following delta equivalence relationship between futures and options.

COMPARING D.MARK FUTURES & OPTIONS
(IN-THE-MONEY 12189 53 CALL)




(*a*)

FIGURE **8.2*a*** Comparing Deutschemark futures and options: (a) in-the-money December 1989, 53 call.

| | | | | | | |
|---|---|---|---|---|---|---|
| Number of futures contracts | × | Delta of each contract | = | Number of options contracts | × | Delta of each option |

or

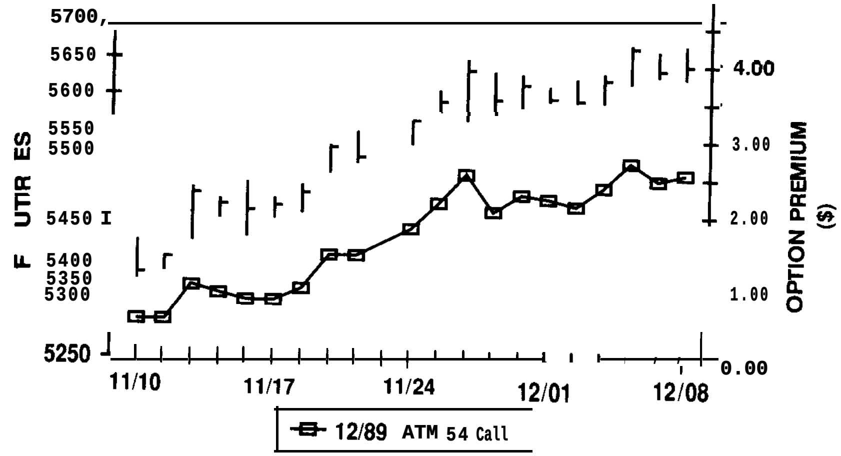
| | | | | | | |
|---|---|---|---|---|---|---|
| Number of futures contracts | × | 1 | = | Number of options contracts | × | Delta of each option |

An allocation of 0.50 futures contracts is equivalent to one option with a delta of 0.50. Therefore, a trader who wishes to trade 0.50 futures contracts might want to buy one at-the-money option with a delta of 0.50 or two out-of-the-money options with a delta of 0.25 each. The trader who uses options to replicate futures must realize that the replication is largely a function of the option strike price and the associated delta value.

Figures 8.2*a* through 8.2*d* outline the relationship between futures prices and options premiums for in-, at-, out-, and deep-out-of-the-money calls on the Deutsche mark futures expiring in December 1989.

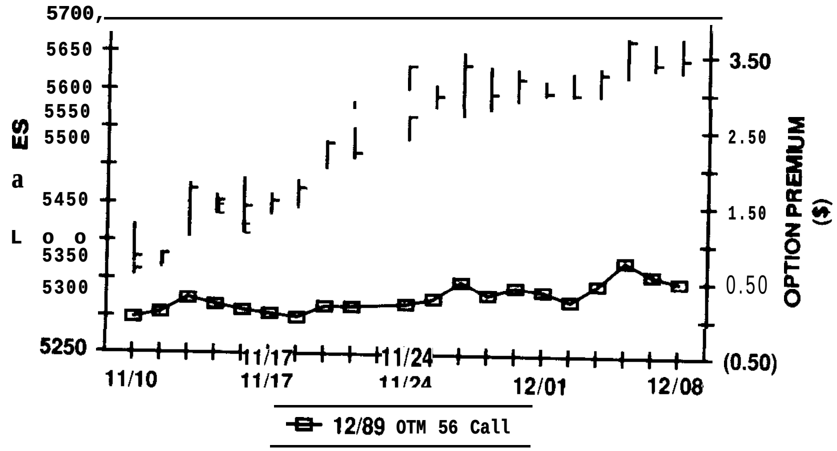


COMPARING D.MARK FUTURES & OPTIONS
(AT-THE-MONEY 12/89 54 CALL)



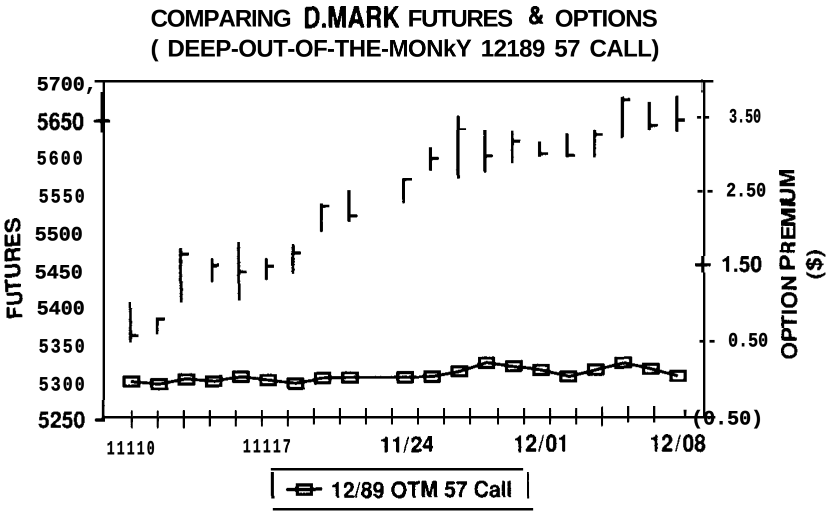

(*b*)

COMPARING D.MARK FUTURES & OPTIONS
(OUT-OF-THE-MONEY 12/89 56 CALL)




(*c*)

**FIGURE 8.2*b* & *c*** Comparing Deutschemark futures and options: (*b*) at-the-money December 1989, 54 call; (c) out-of-the-money December 1989, 56 call.




(*d*)

FIGURE **8.2*d*** Comparing Deutschemark futures and options: (*d*) deep-out-of-the-money December 1989, 57 call.

Notice that the strong rally in the mark is best mirrored by the sharp rise in premiums on the in-the-money 53 calls (Figure 8.2*a*); it has hardly any impact on the deep-out-of-the-money 57 calls (Figure 8.26).

## PYRAMIDING

Pyramiding is the act of increasing exposure by adding to the number of contracts during the life of a trade. It needs to be distinguished from the strategy of adjusting trade exposure consequent upon the outcome of closed-out trades. Pyramiding is typically undertaken with a view to concentrating resources on a winning position, However, pyramids are also used at times to "average out" or dilute the entry price on a losing trade.

This practice of averaging prices has a parallel in stock investing, where it is referred to as "scaled down buying." A notable example Of averaging down is when a commodity is trading at or near its historic lows. A trader might buy the commodity, only to discover that a new



low is emerging. Convinced that the bottom cannot be much farther away, the trader might be tempted to buy more at the lower price.

The practice of adding to a losing position is essentially a case of good money chasing after bad. Since that practice cannot be condoned no matter how compelling the reasons, this section will confine itself strictly to a discussion of adding to profitable positions. Critical to successful pyramiding is an appreciation of the concept of the effective exposure on a trade.

### The Concept of Effective Exposure

The effective exposure on a trade measures the dollar amount at risk during the life of a trade. It is a function of (a) the entry price, (b) the current stop price, and (c) the number of contracts traded of the commodity in question. The effective exposure on a trade depends on whether or not the trade has registered an assured or locked-in unrealized profit.

As long as a trade has not generated an unrealized profit, the effective exposure is positive and represents the difference between the entry price and the protective stop price. A trade protected by a break-even stop has zero effective exposure. Once the stop is moved beyond the break-even level, the trade has a locked-in, or assured, unrealized profit. This is when the effective trade exposure turns negative, implying that the trader's funds are no longer at risk.

For example, if gold has been purchased at $400 an ounce and the current price is $420 an ounce, the unrealized profit on the trade is $20. A trader who now sets a sell stop at $415 is effectively assured of a $15 profit on the trade, assuming that prices do not gap through the stop price.

### Effective Exposure in the Absence of Assured Unrealized Profits

A negative assured unrealized profit, or an assured unrealized loss, represents the maximum permissible loss on the trade. For simplicity, we shall assume that prices do not gap through our stop price. Consequently, the maximum possible loss on the trade is equal to the maximum permissible loss. For example, continuing with our example of the gold trade, if gold were purchased at $400 per ounce and the initial stop were set at $380, this would imply a maximum permissible loss of $20 per ounce.

Once again, assuming that prices will not gap below the stop price of \$380 an ounce, this is also the maximum possible loss on the trade.

As long as the assured unrealized profit on a trade is negative, the effective exposure on the trade measures the maximum amount that can be lost on the trade. On a short position, until such time as the stop price exceeds or is exactly equal to the entry price, the exposure per contract is given by the difference between the current stop price and the entry price. Similarly, on a long position, until such time as the stop price is less than or equal to the entry price, the exposure per contract is given by the difference between the entry price and the current stop price. The effective exposure is the product of the exposure per contract and the number of contracts traded.

To recapitulate, when assured unrealized profits are negative, the effective exposure on a trade is defined as follows:

$$\text{Effective exposure on short trade} = \left(\text{Current stop price} - \text{Entry price}\right) \times \text{Number of contracts}$$

$$\text{Effective exposure on long trade} = \left(\text{Entry price} - \text{Current stop price}\right) \times \text{Number of contracts}$$

The effective exposure is a positive number, signifying that this amount of capital is in danger of being lost.

### Net Exposure with Positive Assured Unrealized Profits

When the current stop price is moved past the entry price, the assured unrealized profit on the trade turns positive, leading to a negative effective exposure on the trade. Now the trader is playing with the market's money. The negative exposure measures the locked-in profit on the trade.

The trader might now wish to expose a part or all of the locked-in profits by adding to the number of contracts traded. The fraction $p$, ranging between 0 and 1, determines the proportion of assured unrealized profits to be reinvested into the trade. A value of $p = 1$ implies that 100 percent of the value of assured unrealized profits is to be reinvested into the trade. A value of $p = 0$ implies that the assured unrealized profits are not to be reinvested into the trade.

The formula for the additional dollar exposure on a trade with positive assured unrealized profits may therefore be written as

$$\text{Additional exposure} = \left[p \times \text{Assured profits}\right] \times \text{Number of contracts}$$



where $p$ is the fraction of assured profits reinvested, ranging between 0 and 1.

The net exposure on a trade with positive assured unrealized profits is the sum of (a) the effective exposure on the trade and (b) the additional exposure resulting from a reinvestment of all or a part of assured unrealized profits. Whereas (a) is a negative quantity, (b) could be either zero or positive. Hence,

$$\text{Net exposure} = \text{Effective exposure} + \text{Additional exposure}$$

The net exposure on a trade with positive assured unrealized profits could be either zero or negative.

When $p = 0$, the trader does not wish to allocate any further amount from assured unrealized profits toward the trade. Consequently, there is no change in the number of contracts traded, leading to a negative net exposure exactly equal to the value of assured unrealized profits. When $p = 1$, the net exposure on the trade is 0 because the trader has chosen to increase exposure by an amount exactly equal to the value of assured unrealized profits, leading to a possible loss that could completely wipe out the assured profits earned on the trade. When $p$ is somewhere between 0 and 1, the net exposure on the trade is negative, suggesting that the assured unrealized profits on a trade exceed the proposed supplementary allocation to the trade from such profits.

Should $p$ exceed 1, the initial risk capital allocation is supplemented by an amount exceeding the assured unrealized profit on the trade. Since there is no compelling logic supporting an increase in risk capital allocation in excess of the level of assured unrealized profits earned, we shall not pursue this alternative further.

Table 8.4 illustrates the concept of net exposure. Assume that one contract of soybeans futures has been sold at 600 cents a bushel, with a protective buy stop at 610 cents. Assume further that prices rise to 605 cents before retreating gradually to 565 cents. The net exposure is positive until such time as the protective buy stop price exceeds the sale price of 600 cents. Once the protective buy stop falls below the entry price of 600 cents, the assured unrealized profits turn positive, leading to a negative net exposure.

Note that the unrealized trade profits are consistently higher than the assured unrealized profits on the trade. Assuming that the fraction of assured profits plowed back into the trade is 0, 0.50, or 1 respectively, the effective exposure in each case is as shown in the table.

**Table 8.4** The Net Exposure on a Short Trade with Differing $p$ Values

| Current Price | Buy Stop Price | Unrealized Profits | Assured Profits | Net Exposure when: $p = 0$ | $p = 0.50$ | $p = 1.00$ |
|---|---|---|---|---|---|---|
| 605 | 610 | − 5 | -10 | +10 | +10 | +10 |
| 600 | 610 | 0 | -10 | +10 | +10 | +10 |
| 595 | 605 | + 5 | -5 | + 5 | + 5 | + 5 |
| 590 | 600 | +10 | 0 | 0 | 0 | 0 |
| 580 | 587 | +20 | +13 | -13 | -6.5 | 0 |
| 575 | 580 | +25 | +20 | -20 | -10 | 0 |
| 565 | 570 | +35 | +30 | -30 | -15 | 0 |

Note: All figures are in cents/bushel on a one-contract basis.

### Incremental Contract Determination

In practice, the trader must decide the value of $p$ he or she is most comfortable with, risking assured unrealized profits accordingly. The value of $p$ could vary from trade to trade.. The fraction, $p$, when multiplied by the assured unrealized profits, gives the incremental exposure. on the trade. This incremental exposure, when divided by the permissible risk per contract, gives the number of additional contracts to be traded, margin requirements permitting. The formula for determining the additional number of contracts to be traded consequent upon plowing back a fraction of assured unrealized profits is given as follows:

$$\text{Increase in number of contracts} = \frac{(p \times \text{Assured unrealized profits}) \times \text{Number of contracts}}{\text{Permissible loss per contract}}$$

To continue with our soybeans example, let us assume that prices have fallen to 575 cents, and our trader, who has sold 1 contract at 600 cents, now moves the stop to 580 cents, locking in an assured profit of 20 cents. Assume further that the trader decides to risk 50% of assured profits, or 10 cents, by selling an additional number, $x$, of futures contracts at 575 cents, with a protective stop at 580 on the entire position. Using the formula just obtained, the value of $x$ works out to be 2, as follows:

$$x = \frac{0.50 \times 20}{5} = 2$$



**Table 8.5** Effects of Price Fluctuations on Incremental Exposure

*(a)* At the current price of 575 cents

| Position | Stop Price | Unrealized Profit (Loss) | Whereof Assured Profit (Loss) |
|---|---|---|---|
| Short 1 @ 600 | 580 | 1 × 25 = 25 | 1 × 20 = 20 |
| Short 2 more @ 575 | 580 | 2 x 0 = 0 | 2 × (5) = (10) |
| | Net Profit | 25 | 10 |

*(b)* At the current price of 580 cents

| Action | Entry Price | Realized Profit |
|---|---|---|
| Liquidate 1 original short | 600 | 1 × 20 = 20 |
| Liquidate 2 new shorts | 575 | 2 × (5) = (10) |
| | Net profit | 10 |

*(c)* At the current price of 565 cents

| Position | Stop Price | Unrealized Profit (Loss) | Whereof Assured Profit (Loss) |
|---|---|---|---|
| Short 1 @ 600 | 570 | 1 x 35 = 35 | 1 × 30 = 30 |
| Short 2 more @ 575 | 570 | 2 × 10 = 20 | 2 × 5 = 10 |
| | Net Profit | 55 | 40 |

Adding two short positions at 575 cents with a stop at 580 cents ensures a worst-case profit of 10 cents on the overall position, which is equal to 50 percent of the assured profits earned on the trade thus far. The positions are tabulated in Table 8.5*a* for ease of comprehension. If prices were to move up to the protective stop level of 580 cents, our trader would be left with a realized profit of 10 cents as explained in Table 8.5*b*. However, if prices were to slide to, say, 565 cents, and our stop were lowered to 570 cents, the assured profit on the trade would amount to 40 cents, as shown in Table 8.5*c*.

### Shape of the Pyramid

The number of contracts to be added to a position and the consequential shape of the pyramid is a function of (a) the assured profits on the trade and (b) the proportion, $p$, of profits to be reinvested into additional contracts. A conventional pyramid is formed by adding a decreasing number of contracts to an existing position. Adding an increasing number of contracts to an existing position creates an inverted pyramid.

The profit-compounding effects of an inverted pyramid are greater than those of the conventional pyramid. However, the leveraging cuts both ways, inasmuch as the impact of an adverse price move will be more severe in case of an inverted pyramid, given the preponderance of recently acquired contracts as a proportion of total exposure.

## CONCLUSION

The most straightforward approach to allocation is the equal-number-of-contracts approach, wherein an equal number of contracts of each commodity is traded. This approach makes eminent sense when a trader is not clear about both the risk and reward potential on a trade. A trader who is unclear about the reward potential of competing trades might want to allocate risk capital equally across all commodities traded. Finally, if the trader is clear as regards both the estimated risk and the estimated reward on a trade, he or she might want to allocate risk capital unequally, allowing for risk and return differences between commodities. This could be done using a portfolio optimization routine or using the optimal allocation fraction, $f$, for a given trade.

The initial risk exposure on a trade is subject to change during the life of the trade, depending on price movement and changes, if any, in the number of contracts traded. Such an increase in the number of contracts during the life of a trade is known as pyramiding. The number of contracts to be added is a function of (a) the assured profits on the trade and (b) the proportion, $p$, of assured profits to be reinvested into the trade.

# 9

# The Role of Mechanical Trading Systems

A mechanical trading system is a set of rules defining entry into and exit out of a trade. There are two kinds of mechanical systems- (a) predictive and (b) reactive.

Predictive systems use historical data to predict future price action. For example, a system that analyzes the cyclical nature of markets might try to predict the timing and magnitude of the next major price cycle.

A reactive system uses historical data to react to price trend shifts. Instead of predicting a trend change, a reactive system would wait for a change to develop, generating a signal to initiate a trade shortly thereafter. The success of any reactive system is gauged by the speed and accuracy with which it reacts to a reversal in the underlying trend.

In this chapter, we will restrict ourselves to a study of the more commonly used mechanical trading systems of the reactive kind. We discuss the design of mechanical trading systems and the implications of such design for trading and money management. Finally, we offer recommendations for improving the effectiveness of fixed-parameter mechanical trading systems.

## THE DESIGN OF MECHANICAL TRADING SYSTEMS

As a rule, mechanical systems are based on fixed parameters defined in terms of either time or price fluctuations. For example, a system may use historical price data over a fixed time period to generate its signals. Alternatively, it may use price breakout by a fixed dollar amount or percentage to generate signals. In this section, we briefly review the logic behind three commonly used mechanical systems: (a) a moving-average crossover system, which is a trend-following system; (b) Lane's stochastics oscillator, which measures overbought/oversold market conditions; and (c) a price reversal or breakout system.

### The Moving-Average Crossover System

A moving-average crossover system is designed to capture trends soon after they develop. It is based on the crossover of two or more historical moving averages. The underlying logic is that one of the moving averages is more responsive to price changes than the others, signaling a shift in the trend when it crosses the longer-term, less responsive moving average(s).

For purposes of illustration, consider a dual moving-average crossover system, where moving averages are calculated over the immediately preceding four days and nine days. The four-day moving average is more responsive to price changes than the nine-day moving average, because it is based on prices over the immediately preceding four days. Therefore, in an uptrend, the four-day average exceeds the nine-day average. As soon as the four-day moving average exceeds or crosses above the nine-day moving average, the system generates a buy signal. Conversely, should the four-day moving average fall below the nine-day moving average, suggesting a pullback in prices, the system generates a sell signal. Therefore, the system always recommends a position, alternating between a buy and a sell.

### The Stochastics Oscillator

Oscillator-based systems acknowledge the fact that markets are often in a sideways, trendless mode, bouncing within a trading range. Accordingly, the oscillator is designed to signal a purchase in an oversold market and a sale in an overbought market. The stochastics oscillator, developed by George C. Lane,[1] is one of the more popular oscillators. It is based

[1] George C. Lane, *Using Stochastics, Cycles, and R.S.I. to the Moment of Decision* (Watseka, IL: Investment Educators, 1986).



on the premise that as prices trend upward, the closing price tends to lie closer to the high end of the trading range for the period. Conversely, as prices trend downward, the closing price tends to be near the lower end of the trading range for the period.

Once again, the stochastics oscillator is based on price history over a fixed time period, $n$, as, for example, the past nine trading sessions. The highest high of the preceding $n$ periods defines the upper limit, or ceiling, of the trading range, just as the lowest low over the same period defines the lower limit, or floor. The difference between the highest high and the lowest low of the preceding $n$ sessions defines the trading range within which prices are expected to move. A close near the ceiling is indicative of an overbought market, just as a close near the floor is indicative of an oversold market.

The stochastics oscillator generates sell signals based on a crossover of two indicators, $K$ and $D$. To arrive at the raw $K$ value for a nine-day stochastic requires the following steps:

1. Subtract the lowest low of the past nine days from the most recent closing price.
2. Subtract the lowest low of the past nine days from the highest high of the past nine days.
3. Divide the result from step 1 by the result from step 2 and multiply by 100 percent to arrive at the raw $K$ value.

Prices are considered to be overbought if the raw $K$ value is above 75 percent, and are oversold if the value is below 25 percent. A three-day average of the raw $K$ value gives a raw $D$ value.

One commonly used approach to safeguard against choppy signals arising from the raw scores is to smooth the $K$ and $D$ values, using a three-day average as follows:

$$\text{Smoothed } K = \tfrac{2}{3} \text{ previous smoothed } K + \tfrac{1}{3} \text{ new raw } K$$

$$\text{Smoothed } D = \tfrac{2}{3} \text{ previous smoothed } D + \tfrac{1}{3} \text{ new smoothed } K$$

The $K$ line is a faster moving average than the $D$ line. Consequently, a buy signal is generated when $K$ crosses $D$ to the upside, provided the crossover occurs when $K$ is less than 25 percent. A sell signal is generated when $K$ crosses and falls below $D$, provided the crossover occurs when $K$ is greater than 75 percent. Since not all crossovers are equally valid as signal generators, the stochastics oscillator, unlike the moving-average crossover system, does not automatically reverse from a buy to a sell or vice versa.

#### Fixed Price Reversal or Breakout Systems

Instead of studying historical prices over a fixed interval of time, some systems choose to generate signals based on a fixed, predetermined reversal in prices. The logic is that once prices break out of a trading range, they are apt to continue in the direction of the breakout. The desired price reversal target could be an absolute amount or a percentage of current prices.

For example, in the case of gold futures, a reversal point could be set a fixed dollar amount, say $5 per ounce, from the most recent close price. Alternatively, the reversal point could be a fixed percentage retracement, say 1 .50 percent, from the most recent close price. The belief is that we have a reversal of trend if prices reverse by an amount equal to or greater than a prespecified value. Accordingly, the system generates a signal to liquidate an existing trade and reverse positions.

## THE ROLE OF MECHANICAL TRADING SYSTEMS

The primary function of mechanical trading systems is to help a trader with precise entry and exit points. In doing so, mechanical trading systems facilitate the setting of stops, enabling a trader to predefine the dollar risk per contract traded. Additionally, a mechanical trading system facilitates back-testing of data, allowing a trader to gain invaluable insight into the system's efficacy. This information can help the trader allocate capital more effectively. Both these functions are addressed in this section.

#### Setting Predefined Stop-loss Orders

Using a mechanical system allows a trader to know the dollar amount at risk going into a trade, since it can make the trader aware of the stop price at which the trade must be liquidated. The lack of fuzziness regarding the exit point gives mechanical systems a definite edge over judgmental systems. Consider a two- and four-day dual moving-average crossover system that recommends buying gold based on the price history in Table 9.1. Since the two-day average is greater than the four-day average, the system



**Table 9.1** Price History for Gold

| Day | Close Price | Two-Day Moving Average | Four-Day Moving Average |
|---|---|---|---|
| 1 | 350 | | |
| 2 | 352 | 351.0 | |
| 3 | 353 | 352.5 | |
| 4 | 354 | 353.5 | 352.25 |
| 5 | Stop Price, x | | |

recommends holding a long position in the commodity. The reversal stop price, $x$, for the upcoming fifth day may be calculated as the price where the two moving averages will cross over to give a sell signal. This is the price at which the two-day moving average equals the four-day moving average. Therefore,

$$\frac{x + 354}{2} = \frac{x + 354 + 353 + 352}{4}$$

$$0.50x + 177 = 0.25x + 264.75$$

$$0.25x = 87.75$$

$$x = 351$$

The trader could place an open order to sell two contracts of gold at $351 on a close-only basis: one contract to cover the existing long position and the second to initiate a new short sale. The trader's risk on the trade is given by the difference between the current price, $354, and the sell stop price, $35 1, namely $3 per ounce or $300 a contract. The open Order is valid until such time it is executed or is canceled or replaced by the trader. The "close-only" stop signifies that the order will be executed only if gold trades at or below $351 during the final minutes of trading on any day.

Calculating the stop price may be tedious for the more advanced trading systems, especially where there is more than one unknown variable in the formula. However, it should be possible to compute reversal stops with the help of suitable simplifying assumptions.

#### Generating Performance Measures Based on Back-Testing

Mechanical trading systems are amenable to back-testing, permitting an objective assessment of historical performance. Simulation permits a trader to observe the effects of a change in one or more system parameters. The underlying rules themselves might be modified and the effects of such modifications back-tested. These "what-if" questions would most likely be unanswered in the absence of mechanization. Back-testing over a historical time period yields performance measures that greatly help in making a determination of the proportion of capital to be risked to trading.

The most useful performance measures are (a) the probability of success of a system and (b) its payoff ratio. The probability of success is the ratio of the number of winning trades to the total number of trades over a given time period. The payoff ratio measures the average dollar profit on winning trades to the average dollar loss on losing trades over the same period. The higher the probability of success and the higher the payoff ratio, the more effective the trading system. Both these measures are synthesized into one aggregate measure, known as the profitability index of a system.

### The Profitability Index

The profitability index of a system is defined as the product of the odds of success and the payoff ratio. Therefore,

$$\text{Profitability index} = \frac{p}{(1-p)} \times \text{Payoff ratio}$$

where $p$ = probability of success

$(1 - p)$ = the complementary probability of failure

When $p = 0.50$, the ratio $p/(1-p)$ is 1. Therefore, the profitability index of such a system is determined exclusively by its payoff ratio. The higher the payoff ratio, the higher the profitability index. When the probability of success, $p$, is greater than 0.50, the ratio $p/(1-p)$ is greater than 1. The higher the probability of success, the higher the odds of success and the resulting profitability index for a given payoff ratio. A profitability index of 2 signals a good system. An index greater than 3 would be exceptional.

The implicit assumption in our discussion thus far is that the profitability index of a system based on back-testing of historical data is indicative of future performance. This may not always be true, especially if the mechanical system is based on constant or fixed parameters. In the ensuing discussion, we discuss (a) the problems associated with fixed parameter systems, (b) the implications of these problems for trading and money management, and (c) possible solutions.



## FIXED-PARAMETER MECHANICAL SYSTEMS

Fixed-parameter mechanical systems hold one of two key parameters constant: (a) the time period over which historical data is analyzed, in the case of trend-following or oscillator-based systems, or (b) the magnitude of the price reversal, in the case of price breakout systems. The implicit assumption is that prices will continue to conform to a fixed set of rules that have best captured market behavior over a historical time period.

While prices do have a tendency to trend every so often, these trends do not seem to recur with definite regularity. Moreover, the magnitude of the price move in a trend varies over time, and no two trends are exact replications. Although the existence of trends cannot be denied, there is an annoying randomness as regards their magnitude and periodicity. This randomness is the Achilles heel of mechanical systems based on fixed, market-invariant parameters, since it is virtually impossible for such systems to capture trends in a timely fashion consistently.

Therefore, the much-touted virtue of consistency in the use of a mechanical rule need not necessarily lead to consistent results. What is needed is a system that responds quickly to changes in market conditions, and this is where a fixed-parameter system falls short. Instead of modifying its parameters to adapt to changes in market conditions, a fixed-parameter system implicitly expects market conditions to adapt to its invariant logic. This could be a cause for concern.

### Analyzing the Performance of a Fixed-Parameter System

Instead of speculating on the consequences of fixed-parameter systems, it would be instructive to analyze the historical performance of one such system. We select for our study the ubiquitous dual moving-average crossover system. A total of 31 dual moving-average crossover rules are analyzed over four equal two-year periods from 1979 to 1987, across four commodities: gold, Japanese yen, Treasury bonds, and soybeans.

The shorter moving average is based on historical data for the past 3 to 15 days in increments of 3 days. The longer moving average is based on historical data for the past 9 to 45 days in increments of 6 days. A total of 31 combinations has been studied. An amount of $50 has been deducted from the profits of each trade to allow for brokerage fees and unfavorable order executions, commonly known as slippage.

Table 9.2 summarizes the average profit and standard deviation of profits across all 3 1 rules for each of four two-year subperiods. Table 9.3

**Table 9.2** Summary of Performance of 31 Moving-Average Crossover Rules by Time Period and Commodity

| | 1979-81 | 1981-83 | 1983-85 | 1985-87 | Average 1979-87 |
|---|---|---|---|---|---|
| Gold: | | | | | |
| Aver Profit | $58,283 | −$2,798 | −$7,421 | −$1,207 | $11,714 |
| Std Dev | $19,595 | $11,606 | $6,557 | $3,904 | $29,576 |
| Min $ Profit | −$10,430 | −$23,410 | −$16,230 | −$11,050 | −$23,410 |
| Max $ Profit | $93,150 | $28,070 | $7,150 | $7,550 | $93,150 |
| Max $ Rule (days) | 12 & 27 | 9 & 15 | 9 & 15 | 12 & 27 | |
| Coeff of Var | 0.34 | -4.15 | -0.88 | -3.23 | 2.52 |
| Treasury bonds: | | | | | |
| Aver Profit | $9,897 | $1,553 | $7,949 | $9,783 | $7,295 |
| Std Dev | $10,117 | $6,930 | $4,473 | $8,769 | $8,485 |
| Min $ Profit | −$12,912 | −$18,694 | −$4,125 | −$5,775 | −$18,694 |
| Max $ Profit | $30,087 | $11,581 | $15,875 | $37,025 | $37,025 |
| Max $ Rule (days) | 3 & 9 | 12 & 15 | 6 & 33 | 3 & 15 | |
| Coeff of Var | 1.02 | 4.46 | 0.56 | 0.89 | 1.16 |
| Japanese yen: | | | | | |
| Aver Profit | $12,816 | $10,044 | $3,937 | $15,961 | $10,690 |
| Std Dev | $5,509 | $2,872 | $3,905 | $6,675 | $6,614 |
| Min $ Profit | −$5,050 | $2,800 | −$4,650 | $2,212 | −$5,050 |
| Max $ Profit | $22,425 | $16,400 | $12,950 | $28,787 | $28,787 |
| Max $ Rule (days) | 9 & 27 | 6 & 9 | 9 & 27 | 3 & 27 | |
| Coeff of Var | 0.43 | 0.28 | 0.99 | 0.42 | 0.62 |
| Soybeans: | | | | | |
| Aver Profit | $9,800 | $11,009 | −$568 | −$5,836 | $3,601 |
| Std Dev | $8,297 | $9,029 | $7,146 | $2,513 | $10,050 |
| Min $ Profit | −$4,662 | −$7,475 | −$9,750 | −$9,762 | −$9,762 |
| Max $ Profit | $28,512 | $25,275 | $14,250 | $862 | $28,512 |
| Max $ Rule (days) | 3 & 45 | 15 & 21 | 6 & 15 | 12 & 15 | |
| Coeff of Var | 0.85 | 0.82 | -12.58 | -0.43 | 2.79 |



summarizes the average profit and standard deviation of profits for each of the 31 rules across the entire period, 1979-87.

Variability of profits across the different rules is measured by the coefficient of variation. The coefficient of variation is arrived at by dividing the standard deviation of profits across different rules by the average profit. A low positive coefficient of variation is desirable, inasmuch as it suggests low variability of average profits.

The Japanese yen has the lowest average coefficient of variation, followed by Treasury bonds, suggesting a healthy consistency of performance. Gold and soybeans have average coefficients of variation in excess of 2, indicating wide swings in the performance of the dual moving-average crossover rules.

The optimal profit and the rule generating it for each commodity are summarized in Table 9.4 for each of the four time periods. The optimal profit for a commodity represents the maximum profit earned in each time period across the 3 1 rules studied. Notice that none of the rules consistently excels across all commodities. Moreover, a rule that is optimal in one period for a given commodity is not necessarily optimal across other time periods. For example, in the case of gold the 12- and 27-day average crossover rule was optimal during 1979-8 1. However, the rule came close to being the worst performer in 1981-83 and 1983-85 before becoming a star performer once again during 1985–87! Similar findings, albeit not as dramatic, hold for each of the other three commodities surveyed.

### A Statistical Test of Performance Differences

To examine more closely the differences in performance of a trading rule across time periods, we employ a two-way analysis of variance (ANOVA) test. The model states that differences in performance could be a function of either (a) differences across trading rules or (b) inherent differences in market conditions across time periods. Differences in performance not explained by either trading rule or time period are attributed to a random error term.

The statistic used to check for significant differences across a test variable X is the $F$ statistic, computed as follows:

$$F(DF_1, DF_2) = \frac{\text{Sums of squares for X} / DF_1}{\text{Sums of squares for error term} / DF_2}$$

Table 9.3 Summary of 31 Moving-Average Crossover Rules by Commodity: Average Performance between 1979 and 1987

| | Gold | | | T. bonds | | | Yen | | | Soybeans | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Parameters | Aver $ | sd | Coeff of Var | Aver $ | sd | Coeff of Var | Aver $ | sd | Coeff of Var | Aver $ | sd | Coeff of Var |
| 3 & 9 days | -$4,405 | $5,539 | -1.26 | $9,930 | $17,571 | 1.77 | $12,603 | $4,051 | 0.32 | -$3,894 | $5,732 | -1.47 |
| 3 & 15 days | $10,208 | $13,128 | 1.28 | $14,352 | $15,775 | 1.10 | $14,191 | $10,541 | 0.74 | -$1,481 | $9,899 | -6.28 |
| 3 & 21 days | $17,155 | $38,201 | 2.22 | $8,379 | $9,864 | 1.18 | $13,091 | $10,278 | 0.78 | $3,200 | $6,450 | 2.01 |
| 3 & 27 days | $15,495 | $43,864 | 2.83 | $9,283 | $3,727 | 0.40 | $14,328 | $10,135 | 0.71 | $3,144 | $9,145 | 2,91 |
| 3 & 33 days | $12,648 | $32,800 | 2.59 | $12,714 | $8,682 | 0.68 | $13,328 | $6,550 | 0.49 | $5,363 | $12,226 | 2.28 |
| 3 & 39 days | $8,773 | $30,101 | 3.43 | $9,505 | $7,192 | 0.75 | $9,153 | $3,698 | 0.40 | $5,869 | $15,452 | 2.63 |
| 3 & 45 days | $6,663 | $25,528 | 3.83 | $10,027 | $11,440 | 1.14 | $10,666 | $3,533 | 0.33 | $9,469 | $17,160 | 1.81 |
| 6 & 9 days | $7,955 | $18,752 | 2.36 | $6,936 | $18,597 | 2.68 | $7,422 | $9,010 | 1.21 | -$444 | $6,267 | -14.11 |
| 6 & 15 days | $16,370 | $28,197 | 1.72 | $4,461 | $7,934 | 1.78 | $9,691 | $8,189 | 0.84 | $3,131 | $8,494 | 2,71 |
| 6 & 21 days | $15,520 | $36,644 | 2.36 | $5,042 | $2,288 | 0.45 | $12,909 | $6,936 | 0.54 | $5,256 | $5,345 | 1.02 |
| 6 & 27 days | $16,860 | $41,428 | 2.46 | $9,770 | $8,496 | 0.87 | $13,653 | $4,487 | 0.33 | $6,700 | $9,664 | 1.44 |
| 6 & 33 days | $9,613 | $29,547 | 3.07 | $13,139 | $6,811 | 0.52 | $14,047 | $5,507 | 0.39 | $4,956 | $12,104 | 2.44 |
| 6 & 39 days | $10,253 | $28,545 | 2.78 | $13,524 | $10,055 | 0.74 | $10,897 | $5,630 | 0.52 | $3,425 | $8,006 | 2.34 |
| 6 & 45 days | $9,708 | $27,905 | 2.87 | $9,830 | $7,277 | 0.74 | $8,166 | $2,613 | 0.32 | $5,406 | $12,218 | 2.26 |
| 9 & [illegible] days | $12,145 | [illegible] | 1.25 | [illegible] | $4,097 | 1.05 | $9,053 | $5,457 | 0.60 | $7,569 | $10,272 | 1.36 |
| 9 & 27 days | $14,245 | $46,946 | 2.35 | $6,930 | $3,858 | 0.55 | $12,766 | $6,907 | 0.54 | $4,400 | $7,670 | 1.74 |
| 9 & 33 days | $11,198 | $36,883 | [illegible] | $7,926 | $6,532 | 0.94 | $14,728 | $5,202 | 0.35 | $2,706 | $10,454 | 3.86 |
| 9 & 39 days | $4,208 | $34,380 | | $8,698 | $3,590 | 0.45 | $10,959 | $8,081 | 0.74 | $2,419 | $9,922 | 4.10 |
| 9 & 45 days | $9,053 | $25,118 | [illegible] | $6,130 | $7,907 | 0.91 | $9,741 | $6,694 | 0.69 | $4,119 | $9,185 | 2.23 |
| | | | | | $3,219 | 0.52 | $9,747 | $5,785 | 0.59 | $5,813 | $11,898 | 2.05 |
| 12 & [illegible] days | [illegible] | [illegible] | [illegible] | [illegible] | $7,940 | 2.35 | $10,228 | $4,391 | 0.43 | $6,394 | $4,324 | 0.67 |
| 12 & 27 days | $18,075 | $51,105 | | $1,033 | $4,844 | 1.18 | $13,097 | $9,191 | 0.70 | -$444 | $10,060 | -22.66 |
| | | | 2.83 | | $11,838 | 11.46 | $11,047 | $7,004 | 0.63 | $1,419 | $14,005 | 9.87 |
| 12 & 33 days | $9,380 | $36,280 | 3.87 | $8,883 | $3,161 | 0.35 | $10,453 | $5,604 | 0.53 | $3,163 | $12,111 | 3.83 |
| 12 & [illegible] days | [illegible] | [illegible] | 3.26 | [illegible] | $6,435 | 0.76 | $6,941 | $6,036 | 0.87 | $3,956 | $11,296 | 2.85 |
| | | | 2.35 | | $4,783 | 0.97 | $9,191 | $9,069 | 0.99 | $7,488 | $14,290 | 1.91 |
| 15 & [illegible] days | [illegible] | [illegible] | 4.10 | [illegible] | $11,042 | -1.93 | $10,134 | $10,820 | 1.07 | $557 | $16,617 | 29.83 |
| 15 & 33 days | $8,918 | $40,501 | 3.04 | $8,939 | $5,617 | 1.42 | $11,066 | $7,836 | 0.71 | $4,113 | $15,598 | 3.79 |
| 15 & 39 days | $13,368 | $30,577 | 4.54 | $6,348 | $5,513 | 0.62 | $6,684 | $6,074 | 0.91 | $3,450 | $11,665 | 3.38 |
| 15 & 45 days | $14,103 | $27,039 | 2.29 | $4,448 | $5,298 | 0.83 | $4,828 | $4,835 | 1.00 | $2,313 | $10,799 | 4.67 |
| | | | 1.92 | | $4,443 | 1.00 | $6,578 | $6,573 | 1.00 | $2,106 | $11,148 | 5.29 |

**Table 9.4** Optimal Profit ($) and Optimal Rule Analysis

| | 1979-81 | 1981-83 | 1983-85 | 1985-87 |
|---|---|---|---|---|
| Gold: | | | | |
| Optimal Profit | 93150 | 28070 | 7150 | 7550 |
| Optimal Rule | 12 & 27 | 9 & 15 | 9 & 15 | 12 & 27 |
| Treasury bonds: | | | | |
| Optimal Profit | 30087 | 11581 | 15875 | 37025 |
| Optimal Rule | 3 & 9 | 12 & 15 | 6 & 33 | 3 & 15 |
| Japanese yen: | | | | |
| Optimal Profit | 22425 | 16400 | 12950 | 28787 |
| Optimal Rule | 9 & 27 | 6 & 9 | 9 & 27 | 3 & 27 |
| Soybeans: | | | | |
| Optimal Profit | 28512 | 25275 | 14250 | 862 |
| Optimal Rule | 3 & 45 | 15 & 21 | 6 & 15 | 12 & 15 |

or,

$$F(DF_1, DF_2) = \frac{\text{Mean square across X}}{\text{Mean square of error term}}$$

where $DF_1$ represents the degrees of freedom for X, the numerator, and $DF_2$ represents the degrees of freedom for the unexplained error term, the denominator. The degrees of freedom are equal to the number of parameters estimated in the analysis less 1.

In our study, we have a matrix of 31 x 4 observations, with a row for each of the 31 rules studied and a column for each of the 4 time periods surveyed. Each cell of the 31 x 4 matrix represents the profit earned by a trading rule for a given time period. Since we have a total of 124 data cells, there are 123 degrees (124 – 1) of freedom. There are 3 degrees of freedom for the 4 time periods, and 30 degrees of freedom for the 31 moving-average crossover rules analyzed, leaving 90 degrees of freedom (123 – 30 – 3) for the unexplained error term.

Table 9.5 checks for differences in average profits generated by each of the 31 trading rules across four time periods. The calculated $F$ value for the observed data is compared with the corresponding theoretical $F$ value derived from the $F$ tables at a level of significance of 1 percent,

If the calculated $F$ value exceeds the tabulated $F$ value, the hypothesis of equality of profits over the different subperiods is rejected. A 1 percent

**Table 9.5** Testing for Differences Across Time in Average Profits for a Moving Average C...

| Commodity | Mean Square Value Across: Rules | Time | Error | F Value: Rules: Calculated | Table | F Value: Time: Calculated | Table | Degrees of Freedom: Rule | Time |
|---|---|---|---|---|---|---|---|---|---|
| Soybeans | 32.08 | 2064.21 | 58.56 | 0.55 | 1.94 | 35.25 | 4.04 | 30 | 3 |
| Gold | 89.34 | 30095.45 | 162.53 | 0.55 | 1.94 | 185.17 | 4.04 | 30 | 3 |
| Yen | 27.03 | 809.35 | 23.80 | 1.14 | 1.94 | 34.01 | 4.04 | 30 | 3 |
| Bonds | 64.56 | 479.01 | 60.92 | 1.06 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |

Note: The table values correspond to a 1% level of significance for a 1-tail $F$ test. There are 90 degrees of freedom for the denominator, the Error term.

$$F \text{ calculated value: Rules} = \frac{\text{Mean square value across rules}}{\text{Mean square value across error}}$$

$$F \text{ calculated value: Time} = \frac{\text{Mean square value across time}}{\text{Mean square value across error}}$$

level of significance implies that the theoretical value of ***F*** is likely to lead to an erroneous rejection of the null hypothesis in 1 percent of the cases, a highly remote possibility.

Interestingly, the calculated ***F*** value across time is greater than the tabulated value at the 1 percent level of significance for all four commodities. The calculated *F* value across rules is less than the tabulated value at a 1 percent level of significance across all four commodities. Therefore, we can conclude that differences in profits are significantly affected by changes in market conditions across time, rather than by parameter differences in the construction of the rules themselves.

Table 9.6 extends the above analysis of variance to check for differences in the average probability of success across time for each of the 31 trading rules. Again, we have a 31 $\times$ 4 data matrix, with each cell now representing the probability of success for a trading rule during a given time period. Once again, we find the difference in the probability of success across all four commodities to be significantly affected by changes in market conditions across time. This is in line with the results of the analysis of profit differences given in Table 9.5. Rule differences account for significant changes in the probability of success only in case of the Japanese yen.

Table 9.7 checks for differences in the average payoff ratio across time for each of the 3 1 rules. Each cell of the 31 x 4 matrix now represents the payoff ratio for a trading rule during a given time period. The results of the analysis reveal that differences in the payoff ratio are influenced primarily by changes in market conditions across time, except for the yen. Rule differences account for significant changes in the payoff ratio in the case of the yen and Treasury bonds.

### Implications for Trading and Money Management

To the extent the dual moving-average crossover system is a typical example of conventional fixed-parameter systems, the results are fairly representative of what could be expected of similar fixed-parameter systems. The implications for trading and money management are discussed here.

Swings in performance could result in corresponding swings in the probability of success and the payoff ratio for a given mechanical rule across different time periods. As a result, the profitability index of a system is suspect. Further, risk capital allocations based on historic performance measures are likely to be inaccurate. Most significantly, wide swings in performance could also have a deleterious effect on the

**Table 9.6** Testing for Differences Across Time in the Probability of Success for a Moving-Average Crossover Rule

| Commodity | Mean Square Value Across: Rules | Time | Error | *F* Value: Rules: Calculated | Table | *F* Value: Time: Calculated | Table | Degrees of Freedom: Rule | Time |
|---|---|---|---|---|---|---|---|---|---|
| Soybeans | 0.007 | 0.163 | 0.010 | 0.70 | 1.94 | 16.30 | 4.04 | 30 | 3 |
| Gold | 0.009 | 0.431 | 0.010 | 0.90 | 1.94 | 43.10 | 4.04 | 30 | 3 |
| Yen | 0.011 | 0.062 | 0.005 | 2.20 | 1.94 | 12.40 | 4.04 | 30 | 3 |
| Bonds | 0.005 | 0.070 | 0.006 | 0.83 | 1.94 | 11.67 | 4.04 | 30 | 3 |

Note: The table values correspond to a 1% level of significance for a 1-tail *F* test. There are 90 degrees of freedom for the denominator, the Error term.

$$F \text{ calculated value: Rules} = \frac{\text{Mean square value across rules}}{\text{Mean square value across error}}$$

$$F \text{ calculated value: Time} = \frac{\text{Mean square value across time}}{\text{Mean square value across error}}$$

**Table 9.7** Testing for Differences Across Time in the Payoff Ratio for a Moving-Average Crossover Rule

| Commodity | Mean Square Value Across | | | *F* Value: Rules | | *F* Value: Time | | Degrees of Freedom | |
|---|---|---|---|---|---|---|---|---|---|
| | Rules | Time | Error | Calculated | Table | Calculated | Table | Rule | Time |
| Soybeans | 3.065 | 32.069 | 1.745 | 1.76 | 1.94 | 18.37 | 4.04 | 30 | 3 |
| Gold | 1.331 | 44.573 | 0.894 | 1.49 | 1.94 | 49.86 | 4.04 | 30 | 3 |
| Yen | 1.997 | 2.767 | 0.850 | 2.35 | 1.94 | 3.26 | 4.04 | 30 | 3 |
| Bonds | 1.724 | 10.144 | 0.822 | 2.10 | 1.94 | 12.34 | 4.04 | 30 | 3 |

Note: The table values correspond to a 1% level of significance for a 1-tail *F* test. There are 90 degrees of freedom for the denominator, the Error term.

$$F \text{ calculated value: Rules} = \frac{\text{Mean square value across rules}}{\text{Mean square value across error}}$$

$$F \text{ calculated value: Time} = \frac{\text{Mean square value across time}}{\text{Mean square value across error}}$$





precision of system-generated entry signals or exit stops. These are genuine difficulties, which merit attention and suitable resolution. In the following section, we offer possible solutions.

## POSSIBLE SOLUTIONS TO THE PROBLEMS OF MECHANICAL SYSTEMS

The most obvious solution to the problems raised in the preceding section would be to rid a mechanical system of its inflexibility. A good starting point would be to think of more effective alternatives to rules that have been defined in terms of fixed parameters such as a prespecified number, $n$, of completed trading sessions to evaluate market behavior or a fixed dollar or percentage price value for assessing a valid breakout.

### Toward Flexible-Parameter Systems

A flexible-parameter system, as the name suggests, would adjust its parameters in line with market action. For example, in a choppy market devoid of direction, the system would call for a loosening of trigger points to enter into or exit out of a position. Conversely, in a directional market, such triggers would be tightened.

Unlike a fixed-parameter system, a flexible-parameter system does not expect the market to abide by the logic of its rules; instead, it adapts its rules to accommodate shifts in market conditions. Efforts to develop such systems would be extremely helpful from the standpoint of both trading and money management. Although the construction flexible-parameter systems is beyond the purview of this book, it would suffice to note that such systems can be designed. Neural networks are one such example. They learn by example and adapt to changing market conditions rather than expecting the market to adapt to a set of predefined, unalterable rules.

### Using Most Recent Results as Predictors of the Future

Assuming a trader is unable to inject flexibility into a mechanical system, he or she would have to make the most of it as a fixed-parameter system. One possible solution is to use the performance parameters generated by a fixed-parameter system over the most recent past. The definition of "recent past" depends on the trading horizon of the trader. A trader using a system based on weekly data would consider a longer history in defining the recent past than would a trader using a system based on daily data. Similarly, a trader who relies on a system that generates multiple signals per day would have a different understanding of the term "recent past" from that of a trader using a system based on daily data.

The assumption here is that the most recent past is the best estimator of the future. This is true as long as there is no reason to suspect a fundamental shift in market behavior. However, if recent market action belies the assumption of stability, past performance can no longer be used as a reflector of the future. In such a case, it would be necessary to determine and use those parameters that are optimal in an environment after the change occurred. This is accomplished through a procedure known as curve fitting or optimizing.

### The Role of Curve Fitting or Optimizing a System

The process of curve fitting or finding the optimal parameters for a system entails back-testing the system over a historical time period using a variety of different parameters. Ideally, the time period selected for analysis should be representative of current market conditions. This is to ensure that the optimality of parameters is not unique to the period under review. One way of checking that this is indeed so is to retest the mechanical rule over yet another sample period. If the parameters originally found to be optimal are truly optimal, they should continue to turn in superior results over the new sample period.

For example, a trader might want to back-test a dual moving-average crossover system using all feasible combinations of short and long moving averages. The trader would then scan the results to select the combination that yields the highest profitability index. Next, he or she would rerun the test over yet another sample period to check for consistency of the results. If a certain combination does yield superior performance over the two sample periods, the trader can be reasonably sure of its optimality. The following subsection summarizes the rules for optimization.

### Rules for Optimization

The greater the number of variables in a system, the more complex the system is from an optimization standpoint. If even one of the optimized



parameters were to malfunction, this would hurt the overall performance of the system. Consequently, the fewer the number of system parameters to be optimized, the more robust the results of the optimization are likely to be. This is a compelling argument in favor of simplifying the logic of a mechanical system.

The implicit assumption in any curve fitting exercise is that a set of parameters found to be optimal over a given time period will continue to perform optimally in the future. However, if conditions are fundamentally different from those considered in the sample period, this would render invalid the results from an earlier back-testing. In this case, it would be incumbent upon the analyst to repeat the optimization exercise, using price history after the change as a basis for the new analysis.

One way around the problem of changing market conditions is to use as long a historical database as possible. This allows the analyst to examine the performance of the system over varying market conditions. For example, a moving-average crossover system might work wonderfully in trending markets only to get whipsawed in sideways markets. Ideally, therefore, the optimization study should be carried out over a sample period that covers both trending and sideways markets. Generally, the sample period should be no less than five years. In terms of completed trades, the back-testing should cover at least 30 trades.

Once the optimal parameters have been established, the next step would be to conduct an out-of-sample or forward test of these parameters. An out-of-sample or forward test is conducted using a period of time that is beyond the original sample period. For example, if the optimal parameters were arrived at by analyzing data over the 1980 to 1985 time period, a forward test would check the efficacy of these optimal parameters over a subsequent period, say 1986 to 1990. This process enables the analyst to judge the robustness, or lack thereof, of the optimal parameters. If the optimal parameters are found to be equally effective over the periods 1980 to 1985 and over 1986 to 1990, there is reason to be confident about the future effectiveness of these parameters.

## CONCLUSION

Mechanical trading systems are objective inasmuch as they are not swayed by emotions when they recommend entry into or exit out of a market. However, a mechanical system may also introduce a certain amount of rigidity, especially if the system expects the market to adjust to a given set of rules instead of adapting its rules to adjust to current market conditions.

This could lead to imprecision in the timing of signals generated by the system. Consequently, fixed-parameter systems are subject to major shifts in trading performance; what is optimal in one time period need not necessarily be optimal in another period. Accompanying the shifts in trading performance are related shifts in performance measures, such as the probability of success and the payoff ratio. These measures are useful for determining the proportion of capital to be risked to trading.

One solution would be to rid the system of its inflexibility by adapting the rules to adjust quickly and effectively to changes in market conditions. In the absence of a flexible system, it would be appropriate to use the most recent past performance as being indicative of the future. The assumption is that market conditions that prevailed in the recent past will not change dramatically in the immediate future. If such a change is evident, do not regard past performance as being reflective of the future. Instead, find out what parameters perform best for a given rule under the new environment, using data for the period since the change occurred.

# 10

# Back to the Basics

Judicious market selection and capital allocation separate the outstanding trader from the marginally successful trader. However, it is failure to control losses, coupled with a knack for letting emotions overrule logic, that often makes the difference between success and failure at futures trading. Although these issues are hard to quantify, they cannot be ignored or taken for granted. This chapter outlines the key issues responsible for poor performance, in the hope that reiterating them will help keep the reader from falling prey to them.

## AVOIDING FOUR-STAR BLUNDERS

Success in the futures markets is measured in terms of the growth of one's account balance. A trader is not expected to play God and call market turns correctly at all times. Therefore, she should not berate herself for errors of judgment. Even the most successful traders commit errors of judgment every so often. What distinguishes them from their less successful colleagues is their ability (a) to recognize an error promptly and (b) to take necessary corrective action to prevent the error from becoming a financial disaster. Therefore, the key to avoiding ruin is simply to make sure that one can live with the financial consequences of one's errors.

An error of judgment results from inaction or incorrect action on the trader's part. Such an error could either (a) stymie growth of a trader's account balance or (b) lead to a reduction in the account balance.

Let us assume for a moment that errors could be ranked on a scale, with one star being awarded to the least significant of errors and four stars reserved for the most serious blunders.

### One-Star Errors

There is a commonly held misconception that a profitable trade precludes the possibility of an error of judgment. The truth is that a trader can get out of a profitable trade prematurely, just as he or she can exit the trade after giving back most of the profits earned. As the final profit figure is a mere fraction of what could have been earned, there is cause for concern. This error of judgment is termed a one-star error. A one-star error is the least damaging of errors, because there is some growth in the trader's account balance notwithstanding the error.

### Two-Star Errors

A two-star error results from completely ignoring what turns out to be a highly profitable trade. A two-star error tops a one-star error inasmuch as there is absolutely no growth in the account balance. A major move has just whizzed by, and the trader has missed the move. In a period when major rallies are few and far between, the missed opportunity might prove to be quite expensive.

### Three-Star Errors

When a trader observes a gradual shrinking of equity, but refuses to liquidate a losing trade, he or she commits a three-star error. Clearly, this error is more serious than the earlier errors, given the reduction in the account balance. A three-star error of judgment typically arises as a result of not using stop-loss orders, or setting such loose stops as to negate their very purpose.

For example, if a trader were to short-sell a contract of gold at $370 an ounce, omit to enter a buy stop order, and finally pull out of the trade when gold touched $400, the resulting loss of $3000 per contract would qualify as a three-star error.

### Four-Star Blunders

A four-star blunder is simply a magnified version of a three-star error, caused by overexposure to a single commodity. In the preceding example, short-selling 10 contracts of gold at $370 an ounce would result in a $30,000 loss instead of the $3000 alluded to above. The magnitude of such a loss might well snuff out a promising trading career. Four-star blunders can and must be avoided at all costs.



### Consequences of Four-Star Blunders

A four-star blunder must be avoided simply because it is difficult, if not impossible, to redress the financial consequences of such errors. This is because the percentage profit needed to recoup the loss increases as a geometric function of the loss. For example, a trader who sustained a loss equal to 33 percent of the account balance would need a 50 percent gain to recoup the loss. If the loss were to increase to 50 percent of the account value, the gain needed to offset this loss would jump to 100 percent of the account balance after the loss. In this example, as the loss sustained increases 50 percent, the profits needed to recoup the loss increase 100 percent. In general, the percentage profits needed to recoup a percentage loss, ***L***, are given by the following formula:

$$\text{Percentage profit needed to recoup a loss} = \frac{1}{1 - L} - 1$$

In the limit case, when losses equal 90 percent of the value of the account, the profit needed to recoup this loss equals 900 percent of the balance in the account!

Although four-star blunders are serious, their seriousness is magnified when the market is moving in a narrow trading range, devoid of major trends. If there are strong trends in one or more markets in any given period and the trader has caught the trend, four-star errors of judgment seem to pale in the shadow of the profits generated by the strong trends. However, in nontrending markets, when lucrative opportunities are few and far between, even a two-star error of judgment suddenly seems very significant.

## THE EMOTIONAL AFTERMATH OF LOSS

Losses are always painful, but the emotional repercussions are often more difficult to redress than the financial consequences. By focusing all his attention on an errant trade, the trader is quite possibly overlooking other emerging opportunities. When this cost of forgone opportunities is factored in, the total cost of unexpected adversity can be very substantial indeed.

When confronted with unexpected adversity, a trader is likely to be gripped by a mix of emotions: panic, hopelessness, or a dogged determination to get even. The consequences of each of these reactions are discussed below.

#### Trading More Frequently

First, the trading horizon may shrink drastically. If a trader were a position trader trading off daily price charts, he may now convince himself that the daily charts are not responsive enough to market fluctuations. Accordingly, he might step down to the intraday charts. In so doing, the trader hopes that he can react more quickly to market turns, increasing his probability of success.

#### Trading More Extensively

Looking for instant gratification, the trader may also decide to trade a greater number of commodities in order to recoup his earlier losses. He figures that if he trades more extensively, the number of profitable trades will increase, enabling him to recoup his losses faster.

#### Taking Riskier Positions

When in trouble, a trader might decide to trade the most volatile commodities, hoping to score big profits in a hurry, rationalizing that there is, after all, a positive correlation between risk and reward: the higher the risk, the higher the expected reward. For example, a trader who has hitherto shunned the highly volatile Standard & Poor's 500 Index futures might be tempted to jump into that market to recoup earlier losses in a hurry.

#### Despair-Induced Paralysis

Instead of trading more fervently or assuming positions in more volatile commodities, a trader might swing to the other extreme of not trading at all. Although a string of losses hurts a trader's finances, the associated loss of confidence is much harder to restore. A trader who has suffered



serious losses will start doubting himself and his approach to trading. Very soon, he may decide to close his account and salvage the balance.

#### Selective Acceptance of System Signals

The trader might decide to stay on but trade hesitantly, perhaps second-guessing the trading system or being selective in accepting the signals it generates. This could be potentially disastrous, as the trader might go ahead with losing trades, ignoring the profitable ones!

#### System Switching

A despondent trader might decide to forsake a system and experiment with alternative systems, hoping eventually to find the "Perfect System". Through anxiety, such a trader forgets that no system is perfect under all market conditions. Lack of discipline and second-guessing of signals are the likely consequences of system switching.

## MAINTAINING EMOTIONAL BALANCE

In a sense, a serious adversity might push a trader into an emotional rut by fostering some of the behavior patterns just outlined. As a general rule, the greater the unexpected adversity, the deeper the scar on the trading psyche: the higher the self-doubt and the greater the loss of confidence. The most effective way of maintaining emotional balance is to steer clear of errors of judgment with serious financial repercussions. Another solution is to reiterate some basic market truisms and to reinforce them with the help of statistics. That is the purpose of this section.

#### Back-to-Back Trades Are Unrelated

Often, a trader will be heard to remark that he does not care to trade a particular commodity because of the nasty setbacks he has suffered in this market. This is a good example of emotional trading, for in reality the market does not play favorites, just as the market does not take any hostages! If only a trader could treat back-to-back trades as discrete, independent events, the outcome of an earlier trade would in no way influence the trader's future responses. This is easier said than done, given that traders are human and have to contend with their emotional selves at all times. However, proving statistical independence between trade outcomes might help dissolve this mental block.

Trade outcomes may be analyzed using the one sample runs test given by Sidney Siegel.[1] A run is defined as a succession of identical outcomes that is followed and preceded by different outcomes or by no outcomes at all. Denoting a win by a +, and a loss by a −, the outcomes may look as follows:

+ + + - - - - + - + - - + + - - - + + - +

Here we have a total of 10 wins and 11 losses. The first three wins (+) constitute a run. Similarly, the next four losses (-) constitute yet another run. The following win is another run by itself, as is the subsequent losing trade. The total number of runs, $r$, is 11 in our example. Our null hypothesis ($H_0$) is that trade outcomes occurred in a random sequence. The alternative hypothesis ($H_1$) is that there was a pattern to the trade outcomes-that is, the outcomes were nonrandom. The dollar value of the profits and losses is irrelevant for this test of randomness of occurrences. We use the following formula to calculate the $z$ statistic for the observed sequence of trades:

$$z = \frac{r - \left(\dfrac{2n_1n_2}{n_1 + n_2} + 1\right)}{\sqrt{\dfrac{2n_1n_2(2n_1n_2 - n_1 - n_2)}{(n_1 + n_2)^2(n_1 + n_2 - 1)}}}$$

where $n_1$ = the number of winning trades

$n_2$ = the number of losing trades

$r$ = the number of runs observed in the sample

Compare the calculated $z$ value with the tabulated $z$ value given for a prespecified level of significance, typically 1 percent or 5 percent. Since $H_1$ does not predict the direction of the deviation from randomness, a two-tailed test of rejection is used.

A 1 percent level of significance implies that the theoretical z value encompasses 99 percent of the distribution under the bell-shaped curve.

[1] Sidney Siegel, ***Nonparametric Statistics for the Behavioral Sciences*** (New York: McGraw-Hill, 1956).



The theoretical or tabulated z value at the 1 percent level of significance for a two-tailed test is $\pm 2.58$. Similarly, a 5 percent level of significance implies that the theoretical z value encompasses 95 percent of the distribution under the bell-shaped curve. The corresponding tabulated $z$ value for a two-tailed test is $\pm$ 1.96.

If the calculated z value lies beyond the theoretical or tabulated value, there is reason to believe that the sequence of trade outcomes is significantly different from a random distribution. Accordingly, if the calculated z value exceeds $+2.58(+1.96)$ or falls below -2.58 $(-1.96)$, the null hypothesis of randomness is rejected at the 1 percent (5 percent) level. However, if the calculated z value lies between $\pm 2.58$ $(\pm 1.96)$, the null hypothesis of randomness cannot be rejected at 1 percent (5 percent). At least 30 trades are needed to ensure the validity of the test results.

For purposes of illustration, we have analyzed the outcomes of trades generated by a three- and nine-day dual moving-average crossover system for three commodities over a two-year period, January 1987 to December 1988. The commodities studied are Eurodollars, Swiss francs, and the Standard & Poor's (S&P) 500 Index. The results are presented in Table 10.1. They reveal that wins and losses occur randomly across all three commodities at the 1 percent level of significance.

## Looking for Trades with Positive Profit Expectation

Particularly worrisome is the phenomenon of withdrawing into one's shell, becoming "gun-shy" as it were, consequent upon a series of bad

**Table 10.1** Testing for Randomness in the Sequence of Trade Outcomes

| | Swiss Franc | S&P 500 | Eurodollars |
|---|---|---|---|
| Total trades | 66 | 73 | 62 |
| Wins ($n_1$) | 20 | 17 | 21 |
| Losses ($n_2$) | 46 | 56 | 41 |
| Runs (r) | 37 | 28 | 30 |
| z, calculated | +2.39 | +0.30 | +0.35 |
| z, table value at 1% | ±2.58 | k2.58 | ±2.58 |

Note: The three- and nine-day dual moving-average crossover system has been used over the period January 1987 to December 1988.

trades. Even if there is money in the, trader's account, and his logical self senses a good trade emerging, his heart tends to pull him away from taking the plunge. In the process, the trader will most likely let many worthwhile opportunities slip by-an irrational move, given that these opportunities would have enabled the trader to recoup most or all of the earlier losses.

At the other end of the emotional scale, a trader might be tempted to trade, simply because she feels obliged to trade each day. A compulsive trader is as much a victim of emotional distress as is the gun-shy trader who cannot seem to execute when the system so demands. A compulsive trader is driven by the urge to trade and is mesmerized by unfolding price action. She feels she must trade every day, simply to justify her existence as a trader.

Perhaps the best way to overcome gun-shy behavior or the tendency to overtrade is to make an objective assessment of the expected profit of each trade. The expected profit on a trade is a function of (a) the probability of success, (b) the anticipated profit, and (c) the permissible loss. The formula for calculating the expected profit is

$$\text{Expected profit} = p(W) - (1 - p)L$$

where $p$ = the probability of winning

$(1 - p)$ = the associated probability of losing

$W$ = the dollar value of the anticipated win

$L$ = the dollar value of the permissible loss

The greater the expected profit, the more desirable the trade. By the same token, if the expected profit is not large enough to recover the commissions charged to execute the trade, one would do well to refrain from the trade.

The only exception to this rule is when a trader is considering trading two negatively correlated markets concurrently. In such a case, it is conceivable that the optimal risk capital allocation across a portfolio of two negatively correlated commodities could exceed the sum of the optimal allocations for each commodity individually. This is notwithstanding the fact that one of the commodities has a negative expectation and would not qualify for consideration on its own merits.

The above formula presupposes that a trader has a clear idea of (a) the estimated reward on the trade, (b) the risk he or she is willing to assume



to earn that reward, and (c) the odds of success. As a rule, system traders are not clear about the estimated reward on a trade. However, they are aware of the probability of success and the payoff ratio associated with the system over the most recent past. Using this historical information as a proxy for the future, they can calculate the expected trade profit, using a given system, as follows:

$$\text{Expected profit} = [p(A + 1) - 1]$$

where $p$ = the historical probability of success

$A$ = the historical payoff ratio or the ratio of the dollars won on average for a \$1 loss

Once again, a system turning in a negative expected profit or an expected profit that barely recovers commissions should be avoided.

## PUTTING IT ALL TOGETHER

Football coach Bear Bryant posted this sign outside his teams' lockers: "Cause something to happen." He believed that if a player did not cause something to happen, the other team would run all over him. Bryant did make something happen: He won more college football games than any other coach. For "other team" read "futures markets," and the analogy is equally applicable to futures trading. Yes, a trader can make something worthwhile happen in the futures markets, if he or she chooses to.

First, a trader must develop a game plan that is fanatical about controlling losses. Second, he or she must practice discipline to adhere to that game plan, constantly recalling that success is measured not by the number of times he or she called the market correctly but in terms of the growth in the account balance. Errors of judgment are inevitable, but their consequences can and must be controlled. If the trader does not take charge of losses, the losses will eventually force him or her out of the game. Controlling loss is easier said than done, but it is skill in this area that will determine whether the trader ends up as a winner or as yet another statistic.

Finally, the trader must learn to let logic rather than emotions dictate his or her trading decisions, constantly recalling that back-to-back trades are independent events: There are no permanently "bad" markets. Just as withdrawing from trading after a series of reverses does not help, compulsive overtrading in an attempt to recoup losses can hurt. One way to overcome gun-shy behavior or overtrading is to calculate the expected profit on each trade: If the number is a significant positive, go ahead with the trade; if the expected profit is barely enough to recover commissions, pass the trade.

Futures trading is one activity where performance is easy to measure and the report card is always in at the end of each trading day. In an activity where performance speaks far louder than words, it is hoped that this book will help the reader "speak' more eloquently than before!

# A

# Turbo Pascal 4.0 Program to Compute the Risk of Ruin

```
Program ruin :
  {[A+,T=3] Instruction to PasMat.}

  Uses
    Dos;

  Type
    String80 = String [80];

  Var
    Name: String80;
    Infile, Outfile: Text;
    C22, NSet, NSetL, Index: LongInt;
    BoundLower, BoundUpper, Cap, Capital, Del,
      Probability, ProbabilityWin, ProbabilityLose,
      TradeWin, TradeLose: Extended;
    Hour, Minute, Sec, Sec100, Year, Month, Day,
      DayOfWeek: Word;

 Begin
    Write(' Input file name: ');
    ReadLn(Name);
    Assign(Infile, Name);
    Reset(Infile);
    Write('Output file name: ');
```

```
ReadLn(Name)
Assign(Outfile, Name);
Rewrite(Outfile);
Randomize;
WriteLn;
Repeat
   GetTime(Hour, Minute, Sec, Sec100);
   GetDate(Year, Month, Day, DayOfWeek);
   ReadLn(Infile, Name);
   WriteLn(Outfile, Name);
   ReadLn(Infile, Capital, TradeWin, TradeLose,
         NSetL);
   WriteLn(Outfile);
   WriteLn(Outfile,
      'Probability of Win   Probability of Ruin');
   Del := 0.05;
   ProbabilityWin := 0.00;
   BoundLower := 0.0;
   BoundUpper := 100 * Capital;
   For Index := 0 to 17 do
      Begin
         ProbabilityWin := ProbabilityWin + Del;
         NSet := 0;
         C22 := 0;
         Repeat
            Cap := Capital;
            Inc(NSet);
            If (NSet / 10 = NSet Div 10) then
               Write(^M, 'Iteration Number ',
                    (NSet + (Index * NSetL)): 1, ' of ',
                    (18 * NSetL): 1);
            Repeat
               Probability := Random;
                 {random betweeen 0 and 1}
               If (Probability <= ProbabilityWin) then
                  Cap := Cap + TradeWin
               else
                  Begin
                     Cap := Cap + TradeLose;
                     If (Cap <= Cl) then
                        Inc(C22)
                     End
```



```
            Until ((Cap >= BoundUpper)
                  or (Cap <= BoundLower))
         Until (NSet >= NSetL);
         ProbabilityLose := C22 / NSet;
         WriteLn(Outfile, '      ',
               ProbabilityWin: 10: 8,
                     ', ProbabilityLose: 10: 8)
      End;
   WriteLn;
   WriteLn;
   WriteLn(Outfile);
   WriteLn('Starting at ', Hour: 2, ':', Minute: 2,
         ':', Sec: 2, ' on ', Month: 2, '/',
         Day, '/', Year);
   WriteLn(Outfile, 'Starting at ', Hour: 2, ':',
         Minute: 2, ':', Sec: 2, ' on ', Month: 2,
         '/', Day, '/', Year);
   GetTime(Hour, Minute, Sec, Sec100);
   GetDate(Year, Month, Day, DayOfWeek);
   WriteLn(' Ending at ', Hour: 2, ':', Minute: 2,
         ':', Sec: 2, ' on ', Month: 2, '/',
         Day, '/', Year);
   WriteLn;
   WriteLn(Outfile, ' Ending at ', Hour: 2, ':',
         Minute: 2, ':', Sec: 2, ' on ', Month: 2,
         '/', Day, '/', Year);
   WriteLn(Outfile)
Until Eof(Infile);
Close(Infile);
Close(Outfile);
End.
```

# B

# BASIC Program to Compute the Risk of Ruin

```
001 REM THIS BASIC PROGRAM IS DESIGNED TO CALCULATE
    THE RISK OF RUIN
002 REM INPUTS: PROB. OF SUCCESS, PAYOFF RATIO,
    UNITS OF CAPITAL
007 OPEN "RUIN.OUT" FOR OUTPUT AS 1
010 PRINT " INPUT CAPITAL: ";
020 INPUT CAPITAL
030 PRINT " INPUT TRADEW: ";
040 INPUT TRADEW
050 PRINT " INPUT TRADEL: ";
060 INPUT TRADEL
070 PRINT " INPUT SETL: ";
080 INPUT SETL
081 NSETL = SETL
082 CLS:PRINT
083 CLS:PRINT #1,
085 PRINT "CAPITAL      TRADEW        TRADEL        SETL "
091 PRINT #1, "CAPITAL    TRADEW        TRADEL        SETL "
092 PRINT CAPITAL,TRADEW,TRADEL,SETL
095 PRINT #1, CAPITAL,TRADEW,TRADEL,SETL
100 DEL = 0.05
110 PROW = 0
120 PRINT " PROB(WIN)  PROB(RUIN)   TIME FOR COMPUTATION "
```





```
125 PRINT #1, " PROB(WIN) PROB(RUIN)
    TIME FOR COMPUTATION "
130 FOR IPR = 1 TO 28
140 PROBW = PROBW + DEL
150 BOUNDL = 0
160 BOUNDU = 100* CAPITAL
170 NSET = 0
210 C22 = 0
211 WIN$ = "W"
212 LOSE$ = "L"
220 PROBL = 1 - PROBW
230 CAP = CAPITAL
240 NSET = NSET + 1
250 NTRADE = 0
260 X = RND
270 NTRADE = NTRADE + 1
280 PROB = X
290 IF( PROB <= PROBW ) THEN EVENT$ = WIN$
300 IF( PROB > PROBW ) THEN EVENT$ = LOSE$
310 IF( EVENT$ = WIN$ ) THEN CAP = CAP + TRADEW
320 IF( EVENT$ = LOSE$) THEN CAP = CAP + TRADEL
330 IF( EVENT$ = WIN$ ) THEN NWIN = NWIN + 1
340 IF( EVENT$ = LOSE$) THEN NLOS = NLOS + 2
350 RUIN = 0
360 IF( CAP <= 0 ) THEN RUIN = 1
370 IF( CAP <= 0 ) THEN NRUIN = NRUIN + 1
380 IF( EVENT = LOSE AND RUIN = 1 ) THEN C22 = C22 + 1
390 IF( CAP >= BOUNDU) THEN GO TO 420
400 IF( CAP <= BOUNDL) THEN GO TO 420
410 GO TO 260
420 IF( NSET >= NSETL ) THEN GO TO 460
430 NWIN = 0
440 NLOS = 0
450 GO TO 230
460 PROBR = C22/NSET
470 PRINT PROBW, PROBR, TIME$
475 PRINT #1, PROBW, PROBR, TIME$
480 NEXT IPR
490 CLOSE 1
500 END
```

C

# Correlation Data for 24 Commodities

This Appendix presents correlation data for 24 commodities between 1983 and 1988. To ensure that correlations are not spurious, the sample period has been subdivided into three equal subperiods, 1983 to 1984, 1985 to 1986, and 1987 to 1988. A positive correlation over 0.80 in each of the three subperiods would suggest that the commodities are positively correlated. Similarly, a negative correlation below -0.80 in each of the three subperiods would suggest that the commodities are negatively correlated.

The trader should be wary of trading the same side of two positively correlated commodities. He or she should select the commodity that offers the highest reward potential. Alternatively, the trader might want to trade opposite sides of two positively correlated commodities; for example, either the Deutsche mark or the Swiss franc, but not both simultaneously. The trader could also spread the Deutsche mark and the Swiss franc, buying one and selling the other.

Using the same logic, it pays to be on the same side of two negatively correlated commodities. The rationale is that if one commodity fares poorly, the other will make up for the poor performance of the first.





Correlation Table for British Pound

| | Correlation Coefficient | | | |
|---|---|---|---|---|
| | 1983-88 | 1983-84 | 1985-86 | 1987-88 |
| Swiss franc | 0.901 | 0.973 | 0.809 | 0.913 |
| Deutsche mark | 0.889 | 0.947 | 0.800 | 0.928 |
| Japanese yen | 0.854 | 0.479 | 0.779 | 0.974 |
| Gold (COMEX) | 0.853 | 0.943 | 0.565 | 0.596 |
| Copper | 0.768 | 0.824 | 0.134 | 0.829 |
| Sugar (world) | 0.646 | 0.823 | 0.710 | 0.686 |
| S&P 500 Stock Index | 0.637 | -0.046 | 0.754 | -0.641 |
| NYSE Composite Index | 0.621 | -0.024 | 0.753 | -0.673 |
| Treasury bonds | 0.517 | 0.206 | 0.786 | -0.507 |
| Treasury bills | 0.496 | 0.099 | 0.798 | -0.176 |
| Treasury notes | 0.494 | 0.208 | 0.801 | -0.534 |
| Soymeal | 0.494 | 0.854 | 0.588 | 0.881 |
| Eurodollar | 0.419 | 0.166 | 0.777 | -0.423 |
| Live cattle | 0.266 | -0.229 | -0.559 | 0.600 |
| Oats | 0.076 | -0.111 | -0.825 | 0.498 |
| Silver (COMEX) | 0.068 | 0.851 | -0.564 | 0.011 |
| Soybeans | 0.018 | 0.732 | -0.754 | 0.882 |
| Hogs | -0.042 | -0.418 | 0.117 | -0.229 |
| Wheat (Chicago) | -0.359 | 0.327 | -0.680 | 0.715 |
| Wheat (Kansas City) | -0.374 | 0.297 | -0.732 | 0.830 |
| Corn | -0.435 | 0.830 | -0.618 | 0.853 |
| Soybean oil | -0.449 | 0.133 | -0.803 | 0.859 |
| Crude oil | -0.508 | 0.811 | -0.609 | -0.542 |

Correlation Table for Corn

| | Correlation Coefficient | | | |
|---|---|---|---|---|
| | **1983-88** | **1983-84** | **1985-86** | **1987-88** |
| Wheat (Kansas City) | 0.891 | 0.440 | 0.825 | 0.803 |
| Soybean oil | 0.886 | 0.573 | 0.871 | 0.848 |
| Wheat (Chicago) | 0.844 | 0.426 | 0.769 | 0.692 |
| Soybeans | 0.826 | 0.925 | 0.875 | 0.912 |
| Crude oil | 0.808 | 0.735 | 0.645 | -0.423 |
| Silver (COMEX) | 0.673 | 0.658 | 0.596 | 0.145 |
| Soymeal | 0.436 | 0.865 | -0.494 | 0.837 |
| Oats | 0.391 | 0.266 | 0.422 | 0.407 |
| Live cattle | 0.094 | -0.126 | 0.369 | 0.704 |
| Sugar (world) | 0.072 | 0.577 | -0.541 | 0.602 |
| Hogs | -0.116 | -0.103 | -0.472 | 0.063 |
| Copper | -0.233 | 0.611 | 0.421 | 0.614 |
| Gold (COMEX) | -0.383 | 0.773 | -0.862 | 0.503 |
| British pound | -0.435 | 0.830 | -0.618 | 0.853 |
| Swiss franc | -0.726 | 0.846 | -0.895 | 0.719 |
| Deutsche mark | -0.743 | 0.830 | -0.876 | 0.726 |
| Japanese yen | -0.780 | 0.643 | -0.849 | 0.866 |
| Treasury bonds | -0.853 | -0.153 | -0.760 | -0.477 |
| S&P 500 Stock Index | -0.862 | -0.283 | -0.749 | -0.523 |
| Eurodollar | -0.866 | -0.106 | -0.839 | -0.440 |
| Treasury notes | -0.869 | -0.156 | -0.804 | -0.514 |
| NYSE Composite Index | -0.869 | -0.281 | -0.741 | -0.548 |
| Treasury bills | -0.897 | -0.138 | -0.853 | -0.229 |



Correlation Table f'or Crude Oil

| | Correlation Coefficient | | | |
|---|---|---|---|---|
| | **1983-88** | **1983-84** | **1985-86** | **1987-88** |
| Wheat (Kansas City) | 0.843 | 0.423 | 0.818 | -0.671 |
| Corn | 0.808 | 0.735 | 0.645 | -0.423 |
| Soybean oil | 0.794 | 0.261 | 0.755 | -0.619 |
| Wheat (Chicago) | 0.767 | 0.468 | 0.686 | -0.697 |
| Silver (COMEX) | 0.631 | 0.862 | 0.824 | 0.547 |
| Soybeans | 0.593 | 0.632 | 0.474 | -0.487 |
| Oats | 0.435 | -0.135 | 0.519 | -0.319 |
| Soymeal | 0.194 | 0.643 | -0.729 | -0.313 |
| Live cattle | 0.168 | -0.287 | 0.533 | -0.465 |
| Hogs | -0.133 | -0.325 | -0.361 | 0.537 |
| Sugar (world) | -0.141 | 0.660 | -0.703 | -0.769 |
| Copper | -0.287 | 0.824 | -0.031 | -0.503 |
| Gold (COMEX) | -0.380 | 0.877 | -0.661 | 0.077 |
| British pound | -0.508 | 0.811 | -0.609 | -0.542 |
| Swiss franc | -0.736 | 0.769 | -0.824 | -0.633 |
| Deutsche mark | -0.748 | 0.784 | -0.836 | -0.664 |
| S&P 500 Stock Index | -0.777 | -0.113 | -0.910 | 0.611 |
| NYSE Composite Index | -0.787 | -0.098 | -0.912 | 0.608 |
| Japanese yen | -0.809 | 0.341 | -0.880 | -0.637 |
| Eurodollar | -0.822 | -0.110 | -0.780 | -0.204 |
| Treasury bills | -0.851 | -0.181 | -0.792 | -0.274 |
| Treasury notes | -0.902 | -0.042 | -0.896 | -0.179 |
| Treasury bonds | -0.914 | -0.025 | -0.917 | -0.195 |

Correlation Table for Copper (Standard)

| | Correlation Coefficient | | | |
|---|---|---|---|---|
| | 1983-88 | 1983-84 | 1985-86 | 1987-88 |
| British pound | 0.768 | 0.824 | 0.134 | 0.829 |
| Gold (COMEX) | 0.694 | 0.906 | -0.188 | 0.678 |
| Swiss franc | 0.669 | 0.806 | -0.132 | 0.905 |
| Deutsche mark | 0.658 | 0.800 | -0.092 | 0.898 |
| Japanese yen | 0.641 | 0.254 | -0.110 | 0.819 |
| Sugar (world) | 0.483 | 0.775 | 0.208 | 0.652 |
| Soymeal | 0.464 | 0.638 | 0.248 | 0.769 |
| Oats | 0.383 | -0.233 | -0.123 | 0.707 |
| Live cattle | 0.375 | -0.217 | -0.043 | 0.276 |
| S&P 500 Stock Index | 0.352 | 0.030 | -0.037 | -0.622 |
| NYSE Composite Index | 0.328 | 0.049 | -0.030 | -0.663 |
| Treasury bills | 0.251 | 0.120 | -0.180 | -0.183 |
| Treasury bonds | 0.190 | 0.274 | -0.034 | -0.497 |
| Treasury notes | 0.169 | 0.261 | -0.059 | -0.520 |
| Eurodollar | 0.165 | 0.201 | -0.193 | -0.424 |
| Soybeans | 0.135 | 0.521 | 0.268 | 0.651 |
| Silver (COMEX) | 0.100 | 0.937 | 0.224 | -0.049 |
| Wheat (Chicago) | -0.025 | 0.531 | 0.313 | 0.657 |
| Wheat (Kansas City) | -0.059 | 0.355 | 0.250 | 0.714 |
| Soybean oil | -0.127 | 0.019 | 0.118 | 0.717 |
| Hogs | -0.202 | -0.346 | -0.483 | -0.481 |
| Corn | -0.233 | 0.611 | 0.421 | 0.614 |
| Crude oil | -0.287 | 0.824 | -0.031 | -0.503 |



Correlation Table for Deutsche Mark

| | Correlation Coefficient | | | |
|---|---|---|---|---|
| | 1983-88 | 1983-84 | 1985-86 | 1987-88 |
| Swiss franc | 0.998 | 0.966 | 0.997 | 0.991 |
| Japanese yen | 0.983 | 0.642 | 0.981 | 0.933 |
| British pound | 0.889 | 0.947 | 0.800 | 0.928 |
| S&P 500 Stock Index | 0.857 | -0.195 | 0.933 | -0.766 |
| NYSE Composite Index | 0.846 | -0.170 | 0.928 | -0.796 |
| Gold (COMEX) | 0.841 | 0.893 | 0.875 | 0.561 |
| Treasury bonds | 0.748 | 0.048 | 0.938 | -0.363 |
| Treasury notes | 0.734 | 0.053 | 0.964 | -0.388 |
| Treasury bills | 0.724 | -0.013 | 0.933 | -0.041 |
| Copper | 0.658 | 0.800 | -0.092 | 0.898 |
| Eurodollar | 0.651 | 0.035 | 0.922 | -0.303 |
| Sugar (world) | 0.446 | 0.679 | 0.748 | 0.762 |
| live cattle | 0.205 | -0.101 | -0.455 | 0.420 |
| Soymeal | 0.205 | 0.749 | 0.734 | 0.779 |
| Hogs | 0.099 | -0.270 | 0.414 | -0.447 |
| Oats | -0.003 | -0.089 | -0.530 | 0.599 |
| Silver (COMEX) | -0.222 | 0.785 | -0.726 | -0.132 |
| Soybeans | -0.307 | 0.686 | -0.800 | 0.739 |
| Wheat (Chicago) | -0.596 | 0.297 | -0.730 | 0.737 |
| Wheat (Kansas City) | -0.643 | 0.222 | -0.862 | 0.799 |
| Soybean oil | -0.691 | 0.192 | -0.932 | 0.787 |
| Corn | -0.743 | 0.830 | -0.876 | 0.726 |
| Crude oil | -0.748 | 0.784 | -0.836 | -0.664 |

Correlation Table for Treasury Bonds

| | Correlation Coefficient | | | |
|---|---|---|---|---|
| | 1983-88 | 1983-84 | 1985-86 | 1987-88 |
| Treasury notes | 0.996 | 0.996 | 0.993 | 0.996 |
| Treasury bills | 0.942 | 0.876 | 0.928 | 0.842 |
| Eurodollar | 0.937 | 0.933 | 0.919 | 0.948 |
| NYSE Composite Index | 0.832 | 0.748 | 0.976 | 0.044 |
| S&P 500 Stock Index | 0.818 | 0.747 | 0.975 | -0.004 |
| Japanese yen | 0.776 | -0.295 | 0.950 | -0.451 |
| Deutsche mark | 0.748 | 0.048 | 0.938 | -0.363 |
| Swiss franc | 0.736 | 0.205 | 0.929 | -0.394 |
| British pound | 0.517 | 0.206 | 0.786 | -0.507 |
| Gold (COMEX) | 0.373 | 0.215 | 0.738 | -0.826 |
| Sugar (world) | 0.206 | 0.580 | 0.775 | -0.032 |
| Copper | 0.190 | 0.274 | -0.034 | -0.497 |
| Hogs | 0.064 | -0.634 | 0.383 | -0.078 |
| Live cattle | -0.234 | -0.175 | -0.527 | -0.284 |
| Soymeal | -0.235 | 0.271 | 0.735 | -0.617 |
| Oats | -0.520 | -0.091 | -0.588 | -0.544 |
| Silver (COMEX) | -0.597 | 0.290 | -0.849 | -0.636 |
| Soybeans | -0.655 | -0.027 | -0.669 | -0.411 |
| Wheat (Chicago) | -0.808 | 0.117 | -0.734 | -0.282 |
| Corn | -0.853 | -0.153 | -0.760 | -0.477 |
| Soybean oil | -0.870 | -0.486 | -0.864 | -0.316 |
| Wheat (Kansas City) | -0.891 | 0.209 | -0.871 | -0.406 |
| Crude oil | -0.914 | -0.025 | -0.917 | -0.195 |



Correlation Table for Eurodollar

| | Correlation Coefficient | | | |
|---|---|---|---|---|
| | 1983-88 | 1983-84 | 1985-86 | 1987–88 |
| Treasury bills | 0.989 | 0.976 | 0.995 | 0.909 |
| Treasury notes | 0.953 | 0.937 | 0.946 | 0.945 |
| Treasury bonds | 0.937 | 0.933 | 0.919 | 0.948 |
| NYSE Composite Index | 0.777 | 0.589 | 0.887 | 0.000 |
| S&P 500 Stock Index | 0.762 | 0.589 | 0.890 | -0.041 |
| Japanese yen | 0.692 | -0.157 | 0.907 | -0.364 |
| Deutsche mark | 0.651 | 0.035 | 0.922 | -0.303 |
| Swiss franc | 0.641 | 0.195 | 0.928 | -0.332 |
| British pound | 0.419 | 0.166 | 0.777 | -0.423 |
| Gold (COMEX) | 0.266 | 0.158 | 0.839 | -0.753 |
| Copper | 0.165 | 0.201 | -0.193 | -0.424 |
| Sugar (world) | 0.057 | 0.480 | 0.617 | -0.042 |
| Hogs | 0.014 | -0.503 | 0.478 | -0.051 |
| Live cattle | -0.236 | -0.002 | -0.501 | -0.263 |
| Soymeal | -0.353 | 0.292 | 0.554 | -0.524 |
| Oats | -0.547 | 0.034 | -0.534 | -0.484 |
| Silver (COMEX) | -0.661 | 0.198 | -0.700 | -0.611 |
| Soybeans | -0.718 | 0.057 | -0.761 | -0.319 |
| Wheat (Chicago) | -0.804 | 0.060 | -0.795 | -0.262 |
| Soybean oil | -0.821 | -0.327 | -0.829 | -0.238 |
| Crude oil | -0.822 | -0.110 | -0.780 | -0.204 |
| Corn | -0.866 | -0.106 | -0.839 | -0.440 |
| Wheat (Kansas City) | -0.883 | 0.148 | -0.898 | -0.370 |

Correlation Table for Gold (COMEX)

| | Correlation Coefficient | | | |
|---|---|---|---|---|
| | 1983-88 | 1983-84 | 1985-86 | 1987-88 |
| Swiss franc | 0.855 | 0.916 | 0.879 | 0.627 |
| British pound | 0.853 | 0.943 | 0.565 | 0.596 |
| Deutsche mark | 0.841 | 0.893 | **0.875** | **0.561** |
| Japanese yen | 0.769 | **0.367** | **0.835** | **0.553** |
| Copper | 0.694 | 0.906 | **-0.188** | **0.678** |
| Sugar (world) | 0.618 | **0.835** | **0.492** | 0.138 |
| S&P 500 Stock Index | **0.606** | -0.014 | **0.745** | **-0.244** |
| NYSE Composite Index | **0.584** | **0.006** | **0.740** | **-0.299** |
| Soymeal | **0.554** | **0.796** | **0.522** | **0.656** |
| Treasury bonds | **0.373** | **0.215** | **0.738** | **-0.826** |
| Treasury notes | **0.353** | **0.208** | 0.791 | **-0.845** |
| Oats | 0.351 | -0.139 | -0.289 | **0.622** |
| Treasury bills | **0.342** | **0.086** | **0.841** | **-0.513** |
| Live cattle | **0.320** | **-0.287** | **-0.333** | **0.094** |
| Silver (COMEX) | 0.293 | 0.952 | **-0.440** | **0.641** |
| Eurodollar | **0.266** | 0.158 | 0.839 | **-0.753** |
| Hogs | 0.108 | **-0.437** | **0.439** | **-0.004** |
| Soybeans | 0.105 | 0.701 | **-0.734** | **0.409** |
| Wheat (Chicago) | -0.269 | **0.440** | **-0.644** | **0.306** |
| Wheat (Kansas City) | **-0.280** | **0.367** | **-0.766** | **0.421** |
| Soybean oil | **-0.373** | 0.166 | **-0.765** | **0.339** |
| Crude oil | **-0.380** | **0.877** | **-0.661** | **0.077** |
| Corn | **-0.383** | **0.773** | **-0.862** | **0.503** |



Correlation Table for Japanese Yen

| | Correlation Coefficient | | | |
|---|---|---|---|---|
| | 1983-88 | 1983-84 | 1985-86 | 1987-88 |
| Deutsche mark | 0.983 | **0.642** | 0.981 | 0.933 |
| Swiss franc | 0.981 | 0.613 | 0.983 | 0.925 |
| S&P 500 Stock Index | **0.864** | **-0.363** | 0.949 | **-0.644** |
| NYSE Composite Index | **0.855** | **-0.350** | 0.945 | **-0.676** |
| British pound | **0.854** | 0.479 | 0.779 | 0.974 |
| Treasury bonds | **0.776** | -0.295 | 0.950 | **-0.451** |
| Gold (COMEX) | 0.769 | **0.367** | **0.835** | **0.553** |
| Treasury bills | **0.764** | **-0.157** | 0.917 | -0.138 |
| Treasury notes | **0.763** | -0.279 | 0.963 | |
| Eurodollar | 0.692 | **-0.157** | 0.907 | -0.477 -0.364 |
| Sugar (world) | 0.341 0.367 | 0.254 0.669 | -0.110 0.758 | 0.728 0.819 |
| Live cattle | 0.210 0.145 | 0.488 0.265 | **-0.438** | **0.630** |
| Soymeal Hogs | 0.129 | **0.375** | 0.756 0.483 | -0.237 0.835 |
| Oats | **-0.072** | **0.182** | **-0.573** | **0.521** |
| Silver (COMEX) | -0.366 -0.335 | 0.493 0.150 | -0.794 -0.753 | -0.021 0.884 |
| Soybeans Wheat (Chicago) | **-0.635** | **-0.047** | **-0.756** | **0.773** |
| Wheat (Kansas City) | **-0.682** | -0.015 | -0.881 | 0.871 |
| Soybean oil | **-0.707** | **0.373** | -0.921 | 0.890 |
| Crude oil | -0.780 -0.809 | **0.643** | -0.849 | **0.866** |
| | | **0.341** | **-0.880** | **-0.637** |

Correlation Table for Live Cattle

| | Correlation Coefficient | | | |
|---|---|---|---|---|
| | 1983–88 | 1983–84 | 1985–86 | 1987–88 |
| Oats | **0.572** | 0.015 | **0.543** | 0.192 |
| Copper | **0.375** | **-0.217** | **-0.043** | **0.276** |
| Wheat (Kansas City) | 0.338 | **-0.402** | **0.647** | 0.678 |
| Soymeal | 0.321 | -0.289 | -0.135 | 0.461 |
| Gold (COMEX) | **0.320** | -0.287 | **-0.333** | 0.094 |
| Wheat (Chicago) | 0.316 | -0.410 | 0.671 | **0.563** |
| Soybeans | **0.303** | -0.199 | 0.383 | **0.676** |
| British pound | **0.266** | -0.229 | -0.559 | **0.600** |
| Hogs | **0.230** | **0.531** | 0.139 | 0.038 |
| Silver (COMEX) | 0.216 | -0.413 | 0.508 | **0.020** |
| Japanese yen | 0.210 | 0.488 | -0.438 | **0.630** |
| Soybean oil | 0.210 | **-0.030** | **0.422** | **0.643** |
| Swiss franc | 0.208 | -0.101 | **-0.454** | 0.393 |
| Deutsche mark | **0.205** | -0.101 | **-0.455** | **0.420** |
| Crude oil | 0.168 | -0.287 | **0.533** | **-0.465** |
| Sugar (world) | 0.098 | -0.480 | -0.396 | **0.450** |
| Corn | 0.094 | -0.126 | 0.369 | **0.704** |
| S&P 500 Stock Index | **0.050** | -0.292 | **-0.526** | -0.175 |
| NYSE Composite Index | 0.028 | -0.292 | **-0.530** | -0.183 |
| Treasury bills | -0.186 | 0.029 | **-0.525** | **-0.213** |
| Treasury bonds | **-0.234** | -0.175 | **-0.527** | -0.284 |
| Eurodollar | **-0.236** | **-0.002** | **-0.501** | **-0.263** |
| Treasury notes | **-0.245** | -0.151 | -0.513 | **-0.300** |



Correlation Table for Live Hogs

| | Correlation Coefficient | | | |
|---|---|---|---|---|
| | 1983-88 | 1983-84 | 1985-86 | 1987-88 |
| Live cattle | **0.230** | **0.531** | 0.139 | 0.038 |
| S&P 500 Stock Index | **0.151** | **-0.546** | **0.432** | **0.473** |
| NYSE Composite Index | 0.149 | -0.549 | **0.425** | **0.476** |
| Japanese yen | **0.145** | **0.265** | 0.483 | **-0.237** |
| Gold (COMEX) | 0.108 | **-0.437** | 0.439 | **-0.004** |
| Swiss franc | 0.101 | **-0.345** | **0.437** | **-0.423** |
| Deutsche mark | 0.099 | **-0.270** | **0.414** | **-0.447** |
| Treasury bonds | **0.064** | **-0.634** | 0.383 | -0.078 |
| Treasury notes | 0.059 | **-0.624** | 0.395 | -0.085 |
| Treasury bills | 0.029 | **-0.417** | **0.446** | -0.152 |
| Oats | **0.027** | **0.145** | **0.046** | -0.478 |
| Eurodollar | **0.014** | **-0.503** | 0.478 | -0.051 |
| Soybeans | **-0.026** | -0.195 | -0.186 | **0.022** |
| British pound | **-0.042** | -0.418 | 0.117 | -0.229 |
| Soymeal | **-0.051** | -0.429 | **0.237** | -0.099 |
| Silver (COMEX) | **-0.061** | -0.495 | -0.438 | **0.552** |
| Soybean oil | **-0.063** | 0.280 | -0.288 | -0.165 |
| Corn | -0.116 | -0.103 | **-0.472** | **0.063** |
| Crude oil | -0.133 | **-0.325** | **-0.361** | **0.537** |
| Wheat (Kansas City) | -0.186 | **-0.377** | **-0.437** | -0.339 |
| Wheat (Chicago) | -0.196 | -0.176 | **-0.371** | -0.382 |
| Copper | **-0.202** | **-0.346** | -0.483 | -0.481 |
| Sugar (world) | -0.239 | **-0.660** | **0.036** | **-0.445** |

Correlation Table for Treasury Notes

| | Correlation Coefficient | | | |
|---|---|---|---|---|
| | 1983–88 | 1983–84 | 1985–86 | 1987–88 |
| Treasury bonds | 0.996 | 0.996 | 0.993 | 0.996 |
| Treasury bills | 0.955 | 0.879 | 0.953 | 0.822 |
| Eurodollar | 0.953 | 0.937 | 0.946 | 0.945 |
| NYSE Composite Index | 0.825 | 0.733 | 0.970 | 0.061 |
| S&P 500 Stock Index | 0.811 | 0.731 | 0.971 | 0.010 |
| Japanese yen | 0.763 | -0.279 | 0.963 | -0.477 |
| Deutsche mark | 0.734 | 0.053 | 0.964 | -0.388 |
| Swiss franc | 0.722 | 0.206 | 0.956 | -0.422 |
| British pound | 0.494 | 0.208 | 0.801 | -0.534 |
| Gold (COMEX) | 0.353 | 0.208 | 0.791 | -0.845 |
| Copper | 0.169 | 0.261 | -0.059 | -0.520 |
| Sugar (world) | 0.168 | 0.565 | 0.759 | -0.043 |
| Hogs | 0.059 | -0.624 | 0.395 | -0.085 |
| Live cattle | -0.245 | -0.151 | -0.513 | -0.300 |
| Soymeal | -0.273 | 0.265 | 0.725 | -0.645 |
| Oats | -0.541 | -0.104 | -0.577 | -0.559 |
| Silver (COMEX) | -0.621 | 0.276 | -0.811 | -0.644 |
| Soybeans | -0.685 | -0.033 | -0.723 | -0.436 |
| Wheat (Chicago) | -0.817 | 0.091 | -0.742 | -0.292 |
| Corn | -0.869 | -0.156 | -0.804 | -0.514 |
| Soybean oil | -0.877 | -0.488 | -0.888 | -0.337 |
| Wheat (Kansas City) | -0.901 | 0.196 | -0.878 | -0.426 |
| Crude oil | -0.902 | -0.042 | -0.896 | -0.179 |



Correlation Table for NYSE Composite Index

| | Correlation Coefficient | | | |
|---|---|---|---|---|
| | 1983–88 | 1983–84 | 1985–86 | 1987–88 |
| S&P 500 Stock Index | 0.999 | 0.991 | 1.000 | 0.997 |
| Japanese yen | 0.855 | -0.350 | 0.945 | -0.676 |
| Deutsche mark | 0.846 | -0.170 | 0.928 | -0.796 |
| Treasury bonds | 0.832 | 0.748 | 0.976 | 0.044 |
| Swiss franc | 0.828 | -0.022 | 0.917 | -0.776 |
| Treasury notes | 0.825 | 0.733 | 0.970 | 0.061 |
| Treasury bills | 0.816 | 0.533 | 0.892 | -0.257 |
| Eurodollar | 0.777 | 0.589 | 0.887 | 0.000 |
| British pound | 0.621 | -0.024 | 0.753 | -0.673 |
| Gold (COMEX) | 0.584 | 0.006 | 0.740 | -0.299 |
| Copper | 0.328 | 0.049 | -0.030 | -0.663 |
| Sugar (world) | 0.151 | 0.370 | 0.735 | -0.753 |
| Hogs | 0.149 | -0.549 | 0.425 | 0.476 |
| Live cattle | 0.028 | -0.292 | -0.530 | -0.183 |
| Soymeal | -0.162 | 0.050 | 0.710 | -0.612 |
| Oats | -0.248 | 0.016 | -0.532 | -0.499 |
| Silver (COMEX) | -0.419 | 0.092 | -0.855 | 0.358 |
| Soybeans | -0.590 | -0.164 | -0.634 | -0.592 |
| Wheat (Chicago) | -0.775 | 0.134 | -0.734 | -0.698 |
| Crude oil | -0.787 | -0.098 | -0.912 | 0.608 |
| Soybean oil | -0.805 | -0.421 | -0.834 | -0.679 |
| Wheat (Kansas City) | -0.822 | 0.273 | -0.874 | -0.663 |
| Corn | -0.869 | -0.281 | -0.741 | -0.548 |

Correlation Table for Oats

| | Correlation Coefficient | | | |
|---|---|---|---|---|
| | 1983-88 | 1983-84 | 1985-86 | 1987-88 |
| Soybeans | 0.615 | 0.467 | 0.612 | 0.365 |
| Wheat (Kansas City) | 0.613 | 0.469 | 0.610 | 0.636 |
| Wheat (Chicago) | 0.596 | 0.409 | 0.643 | 0.612 |
| Live cattle | 0.572 | 0.015 | 0.543 | 0.192 |
| Silver (COMEX) | 0.557 | -0.144 | 0.492 | 0.115 |
| Soymeal | 0.545 | 0.295 | -0.465 | 0.578 |
| Soybean oil | 0.529 | 0.656 | 0.648 | 0.427 |
| Crude oil | 0.435 | -0.135 | 0.519 | -0.319 |
| Corn | 0.391 | 0.266 | 0.422 | 0.407 |
| Copper | 0.383 | -0.233 | -0.123 | 0.707 |
| Gold (COMEX) | 0.351 | -0.139 | -0.289 | 0.622 |
| Sugar (world) | 0.208 | -0.032 | -0.619 | 0.371 |
| British pound | 0.076 | -0.111 | -0.825 | 0.498 |
| Hogs | 0.027 | 0.145 | 0.046 | -0.478 |
| Swiss franc | 0.007 | -0.017 | -0.559 | 0.636 |
| Deutsche mark | -0.003 | -0.089 | -0.530 | 0.599 |
| Japanese yen | -0.072 | 0.182 | -0.573 | 0.521 |
| S&P 500 Stock Index | -0.219 | 0.038 | -0.528 | -0.456 |
| NYSE Composite index | -0.248 | 0.016 | -0.532 | -0.499 |
| Treasury bills | -0.500 | 0.095 | -0.572 | -0.307 |
| Treasury bonds | -0.520 | -0.091 | -0.588 | -0.544 |
| Treasury notes | -0.541 | -0.104 | -0.577 | -0.559 |
| Eurodollar | -0.547 | 0.034 | -0.534 | -0.484 |



Correlation Table for Soybeans

| | Correlation Coefficient | | | |
|---|---|---|---|---|
| | 1983-88 | 1983-84 | 1985-86 | 1987-88 |
| Corn | 0.826 | 0.925 | 0.875 | 0.912 |
| Soymeal | 0.811 | 0.919 | -0.443 | 0.886 |
| Silver (COMEX) | 0.788 | 0.627 | 0.471 | -0.033 |
| Soybean oil | 0.788 | 0.703 | 0.884 | 0.948 |
| Wheat (Kansas City) | 0.780 | 0.565 | 0.719 | 0.815 |
| Wheat (Chicago) | 0.745 | 0.544 | 0.698 | 0.729 |
| Oats | 0.615 | 0.467 | 0.612 | 0.365 |
| Crude oil | 0.593 | 0.632 | 0.474 | -0.487 |
| Sugar (world) | 0.425 | 0.597 | -0.612 | 0.683 |
| live cattle | 0.303 | -0.199 | 0.383 | 0.676 |
| Copper | 0.135 | 0.521 | 0.268 | 0.651 |
| Gold (COMEX) | 0.105 | 0.701 | -0.734 | 0.409 |
| British pound | 0.018 | 0.732 | -0.754 | 0.882 |
| Hogs | -0.026 | -0.195 | -0.186 | 0.022 |
| Swiss franc | -0.281 | 0.746 | -0.821 | 0.706 |
| Deutsche mark | -0.307 | 0.686 | -0.800 | 0.739 |
| Japanese yen | -0.366 | 0.493 | -0.753 | 0.884 |
| S&P 500 Stock Index | -0.572 | -0.156 | -0.642 | -0.573 |
| NYSE Composite Index | -0.590 | -0.164 | -0.634 | -0.592 |
| Treasury bonds | -0.655 | -0.027 | -0.669 | -0.411 |
| Treasury notes | -0.685 | -0.033 | -0.723 | -0.436 |
| Treasury bills | -0.712 | 0.037 | -0.787 | -0.151 |
| Eurodollar | -0.718 | 0.057 | -0.761 | -0.319 |

Correlation Table for Swiss Franc

| | Correlation Coefficient | | | |
|---|---|---|---|---|
| | 1983–88 | 1983-84 | 1985-86 | 1987–88 |
| Deutsche mark | 0.998 | 0.966 | 0.997 | 0.991 |
| Japanese yen | 0.981 | 0.613 | 0.983 | 0.925 |
| British pound | 0.901 | 0.973 | 0.809 | 0.913 |
| Gold (COMEX) | 0.855 | 0.916 | 0.879 | 0.627 |
| S&P 500 Stock Index | 0.840 | -0.045 | 0.922 | -0.741 |
| NYSE Composite Index | 0.828 | -0.022 | 0.917 | -0.776 |
| Treasury bonds | 0.736 | 0.205 | 0.929 | -0.394 |
| Treasury notes | 0.722 | 0.206 | 0.956 | -0.422 |
| Treasury bills | 0.714 | 0.139 | 0.940 | -0.057 |
| Copper | 0.669 | 0.806 | -0.132 | 0.905 |
| Eurodollar | 0.641 | 0.195 | 0.928 | -0.332 |
| Sugar (world) | 0.472 | 0.786 | 0.733 | 0.720 |
| Soymeal | 0.237 | 0.846 | 0.715 | 0.763 |
| Live cattle | 0.208 | -0.101 | -0.454 | 0.393 |
| Hogs | 0.101 | -0.345 | 0.437 | -0.423 |
| Oats | 0.007 | -0.017 | -0.559 | 0.636 |
| Silver (COMEX) | -0.196 | 0.804 | -0.721 | -0.051 |
| Soybeans | -0.281 | 0.746 | -0.821 | 0.706 |
| Wheat (Chicago) | -0.586 | 0.324 | -0.757 | 0.720 |
| Wheat (Kansas City) | -0.628 | 0.292 | -0.877 | 0.785 |
| Soybean oil | -0.681 | 0.170 | -0.937 | 0.753 |
| Corn | -0.726 | 0.846 | -0.895 | 0.719 |
| Crude oil | -0.736 | 0.769 | -0.824 | -0.633 |



Correlation Table for Soymeal

| | Correlation Coefficient | | | |
|---|---|---|---|---|
| | 1983-88 | 1983-84 | 1985-86 | 1987-88 |
| Soybeans | 0.811 | 0.919 | -0.443 | 0.886 |
| Sugar (world) | 0.765 | 0.814 | 0.780 | 0.540 |
| Silver (COMEX) | 0.714 | 0.731 | -0.578 | 0.112 |
| Gold (COMEX) | 0.554 | 0.796 | 0.522 | 0.656 |
| Oats | 0.545 | 0.295 | -0.465 | 0.578 |
| British pound | 0.494 | 0.854 | 0.588 | 0.881 |
| Copper | 0.464 | 0.638 | 0.248 | 0.769 |
| Corn | 0.436 | 0.865 | -0.494 | 0.837 |
| Wheat (Kansas City) | 0.434 | 0.544 | -0.462 | 0.737 |
| Wheat (Chicago) | 0.419 | 0.517 | -0.314 | 0.624 |
| Live cattle | 0.321 | -0.289 | -0.135 | 0.461 |
| Soybean oil | 0.311 | 0.379 | -0.775 | 0.791 |
| Swiss franc | 0.237 | 0.846 | 0.715 | 0.763 |
| Deutsche mark | 0.205 | 0.749 | 0.734 | 0.779 |
| Crude oil | 0.194 | 0.643 | -0.729 | -0.313 |
| Japanese yen | 0.129 | 0.375 | 0.756 | 0.835 |
| Hogs | -0.051 | -0.429 | 0.237 | -0.099 |
| S&P 500 Stock Index | -0.140 | 0.050 | 0.710 | -0.576 |
| NYSE Composite Index | -0.162 | 0.050 | 0.710 | -0.612 |
| Treasury bonds | -0.235 | 0.271 | 0.735 | -0.617 |
| Treasury notes | -0.273 | 0.265 | 0.725 | -0.645 |
| Treasury bills | -0.317 | 0.242 | 0.576 | -0.292 |
| Eurodollar | -0.353 | 0.292 | 0.554 | -0.524 |

Correlation Table for Sugar (#11 World)

| | Correlation Coefficient | | | |
|---|---|---|---|---|
| | 1983-88 | 1983-84 | 1985-86 | 1987-88 |
| Soymeal | 0.765 | 0.814 | 0.780 | 0.540 |
| British pound | 0.646 | 0.823 | 0.710 | 0.686 |
| Gold (COMEX) | 0.618 | 0.835 | 0.492 | 0.138 |
| Silver (COMEX) | 0.486 | 0.855 | -0.660 | -0.447 |
| Copper | 0.483 | 0.775 | 0.208 | 0.652 |
| Swiss franc | 0.472 | 0.786 | 0.733 | 0.720 |
| Deutsche mark | 0.446 | 0.679 | 0.748 | 0.762 |
| Soybeans | 0.425 | 0.597 | -0.612 | 0.683 |
| Japanese yen | 0.367 | 0.069 | 0.758 | 0.728 |
| Oats | 0.208 | -0.032 | -0.619 | 0.371 |
| Treasury bonds | 0.206 | 0.580 | 0.775 | -0.032 |
| Treasury notes | 0.168 | 0.565 | 0.759 | -0.043 |
| S&P 500 Stock Index | 0.161 | 0.353 | 0.735 | -0.753 |
| NYSE Composite Index | 0.151 | 0.370 | 0.735 | -0.753 |
| Wheat (Chicago) | 0.110 | 0.487 | -0.480 | 0.825 |
| Live cattle | 0.098 | -0.480 | -0.396 | 0.450 |
| Wheat (Kansas City) | 0.074 | 0.476 | -0.600 | 0.783 |
| Treasury bills | 0.073 | 0.397 | 0.648 | 0.102 |
| Corn | 0.072 | 0.577 | -0.541 | 0.602 |
| Eurodollar | 0.057 | 0.480 | 0.617 | -0.042 |
| Soybean oil | -0.124 | -0.048 | -0.815 | 0.818 |
| Crude oil | -0.141 | 0.660 | -0.703 | -0.769 |
| Hogs | -0.239 | -0.660 | 0.036 | -0.445 |



Correlation Table for Soybean Oil

| | Correlation Coefficient | | | |
|---|---|---|---|---|
| | 1983-88 | 1983-84 | 1985-86 | 1987-88 |
| Corn | 0.886 | 0.573 | 0.871 | 0.848 |
| Wheat (Kansas City) | 0.868 | 0.410 | 0.804 | 0.876 |
| Wheat (Chicago) | 0.837 | 0.420 | 0.727 | 0.838 |
| Crude oil | 0.794 | 0.261 | 0.755 | -0.619 |
| Soybeans | 0.788 | 0.703 | 0.884 | 0.948 |
| Silver (COMEX) | 0.535 | 0.134 | 0.697 | -0.196 |
| Oats | 0.529 | 0.656 | 0.648 | 0.427 |
| Soymeal | 0.311 | 0.379 | -0.775 | 0.791 |
| Live cattle | 0.210 | -0.030 | 0.422 | 0.643 |
| Hogs | -0.063 | 0.280 | -0.288 | -0.165 |
| Sugar (world) | -0.124 | -0.048 | -0.815 | 0.818 |
| Copper | -0.127 | 0.019 | 0.118 | 0.717 |
| Gold (COMEX) | -0.373 | 0.166 | -0.765 | 0.339 |
| British pound | -0.449 | 0.133 | -0.803 | 0.859 |
| Swiss franc | -0.681 | 0.170 | -0.937 | 0.753 |
| Deutsche mark | -0.691 | 0.192 | -0.932 | 0.787 |
| Japanese yen | -0.707 | 0.373 | -0.921 | 0.890 |
| S&P 500 Stock Index | -0.795 | -0.398 | -0.840 | -0.662 |
| NYSE Composite index | -0.805 | -0.421 | -0.834 | -0.679 |
| Eurodollar | -0.821 | -0.327 | -0.829 | -0.238 |
| Treasury bills | -0.833 | -0.279 | -0.855 | -0.078 |
| Treasury bonds | -0.870 | -0.486 | -0.864 | -0.316 |
| Treasury notes | -0.877 | -0.488 | -0.888 | -0.337 |

Correlation Table for S&P 500 Stock Index

| | Correlation Coefficient | | | |
|---|---|---|---|---|
| | 1983–88 | 1983-84 | 1985-86 | 1987–88 |
| NYSE Composite Index | 0.999 | 0.991 | 1 .000 | 0.997 |
| Japanese yen | 0.864 | -0.363 | 0.949 | -0.644 |
| Deutsche mark | 0.857 | -0.195 | 0.933 | -0.766 |
| Swiss franc | 0.840 | -0.045 | 0.922 | -0.741 |
| Treasury bonds | 0.81% | 0.747 | 0.975 | -0.004 |
| Treasury notes | 0.811 | 0.731 | 0.971 | 0.010 |
| Treasury bills | 0.804 | 0.530 | 0.894 | -0.286 |
| Eurodollar | 0.762 | 0.589 | 0.890 | -0.041 |
| British pound | 0.637 | -0.046 | 0.754 | -0.641 |
| Gold (COMEX) | 0.606 | -0.014 | 0.745 | -0.244 |
| Copper | 0.352 | 0.030 | -0.037 | -0.622 |
| Sugar (world) | 0.161 | 0.353 | 0.735 | -0.753 |
| Hogs | 0.151 | -0.546 | 0.432 | 0.473 |
| Live cattle | 0.050 | -0.292 | -0.526 | -0.175 |
| Soymeal | -0.140 | 0.050 | 0.710 | -0.576 |
| Oats | -0.219 | 0.03% | -0.52% | -0.456 |
| Silver (COMEX) | -0.399 | 0.079 | -0.855 | 0.393 |
| Soybeans | -0.572 | -0.156 | -0.642 | -0.573 |
| Wheat (Chicago) | -0.764 | 0.150 | -0.737 | -0.685 |
| Crude oil | -0.777 | -0.113 | -0.910 | 0.611 |
| Soybean oil | -0.795 | -0.39% | -0.840 | -0.662 |
| Wheat (Kansas City) | -0.80% | 0.30% | -0.876 | -0.640 |
| Corn | -0.862 | -0.283 | -0.749 | -0.523 |



Correlation Table for Silver (COMEX)

| | Correlation Coefficient | | | |
|---|---|---|---|---|
| | 1983–88 | 1983-84 | 1985-86 | 1987–88 |
| Soybeans | 0.78% | 0.627 | 0.471 | -0.033 |
| Soymeal | 0.714 | 0.731 | -0.57% | 0.112 |
| Corn | 0.673 | 0.65% | 0.596 | 0.145 |
| Wheat (Kansas City) | 0.659 | 0.456 | 0.771 | -0.103 |
| Crude oil | 0.631 | 0.862 | 0.824 | 0.547 |
| Wheat (Chicago) | 0.613 | 0.577 | 0.692 | -0.226 |
| Oats | 0.557 | -0.144 | 0.492 | 0.115 |
| Soybean oil | 0.535 | 0.134 | 0.697 | -0.196 |
| Sugar (world) | 0.486 | 0.855 | -0.660 | -0.447 |
| Gold (COMEX) | 0.293 | 0.952 | -0.440 | 0.641 |
| live cattle | 0.216 | -0.413 | 0.50% | 0.020 |
| Copper | 0.100 | 0.937 | 0.224 | -0.049 |
| British pound | 0.06% | 0.851 | -0.564 | 0.011 |
| Hogs | -0.061 | -0.495 | -0.43% | 0.552 |
| Swiss franc | -0.196 | 0.804 | -0.721 | -0.051 |
| Deutsche mark | -0.222 | 0.785 | -0.726 | -0.132 |
| Japanese yen | -0.335 | 0.150 | -0.794 | -0.021 |
| S&P 500 Stock Index | -0.399 | 0.079 | -0.855 | 0.393 |
| NYSE Composite Index | -0.419 | 0.092 | -0.855 | 0.35% |
| Treasury bonds | -0.597 | 0.290 | -0.849 | -0.636 |
| Treasury notes | -0.621 | 0.276 | -0.811 | -0.644 |
| Treasury bills | -0.659 | 0.117 | -0.706 | -0.55% |
| Eurodollar | -0.661 | 0.19% | -0.700 | -0.611 |

Correlation Table for Treasury Bills

| | Correlation Coefficient | | | |
|---|---|---|---|---|
| | 1983-88 | 1983-84 | 1985-86 | 1987-88 |
| Eurodollar | 0.989 | 0.976 | 0.995 | 0.909 |
| Treasury notes | 0.955 | 0.879 | 0.953 | 0.822 |
| Treasury bonds | 0.942 | 0.876 | 0.92% | 0.842 |
| NYSE Composite Index | 0.816 | 0.533 | 0.892 | -0.257 |
| S&P 500 Stock Index | 0.804 | 0.530 | 0.894 | -0.286 |
| Japanese yen | 0.764 | -0.157 | 0.917 | -0.138 |
| Deutsche mark | 0.724 | -0.013 | 0.933 | -0.041 |
| Swiss franc | 0.714 | 0.139 | 0.940 | -0.057 |
| British pound | 0.496 | 0.099 | 0.79% | -0.176 |
| Gold (COMEX) | 0.342 | 0.086 | 0.841 | -0.513 |
| Copper | 0.251 | 0.120 | -0.180 | -0.183 |
| Sugar (world) | 0.073 | 0.397 | 0.64% | 0.102 |
| Hogs | 0.029 | -0.417 | 0.446 | -0.152 |
| Live cattle | -0.186 | 0.029 | -0.525 | -0.213 |
| Soymeal | -0.317 | 0.242 | 0.576 | -0.292 |
| Oats | -0.500 | 0.095 | -0.572 | -0.307 |
| Silver (COMEX) | -0.659 | 0.117 | -0.706 | -0.558 |
| Soybeans | -0.712 | 0.037 | -0.787 | -0.151 |
| Wheat (Chicago) | -0.818 | 0.011 | -0.805 | -0.123 |
| Soybean oil | -0.833 | -0.279 | -0.855 | -0.078 |
| Crude oil | -0.851 | -0.181 | -0.792 | -0.274 |
| Wheat (Kansas City) | -0.893 | 0.06% | -0.905 | -0.183 |
| Corn | -0.897 | -0.13% | -0.853 | -0.229 |



Correlation Table for Wheat (Chicago)

| | Correlation Coefficient | | | |
|---|---|---|---|---|
| | 1983-88 | 1983-84 | 1985-86 | 1987-88 |
| Wheat (Kansas City) | 0.964 | 0.817 | 0.954 | 0.950 |
| Corn | 0.844 | 0.426 | 0.769 | 0.692 |
| Soybean oil | 0.837 | 0.420 | 0.727 | 0.83% |
| Crude oil | 0.767 | 0.46% | 0.686 | -0.697 |
| Soybeans | 0.745 | 0.544 | 0.69% | 0.729 |
| Silver (COMEX) | 0.613 | 0.577 | 0.692 | -0.226 |
| Oats | 0.596 | 0.409 | 0.643 | 0.612 |
| Soymeal | 0.419 | 0.517 | -0.314 | 0.624 |
| Live cattle | 0.316 | -0.410 | 0.671 | 0.563 |
| Sugar (world) | 0.110 | 0.487 | -0.480 | 0.825 |
| Copper | -0.025 | 0.531 | 0.313 | 0.657 |
| Hogs | -0.196 | -0.176 | -0.371 | -0.382 |
| Gold (COMEX) | -0.269 | 0.440 | -0.644 | 0.306 |
| British pound | -0.359 | 0.327 | -0.680 | 0.715 |
| Swiss franc | -0.586 | 0.324 | -0.757 | 0.720 |
| Deutsche mark | -0.596 | 0.297 | -0.730 | 0.737 |
| Japanese yen | -0.635 | -0.047 | -0.756 | 0.773 |
| S&P 500 Stock Index | -0.764 | 0.150 | -0.737 | -0.685 |
| NYSE Composite Index | -0.775 | 0.134 | -0.734 | -0.69% |
| Eurodollar | -0.804 | 0.060 | -0.795 | -0.262 |
| Treasury bonds | -0.80% | 0.117 | -0.734 | -0.282 |
| Treasury notes | -0.817 | 0.091 | -0.742 | -0.292 |
| Treasury bills | -0.81% | 0.011 | -0.805 | -0.123 |

Correlation Table for Wheat (Kansas City)

| | Correlation Coefficient | | | |
|---|---|---|---|---|
| | 1983-88 | 1983-84 | 1985-86 | 1987-88 |
| Wheat (Chicago) | 0.964 | 0.817 | 0.954 | 0.950 |
| Corn | 0.891 | 0.440 | 0.825 | 0.803 |
| Soybean oil | 0.868 | 0.410 | 0.804 | 0.876 |
| Crude oil | 0.843 | 0.423 | 0.818 | -0.671 |
| Soybeans | 0.780 | 0.565 | 0.719 | 0.815 |
| Silver (COMEX) | 0.659 | 0.456 | 0.771 | -0.103 |
| Oats | 0.613 | 0.469 | 0.610 | 0.636 |
| Soymeal | 0.434 | 0.544 | -0.462 | 0.737 |
| Live cattle | 0.338 | -0.402 | 0.647 | 0.678 |
| Sugar (world) | 0.074 | 0.476 | -0.600 | 0.783 |
| Copper | -0.059 | 0.355 | 0.250 | 0.714 |
| Hogs | -0.186 | -0.377 | -0.437 | -0.339 |
| Gold (COMEX) | -0.280 | 0.367 | -0.766 | 0.421 |
| British pound | -0.374 | 0.297 | -0.732 | 0.830 |
| Swiss franc | -0.628 | 0.292 | -0.877 | 0.785 |
| Deutsche mark | -0.643 | 0.222 | -0.862 | 0.799 |
| Japanese yen | -0.682 | -0.015 | -0.881 | 0.871 |
| S&P 500 Stock Index | -0.808 | 0.308 | -0.876 | -0.640 |
| NYSE Composite Index | -0.822 | 0.273 | -0.874 | -0.663 |
| Eurodollar | -0.883 | 0.148 | -0.898 | -0.370 |
| Treasury bonds | -0.891 | 0.209 | -0.871 | -0.406 |
| Treasury bills | -0.893 | 0.068 | -0.905 | -0.183 |
| Treasury notes | -0.901 | 0.196 | -0.878 | -0.426 |

# D

# Dollar Risk Tables for 24 Commodities

This Appendix gives a percentile distribution of the daily/weekly true range in ticks across 24 commodities. It also defines the dollar value of a prespecified exposure in ticks resulting from trading anywhere from one to 10 contracts.

For example, a 52-tick exposure in the British pound is equivalent to a dollar risk of $650 for one contract. The same exposure amounts to a dollar risk of $3250 on five contracts and to $6500 on 10 contracts. Our analysis reveals that 40 percent of the daily true ranges for the pound between January 1980 and June 1988 have a tick value less than or equal to 52 ticks. 90 percent of the daily true ranges for the pound have a tick value of 117 ticks, or a risk exposure of $1463 on a one-contract basis. For five contracts, a 117-tick exposure would amount to $7313. For 10 contracts, the exposure would amount to $14,625.

The appendix could also be used to determine the number of contracts to be traded for a given aggregate dollar exposure and a permissible risk in ticks per contract. For example, assume that a trader wishes to risk $5000 to a British pound trade. The trader's permissible risk is 80 ticks per contract, which covers 70 percent of the distribution of all daily true ranges in our sample. This risk translates into $1000 per contract, allowing our trader to trade five contracts, for a total exposure of $5000.

## Dollar Risk Table for British Pound Futures

Based on daily true ranges from January 1980 through June 1988

| Percent of Days | Max Tick Range | Dollar Risk for 1 through 10 Contracts | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | | $ | $ | $ | $ | $ | $ | $ | $ | $ | $ |
| 10 | 32 | 400 | 800 | 1200 | 1600 | 2000 | 2400 | 2800 | 3200 | 3600 | 4000 |
| 20 | 40 | 500 | 1000 | 1500 | 2000 | 2500 | 3000 | 3500 | 4000 | 4500 | 5000 |
| 30 | 45 | 563 | 1125 | 1688 | 2250 | 2813 | 3375 | 3938 | 4500 | 5063 | 5625 |
| 40 | 52 | 650 | 1300 | 1950 | 2600 | 3250 | 3900 | 4550 | 5200 | 5850 | 6500 |
| 50 | 60 | 750 | 1500 | 2250 | 3000 | 3750 | 4500 | 5250 | 6000 | 6750 | 7500 |
| 60 | 70 | 875 | 1750 | 2625 | 3500 | 4375 | 5250 | 6125 | 7000 | 7875 | 8750 |
| 70 | 80 | 1000 | 2000 | 3000 | 4000 | 5000 | 6000 | 7000 | 8000 | 9000 | 10000 |
| 80 | 93 | 1163 | 2325 | 3488 | 4650 | 5813 | 6975 | 8138 | 9300 | 10463 | 11625 |
| 90 | 117 | 1463 | 2925 | 4388 | 5850 | 7313 | 8775 | 10238 | 11700 | 13163 | 14625 |

Based on weekly true ranges from January 1980 through June 1988

| Percent of Weeks | Max Tick Range | Dollar Risk for 1 through 10 Contracts | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | | $ | $ | $ | $ | $ | $ | $ | $ | $ | $ |
| 10 | 92 | 1150 | 2300 | 3450 | 4600 | 5750 | 6900 | 8050 | 9200 | 10350 | 11500 |
| 20 | 108 | 1350 | 2700 | 4050 | 5400 | 6750 | 8100 | 9450 | 10800 | 12150 | 13500 |
| 30 | 123 | 1538 | 3075 | 4613 | 6150 | 7688 | 9225 | 10763 | 12300 | 13838 | 15375 |
| 40 | 140 | 1750 | 3500 | 5250 | 7000 | 8750 | 10500 | 12250 | 14000 | 15750 | 17500 |
| 50 | 160 | 2000 | 4000 | 6000 | 8000 | 10000 | 12000 | 14000 | 16000 | 18000 | 20000 |
| 60 | 177 | 2213 | 4425 | 6638 | 8850 | 11063 | 13275 | 15488 | 17700 | 19913 | 22125 |
| 70 | 202 | 2525 | 5050 | 7575 | 10100 | 12625 | 15150 | 17675 | 20200 | 22725 | 25250 |
| 80 | 230 | 2875 | 5750 | 8625 | 11500 | 14375 | 17250 | 20125 | 23000 | 25875 | 28750 |
| 90 | 282 | 3525 | 7050 | 10575 | 14100 | 17625 | 21150 | 24675 | 28200 | 31725 | 35250 |

Minimum price fluctuation of one tick, or $0.0002 per Pound, is equivalent to $12.50 per contract.



## Dollar Risk Table for Corn Futures

Based on daily true ranges from January 1980 through June 1988

| Percent of Days | Max Tick Range | Dollar Risk for 1 through 10 Contracts | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | | $ | $ | $ | $ | $ | $ | $ | $ | $ | $ |
| 10 | 6 | 75 | 150 | 225 | 300 | 375 | 450 | 525 | 600 | 675 | 750 |
| 20 | 8 | 100 | 200 | 300 | 400 | 500 | 600 | 700 | 800 | 900 | 1000 |
| 30 | 9 | 113 | 225 | 338 | 450 | 563 | 675 | 788 | 900 | 1013 | 1125 |
| 40 | 10 | 125 | 250 | 375 | 500 | 625 | 750 | 875 | 1000 | 1125 | 1250 |
| 50 | 12 | 150 | 300 | 450 | 600 | 750 | 900 | 1050 | 1200 | 1350 | 1500 |
| 60 | 14 | 175 | 350 | 525 | 700 | 875 | 1050 | 1225 | 1400 | 1575 | 1750 |
| 70 | 16 | 200 | 400 | 600 | 800 | 1000 | 1200 | 1400 | 1600 | 1800 | 2000 |
| 80 | 20 | 250 | 500 | 750 | 1000 | 1250 | 1500 | 1750 | 2000 | 2250 | 2500 |
| 90 | 28 | 350 | 700 | 1050 | 1400 | 1750 | 2100 | 2450 | 2800 | 3150 | 3500 |

Based on weekly true ranges from January 1980 through June 1988

| Percent of Weeks | Max Tick Range | Dollar Risk for 1 through 10 Contracts | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | | $ | $ | $ | $ | $ | $ | $ | $ | $ | $ |
| 10 | 17 | 213 | 425 | 638 | 850 | 1063 | 1275 | 1488 | 1700 | 1913 | 2125 |
| 20 | 21 | 263 | 525 | 788 | 1050 | 1313 | 1575 | 1838 | 2100 | 2363 | 2625 |
| 30 | 25 | 313 | 625 | 938 | 1250 | 1563 | 1875 | 2188 | 2500 | 2813 | 3125 |
| 40 | 28 | 350 | 700 | 1050 | 1400 | 1750 | 2100 | 2450 | 2800 | 3150 | 3500 |
| 50 | 32 | 400 | 800 | 1200 | 1600 | 2000 | 2400 | 2800 | 3200 | 3600 | 4000 |
| 60 | 36 | 450 | 900 | 1350 | 1800 | 2250 | 2700 | 3150 | 3600 | 4050 | 4500 |
| 70 | 42 | 525 | 1050 | 1575 | 2100 | 2625 | 3150 | 3675 | 4200 | 4725 | 5250 |
| 80 | 51 | 638 | 1275 | 1913 | 2550 | 3188 | 3825 | 4463 | 5100 | 5738 | 6375 |
| 90 | 65 | 813 | 1625 | 2438 | 3250 | 4063 | 4875 | 5688 | 6500 | 7313 | 8125 |

Minimum price fluctuation of one tick, or 0.25 cents per bushel, is equivalent to $12.50 per contract.

## Dollar Risk Table for Crude Oil Futures

Based on daily true ranges from January 1980 through June 1988

| Percent of Days | Max Tick Range | Dollar Risk for 1 through 10 Contracts | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | | $ | $ | $ | $ | $ | $ | $ | $ | $ | $ |
| 10 | 14 | 140 | 280 | 420 | 560 | 700 | 840 | 980 | 1120 | 1260 | 1400 |
| 20 | 18 | 180 | 360 | 540 | 720 | 900 | 1080 | 1260 | 1440 | 1620 | 1800 |
| 30 | 21 | 210 | 420 | 630 | 840 | 1050 | 1260 | 1470 | 1680 | 1890 | 2100 |
| 40 | 25 | 250 | 500 | 750 | 1000 | 1250 | 1500 | 1750 | 2000 | 2250 | 2500 |
| 50 | 29 | 290 | 580 | 870 | 1160 | 1450 | 1740 | 2030 | 2320 | 2610 | 2900 |
| 60 | 34 | 340 | 680 | 1020 | 1360 | 1700 | 2040 | 2380 | 2720 | 3060 | 3400 |
| 70 | 40 | 400 | 800 | 1200 | 1600 | 2000 | 2400 | 2800 | 3200 | 3600 | 4000 |
| 80 | 50 | 500 | 1000 | 1500 | 2000 | 2500 | 3000 | 3500 | 4000 | 4500 | 5000 |
| 90 | 70 | 700 | 1400 | 2100 | 2800 | 3500 | 4200 | 4900 | 5600 | 6300 | 7000 |

Based on weekly true ranges from January 1980 through June 1988

| Percent of Weeks | Max Tick Range | Dollar Risk for 1 through 10 Contracts | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | | $ | $ | $ | $ | $ | $ | $ | $ | $ | $ |
| 10 | 38 | 380 | 760 | 1140 | 1520 | 1900 | 2280 | 2660 | 3040 | 3420 | 3800 |
| 20 | 48 | 480 | 960 | 1440 | 1920 | 2400 | 2880 | 3360 | 3840 | 4320 | 4800 |
| 30 | 60 | 600 | 1200 | 1800 | 2400 | 3000 | 3600 | 4200 | 4800 | 5400 | 6000 |
| 40 | 67 | 670 | 1340 | 2010 | 2680 | 3350 | 4020 | 4690 | 5360 | 6030 | 6700 |
| 50 | 77 | 770 | 1540 | 2310 | 3080 | 3850 | 4620 | 5390 | 6160 | 6930 | 7700 |
| 60 | 88 | 880 | 1760 | 2640 | 3520 | 4400 | 5280 | 6160 | 7040 | 7920 | 8800 |
| 70 | 103 | 1030 | 2060 | 3090 | 4120 | 5150 | 6180 | 7210 | 8240 | 9270 | 10300 |
| 80 | 128 | 1280 | 2560 | 3840 | 5120 | 6400 | 7680 | 8960 | 10240 | 11520 | 12800 |
| 90 | 171 | 1710 | 3420 | 5130 | 6840 | 8550 | 10260 | 11970 | 13680 | 15390 | 17100 |

Minimum price fluctuation of one tick, or $0.01 per barrel, is equivalent to $10.00 per contract.



## Dollar Risk Table for Copper (Standard) Futures

Based on daily true ranges from January 1980 through June 1988

| Percent of Days | Max Tick Range | Dollar Risk for 1 through 10 Contracts | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | | $ | $ | $ | $ | $ | $ | $ | $ | $ | $ |
| 10 | 9 | 113 | 225 | 338 | 450 | 563 | 675 | 788 | 900 | 1013 | 1125 |
| 20 | 12 | 150 | 300 | 450 | 600 | 750 | 900 | 1050 | 1200 | 1350 | 1500 |
| 30 | 15 | 188 | 375 | 563 | 750 | 938 | 1125 | 1313 | 1500 | 1688 | 1875 |
| 40 | 18 | 225 | 450 | 675 | 900 | 1125 | 1350 | 1575 | 1800 | 2025 | 2250 |
| 50 | 22 | 275 | 550 | 825 | 1100 | 1375 | 1650 | 1925 | 2200 | 2475 | 2750 |
| 60 | 26 | 325 | 650 | 975 | 1300 | 1625 | 1950 | 2275 | 2600 | 2925 | 3250 |
| 70 | 32 | 400 | 800 | 1200 | 1600 | 2000 | 2400 | 2800 | 3200 | 3600 | 4000 |
| 80 | 42 | 525 | 1050 | 1575 | 2100 | 2625 | 3150 | 3675 | 4200 | 4725 | 5250 |
| 90 | 64 | 800 | 1600 | 2400 | 3200 | 4000 | 4800 | 5600 | 6400 | 7200 | 8000 |

Based on weekly true ranges from January 1980 through June 1988

| Percent of Weeks | Max Tick Range | Dollar Risk for 1 through 10 Contracts | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | | $ | $ | $ | $ | $ | $ | $ | $ | $ | $ |
| 10 | 28 | 350 | 700 | 1050 | 1400 | 1750 | 2100 | 2450 | 2800 | 3150 | 3500 |
| 20 | 35 | 438 | 875 | 1313 | 1750 | 2188 | 2625 | 3063 | 3500 | 3938 | 4375 |
| 30 | 42 | 525 | 1050 | 1575 | 2100 | 2625 | 3150 | 3675 | 4200 | 4725 | 5250 |
| 40 | 50 | 625 | 1250 | 1875 | 2500 | 3125 | 3750 | 4375 | 5000 | 5625 | 6250 |
| 50 | 56 | 700 | 1400 | 2100 | 2800 | 3500 | 4200 | 4900 | 5600 | 6300 | 7000 |
| 60 | 68 | 850 | 1700 | 2550 | 3400 | 4250 | 5100 | 5950 | 6800 | 7650 | 8500 |
| 70 | 83 | 1038 | 2075 | 3113 | 4150 | 5188 | 6225 | 7263 | 8300 | 9338 | 10375 |
| 80 | 104 | 1300 | 2600 | 3900 | 5200 | 6500 | 7800 | 9100 | 10400 | 11700 | 13000 |
| 90 | 170 | 2125 | 4250 | 6375 | 8500 | 10625 | 12750 | 14875 | 17000 | 19125 | 21250 |

Minimum price fluctuation of one tick, or 0.05 cents per pound, is equivalent to $12.50 per Contract.

## Dollar Risk Table for Treasury Bond Futures

Based on daily true ranges from January 1980 through June 198%

| Percent of Days | Max Tick Range | Dollar Risk for 1 through 10 Contracts 1 | 2 | 3 | 4 | 5 | 6 | 7 | a | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | $ |
| 10 | 14 | 438 | 875 | 1313 | 1750 | 218% | 2625 | 3063 | 3500 | 393% | 4375 |
| 20 | 17 | 531 | 1063 | 1594 | 2125 | 2656 | 318% | 3719 | 4250 | 4781 | 5313 |
| 30 | 20 | 625 | 1250 | 1875 | 2500 | 3125 | 3750 | 4375 | 5000 | 5625 | 6250 |
| 40 | 23 | 719 | 143% | 2156 | 2875 | 3594 | 4313 | 5031 | 5750 | 6469 | 7188 |
| 50 | 26 | 813 | 1625 | 243% | 3250 | 4063 | 4875 | 568% | 6500 | 7313 | 8125 |
| 60 | 30 | 93% | 1875 | 2813 | 3750 | 468% | 5625 | 6563 | 7500 | 8438 | 9375 |
| 70 | 35 | 1094 | 218% | 3281 | 4375 | 5469 | 6563 | 7656 | 8750 | 9844 | 10938 |
| 80 | 41 | 1281 | 2563 | 3844 | 5125 | 6406 | 768% | 8969 | 10250 | 11531 | 12813 |
| 90 | 53 | 1656 | 3313 | 4969 | 6625 | 8281 | 993% | 11594 | 13250 | 14906 | 16563 |

Based on weekly true ranges from January 1980 through June 198%

| Percent of Weeks | Max Tick Range | Dollar Risk for 1 through 10 Contracts 1 | 2 | 3 | 4 | 5 | 6 | 7 | a | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 5 | 5 | 5 | 5 | 5 | 5 | 5 | $ | 5 | 5 |
| 10 | 37 | 1156 | 2313 | 3469 | 4625 | 5781 | 693% | 8094 | 9250 | 10406 | 11563 |
| 20 | 46 | 143% | 2875 | 4313 | 5750 | 718% | 8625 | 10063 | 11500 | 1293% | 14375 |
| 30 | 53 | 1656 | 3313 | 4969 | 6625 | 8281 | 993% | 11594 | 13250 | 14906 | 16563 |
| 40 | 59 | 1844 | 368% | 5531 | 7375 | 9219 | 11063 | 12906 | 14750 | 16594 | 1843% |
| 50 | 6% | 2125 | 4250 | 6375 | 8500 | 10625 | 12750 | 14875 | 17000 | 19125 | 21250 |
| 60 | 76 | 2375 | 4750 | 7125 | 9500 | 11875 | 14250 | 16625 | 19000 | 21375 | 23750 |
| 70 | 84 | 2625 | 5250 | 7875 | 10500 | 13125 | 15750 | 18375 | 21000 | 23625 | 26250 |
| 80 | 96 | 3000 | 6000 | 9000 | 12000 | 15000 | 18000 | 21000 | 24000 | 27000 | 30000 |
| 90 | 117 | 3656 | 7313 | 10969 | 14625 | 18281 | 2193% | 25594 | 29250 | 32906 | 36563 |

Minimum price fluctuation of one tick, or $\frac{1}{32}$ of one percentage point, is equivalent to $31.25 per contract.



## Dollar Risk Table for Deutsche Mark Futures

Based on daily true ranges from January 1980 through June 198%

| Percent of Days | Max Tick Range | Dollar Risk for 1 through 10 Contracts 1 | 2 | 3 | 4 | 5 | 6 | 7 | a | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | $ |
| 10 | 17 | 213 | 425 | 63% | 850 | 1063 | 1275 | 148% | 1700 | 1913 | 2125 |
| 20 | 21 | 263 | 525 | 78% | 1050 | 1313 | 1575 | 183% | 2100 | 2363 | 2625 |
| 30 | 24 | 300 | 600 | 900 | 1200 | 1500 | 1800 | 2100 | 2400 | 2700 | 3000 |
| 40 | 28 | 350 | 700 | 1050 | 1400 | 1750 | 2100 | 2450 | 2800 | 3150 | 3500 |
| 50 | 32 | 400 | 800 | 1200 | 1600 | 2000 | 2400 | 2800 | 3200 | 3600 | 4000 |
| 60 | 36 | 450 | 900 | 1350 | 1800 | 2250 | 2700 | 3150 | 3600 | 4050 | 4500 |
| 70 | 41 | 513 | 1025 | 153% | 2050 | 2563 | 3075 | 358% | 4100 | 4613 | 5125 |
| 80 | 48 | 600 | 1200 | 1800 | 2400 | 3000 | 3600 | 4200 | 4800 | 5400 | 6000 |
| 90 | 61 | 763 | 1525 | 228% | 3050 | 3813 | 4575 | 533% | 6100 | 6863 | 7625 |

Based on weekly true ranges from January 1980 through June 198%

| Percent of Weeks | Max Tick Range | Dollar Risk for 1 through 10 Contracts 1 | 2 | 3 | 4 | 5 | 6 | 7 | a | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 5 | 5 | 5 | 5 | 5 | 5 | 5 | -5 | 5 | 5 |
| 10 | 47 | 58% | 1175 | 1763 | 2350 | 293% | 3525 | 4113 | 4700 | 528% | 5875 |
| 20 | 57 | 713 | 1425 | 213% | 2850 | 3563 | 4275 | 498% | 5700 | 6413 | 7125 |
| 30 | 66 | 825 | 1650 | 2475 | 3300 | 4125 | 4950 | 5775 | 6600 | 7425 | 8250 |
| 40 | 76 | 950 | 1900 | 2850 | 3800 | 4750 | 5700 | 6650 | 7600 | 8550 | 9500 |
| 50 | a2 | 1025 | 2050 | 3075 | 4100 | 5125 | 6150 | 7175 | 8200 | 9225 | 10250 |
| 60 | 90 | 1125 | 2250 | 3375 | 4500 | 5625 | 6750 | 7875 | 9000 | 10125 | 11250 |
| 70 | 107 | 133% | 2675 | 4013 | 5350 | 668% | 8025 | 9363 | 10700 | 1203% | 13375 |
| 80 | 132 | 1650 | 3300 | 4950 | 6600 | 8250 | 9900 | 11550 | 13200 | 14850 | 16500 |
| 90 | 160 | 2000 | 4000 | 6000 | 8000 | 10000 | 12000 | 14000 | 16000 | 18000 | 20000 |

Minimum price fluctuation of one tick, or $0.0001 per mark, is equivalent to $12.50 per contract.

## Dollar Risk Table for Eurodollar Futures

Based on daily true ranges **from December 1981 through June 1988**

| Percent of Days | Max Tick Range | Dollar Risk for 1 through 10 Contracts | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | a | 9 | 10 |
| | | $ | $ | $ | $ | $ | $ | $ | $ | $ | $ |
| 10 | 5 | 125 | 250 | 375 | 500 | 625 | 750 | 875 | 1000 | 1125 | 1250 |
| 20 | 7 | 175 | 350 | 525 | 700 | 875 | 1050 | 1225 | 1400 | 1575 | 1750 |
| 30 | 9 | 225 | 450 | 675 | 900 | 1125 | 1350 | 1575 | 1800 | 2025 | 2250 |
| 40 | 10 | 250 | 500 | 750 | 1000 | 1250 | 1500 | 1750 | 2000 | 2250 | 2500 |
| 50 | 12 | 300 | 600 | 900 | 1200 | 1500 | 1800 | 2100 | 2400 | 2700 | 3000 |
| 60 | 14 | 350 | 700 | 1050 | 1400 | 1750 | 2100 | 2450 | 2800 | 3150 | 3500 |
| 70 | 17 | 425 | 850 | 1275 | 1700 | 2125 | 2550 | 2975 | 3400 | 3825 | 4250 |
| 80 | 21 | 525 | 1050 | 1575 | 2100 | 2625 | 3150 | 3675 | 4200 | 4725 | 5250 |
| 90 | 29 | 725 | 1450 | 2175 | 2900 | 3625 | 4350 | 5075 | 5800 | 6525 | 7250 |

Based on weekly true ranges from December 1981 through June 1988

| Percent of Weeks | Max Tick Range | Dollar Risk for 1 through 10 Contracts | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | a | 9 | 10 |
| | | $ | $ | $ | $ | $ | $ | $ | $ | $ | $ |
| 10 | 16 | 400 | 800 | 1200 | 1600 | 2000 | 2400 | 2800 | 3200 | 3600 | 4000 |
| 20 | 20 | 500 | 1000 | 1500 | 2000 | 2500 | 3000 | 3500 | 4000 | 4500 | 5000 |
| 30 | 24 | 600 | 1200 | 1800 | 2400 | 3000 | 3600 | 4200 | 4800 | 5400 | 6000 |
| 40 | 27 | 675 | 1350 | 2025 | 2700 | 3375 | 4050 | 4725 | 5400 | 6075 | 6750 |
| 50 | 31 | 775 | 1550 | 2325 | 3100 | 3875 | 4650 | 5425 | 6200 | 6975 | 7750 |
| 60 | 37 | 925 | 1850 | 2775 | 3700 | 4625 | 5550 | 6475 | 7400 | a325 | 9250 |
| 70 | 44 | 1100 | 2200 | 3300 | 4400 | 5500 | 6600 | 7700 | 8800 | 9900 | 11000 |
| 80 | 57 | 1425 | 2850 | 4275 | 5700 | 7125 | 8550 | 9975 | 11400 | 12825 | 14250 |
| 90 | 77 | 1925 | 3850 | 5775 | 7700 | 9625 | 11550 | 13475 | 15400 | 17325 | 19250 |

Minimum price fluctuation of one tick, or 0.01 of one percentage point, is equivalent to $25.00 per contract.



## Dollar Risk Table for Gold (COMEX) Futures

Based on daily true ranges from January 1980 through June 1988

| Percent of Days | Max Tick Range | Dollar Risk for 1 through 10 Contracts | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | | $ | $ | $ | $ | $ | $ | $ | $ | $ | $ |
| 10 | 24 | 240 | 480 | 720 | 960 | 1200 | 1440 | 1680 | 1920 | 2160 | 2400 |
| 20 | 32 | 320 | 640 | 960 | 1280 | 1600 | 1920 | 2240 | 2560 | 2880 | 3200 |
| 30 | 40 | 400 | 800 | 1200 | 1600 | 2000 | 2400 | 2800 | 3200 | 3600 | 4000 |
| 40 | 48 | 480 | 960 | 1440 | 1920 | 2400 | 2880 | 3360 | 3840 | 4320 | 4800 |
| 50 | 58 | 580 | 1160 | 1740 | 2320 | 2900 | 3480 | 4060 | 4640 | 5220 | 5800 |
| 60 | 70 | 700 | 1400 | 2100 | 2800 | 3500 | 4200 | 4900 | 5600 | 6300 | 7000 |
| 70 | 86 | 860 | 1720 | 2580 | 3440 | 4300 | 5160 | 6020 | 6880 | 7740 | 8600 |
| 80 | 110 | 1100 | 2200 | 3300 | 4400 | 5500 | 6600 | 7700 | 8800 | 9900 | 11000 |
| 90 | 155 | 1550 | 3100 | 4650 | 6200 | 7750 | 9300 | 10850 | 12400 | 13950 | 15500 |

Based on weekly true ranges from January 1980 through June 1988

| Percent of Weeks | Max Tick Range | Dollar Risk for 1 through 10 Contracts | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | a | 9 | 10 |
| | | $ | $ | $ | $ | $ | $ | $ | $ | $ | $ |
| 10 | 70 | 700 | 1400 | 2100 | 2800 | 3500 | 4200 | 4900 | 5600 | 6300 | 7000 |
| 20 | 95 | 950 | 1900 | 2850 | 3800 | 4750 | 5700 | 6650 | 7600 | 8550 | 9500 |
| 30 | 110 | 1100 | 2200 | 3300 | 4400 | 5500 | 6600 | 7700 | 8800 | 9900 | 11000 |
| 40 | 126 | 1260 | 2520 | 3780 | 5040 | 6300 | 7560 | 8820 | 10080 | 11340 | 12600 |
| 50 | 146 | 1460 | 2920 | 4380 | 5840 | 7300 | 8760 | 10220 | 11680 | 13140 | 14600 |
| 60 | 175 | 1750 | 3500 | 5250 | 7000 | 8750 | 10500 | 12250 | 14000 | 15750 | 17500 |
| 70 | 204 | 2040 | 4080 | 6120 | 8160 | 10200 | 12240 | 14280 | 16320 | 18360 | 20400 |
| 80 | 255 | 2550 | 5100 | 7650 | 10200 | 12750 | 15300 | 17856 | 20400 | 22950 | 25500 |
| 90 | 345 | 3450 | 6900 | 10350 | 13800 | 17250 | 20700 | 24150 | 27600 | 31050 | 34500 |

Minimum price fluctuation of one tick, or $0.10 per troy ounce, is equivalent to $10.00 per contract.

## Dollar Risk Table for Japanese Yen Futures

Based on daily true ranges from January 1980 through June 1988

| Percent of Days | Max Tick Range | Dollar Risk for 1 through 10 Contracts | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | a | 9 | 10 |
| | | $ | $ | $ | $ | $ | $ | $ | $ | $ | $ |
| 10 | 14 | 175 | 350 | 525 | 700 | 875 | 1050 | 1225 | 1400 | 1575 | 1750 |
| 20 | 18 | 225 | 450 | 675 | 900 | 1125 | 1350 | 1575 | 1800 | 2025 | 2250 |
| 30 | 22 | 275 | 550 | 825 | 1100 | 1375 | 1650 | 1925 | 2200 | 2475 | 2750 |
| 40 | 25 | 313 | 625 | 938 | 1250 | 1563 | 1875 | 2188 | 2500 | 2813 | 3125 |
| 50 | 29 | 363 | 725 | 1088 | 1450 | 1813 | 2175 | 2538 | 2900 | 3263 | 3625 |
| 60 | 35 | 438 | 875 | 1313 | 1750 | 2188 | 2625 | 3063 | 3500 | 3938 | 4375 |
| 70 | 41 | 513 | 1025 | 1538 | 2050 | 2563 | 3075 | 3588 | 4100 | 4613 | 5125 |
| 80 | 49 | 613 | 1225 | 1838 | 2450 | 3063 | 3675 | 4288 | 4900 | 5513 | 6125 |
| 90 | 66 | 825 | 1650 | 2475 | 3300 | 4125 | 4950 | 5775 | 6600 | 7425 | 8250 |

Based on weekly true ranges from January 1980 through June 1988

| Percent of Weeks | Max Tick Range | Dollar Risk for 1 through 10 Contracts | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | a | 9 | 10 |
| | | $ | $ | $ | $ | $ | $ | $ | $ | $ | $ |
| 10 | 43 | 538 | 1075 | 1613 | 2150 | 2688 | 3225 | 3763 | 4300 | 4838 | 5375 |
| 20 | 53 | 663 | 1325 | 1988 | 2650 | 3313 | 3975 | 4638 | 5300 | 5963 | 6625 |
| 30 | 63 | 788 | 1575 | 2363 | 3150 | 3938 | 4725 | 5513 | 6300 | 7088 | 7875 |
| 40 | 74 | 925 | 1850 | 2775 | 3700 | 4625 | 5550 | 6475 | 7400 | 8325 | 9250 |
| 50 | 85 | 1063 | 2125 | 3188 | 4250 | 5313 | 6375 | 7438 | 8500 | 9563 | 10625 |
| 60 | 99 | 1238 | 2475 | 3713 | 4950 | 6188 | 7425 | 8663 | 9900 | 11138 | 12375 |
| 70 | 113 | 1413 | 2825 | 4238 | 5650 | 7063 | 8475 | 9888 | 11300 | 12713 | 14125 |
| 80 | 134 | 1675 | 3350 | 5025 | 6700 | 8375 | 10050 | 11725 | 13400 | 15075 | 16750 |
| 90 | 172 | 2150 | 4300 | 6450 | 8600 | 10750 | 12900 | 15050 | 17200 | 19350 | 21500 |

Minimum price fluctuation of one tick, or $0.0001 per 100 yen, is equivalent to $12.50 per contract.



## Dollar Risk Table for Live Cattle Futures

Based on daily true ranges from January 1980 through June 1988

| Percent of Days | Max Tick Range | Dollar Risk for 1 through 10 Contracts | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | a | 9 | 10 |
| | | $ | $ | $ | $ | $ | $ | $ | $ | $ | $ |
| 10 | 19 | 190 | 380 | 570 | 760 | 950 | 1140 | 1330 | 1520 | 1710 | 1900 |
| 20 | 22 | 220 | 440 | 660 | 880 | 1100 | 1320 | 1540 | 1760 | 1980 | 2200 |
| 30 | 26 | 260 | 520 | 780 | 1040 | 1300 | 1560 | 1820 | 2080 | 2340 | 2600 |
| 40 | 29 | 290 | 580 | 870 | 1160 | 1450 | 1740 | 2030 | 2320 | 2610 | 2900 |
| 50 | 32 | 320 | 640 | 960 | 1280 | 1600 | 1920 | 2240 | 2560 | 2880 | 3200 |
| 60 | 37 | 370 | 740 | 1110 | 1480 | 1850 | 2220 | 2590 | 2960 | 3330 | 3700 |
| 70 | 42 | 420 | 840 | 1260 | 1680 | 2100 | 2520 | 2940 | 3360 | 3780 | 4200 |
| 80 | 48 | 480 | 960 | 1440 | 1920 | 2400 | 2880 | 3360 | 3840 | 4320 | 4800 |
| 90 | 57 | 570 | 1140 | 1710 | 2280 | 2850 | 3420 | 3990 | 4560 | 5130 | 5700 |

Based on weekly true ranges from January 1980 through June 1988

| Percent of Weeks | Max Tick Range | Dollar Risk for 1 through 10 Contracts | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | | $ | $ | $ | $ | $ | $ | $ | $ | $ | $ |
| 10 | 51 | 510 | 1020 | 1530 | 2040 | 2550 | 3060 | 3570 | 4080 | 4590 | 5100 |
| 20 | 61 | 610 | 1220 | 1830 | 2440 | 3050 | 3660 | 4270 | 4880 | 5490 | 6100 |
| 30 | 67 | 670 | 1340 | 2010 | 2680 | 3350 | 4020 | 4690 | 5360 | 6030 | 6700 |
| 40 | 74 | 740 | 1480 | 2220 | 2960 | 3700 | 4440 | 5180 | 5920 | 6660 | 7400 |
| 50 | 83 | 830 | 1660 | 2490 | 3320 | 4150 | 4980 | 5810 | 6640 | 7470 | 8300 |
| 60 | 91 | 910 | 1820 | 2730 | 3640 | 4550 | 5460 | 6370 | 7280 | 8190 | 9100 |
| 70 | 104 | 1040 | 2080 | 3120 | 4160 | 5200 | 6240 | 7280 | 8320 | 9360 | 10400 |
| 80 | 120 | 1200 | 2400 | 3600 | 4800 | 6000 | 7200 | 8400 | 9600 | 10800 | 12000 |
| 90 | 142 | 1420 | 2840 | 4260 | 5680 | 7100 | 8520 | 9940 | 11360 | 12780 | 14200 |

Minimum price fluctuation of one tick, or 0.025 cents per pound, is equivalent to $10.00 per contract.

## Dollar Risk Table for Live Hog Futures

Based on daily true ranges from January 1980 through June 1988

| Percent of Days | Max Tick Range | Dollar Risk for 1 through 10 Contracts | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | | $ | $ | $ | $ | $ | $ | $ | $ | $ | $ |
| 10 | 22 | 220 | 440 | 660 | 880 | 1100 | 1320 | 1540 | 1760 | 1980 | 2200 |
| 20 | 2.5 | 250 | 500 | 750 | 1000 | 1250 | 1500 | 1750 | 2000 | 2250 | 2500 |
| 30 | 28 | 280 | 560 | 840 | 1120 | 1400 | 1680 | 1960 | 2240 | 2520 | 2800 |
| 40 | 32 | 320 | 640 | 960 | 1280 | 1600 | 1920 | 2240 | 2560 | 2880 | 3200 |
| 50 | 35 | 350 | 700 | 1050 | 1400 | 1750 | 2100 | 2450 | 2800 | 3150 | 3500 |
| 60 | 39 | 390 | 780 | 1170 | 1560 | 1950 | 2340 | 2730 | 3120 | 3510 | 3900 |
| 70 | 44 | 440 | 880 | 1320 | 1760 | 2200 | 2640 | 3080 | 3520 | 3960 | 4400 |
| 80 | 50 | 500 | 1000 | 1500 | 2000 | 2500 | 3000 | 3500 | 4000 | 4500 | 5000 |
| 90 | 58 | 580 | 1160 | 1740 | 2320 | 2900 | 3480 | 4060 | 4640 | 5220 | 5800 |

Based on weekly true ranges from January 1980 through June 1988

| Percent of Weeks | Max Tick Range | Dollar Risk for 1 through 10 Contracts | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | | $ | $ | $ | $ | $ | $ | $ | $ | $ | $ |
| 10 | 53 | 530 | 1060 | 1590 | 2120 | 2650 | 3180 | 3710 | 4240 | 4770 | 5300 |
| 20 | 62 | 620 | 1240 | 1860 | 2480 | 3100 | 3720 | 4340 | 4960 | 5580 | 6200 |
| 30 | 71 | 710 | 1420 | 2130 | 2840 | 3550 | 4260 | 4970 | 5680 | 6390 | 7100 |
| 40 | 79 | 790 | 1580 | 2370 | 3160 | 3950 | 4740 | 5530 | 6320 | 7110 | 7900 |
| 50 | 88 | 880 | 1760 | 2640 | 3520 | 4400 | 5280 | 6160 | 7040 | 7920 | 8800 |
| 60 | 95 | 950 | 1900 | 2850 | 3800 | 4750 | 5700 | 6650 | 7600 | 8550 | 9500 |
| 70 | 104 | 1040 | 2080 | 3120 | 4160 | 5200 | 6240 | 7280 | 8320 | 9360 | 10400 |
| 80 | 120 | 1200 | 2400 | 3600 | 4800 | 6000 | 7200 | 8400 | 9600 | 10800 | 12000 |
| 90 | 148 | 1480 | 2960 | 4440 | 5920 | 7400 | 8880 | 10360 | 11840 | 13320 | 14800 |

Minimum price fluctuation of one tick, or 0.025 cents per pound, is equivalent to $10 00 per contract.



## Dollar Risk Table for Treasury Notes Futures

Based on daily true ranges from May 1982 through June 1988

| Percent of Days | Max Tick Range | Dollar Risk for 1 through 10 Contracts | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | | $ | $ | $ | $ | $ | $ | $ | $ | $ | $ |
| 10 | 9 | 281 | 563 | 844 | 1125 | 1406 | 1688 | 1969 | 2250 | 2531 | 2813 |
| 20 | 11 | 344 | 688 | 1031 | 1375 | 1719 | 2063 | 2406 | 2750 | 3094 | 3438 |
| 30 | 13 | 406 | 813 | 1219 | 1625 | 2031 | 2438 | 2844 | 3250 | 3656 | 4063 |
| 40 | 15 | 469 | 938 | 1406 | 1875 | 2344 | 2813 | 3281 | 3750 | 4219 | 4688 |
| 50 | 17 | 531 | 1063 | 1594 | 2125 | 2656 | 3188 | 3719 | 4250 | 4781 | 5313 |
| 60 | 20 | 625 | 1250 | 1875 | 2500 | 3125 | 3750 | 4375 | 5000 | 5625 | 6250 |
| 70 | 23 | 719 | 1438 | 2156 | 2875 | 3594 | 4313 | 5031 | 5750 | 6469 | 7188 |
| 80 | 26 | 813 | 1625 | 2438 | 3250 | 4063 | 4875 | 5688 | 6500 | 7313 | 8125 |
| 90 | 34 | 1063 | 2125 | 3188 | 4250 | 5313 | 6375 | 7438 | 8500 | 9563 | 10625 |

Based on weekly true ranges from May 1982 through June 1988

| Percent of Weeks | Max Tick Range | Dollar Risk for 1 through 10 Contracts | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | | $ | $ | $ | $ | $ | $ | $ | $ | $ | $ |
| 10 | 25 | 781 | 1563 | 2344 | 3125 | 3906 | 4688 | 5469 | 6250 | 7031 | 7813 |
| 20 | 30 | 938 | 1875 | 2813 | 3750 | 4688 | 5625 | 6563 | 7500 | 8438 | 9375 |
| 30 | 35 | 1094 | 2188 | 3281 | 4375 | 5469 | 6563 | 7656 | 8750 | 9844 | 10938 |
| 40 | 40 | 1250 | 2500 | 3750 | 5000 | 6250 | 7500 | 8750 | 10000 | 11250 | 12500 |
| 50 | 46 | 1438 | 2875 | 4313 | 5750 | 7188 | 8625 | 10063 | 11500 | 12938 | 14375 |
| 60 | 51 | 1594 | 3188 | 4781 | 6375 | 7969 | 9563 | 11156 | 12750 | 14344 | 15938 |
| 70 | 58 | 1813 | 3625 | 5438 | 7250 | 9063 | 10875 | 12688 | 14500 | 16313 | 18125 |
| 80 | 66 | 2063 | 4125 | 6188 | 8250 | 10313 | 12375 | 14438 | 16500 | 18563 | 20625 |
| 90 | 78 | 2438 | 4875 | 7313 | 9750 | 12188 | 14625 | 17063 | 19500 | 21938 | 24375 |

Minimum price fluctuation of one tick, or $\frac{1}{32}$ of one percentage point, is equivalent to $31.25 per contract.

## Dollar Risk Table for NYSE Composite Index Futures

Based on daily true ranges from June 1983 through June 1988

| Percent nf Davs | Max Tick Ranee | Dollar Risk for 1 through 10 Contracts | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | | $ | $ | $ | $ | $ | $ | $ | $ | $ | $ |
| 10 | 15 | 375 | 750 | 1125 | 1500 | 1875 | 2250 | 2625 | 3000 | 3375 | 3750 |
| 20 | 19 | 475 | 950 | 1425 | 1900 | 2375 | 2850 | 3325 | 3800 | 4275 | 4750 |
| 30 | 22 | 550 | 1100 | 1650 | 2200 | 2750 | 3300 | 3850 | 4400 | 4950 | 5500 |
| 40 | 26 | 650 | 1300 | 1950 | 2600 | 3250 | 3900 | 4550 | 5200 | 5850 | 6500 |
| 50 | 30 | 750 | 1500 | 2250 | 3000 | 3750 | 4500 | 5250 | 6000 | 6750 | 7500 |
| 60 | 35 | 875 | 1750 | 2625 | 3500 | 4375 | 5250 | 6125 | 7000 | 7875 | 8750 |
| 70 | 41 | 1025 | 2050 | 3075 | 4100 | 5125 | 6150 | 7175 | 8200 | 9225 | 10250 |
| 80 | 51 | 1275 | 2550 | 3825 | 5100 | 6375 | 7650 | 8925 | 10200 | 11475 | 12750 |
| 90 | 66 | 1650 | 3300 | 4950 | 6600 | 8250 | 9900 | 11550 | 13200 | 14850 | 16500 |

Based on weekly true ranges from June 1983 through June 1988

| Percent of Weeks | Max Tick Range | Dollar Risk for 1 through 10 Contracts | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | | $ | $ | $ | $ | $ | $ | $ | $ | $ | $ |
| 10 | 40 | 1000 | 2000 | 3000 | 4000 | 5000 | 6000 | 7000 | 8000 | 9000 | 10000 |
| 20 | 47 | 1175 | 2350 | 3525 | 4700 | 5875 | 7050 | 8225 | 9400 | 10575 | 11750 |
| 30 | 54 | 1350 | 2700 | 4050 | 5400 | 6750 | 8100 | 9450 | 10800 | 12150 | 13500 |
| 40 | 61 | 1525 | 3050 | 4575 | 6100 | 7625 | 9150 | 10675 | 12200 | 13725 | 15250 |
| 50 | 69 | 1725 | 3450 | 5175 | 6900 | 8625 | 10350 | 12075 | 13800 | 15525 | 17250 |
| 60 | 80 | 2000 | 4000 | 6000 | 8000 | 10000 | 12000 | 14000 | 16000 | 18000 | 20000 |
| 70 | 94 | 2350 | 4700 | 7050 | 9400 | 11750 | 14100 | 16450 | 18800 | 21150 | 23500 |
| 80 | 120 | 3000 | 6000 | 9000 | 12000 | 15000 | 18000 | 21000 | 24000 | 27000 | 30000 |
| 90 | 155 | 3875 | 7750 | 11625 | 15500 | 19375 | 23250 | 27125 | 31000 | 34875 | 38750 |

Minimum price fluctuation of one tick, or 0.05 index points, is equivalent to $25.00 per contract.



## Dollar Risk Table for Oats Futures

Based on daily true ranges from January 1980 through June 1988

| Percent of Days | Max Tick Range | Dollar Risk for 1 through 10 Contracts | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | | $ | $ | $ | $ | $ | $ | $ | $ | $ | $ |
| 10 | 10 | 125 | 250 | 375 | 500 | 625 | 750 | 875 | 1000 | 1125 | 1250 |
| 20 | 14 | 175 | 350 | 525 | 700 | 875 | 1050 | 1225 | 1400 | 1575 | 1750 |
| 30 | 18 | 225 | 450 | 675 | 900 | 1125 | 1350 | 1575 | 1800 | 2025 | 2250 |
| 40 | 22 | 275 | 550 | 825 | 1100 | 1375 | 1650 | 1925 | 2200 | 2475 | 2750 |
| 50 | 24 | 300 | 600 | 900 | 1200 | 1500 | 1800 | 2100 | 2400 | 2700 | 3000 |
| 60 | 30 | 375 | 750 | 1125 | 1500 | 1875 | 2250 | 2625 | 3000 | 3375 | 3750 |
| 70 | 34 | 425 | 850 | 1275 | 1700 | 2125 | 2550 | 2975 | 3400 | 3825 | 4250 |
| 80 | 42 | 525 | 1050 | 1575 | 2100 | 2625 | 3150 | 3675 | 4200 | 4725 | 5250 |
| 90 | 52 | 650 | 1300 | 1950 | 2600 | 3250 | 3900 | 4550 | 5200 | 5850 | 6500 |

Based on weekly true ranges from January 1980 through June 1988

| Percent of Weeks | Max Tick Range | Dollar Risk for 1 through 10 Contracts | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | | $ | $ | $ | $ | $ | $ | $ | $ | $ | $ |
| 10 | 32 | 400 | 800 | 1200 | 1600 | 2000 | 2400 | 2800 | 3200 | 3600 | 4000 |
| 20 | 42 | 525 | 1050 | 1575 | 2100 | 2625 | 3150 | 3675 | 4200 | 4725 | 5250 |
| 30 | 52 | 650 | 1300 | 1950 | 2600 | 3250 | 3900 | 4550 | 5200 | 5850 | 6500 |
| 40 | 60 | 750 | 1500 | 2250 | 3000 | 3750 | 4500 | 5250 | 6000 | 6750 | 7500 |
| 50 | 66 | 825 | 1650 | 2475 | 3300 | 4125 | 4950 | 5775 | 6600 | 7425 | 8250 |
| 60 | 74 | 925 | 1850 | 2775 | 3700 | 4625 | 5550 | 6475 | 7400 | 8325 | 9250 |
| 70 | 86 | 1075 | 2150 | 3225 | 4300 | 5375 | 6450 | 7525 | 8600 | 9675 | 10750 |
| 80 | 98 | 1225 | 2450 | 3675 | 4900 | 6125 | 7350 | 8575 | 9800 | 11025 | 12250 |
| 90 | 124 | 1550 | 3100 | 4650 | 6200 | 7750 | 9300 | 10850 | 12400 | 13950 | 15500 |

Minimum price fluctuation of one tick, or 0.25 cents per bushel, is equivalent to $12.50 per contract.

## Dollar Risk Table for Soybeans Futures

Based on daily true ranges from January 1980 through June 1988

| Percent of Days | Max Tick Range | Dollar Risk for 1 through 10 Contracts | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | | $ | $ | $ | $ | $ | 5 | 5 | 5 | 5 | 5 |
| 10 | 16 | 200 | 400 | 600 | 800 | 1000 | 1200 | 1400 | 1600 | 1800 | 2000 |
| 20 | 22 | 275 | 550 | 825 | 1100 | 1375 | 1650 | 1925 | 2200 | 2475 | 2750 |
| 30 | 26 | 325 | 650 | 975 | 1300 | 1625 | 1950 | 2275 | 2600 | 2925 | 3250 |
| 40 | 30 | 375 | 750 | 1125 | 1500 | 1875 | 2250 | 2625 | 3000 | 3375 | 3750 |
| 50 | 34 | 425 | 850 | 1275 | 1700 | 2125 | 2550 | 2975 | 3400 | 3825 | 4250 |
| 60 | 42 | 525 | 1050 | 1575 | 2100 | 2625 | 3150 | 3675 | 4200 | 4725 | 5250 |
| 70 | 50 | 625 | 1250 | 1875 | 2500 | 3125 | 3750 | 4375 | 5000 | 5625 | 6250 |
| 80 | 64 | 800 | 1600 | 2400 | 3200 | 4000 | 4800 | 5600 | 6400 | 7200 | 8000 |
| 90 | 92 | 1150 | 2300 | 3450 | 4600 | 5750 | 6900 | 8050 | 9200 | 10350 | 11500 |

Based on weekly true ranges from January 1980 through June 1988

| Percent of Weeks | Max Tick Range | Dollar Risk for 1 through 10 Contracts | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | | $ | $ | $ | $ | $ | $ | $ | $ | 5 | 5 |
| 10 | 43 | 538 | 1075 | 1613 | 2150 | 2688 | 3225 | 3763 | 4300 | 4838 | 5375 |
| 20 | 55 | 688 | 1375 | 2063 | 2750 | 3438 | 4125 | 4813 | 5500 | 6188 | 6875 |
| 30 | 66 | 825 | 1650 | 2475 | 3300 | 4125 | 4950 | 5775 | 6600 | 7425 | 8250 |
| 40 | 78 | 975 | 1950 | 2925 | 3900 | 4875 | 5850 | 6825 | 7800 | 8775 | 9750 |
| 50 | 88 | 1100 | 2200 | 3300 | 4400 | 5500 | 6600 | 7700 | 8800 | 9900 | 11000 |
| 60 | 104 | 1300 | 2600 | 3900 | 5200 | 6500 | 7800 | 9100 | 10400 | 11700 | 13000 |
| 70 | 124 | 1550 | 3100 | 4650 | 6200 | 7750 | 9300 | 10850 | 12400 | 13950 | 15500 |
| 80 | 153 | 1913 | 3825 | 5738 | 7650 | 9563 | 11475 | 13388 | 15300 | 17213 | 19125 |
| 90 | 198 | 2475 | 4950 | 7425 | 9900 | 12375 | 14850 | 17325 | 19800 | 22275 | 24750 |

Minimum price fluctuation of one tick, or 0.25 cents per bushel, is equivalent to $12.50 per contract.



## Dollar Risk Table for Swiss Franc Futures

Based on daily true ranges from January 1980 through June 1988

| Percent of Days | Max Tick Range | Dollar Risk for 1 through 10 Contracts | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | | 5 | 5 | 5 | 5 | $ | $ | $ | $ | $ | $ |
| 10 | 24 | 300 | 600 | 900 | 1200 | 1500 | 1800 | 2100 | 2400 | 2700 | 3000 |
| 20 | 29 | 363 | 725 | 1088 | 1450 | 1813 | 2175 | 2538 | 2900 | 3263 | 3625 |
| 30 | 34 | 425 | 850 | 1275 | 1700 | 2125 | 2550 | 2975 | 3400 | 3825 | 4250 |
| 40 | 38 | 475 | 950 | 1425 | 1900 | 2375 | 2850 | 3325 | 3800 | 4275 | 4750 |
| 50 | 44 | 550 | 1100 | 1650 | 2200 | 2750 | 3300 | 3850 | 4400 | 4950 | 5500 |
| 60 | 49 | 613 | 1225 | 1838 | 2450 | 3063 | 3675 | 4288 | 4900 | 5513 | 6125 |
| 70 | 56 | 700 | 1400 | 2100 | 2800 | 3500 | 4200 | 4900 | 5600 | 6300 | 7000 |
| 80 | 66 | 825 | 1650 | 2475 | 3300 | 4125 | 4950 | 5775 | 6600 | 7425 | 8250 |
| 90 | 82 | 1025 | 2050 | 3075 | 4100 | 5125 | 6150 | 7175 | 8200 | 9225 | 10250 |

Based on weekly true ranges from January 1980 through June 1988

| Percent of Weeks | Max Tick Range | Dollar Risk for 1 through 10 Contracts | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | | $ | $ | $ | $ | $ | $ | $ | $ | $ | $ |
| 10 | 64 | 800 | 1600 | 2400 | 3200 | 4000 | 4800 | 5600 | 6400 | 7200 | 8000 |
| 20 | 82 | 1025 | 2050 | 3075 | 4100 | 5125 | 6150 | 7175 | 8200 | 9225 | 10250 |
| 30 | 92 | 1150 | 2300 | 3450 | 4600 | 5750 | 6900 | 8050 | 9200 | 10350 | 11500 |
| 40 | 103 | 1288 | 2575 | 3863 | 5150 | 6438 | 7725 | 9013 | 10300 | 11588 | 12875 |
| 50 | 116 | 1450 | 2900 | 4350 | 5800 | 7250 | 8700 | 10150 | 11600 | 13050 | 14500 |
| 60 | 128 | 1600 | 3200 | 4800 | 6400 | 8000 | 9600 | 11200 | 12800 | 14400 | 16000 |
| 70 | 149 | 1863 | 3725 | 5588 | 7450 | 9313 | 11175 | 13038 | 14900 | 16763 | 18625 |
| 80 | 171 | 2138 | 4275 | 6413 | 8550 | 10688 | 12825 | 14963 | 17100 | 19238 | 21375 |
| 90 | 213 | 2663 | 5325 | 7988 | 10650 | 13313 | 15975 | 18638 | 21300 | 23963 | 26625 |

Minimum price fluctuation of one tick, or $0.0001 per Swiss franc, is equivalent to $12.50 per contract.

## Dollar Risk Table for Soymeal Futures

Based on daily true ranges from January 1980 through June 1988

| Percent of Days | Max Tick Range | Dollar Risk for 1 through 10 Contracts | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | a | 9 | 10 |
| | | $ | $ | $ | $ | $ | $ | $ | $ | $ | $ |
| 10 | 12 | 120 | 240 | 360 | 480 | 600 | 720 | 840 | 960 | 1080 | 1200 |
| 20 | 15 | 150 | 300 | 450 | 600 | 750 | 900 | 1050 | 1200 | 1350 | 1500 |
| 30 | 18 | 180 | 360 | 540 | 720 | 900 | 1080 | 1260 | 1440 | 1620 | 1800 |
| 40 | 22 | 220 | 440 | 660 | 880 | 1100 | 1320 | 1540 | 1760 | 1980 | 2200 |
| 50 | 25 | 250 | 500 | 750 | 1000 | 1250 | 1500 | 1750 | 2000 | 2250 | 2500 |
| 60 | 30 | 300 | 600 | 900 | 1200 | 1500 | 1800 | 2100 | 2400 | 2700 | 3000 |
| 70 | 36 | 360 | 720 | 1080 | 1440 | 1800 | 2160 | 2520 | 2880 | 3240 | 3600 |
| 80 | 47 | 470 | 940 | 1410 | 1880 | 2350 | 2820 | 3290 | 3760 | 4230 | 4700 |
| 90 | 65 | 650 | 1300 | 1950 | 2600 | 3250 | 3900 | 4550 | 5200 | 5850 | 6500 |

Based on weekly true ranges from January 1980 through June 1988

| Percent of Weeks | Max Tick Range | Dollar Risk for 1 through 10 Contracts | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | a | 9 | 10 |
| | | $ | $ | $ | $ | $ | $ | $ | $ | $ | $ |
| 10 | 35 | 350 | 700 | 1050 | 1400 | 1750 | 2100 | 2450 | 2800 | 3150 | 3500 |
| 20 | 42 | 420 | 840 | 1260 | 1680 | 2100 | 2520 | 2940 | 3360 | 3780 | 4200 |
| 30 | 50 | 500 | 1000 | 1500 | 2000 | 2500 | 3000 | 3500 | 4000 | 4500 | 5000 |
| 40 | 58 | 580 | 1160 | 1740 | 2320 | 2900 | 3480 | 4060 | 4640 | 5220 | 5800 |
| 50 | 67 | 670 | 1340 | 2010 | 2680 | 3350 | 4020 | 4690 | 5360 | 6030 | 6700 |
| 60 | 80 | 800 | 1600 | 2400 | 3200 | 4000 | 4800 | 5600 | 6400 | 7200 | 8000 |
| 70 | 98 | 980 | 1960 | 2940 | 3920 | 4900 | 5880 | 6860 | 7840 | 8820 | 9800 |
| 80 | 120 | 1200 | 2400 | 3600 | 4800 | 6000 | 7200 | 8400 | 9600 | 10800 | 12000 |
| 90 | 152 | 1520 | 3040 | 4560 | 6080 | 7600 | 9120 | 10640 | 12160 | 13680 | 15200 |

Minimum price fluctuation of one tick, or $0.10 per ton, is equivalent to $10.00 per contract.



## Dollar Risk Table for Sugar (#11 World) Futures

Based on daily true ranges from January 1980 through June 1988

| Percent of Days | Max Tick Range | Dollar Risk for 1 through 10 Contracts | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | a | 9 | 10 |
| | | $ | $ | $ | $ | $ | $ | $ | $ | $ | $ |
| 10 | 11 | 123 | 246 | 370 | 493 | 616 | 739 | 862 | 986 | 1109 | 1232 |
| 20 | 15 | 168 | 336 | 504 | 672 | 840 | 1008 | 1176 | 1344 | 1512 | 1680 |
| 30 | 18 | 202 | 403 | 605 | 806 | 1008 | 1210 | 1411 | 1613 | 1814 | 2016 |
| 40 | 21 | 235 | 470 | 706 | 941 | 1176 | 1411 | 1646 | 1882 | 2117 | 2352 |
| 50 | 25 | 280 | 560 | 840 | 1120 | 1400 | 1680 | 1960 | 2240 | 2520 | 2800 |
| 60 | 30 | 336 | 672 | 1008 | 1344 | 1680 | 2016 | 2352 | 2688 | 3024 | 3360 |
| 70 | 39 | 437 | 874 | 1310 | 1747 | 2184 | 2621 | 3058 | 3494 | 3931 | 4368 |
| 80 | 57 | 638 | 1277 | 1915 | 2554 | 3192 | 3830 | 4469 | 5107 | 5746 | 6384 |
| 90 | 100 | 1120 | 2240 | 3360 | 4480 | 5600 | 6720 | 7840 | 8960 | 10080 | 11200 |

Based on weekly true ranges from January 1980 through June 1988

| Percent of Weeks | Max Tick Range | Dollar Risk for 1 through 10 Contracts | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | a | 9 | 10 |
| | | $ | $ | $ | $ | $ | $ | $ | $ | $ | $ |
| 10 | 32 | 358 | 717 | 1075 | 1434 | 1792 | 2150 | 2509 | 2867 | 3226 | 3584 |
| 20 | 40 | 448 | 896 | 1344 | 1792 | 2240 | 2688 | 3136 | 3584 | 4032 | 4480 |
| 30 | 47 | 526 | 1053 | 1579 | 2106 | 2632 | 3158 | 3685 | 4211 | 4738 | 5264 |
| 40 | 54 | 605 | 1210 | 1814 | 2419 | 3024 | 3629 | 4234 | 4838 | 5443 | 6048 |
| 50 | 62 | 694 | 1389 | 2083 | 2778 | 3472 | 4166 | 4861 | 5555 | 6250 | 6944 |
| 60 | 74 | 829 | 1658 | 2486 | 3315 | 4144 | 4973 | 5802 | 6630 | 7459 | 8288 |
| 70 | 93 | 1042 | 2083 | 3125 | 4166 | 5208 | 6250 | 7291 | 8333 | 9374 | 10416 |
| 80 | 133 | 1490 | 2979 | 4469 | 5958 | 7448 | 8938 | 10427 | 11917 | 13406 | 14896 |
| 90 | 248 | 2778 | 5555 | 8333 | 11110 | 13888 | 16666 | 19443 | 22221 | 24998 | 27776 |

Minimum price fluctuation of one tick, or 0.01 cents per pound, is equivalent to $11.20 per Contract.

## Dollar Risk Table for Soybean Oil Futures

Based on daily true ranges from January 1980 through June 1988

| Percent of Days | Max Tick Range | Dollar Risk for 1 through 10 Contracts | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 10 | 18 | 108 | 216 | 324 | 432 | 540 | 648 | 756 | 864 | 972 | 1080 |
| 20 | 23 | 138 | 276 | 414 | 552 | 690 | 828 | 966 | 1104 | 1242 | 1380 |
| 30 | 28 | 168 | 336 | 504 | 672 | 840 | 1008 | 1176 | 1344 | 1512 | 1680 |
| 40 | 33 | 198 | 396 | 594 | 792 | 990 | 1188 | 1386 | 1584 | 1782 | 1980 |
| 50 | 38 | 228 | 456 | 684 | 912 | 1140 | 1368 | 1596 | 1824 | 2052 | 2280 |
| 60 | 45 | 270 | 540 | 810 | 1080 | 1350 | 1620 | 1890 | 2160 | 2430 | 2700 |
| 70 | 54 | 324 | 648 | 972 | 1296 | 1620 | 1944 | 2268 | 2592 | 2916 | 3240 |
| 80 | 69 | 414 | 828 | 1242 | 1656 | 2070 | 2484 | 2898 | 3312 | 3726 | 4140 |
| 90 | 90 | 540 | 1080 | 1620 | 2160 | 2700 | 3240 | 3780 | 4320 | 4860 | 5400 |

Based on weekly true ranges from January 1980 through June 1988

| Percent of Weeks | Max Tick Range | Dollar Risk for 1 through 10 Contracts | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 10 | 50 | 300 | 600 | 900 | 1200 | 1500 | 1800 | 2100 | 2400 | 2700 | 3000 |
| 20 | 61 | 366 | 732 | 1098 | 1464 | 1830 | 2196 | 2562 | 2928 | 3294 | 3660 |
| 30 | 72 | 432 | 864 | 1296 | 1728 | 2160 | 2592 | 3024 | 3456 | 3888 | 4320 |
| 40 | 81 | 486 | 972 | 1458 | 1944 | 2430 | 2916 | 3402 | 3888 | 4374 | 4860 |
| 50 | 95 | 570 | 1140 | 1710 | 2280 | 2850 | 3420 | 3990 | 4560 | 5130 | 5700 |
| 60 | 110 | 660 | 1320 | 1980 | 2640 | 3300 | 3960 | 4620 | 5280 | 5940 | 6600 |
| 70 | 130 | 780 | 1560 | 2340 | 3120 | 3900 | 4680 | 5460 | 6240 | 7020 | 7800 |
| 80 | 158 | 948 | 1896 | 2844 | 3792 | 4740 | 5688 | 6636 | 7584 | 8532 | 9480 |
| 90 | 218 | 1308 | 2616 | 3924 | 5232 | 6540 | 7848 | 9156 | 10464 | 11772 | 13080 |

Minimum price fluctuation of one tick, or 0.01 cents per pound, is equivalent to $6.00 per contract.



## Dollar Risk Table for S&P 500 Stock Index Futures

Based on daily true ranges from May 1982 through June 1988

| Percent of Days | Max Tick Range | Dollar Risk for 1 through 10 Contracts | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 10 | 26 | 650 | 1300 | 1950 | 2600 | 3250 | 3900 | 4550 | 5200 | 5850 | 6500 |
| 20 | 32 | 800 | 1600 | 2400 | 3200 | 4000 | 4800 | 5600 | 6400 | 7200 | 8000 |
| 30 | 37 | 925 | 1850 | 2775 | 3700 | 4625 | 5550 | 6475 | 7400 | 8325 | 9250 |
| 40 | 44 | 1100 | 2200 | 3300 | 4400 | 5500 | 6600 | 7700 | 8800 | 9900 | 11000 |
| 50 | 50 | 1250 | 2500 | 3750 | 5000 | 6250 | 7500 | 8750 | 10000 | 11250 | 12500 |
| 60 | 57 | 1425 | 2850 | 4275 | 5700 | 7125 | 8550 | 9975 | 11400 | 12825 | 14250 |
| 70 | 68 | 1700 | 3400 | 5100 | 6800 | 8500 | 10200 | 11900 | 13600 | 15300 | 17000 |
| 80 | 82 | 2050 | 4100 | 6150 | 8200 | 10250 | 12300 | 14350 | 16400 | 18450 | 20500 |
| 90 | 107 | 2675 | 5350 | 8025 | 10700 | 13375 | 16050 | 18725 | 21400 | 24075 | 26750 |

Based on weekly true ranges from May 1982 through June 1988

| Percent of Weeks | Max Tick Range | Dollar Risk for 1 through 10 Contracts | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | | $ | $ | $ | 5 | 5 | 5 | 5 | $ | 5 | 5 |
| 10 | 69 | 1725 | 3450 | 5175 | 6900 | 8625 | 10350 | 12075 | 13800 | 15525 | 17250 |
| 20 | 80 | 2000 | 4000 | 6000 | 8000 | 10000 | 12000 | 14000 | 16000 | 18000 | 20000 |
| 30 | 92 | 2300 | 4600 | 6900 | 9200 | 11500 | 13800 | 16100 | 18400 | 20700 | 23000 |
| 40 | 104 | 2600 | 5200 | 7800 | 10400 | 13000 | 15600 | 18200 | 20800 | 23400 | 26000 |
| 50 | 117 | 2925 | 5850 | 8775 | 11700 | 14625 | 17550 | 20475 | 23400 | 26325 | 29250 |
| 60 | 135 | 3375 | 6750 | 10125 | 13500 | 16875 | 20250 | 23625 | 27000 | 30375 | 33750 |
| 70 | 157 | 3925 | 7850 | 11775 | 15700 | 19625 | 23550 | 27475 | 31400 | 35325 | 39250 |
| 80 | 205 | 5125 | 10250 | 15375 | 20500 | 25625 | 30750 | 35875 | 41000 | 46125 | 51250 |
| 90 | 252 | 6300 | 12600 | 18900 | 25200 | 31500 | 37800 | 44100 | 50400 | 56700 | 63000 |

Minimum price fluctuation of one tick, or 0.05 index points, is equivalent to $25.00 per contract.

## Dollar Risk Table for Silver (COMEX) Futures

Based on daily true ranges from January 1980 through June 1988

| Percent of Days | Max Tick Range | Dollar Risk for 1 through 10 Contracts 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $ | $ | $ | $ | $ | $ | $ | $ | $ | $ |
| 10 | 65 | 325 | 650 | 975 | 1300 | 1625 | 1950 | 2275 | 2600 | 2925 | 3250 |
| 20 | 90 | 450 | 900 | 1350 | 1800 | 2250 | 2700 | 3150 | 3600 | 4050 | 4500 |
| 30 | 117 | 585 | 1170 | 1755 | 2340 | 2925 | 3510 | 4095 | 4680 | 5265 | 5850 |
| 40 | 150 | 750 | 1500 | 2250 | 3000 | 3750 | 4500 | 5250 | 6000 | 6750 | 7500 |
| 50 | 180 | 900 | 1800 | 2700 | 3600 | 4500 | 5400 | 6300 | 7200 | 8100 | 9000 |
| 60 | 220 | 1100 | 2200 | 3300 | 4400 | 5500 | 6600 | 7700 | 8800 | 9900 | 11000 |
| 70 | 290 | 1450 | 2900 | 4350 | 5800 | 7250 | 8700 | 10150 | 11600 | 13050 | 14500 |
| 80 | 395 | 1975 | 3950 | 5925 | 7900 | 9875 | 11850 | 13825 | 15800 | 17775 | 19750 |
| 90 | 550 | 2750 | 5500 | 8250 | 11000 | 13750 | 16500 | 19250 | 22000 | 24750 | 27500 |

Based on weekly true ranges from January 1980 through June 1988

| Percent of Weeks | Max Tick Range | Dollar Risk for 1 through 10 Contracts 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $ | $ | $ | $ | $ | $ | $ | $ | $ | $ |
| 10 | 175 | 875 | 1750 | 2625 | 3500 | 4375 | 5250 | 6125 | 7000 | 7875 | 8750 |
| 20 | 235 | 1175 | 2350 | 3525 | 4700 | 5875 | 7050 | 8225 | 9400 | 10575 | 11750 |
| 30 | 310 | 1550 | 3100 | 4650 | 6200 | 7750 | 9300 | 10850 | 12400 | 13950 | 15500 |
| 40 | 399 | 1995 | 3990 | 5985 | 7980 | 9975 | 11970 | 13965 | 15960 | 17955 | 19950 |
| 50 | 460 | 2300 | 4600 | 6900 | 9200 | 11500 | 13800 | 16100 | 18400 | 20700 | 23000 |
| 60 | 575 | 2875 | 5750 | 8625 | 11500 | 14375 | 17250 | 20125 | 23000 | 25875 | 28750 |
| 70 | 750 | 3750 | 7500 | 11250 | 15000 | 18750 | 22500 | 26250 | 30000 | 33750 | 37500 |
| 80 | 970 | 4850 | 9700 | 14550 | 19400 | 24250 | 29100 | 33950 | 38800 | 43650 | 48500 |
| 90 | 1300 | 6500 | 13000 | 19500 | 26000 | 32500 | 39000 | 45500 | 52000 | 58500 | 65000 |

Minimum price fluctuation of one tick, or 0.10 cents per troy ounce, is equivalent to $5.00 per contract.



## Dollar Risk Table for Treasury Bills Futures

Based on daily true ranges from January 1980 through June 1988

| Percent of Days | Max Tick Range | Dollar Risk for 1 through 10 Contracts 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $ | $ | $ | $ | $ | $ | $ | $ | $ | $ |
| 10 | 6 | 150 | 300 | 450 | 600 | 750 | 900 | 1050 | 1200 | 1350 | 1500 |
| 20 | 8 | 200 | 400 | 600 | 800 | 1000 | 1200 | 1400 | 1600 | 1800 | 2000 |
| 30 | 10 | 250 | 500 | 750 | 1000 | 1250 | 1500 | 1750 | 2000 | 2250 | 2500 |
| 40 | 12 | 300 | 600 | 900 | 1200 | 1500 | 1800 | 2100 | 2400 | 2700 | 3000 |
| 50 | 14 | 350 | 700 | 1050 | 1400 | 1750 | 2100 | 2450 | 2800 | 3150 | 3500 |
| 60 | 18 | 450 | 900 | 1350 | 1800 | 2250 | 2700 | 3150 | 3600 | 4050 | 4500 |
| 70 | 25 | 625 | 1250 | 1875 | 2500 | 3125 | 3750 | 4375 | 5000 | 5625 | 6250 |
| 80 | 33 | 825 | 1650 | 2475 | 3300 | 4125 | 4950 | 5775 | 6600 | 7425 | 8250 |
| 90 | 45 | 1125 | 2250 | 3375 | 4500 | 5625 | 6750 | 7875 | 9000 | 10125 | 11250 |

Based on weekly true ranges from January 1980 through June 1988

| Percent of Weeks | Max Tick Range | Dollar Risk for 1 through 10 Contracts 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $ | $ | $ | $ | $ | $ | $ | $ | $ | $ |
| 10 | 16 | 400 | 800 | 1200 | 1600 | 2000 | 2400 | 2800 | 3200 | 3600 | 4000 |
| 20 | 21 | 525 | 1050 | 1575 | 2100 | 2625 | 3150 | 3675 | 4200 | 4725 | 5250 |
| 30 | 25 | 625 | 1250 | 1875 | 2500 | 3125 | 3750 | 4375 | 5000 | 5625 | 6250 |
| 40 | 29 | 725 | 1450 | 2175 | 2900 | 3625 | 4350 | 5075 | 5800 | 6525 | 7250 |
| 50 | 35 | 875 | 1750 | 2625 | 3500 | 4375 | 5250 | 6125 | 7000 | 7875 | 8750 |
| 60 | 47 | 1175 | 2350 | 3525 | 4700 | 5875 | 7050 | 8225 | 9400 | 10575 | 11750 |
| 70 | 61 | 1525 | 3050 | 4575 | 6100 | 7625 | 9150 | 10675 | 12200 | 13725 | 15250 |
| 80 | 81 | 2025 | 4050 | 6075 | 8100 | 10125 | 12150 | 14175 | 16200 | 18225 | 20250 |
| 90 | 105 | 2625 | 5250 | 7875 | 10500 | 13125 | 15750 | 18375 | 21000 | 23625 | 26250 |

Minimum price fluctuation of one tick, or 0.01 of one percentage point, is equivalent to $25.00 per contract.

## Dollar Risk Table for Wheat (Chicago) Futures

Based on daily true ranges from January 1980 through June 1988

| Percent of Days | Max Tick Range | Dollar Risk for 1 through 10 Contracts 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $ | $ | $ | $ | $ | $ | $ | $ | 5 | $ |
| 10 | 12 | 150 | 300 | 450 | 600 | 750 | 900 | 1050 | 1200 | 1350 | 1500 |
| 20 | 14 | 175 | 350 | 525 | 700 | 875 | 1050 | 1225 | 1400 | 1575 | 1750 |
| 30 | 16 | 200 | 400 | 600 | 800 | 1000 | 1200 | 1400 | 1600 | 1800 | 2000 |
| 40 | 18 | 225 | 450 | 675 | 900 | 1125 | 1350 | 1575 | 1800 | 2025 | 2250 |
| 50 | 21 | 263 | 525 | 788 | 1050 | 1313 | 1575 | 1838 | 2100 | 2363 | 2625 |
| 60 | 24 | 300 | 600 | 900 | 1200 | 1500 | 1800 | 2100 | 2400 | 2700 | 3000 |
| 70 | 28 | 350 | 700 | 1050 | 1400 | 1750 | 2100 | 2450 | 2800 | 3150 | 3500 |
| 80 | 32 | 400 | 800 | 1200 | 1600 | 2000 | 2400 | 2800 | 3200 | 3600 | 4000 |
| 90 | 42 | 525 | 1050 | 1575 | 2100 | 2625 | 3150 | 3675 | 4200 | 4725 | 5250 |

Based on weekly true ranges from January 1980through June 1988

| Percent of Weeks | Max Tick Range | Dollar Risk for 1 through 10 Contracts 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 5 | $ | $ | $ | $ | 5 | $ | $ | $ | $ |
| 10 | 31 | 388 | 775 | 1163 | 1550 | 1938 | 2325 | 2713 | 3100 | 3488 | 3875 |
| 20 | 37 | 463 | 925 | 1388 | 1850 | 2313 | 2775 | 3238 | 3700 | 4163 | 4625 |
| 30 | 43 | 538 | 1075 | 1613 | 2150 | 2688 | 3225 | 3763 | 4300 | 4838 | 5375 |
| 40 | 48 | 600 | 1200 | 1800 | 2400 | 3000 | 3600 | 4200 | 4800 | 5400 | 6000 |
| 50 | 53 | 663 | 1325 | 1988 | 2650 | 3313 | 3975 | 4638 | 5300 | 5963 | 6625 |
| 60 | 60 | 750 | 1500 | 2250 | 3000 | 3750 | 4500 | 5250 | 6000 | 6750 | 7500 |
| 70 | 67 | 838 | 1675 | 2513 | 3350 | 4188 | 5025 | 5863 | 6700 | 7538 | 8375 |
| 80 | 76 | 950 | 1900 | 2850 | 3800 | 4750 | 5700 | 6650 | 7600 | 8550 | 9500 |
| 90 | 94 | 1175 | 2350 | 3525 | 4700 | 5875 | 7050 | 8225 | 9400 | 10575 | 11750 |

Minimum price fluctuation of one tick, or 0.25 cents per bushel, is equivalent to $12.50 per contract.



## Dollar Risk Table for Wheat (Kansas City) Futures

Based on daily true ranges from January 1980 through June 1988

| Percent of Days | Max Tick Range | Dollar Risk for 1 through 10 Contracts 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $ | $ | $ | $ | $ | $ | $ | $ | $ | $ |
| 10 | 6 | 75 | 150 | 225 | 300 | 375 | 450 | 525 | 600 | 675 | 750 |
| 20 | 8 | 100 | 200 | 300 | 400 | 500 | 600 | 700 | 800 | 900 | 1000 |
| 30 | 10 | 125 | 250 | 375 | 500 | 625 | 750 | 875 | 1000 | 1125 | 1250 |
| 40 | 12 | 150 | 300 | 450 | 600 | 750 | 900 | 1050 | 1200 | 1350 | 1500 |
| 50 | 14 | 175 | 350 | 525 | 700 | 875 | 1050 | 1225 | 1400 | 1575 | 1750 |
| 60 | 16 | 200 | 400 | 600 | 800 | 1000 | 1200 | 1400 | 1600 | 1800 | 2000 |
| 70 | 19 | 238 | 475 | 713 | 950 | 1188 | 1425 | 1663 | 1900 | 2138 | 2375 |
| 80 | 24 | 300 | 600 | 900 | 1200 | 1500 | 1800 | 2100 | 2400 | 2700 | 3000 |
| 90 | 32 | 400 | 800 | 1200 | 1600 | 2000 | 2400 | 2800 | 3200 | 3600 | 4000 |

Based on weekly true ranges from January 1980 through June 1988

| Percent of Weeks | Max Tick Range | Dollar Risk for 1 through 10 Contracts 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $ | $ | $ | $ | $ | $ | $ | $ | $ | $ |
| 10 | 18 | 225 | 450 | 675 | 900 | 1125 | 1350 | 1575 | 1800 | 2025 | 2250 |
| 20 | 23 | 288 | 575 | 863 | 1150 | 1438 | 1725 | 2013 | 2300 | 2588 | 2875 |
| 30 | 28 | 350 | 700 | 1050 | 1400 | 1750 | 2100 | 2450 | 2800 | 3150 | 3500 |
| 40 | 33 | 413 | 825 | 1238 | 1650 | 2063 | 2475 | 2888 | 3300 | 3713 | 4125 |
| 50 | 39 | 488 | 975 | 1463 | 1950 | 2438 | 2925 | 3413 | 3900 | 4388 | 4875 |
| 60 | 46 | 575 | 1150 | 1725 | 2300 | 2875 | 3450 | 4025 | 4600 | 5175 | 5750 |
| 70 | 52 | 650 | 1300 | 1950 | 2600 | 3250 | 3900 | 4550 | 5200 | 5850 | 6500 |
| 80 | 60 | 750 | 1500 | 2250 | 3000 | 3750 | 4500 | 5250 | 6000 | 6750 | 7500 |
| 90 | 82 | 1025 | 2050 | 3075 | 4100 | 5125 | 6150 | 7175 | 8200 | 9225 | 10250 |

Minimum price fluctuation of one tick, or 0.25 cents per bushel, is equivalent to $12.50 per contract.

# E

# Analysis of Opening Prices for 24 Commodities

This Appendix analyzes the location of up and down periods for 24 commodities. An up period is one where the close price is higher than the opening price. A down period is one where the close price is lower than the opening price. The analysis is conducted separately for daily and weekly data. A percentile distribution is provided for (a) the difference between the open and the low, for up periods, and (b) the difference between the high and the open, for down periods.

For example, in 90 percent of the up days analyzed for the British pound, the opening price was found to be within 32 ticks of the daily low. In 90 percent of the down weeks analyzed for the British pound, the opening price was found to be within 85 ticks of the weekly high.





Analysis of Opening Prices for British Pound Futures

Analysis for Up Periods

| | Difference in Ticks[a] between the Open (O) and the Low (L) | |
|---|---|---|
| Percent of Total Obs. | Daily Data (0 – L) in Ticks | Weekly Data (0 – L) in Ticks |
| 10 | 2 | 2 |
| 20 | 5 | 7 |
| 30 | 7 | 10 |
| 40 | 10 | 15 |
| 50 | 12 | 20 |
| 60 | 15 | 28 |
| 70 | 18 | 37 |
| 80 | 23 | 50 |
| 90 | 32 | 75 |

Analysis for Down Periods

| | Difference in Ticks[a] between the High (H) and the Open (0) | |
|---|---|---|
| Percent of Total Obs. | Daily Data (H – 0) in Ticks | Weekly Data (H – 0) in Ticks |
| 10 | 2 | 3 |
| 20 | 5 | 7 |
| 30 | 5 | 12 |
| 40 | 10 | 18 |
| 50 | 12 | 25 |
| 60 | 15 | 32 |
| 70 | 18 | 42 |
| 80 | 23 | 58 |
| 90 | 32 | 85 |

Based on price data from January 1980 through June 1988.

[a]Minimum price fluctuation of one tick, or $0.0002 per Pound, is equivalent to $12.50 per contract.

Analysis of Opening Prices for Corn Futures

Analysis for Up Periods

| Percent of Total Obs. | Difference in Ticks[a] between the Open (0) and the Low (L): Daily Data (0 − L) in Ticks | Weekly Data (0 L) in Ticks |
|---|---|---|
| 10 | 0 | 0 |
| 20 | 0 | 2 |
| 30 | 1 | 3 |
| 40 | 2 | 4 |
| 50 | 3 | 6 |
| 60 | 3 | 7 |
| 70 | 4 | 9 |
| 80 | 5 | 12 |
| 90 | 8 | 18 |

Analysis for Down Periods

| Percent of Total Obs. | Difference in Ticks" between the High (H) and the Open (0): Daily Data (H − 0) in Ticks | Weekly Data (H − 0) in Ticks |
|---|---|---|
| 10 | 0 | 0 |
| 20 | 0 | 2 |
| 30 | 1 | 2 |
| 40 | 1 | 4 |
| 50 | 2 | 6 |
| 60 | 2 | 7 |
| 70 | 4 | 11 |
| 80 | 4 | 13 |
| 90 | 7 | 18 |

Based on price data from January 1980 through June 1988.

"Minimum price fluctuation of one tick, or 0.25 cents per bushel, is equivalent to $12.50 per contract.



Analysis of Opening Prices for Crude Oil Futures

Analysis for Up Periods

| Percent of Total Obs. | Difference in Ticks" between the Open (0) and the Low (L): Daily Data (0 − L) in Ticks | Weekly Data (0 − L) in Ticks |
|---|---|---|
| IO | 0 | 0 |
| 20 | 1 | 5 |
| 30 | 3 | 8 |
| 40 | 5 | 10 |
| 50 | 6 | 12 |
| 60 | 7 | 14 |
| 70 | 9 | 20 |
| 80 | 11 | 28 |
| 90 | 17 | 47 |

Analysis for Down Periods

| Percent of Total Obs. | Difference in Ticks[a] between the High (H) and the Open (0): Daily Data (H − 0) in Ticks | Weekly Data (H 0) in Ticks |
|---|---|---|
| 10 | 0 | 1 |
| 20 | 1 | 3 |
| 30 | 2 | 5 |
| 40 | 4 | 7 |
| 50 | 5 | 12 |
| 60 | 7 | 17 |
| 70 | 9 | 20 |
| 80 | 12 | 26 |
| 90 | 18 | 38 |

Based on price data from January 1980 through June 1988.

"Minimum price fluctuation of one tick, or $0.01 per barrel, is equivalent to $10.00 per contract.

Analysis of Opening Prices
for Copper (Standard) Futures

Analysis for Up Periods

| Percent of Total Obs. | Daily Data (O − L) in Ticks | Weekly Data (O − L) in Ticks |
|---|---|---|
| | Difference in Ticks[a] between the Open (O) and the Low (L) | |
| 10 | 0 | 0 |
| 20 | 0 | 2 |
| 30 | 0 | 4 |
| 40 | 1 | 6 |
| 50 | 2 | 10 |
| 60 | 4 | 14 |
| 70 | 5 | 18 |
| 80 | 8 | 28 |
| 90 | 14 | 44 |

Analysis for Down Periods

| Percent of Total Obs. | Daily Data (H − O) in Ticks | Weekly Data (H − O) in Ticks |
|---|---|---|
| | Difference in Ticks[a] between the High (H) and the Open (O) | |
| 10 | 0 | 1 |
| 20 | 1 | 4 |
| 30 | 2 | 5 |
| 40 | 4 | 7 |
| 50 | 4 | 10 |
| 60 | 6 | 14 |
| 70 | 8 | 17 |
| 80 | 10 | 22 |
| 90 | 16 | 29 |

Based on price data from January 1980 through June 1988.

[a]Minimum price fluctuation of one tick, or 0.05 cents per pound, is equivalent to $12.50 per contract.



Analysis of Opening Prices
for Treasury Bond Futures

Analysis for Up Periods

| Percent of Total Obs. | Daily Data (O − L) in Ticks | Weekly Data (O − L) in Ticks |
|---|---|---|
| | Difference in Ticks[a] between the Open (O) and the Low (L) | |
| 10 | 0 | 2 |
| 20 | 1 | 4 |
| 30 | 2 | 6 |
| 40 | 4 | 9 |
| 50 | 5 | 12 |
| 60 | 6 | 16 |
| 70 | 8 | 20 |
| 80 | 10 | 27 |
| 90 | 14 | 36 |

Analysis for Down Periods

| Percent of Total Obs. | Daily Data (H − O) in Ticks | Weekly Data (H − O) in Ticks |
|---|---|---|
| | Difference in Ticks[a] between the High (H) and the Open (O) | |
| 10 | 0 | 0 |
| 20 | 2 | 3 |
| 30 | 3 | 6 |
| 40 | 4 | 8 |
| 50 | 5 | 11 |
| 60 | 7 | 14 |
| 70 | 8 | 19 |
| 80 | 11 | 27 |
| 90 | 15 | 39 |

Based on price data from January 1980 through June 1988.

[a]Minimum price fluctuation of one tick, or $1/32$ of one percentage point, is equivalent to $31.25 per contract.

## Analysis of Opening Prices for Deutsche Mark' Futures

### Analysis for Up Periods

| Percent of Total Obs. | Difference in Ticks[a] between the Open (0) and the Low (L): Daily Data (0 − L) in Ticks | Weekly Data (0 − L) in Ticks |
|---|---|---|
| 10 | 1 | 2 |
| 20 | 2 | 4 |
| 30 | 3 | 7 |
| 40 | 4 | 9 |
| 50 | 6 | 13 |
| 60 | 7 | 18 |
| 70 | 9 | 22 |
| 80 | 12 | 31 |
| 90 | 17 | 40 |

### Analysis for Down Periods

| Percent of Total Obs. | Difference in Ticks[a] between the High (H) and the Open (0): Daily Data (H − 0) in Ticks | Weekly Data (H − 0) in Ticks |
|---|---|---|
| 10 | 1 | 2 |
| 20 | 2 | 4 |
| 30 | 4 | 6 |
| 40 | 5 | 9 |
| 50 | 6 | 11 |
| 60 | 7 | 15 |
| 70 | 9 | 20 |
| 80 | 12 | 29 |
| 90 | 17 | 39 |

Based on price data from January 1980 through June 1988.

[a] Minimum price fluctuation of one tick, or $0.0001 per mark, is equivalent to $12.50 per contract.



## Analysis of Opening Prices for Eurodollar Futures

### Analysis for Up Periods

| Percent of Total Obs. | Difference in Ticks[a] between the Open (0) and the Low (L): Daily Data (0 − L) in Ticks | Weekly Data (0 − L) in Ticks |
|---|---|---|
| 10 | 0 | 0 |
| 20 | 1 | 2 |
| 30 | 1 | 3 |
| 40 | 2 | 4 |
| 50 | 2 | 5 |
| 60 | 3 | 7 |
| 70 | 4 | 9 |
| 80 | 5 | 11 |
| 90 | 7 | 18 |

### Analysis for Down Periods

| Percent of Total Obs. | Difference in Tick9 between the High (H) and the Open (0): Daily Data (H − 0) in Ticks | Weekly Data (H 0) in Ticks |
|---|---|---|
| 10 | 0 | 0 |
| 20 | 0 | 2 |
| 30 | 1 | 3 |
| 40 | 1 | 5 |
| 50 | 2 | 6 |
| 60 | 3 | 8 |
| 70 | 4 | 10 |
| 80 | 5 | 14 |
| 90 | 7 | 20 |

Based on price data from December 1981 through June 1988.

[a] Minimum price fluctuation of one tick, or 0.01 of one percentage point, is equivalent to $25.00 per contract.

## Analysis of Opening Prices for Gold (COMEX) Futures

### Analysis for Up Periods

| Percent of Total Obs. | Difference in Ticks[a] between the Open (0) and the Low (L) | |
|---|---|---|
| | Daily Data (0 – L) in Ticks | Weekly Data (0 – L) in Ticks |
| 10 | 0 | 3 |
| 20 | 3 | 10 |
| 30 | 5 | 15 |
| 40 | 9 | 20 |
| 50 | 10 | 25 |
| 60 | 15 | 35 |
| 70 | 19 | 45 |
| 80 | 26 | 70 |
| 90 | 40 | 110 |

### Analysis for Down Periods

| Percent of Total Obs. | Difference in Ticks[a] between the High (H) and the Open (0) | |
|---|---|---|
| | Daily Data (H – 0) in Ticks | Weekly Data (H – 0) in Ticks |
| 10 | 0 | 3 |
| 20 | 4 | 6 |
| 30 | 5 | 10 |
| 40 | 8 | 18 |
| 50 | 10 | 24 |
| 60 | 14 | 30 |
| 70 | 18 | 40 |
| 80 | 25 | 60 |
| 90 | 35 | 90 |

Based on price data from January 1980 through June 1988.

[a]Minimum price fluctuation of one tick, or $0.10 per troy ounce, is equivalent to $10.00 per contract.



## Analysis of Opening Prices for Japanese Yen Futures

### Analysis for Up Periods

| Percent of Total Obs. | Difference in Ticks[a] between the Open (0) and the Low (L) | |
|---|---|---|
| | Daily Data (0 – L) in Ticks | Weekly Data (0 – L) in Ticks |
| 10 | 1 | 2 |
| 20 | 2 | 4 |
| 30 | 3 | 8 |
| 40 | 4 | 10 |
| 50 | 5 | 13 |
| 60 | 7 | 17 |
| 70 | 9 | 22 |
| 80 | 12 | 27 |
| 90 | 15 | 37 |

### Analysis for Down Periods

| Percent of Total Obs. | Difference in Ticks[a] between the High (H) and the Open (0) | |
|---|---|---|
| | Daily Data (H – 0) in Ticks | Weekly Data (H – 0) in Ticks |
| 10 | 0 | 2 |
| 20 | 2 | 5 |
| 30 | 3 | 6 |
| 40 | 4 | 9 |
| 50 | 6 | 13 |
| 60 | 7 | 16 |
| 70 | 9 | 22 |
| 80 | 12 | 31 |
| 90 | 18 | 44 |

Based on price data from January 1980 through June 1988.

[a]Minimum price fluctuation of one tick, or $0.0001 per 100 yen, is equivalent to $12.50 per contract.

Analysis of Opening Prices for Live Cattle Futures

Analysis for Up Periods

| Percent of Total Obs. | Difference in Ticks[a] between the Open (0) and the Low (L): Daily Data (0 − L) in Ticks | Weekly Data (0 − L) in Ticks |
|---|---|---|
| IO | 0 | 2 |
| 20 | 2 | 5 |
| 30 | 4 | 9 |
| 40 | 5 | 13 |
| 50 | 6 | 18 |
| 60 | 8 | 22 |
| 70 | IO | 29 |
| 80 | 13 | 36 |
| 90 | 17 | 50 |

Analysis for Down Periods

| Percent of Total Obs. | Difference in Ticks[a] between the High (H) and the Open (0): Daily Data (H − 0) in Ticks | Weekly Data (H − 0) in Ticks |
|---|---|---|
| 10 | 0 | 2 |
| 20 | 2 | 4 |
| 30 | 4 | 8 |
| 40 | 5 | 11 |
| 50 | 6 | 14 |
| 60 | 8 | 18 |
| 70 | 10 | 21 |
| 80 | 13 | 28 |
| 90 | 17 | 38 |

Based on price data from January 1980 through June 1988.

[a] Minimum price fluctuation of one tick, or 0.025 cents per pound, is equivalent to $10.00 per contract.



Analysis of Opening Prices for Live **Hog** Futures

Analysis for Up Periods

| Percent of Total Obs. | Difference in Ticks[a] between the Open (0) and the Low (L): Daily Data (0 − L) in Ticks | Weekly Data (0 − L) in Ticks |
|---|---|---|
| 10 | 0 | 2 |
| 20 | 2 | 6 |
| 30 | 4 | 8 |
| 40 | 5 | 12 |
| 50 | 7 | 16 |
| 60 | 9 | 22 |
| 70 | 12 | 28 |
| 80 | 14 | 34 |
| 90 | 20 | 44 |

Analysis for Down Periods

| Percent of Total Obs. | Difference in Ticks[a] between the High (H) and the Open (0): Daily Data (H − 0) in Ticks | Weekly Data (H − 0) in Ticks |
|---|---|---|
| 10 | 0 | 2 |
| 20 | 2 | 4 |
| 30 | 4 | 8 |
| 40 | 5 | 12 |
| 50 | 7 | 18 |
| 60 | 9 | 24 |
| 70 | 12 | 28 |
| 80 | 14 | 34 |
| 90 | 19 | 43 |

Based on price data from January 1980 through June 1988.

[a] Minimum price fluctuation of one tick, or 0.025 cents per pound, is equivalent to $10.00 per contract.

## Analysis of Opening Prices for Treasury Notes Futures

Analysis for Up Periods

| Percent of Total Obs. | Difference in Ticks[a] between the Open (O) and the Low (L) — Daily Data (O − L) in Ticks | Weekly Data (O − L) in Ticks |
|---|---|---|
| 10 | 0 | 1 |
| 20 | 1 | 2 |
| 30 | 1 | 4 |
| 40 | 2 | 5 |
| 50 | 3 | 7 |
| 60 | 4 | 9 |
| 70 | 5 | 13 |
| 80 | 7 | 18 |
| 90 | 9 | 25 |

Analysis for Down Periods

| Percent of Total Obs. | Difference in Ticks[a] between the High (H) and the Open (O) — Daily Data (H − O) in Ticks | Weekly Data (H − O) in Ticks |
|---|---|---|
| 10 | 0 | 2 |
| 20 | 1 | 3 |
| 30 | 2 | 5 |
| 40 | 2 | 6 |
| 50 | 3 | 8 |
| 60 | 4 | 10 |
| 70 | 6 | 13 |
| 80 | 7 | 16 |
| 90 | 10 | 25 |

Based on price data from May 1982 through June 1988.

[a] Minimum price fluctuation of one tick, or 1/32 of one percentage point, is equivalent to $31.25 per contract.



## Analysis of Opening Prices for NYSE Composite Index Futures

Analysis for Up Periods

| Percent of Total Obs. | Difference in Ticks[a] between the Open (O) and the Low (L) — Daily Data (O − L) in Ticks | Weekly Data (O − L) in Ticks |
|---|---|---|
| 10 | 1 | 3 |
| 20 | 2 | 5 |
| 30 | 4 | 8 |
| 40 | 5 | 12 |
| 50 | 6 | 15 |
| 60 | 8 | 19 |
| 70 | 10 | 25 |
| 80 | 14 | 31 |
| 90 | 20 | 41 |

Analysis for Down Periods

| Percent of Total Obs. | Difference in Ticks[a] between the High (H) and the Open (O) — Daily Data (H − O) in Ticks | Weekly Data (H − O) in Ticks |
|---|---|---|
| 10 | 1 | 1 |
| 20 | 2 | 4 |
| 30 | 3 | 7 |
| 40 | 4 | 9 |
| 50 | 6 | 11 |
| 60 | 7 | 15 |
| 70 | 10 | 18 |
| 80 | 13 | 21 |
| 90 | 19 | 29 |

Based on price data from June 1983 through June 1988.

[a] Minimum price fluctuation of one tick, or 0.05 index points, is equivalent to $25.00 per contract.

Analysis of Opening Prices for Oats Futures

Analysis for Up Periods

| Percent of Total Obs. | Difference in Ticks” between the Open (0) and the Low (L) — Daily Data (0 - L) in Ticks | Weekly Data (0 - L) in Ticks |
|---|---|---|
| 10 | 0 | 0 |
| 20 | 0 | 2 |
| 30 | 0 | 4 |
| 40 | 2 | 8 |
| 50 | 4 | 12 |
| 60 | 4 | 16 |
| 70 | 6 | 20 |
| 80 | 10 | 26 |
| 90 | 14 | 36 |

Analysis for Down Periods

| Percent of Total Obs. | Difference in Tick9 between the High (H) and the Open (0) — Daily Data (H - 0) in Ticks | Weekly Data (H - 0) in Ticks |
|---|---|---|
| 10 | 0 | 0 |
| 20 | 0 | 2 |
| 30 | 0 | 4 |
| 40 | 2 | a |
| 50 | 4 | 10 |
| 60 | 4 | 16 |
| 70 | 8 | 20 |
| 80 | 10 | 28 |
| 90 | 16 | 44 |

Based on price data from January 1980 through June 1988.

“Minimum price fluctuation of one tick, or 0.25 cents per bushel, is equivalent to $12.50 per contract.



Analysis of Opening Prices for Soybeans Futures

Analysis for Up Periods

| Percent of Total Obs. | Difference in Ticks” between the Open (0) and the Low (L) — Daily Data (0 - L) in Ticks | Weekly Data (0 - L) in Ticks |
|---|---|---|
| 10 | 0 | 0 |
| 20 | 0 | 4 |
| 30 | 2 | 8 |
| 40 | 4 | 10 |
| 50 | 6 | 16 |
| 60 | 8 | 22 |
| 70 | 12 | 26 |
| 80 | 15 | 42 |
| 90 | 22 | 62 |

Analysis for Down Periods

| Percent of Total Obs. | Difference in Ticks[a] between the High (H) and the Open (0) — Daily Data (H - 0) in Ticks | Weekly Data (H - 0) in Ticks |
|---|---|---|
| 10 | 0 | 0 |
| 20 | 1 | 6 |
| 30 | 3 | 10 |
| 40 | 5 | 12 |
| 50 | 7 | 18 |
| 60 | 10 | 22 |
| 70 | 12 | 26 |
| 80 | 16 | 36 |
| 90 | 24 | 52 |

Based on price data from January 1980 through June 1988.

“Minimum price fluctuation of one tick, or 0.25 cents per bushel, is equivalent to $12.50 per contract.

Analysis of Opening Prices for Swiss Franc Futures

Analysis for Up Periods

| Percent of Total Obs. | Difference in Ticks[a] between the Open (0) and the Low (L): Daily Data (0 L) in Ticks | Weekly Data (0 − L) in Ticks |
|---|---|---|
| 10 | 1 | 4 |
| 20 | 2 | 7 |
| 30 | 5 | 10 |
| 40 | 6 | 13 |
| 50 | 8 | 18 |
| 60 | 11 | 24 |
| 70 | 13 | 29 |
| 80 | 17 | 40 |
| 90 | 24 | 58 |

Analysis for Down Periods

| Percent of Total Obs. | Difference in Ticks" between the High (H) and the Open (0): Daily Data (H − 0) in Ticks | Weekly Data (H − 0) in Ticks |
|---|---|---|
| 10 | 1 | 3 |
| 20 | 3 | 5 |
| 30 | 5 | 9 |
| 40 | 7 | 11 |
| 50 | 9 | 17 |
| 60 | 11 | 23 |
| 70 | 13 | 32 |
| 80 | 17 | 40 |
| 90 | 23 | 65 |

Based on price data from January 1980 through June 1988.

“Minimum price fluctuation of one tick, or $0.0001 per Swiss franc, is equivalent to $12.50 per contract.



Analysis of Opening Prices for Soymeal Futures

Analysis for Up Periods

| Percent of Total Obs. | Difference in Ticks[a] between the Open (0) and the Low (L): Daily Data (0 − L) in Ticks | Weekly Data (0 − L) in Ticks |
|---|---|---|
| 10 | 0 | 0 |
| 20 | 0 | 4 |
| 30 | 2 | 7 |
| 40 | 3 | 10 |
| 50 | 5 | 13 |
| 60 | 6 | 17 |
| 70 | 8 | 21 |
| 80 | 11 | 29 |
| 90 | 17 | 41 |

Analysis for Down Periods

| Percent of Total Obs. | Difference in Ticks" between the High (H) and the Open (0): Daily Data (H − 0) in Ticks | Weekly Data (H − 0) in Ticks |
|---|---|---|
| 10 | 0 | 0 |
| 20 | 0 | 2 |
| 30 | 0 | 4 |
| 40 | 2 | 5 |
| 50 | 3 | 8 |
| 60 | 5 | 11 |
| 70 | 7 | 16 |
| 80 | 10 | 23 |
| 90 | 15 | 35 |

Based on price data from January 1980 through June 1988.

“Minimum price fluctuation of one tick, or $0.10 per ton, is equivalent to $10.00 per contract.

## Analysis of Opening Prices for Sugar (#11 World) Futures

### Analysis for Up Periods

| Percent of Total Obs. | Difference in Ticks[a] between the Open (0) and the Low (L): Daily Data (0 − L) in Ticks | Difference in Ticks[a] between the Open (0) and the Low (L): Weekly Data (0 − L) in Ticks |
|---|---|---|
| 10 | 0 | 0 |
| 20 | 0 | 3 |
| 30 | 0 | 5 |
| 40 | 1 | 7 |
| 50 | 3 | 10 |
| 60 | 5 | 15 |
| 70 | 6 | 20 |
| 80 | 10 | 29 |
| 90 | 15 | 45 |

### Analysis for Down Periods

| Percent of Total Obs. | Difference in Ticks[a] between the High (H) and the Open (0): Daily Data (H − 0) in Ticks | Difference in Ticks[a] between the High (H) and the Open (0): Weekly Data (H − 0) in Ticks |
|---|---|---|
| 10 | 2 | 2 |
| 20 | 2 | 4 |
| 30 | 4 | 6 |
| 40 | 5 | 10 |
| 50 | 6 | 12 |
| 60 | 8 | 15 |
| 70 | 10 | 21 |
| 80 | 15 | 29 |
| 90 | 25 | 43 |

Based on price data from January 1980 through June 1988.

[a]Minimum price fluctuation of one tick, or 0.01 cents per pound, is equivalent to $11.20 per contract.



## Analysis of Opening Prices for Soybean Oil Futures

### Analysis for Up Periods

| Percent of Total Obs. | Difference in Ticks[a] between the Open (0) and the Low (L): Daily Data (0 − L) in Ticks | Difference in Ticks[a] between the Open (0) and the Low (L): Weekly Data (0 − L) in Ticks |
|---|---|---|
| 10 | 0 | 1 |
| 20 | 1 | 4 |
| 30 | 3 | 7 |
| 40 | 5 | 12 |
| 50 | 7 | 17 |
| 60 | 9 | 23 |
| 70 | 12 | 32 |
| 80 | 15 | 40 |
| 90 | 24 | 55 |

### Analysis for Down Periods

| Percent of Total Obs. | Difference in Ticks[a] between the High (H) and the Open (0): Daily Data (H − 0) in Ticks | Difference in Ticks[a] between the High (H) and the Open (0): Weekly Data (H − 0) in Ticks |
|---|---|---|
| 10 | 0 | 0 |
| 20 | 0 | 3 |
| 30 | 1 | 5 |
| 40 | 3 | 8 |
| 50 | 5 | 15 |
| 60 | 7 | 22 |
| 70 | 10 | 30 |
| 80 | 15 | 40 |
| 90 | 22 | 53 |

Based on price data from January 1980 through June 1988.

[a]Minimum price fluctuation of one tick, or 0.01 cents per pound, is equivalent to $6.00 per contract.

Analysis of Opening Prices for
S&P 500 Stock Index Futures

Analysis for Up Periods

| Percent of Total Obs. | Difference in Ticks[a] between the Open (0) and the Low (L): Daily Data (0 − L) in Ticks | Weekly Data (0 − L) in Ticks |
|---|---|---|
| 10 | 1 | 4 |
| 20 | 3 | 8 |
| 30 | 6 | 12 |
| 40 | 8 | 16 |
| 50 | 10 | 22 |
| 60 | 13 | 29 |
| 70 | 16 | 36 |
| 80 | 22 | 44 |
| 90 | 30 | 58 |

Analysis for Down Periods

| Percent of Total Obs. | Difference in Ticks” between the High (H) and the Open (0): Daily Data (H − 0) in Ticks | Weekly Data (H − 0) in Ticks |
|---|---|---|
| 10 | 1 | 5 |
| 20 | 3 | 10 |
| 30 | 5 | 16 |
| 40 | 8 | 20 |
| 50 | 10 | 25 |
| 60 | 12 | 28 |
| 70 | 16 | 34 |
| 80 | 20 | 44 |
| 90 | 30 | 58 |

Based on price data from May 1982 through June 1988.

“Minimum price fluctuation of one tick, or 0.05 index points, is equivalent to $25.00 per contract.



Analysis of Opening Prices
for Silver (COMEX) Futures

Analysis for Up Periods

| Percent of Total Obs. | Difference in Ticks” between the Open (0) and the Low (L): Daily Data (0 − L) in Ticks | Weekly Data (0 − L) in Ticks |
|---|---|---|
| 10 | 0 | 0 |
| 20 | 0 | 15 |
| 30 | 9 | 30 |
| 40 | 15 | 40 |
| 50 | 25 | 60 |
| 60 | 35 | 80 |
| 70 | 50 | 110 |
| 80 | 70 | 170 |
| 90 | 100 | 270 |

Analysis for Down Periods

| Percent of Total Obs. | Difference in Ticks[a] between the High (H) and the Open (0): Daily Data (H − 0) in Ticks | Weekly Data (H − 0) in Ticks |
|---|---|---|
| 10 | 0 | 0 |
| 20 | 10 | 15 |
| 30 | 20 | 30 |
| 40 | 25 | 40 |
| 50 | 35 | 60 |
| 60 | 50 | 95 |
| 70 | 69 | 130 |
| 80 | 90 | 190 |
| 90 | 140 | 295 |

Based on price data from January 1980 through June 1988.

“Minimum price fluctuation of one tick, or 0.10 cents per troy ounce, is equivalent to $5.00 per contract.

Analysis of Opening Prices for Treasury Bills Futures

Analysis for Up Periods

| | Difference in Ticks[a] between the Open (0) and the Low (L) | |
|---|---|---|
| Percent of Total Obs. | Daily Data (0 − L) in Ticks | Weekly Data (0 L) in Ticks |
| 10 | 0 | 1 |
| 20 | 1 | 2 |
| 30 | 1 | 4 |
| 40 | 2 | 5 |
| 50 | 3 | 7 |
| 60 | 3 | 9 |
| 70 | 4 | 12 |
| 80 | 6 | 18 |
| 90 | 10 | 28 |

Analysis for Down Periods

| | Difference in Ticks[a] between the High (H) and the Open (0) | |
|---|---|---|
| Percent of Total Obs. | Daily Data (H − 0) in Ticks | Weekly Data (H − 0) in Ticks |
| 10 | 0 | 0 |
| 20 | 1 | 2 |
| 30 | 1 | 2 |
| 40 | 2 | 4 |
| 50 | 3 | 5 |
| 60 | 3 | 6 |
| 70 | 5 | 9 |
| 80 | 7 | 14 |
| 90 | 12 | 23 |

Based on price data from January 1980 through June 1988.

[a] Minimum price fluctuation of one tick, or 0.01 of one percentage point, is equivalent to $25.00 per contract.



Analysis of Opening Prices for Wheat (Chicago) Futures

Analysis for Up Periods

| | Difference in Ticks[a] between the Open (0) and the Low (L) | |
|---|---|---|
| Percent of Total Obs. | Daily Data (0 − L) in Ticks | Weekly Data (0 L) in Ticks |
| 10 | 0 | 0 |
| 20 | 0 | 2 |
| 30 | 2 | 4 |
| 40 | 2 | 7 |
| 50 | 4 | 9 |
| 60 | 5 | 11 |
| 70 | 6 | 16 |
| 80 | 8 | 21 |
| 90 | 12 | 28 |

Analysis for Down Periods

| | Difference in Ticks[a] between the High (H) and the Open (0) | |
|---|---|---|
| Percent of Total Obs. | Daily Data (H − 0) in Ticks | Weekly Data (H − 0) in Ticks |
| 10 | 0 | 0 |
| 20 | 1 | 3 |
| 30 | 2 | 5 |
| 40 | 3 | 8 |
| 50 | 4 | 11 |
| 60 | 5 | 14 |
| 70 | 6 | 20 |
| 80 | 8 | 24 |
| 90 | 12 | 34 |

Based on price data from January 1980 through June 1988.

[a] Minimum price fluctuation of one tick, or 0.25 cents per bushel, is equivalent to $12.50 per contract.

Analysis of Opening prices for
Wheat (Kansas City) Futures

Analysis for Up Periods

| | Difference in Ticks[a] between the Open (O) and the Low (L) | |
|---|---|---|
| Percent of Total Obs. | Daily Data (0 − L) in Ticks | Weekly Data (0 − L) in Ticks |
| 10 | 0 | 0 |
| 20 | 0 | 1 |
| 30 | 0 | 2 |
| 40 | 1 | 3 |
| 50 | 2 | 5 |
| 60 | 2 | 7 |
| 70 | 3 | 10 |
| 80 | 5 | 14 |
| 90 | 8 | 20 |

Analysis for Down Periods

| | Difference in Tick9 between the High (H) and the Open (0) | |
|---|---|---|
| Percent of Total Obs. | Daily Data (H − 0) in Ticks | Weekly Data (H 0) in Ticks |
| 10 | 0 | 0 |
| 20 | 0 | 2 |
| 30 | 1 | 3 |
| 40 | 2 | 4 |
| 50 | 2 | 7 |
| 60 | 3 | 9 |
| 70 | 4 | 12 |
| 80 | 6 | 14 |
| 90 | 8 | 22 |

Based on price data from January 1980 through June 1988.

“Minimum price fluctuation of one tick, or 0.25 cents per bushel, is equivalent to $ 12.50 per contract.

# F

# Deriving Optimal Portfolio Weights: A Mathematical Statement of the Problem

Minimize

$$S_p^2 = \sum_i (w_i)^2 s_i^2 + \sum_i \sum_j (w_i)(w_j) s_{ij}$$

subject to the following constraints:

$$R_p = \sum w_i r_i = T$$

$$\sum_i w_i = 1$$

$$w_i \geq 0$$

where $R_p$ = portfolio expected return
$r_i$ = expected return on commodity $i$

$w_i$ = proportion of risk capital allocated to $i$

$s_p^2$ = portfolio variance

$s_i^2$ = variance of returns on commodity $i$

$s_{ij}$ = covariance between returns on $i$ and $j$

$T$ = prespecified portfolio return target

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