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THE APPLICATION OF OPTIMAL STOPPING RULES TO FORECAST THE FUTURES PRICES

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THE APPLICATION OF OPTIMAL STOPPING RULES TO FORECAST THE FUTURES PRICES

by

GANG SHYY

A dissertation submitted to the Graduate Faculty in Economics in partial fulfillment of the requirements for the degree of Doctor of Philosophy, The City University of New York.

1986

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Abstract

THE APPLICATION OF OPTIMAL STOPPING RULES
TO FORECAST THE FUTURES PRICES

by

Gang Shyy

Advisor: Professor Salih Neftci

The forecasting mothodology, known as "technical analysis", used by most financial market traders has been generally ignored by academic professional and is lack of statistical justification. This work tests some of the rules of thumb in technical analysis and compares them with the optimal stopping rules. The results show that the price trend does exist in the technical sense and optimal stopping rules may indeed be a useful procedure for predicting price trend in financial market.

Preface

After I entered a Wall Street futures trading consulting firm in my practical training period for my Ph.D. degree, the most interesting thing attracting my attention was that the financial world was using totally different methodology and assumptions to forecast the market prices. They call it "technical analysis", which the academic world regards as useless and pays few attention to. The most familiar argument to "prove" the failure of technical rules is that if people are "rational", any sucessful rules will be known to public and therefore buries itself. Ironically, the long lasting of the popularity of the technical analysis can be used to prove its usefulness by the same token. If the technical analysis is not useful, why would professional traders keep on applying it to the market trading? More important, I believe there should be some statistical justification for the technical analysis and those naive rules of thumb can be replaced by more complicated statistical method.

As a summary of my research on the financial market behavior, this thesis tries to answer two questions concerning the technical analysis:

1. Is it useful to apply technical rules?

2. Can we replace those rules of thumb by more complicated statistic method?

Chapter 1 gives an overall view of market behavior and technical analysis. The market transaction practice, i.e., stop order, and psychological behavior are described to support the possibility of market trend. Chapter 2 tries to test some rules of thumb to see the statistical performances of technical analysis. We test some simple conditional probabilities on the application of technical rules to check wether they are useful to predict market trends and price corrections. Chapter 3 introduces sequential analysis and optimal stopping rules. I think that its dichonomous model fits perfectly the basic assumptions in the technical analysis and can be used to replace the naive rules of thumb. Finally, we design a new trading rules in Chapter 4 and compare its performance with one of the technical rules, i.e., oscillator rules.

By and large, I conclude that there is price trend in technical sense, even though the rules failed to improve the prediction of price corrections. Futhermore, optimal stopping rules can be used to improve the performance and controllability of all those simple rules of thumb.

Gang Shyy

August, 1986

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As a Chinese, family is always the most important supporting power behind me. I never said "Thank you", but I know they were, are, and will be there. To my wife, Yvonne, this work is dedicated, because she is the one who sacrificed the most for my degree.

to

Yvonne

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Chapter 1

Technical Analysis

1.1 Introduction

Most of the studies of the efficient market have shown that the market price series is a random walk, whether in the weak or strong sense, without any general trend. However, they failed to realize that the market underlying character and sentiment changes all the time. It may be true that market is "dull" without any price trend most of the time. Once in a while, the "animal spirit" of the market participants can contribute to a speculative bubble from which the experienced traders can make profit. One important tool used by traders to identify the "bubble" is the so called "technical analysis".

Probably because of the reason mentioned above, it is interesting to note that there are two totally different views toward the technical analysis between market traders and academic researcher. Quite often, academic professional used those testing results showing there is no general price trend to attack the validity of technical analysis. The consensus in

academic world about the technical analysis is that the method is nothing but a way to earn more commission for the traders. On the other hand, most of the traders believe that technical analysis is the best tool to detect the market trend and correction while fundamental facts have already been discounted in the market prices.

In author's opinion, it is misunderstood that technical analysis is nothing but using only previous prices to forecast the market prices. As a matter of fact, technicians use the wide variety of indicators such as closing price, volume, open/high/low, to test the changing market sentiment and try to identify current price movement as a persistent trend or random walk. Technical analysis should be regarded as a method to filter out the random noises and detect the temporary speculative bubbles. Using the futures market as an example, I will discuss some aspects of technical analysis in this chapter. Then, I will proceed to describe how technician use volume and open interest along with price to test the market sentiment. In Chaper 4, I will use optimal stopping rules to build a trading system and detect the market price trend in the technical sense.

1.2 Market Sentiment

The goal of technical analysis is to develop quantitative criteria for estimating the relative strength of buying and selling forces; determining what to buy, what to sell, and when to take action; predicting how much of a price move is indicated; and, controlling and limiting risk. The technical market analyst concentrates on price movement, treading volume and open interest. The basic premise of technical market analysis is that the interaction of supply and demand for futures contracts governs their prices. When the cumulative number of buyers at a prevailing price level is larger and more aggressive than the combined number of sellers, prices rise. However, the equilibrium will not take place immediately after the fundamental environment changes. Technicians observe that market prices have a tendency to move upward or downward in trends, that these trends tend to persist when certain pattern happens, and that their duration and extent are sufficient to create opportunities for profits over the long run. This trend principle is a cornerstone of the technical approach.

Most market analysts agree that futures prices are in the final analysis linked to the economic climate, but the relationship seems to be that of a barometer rather than a thermometer. Markets often make significant moves for no discernible fundamental reason. Changes in fundamentals are often taken into account by market prices long before they become

common knowledge. Technicians contend that the major reason fundamentalists cannot predict commodity prices with assurance is that the most important factor underlying all price movements cannot be measured by orthodox supply-demand analysis:human psychology. Trading on the statistical production and consumption situation alone ignores that factor. To determine what the majority of traders are doing in a market, the technician makes extensive use of charts showing price and volume fluctuations and other indicators which reflect shifts in sentiment and changes in market psychology.

Intuitively, the following observations in financial market seem to give some explanations for the use of technical analysis:

1. Contrary to common belief, the market tends to "buy the rumor, sell the fact", i.e., the market will discount the possibility of a major event to happen in the future and, when the fundamental event actually happened, the price is unlikly to be affected. Therefore, the individual speculation is crucial in the financial market.

2. As it is better known in psychology than in economics, the human judgement can be very easily affected by the environment. The individual's expectation of the trend of price trends will be influenced in a "bull market" or in a "bear market". While the market sentiment is not observable, the price movement is the best and fast indicator to measure the market situation and mood.

3. When an important fundamental shock happens, e.g. oil price

shock or G-5 meeting, no one in the market can tell what is the "equilibrium price". The price adjustment process must go through several psychological "resistant level" and "supporting level". Then, the traders can have a feeling about what will be the fair market value which reflects the supply and demand equilibrium.

4. It is claimed by the traders that an overbought market tends to hear the bad news and the oversold market tends to hear the good news. Most of the time, the bull/bear market is an market expectation shifting process. It is interesting to note that one of the best occasions for an experienced trader to buy is when most of the market participants, say 85 percent, are bearish, i.e., the market is oversold. With the same reason, the best time to sell is when most people are bullish, i.e., the market is overbought. It seems to suggest the shifting of market's expectation as a whole happens suddenly[1].

By and large, the consistent price trend and the sudden shift of market sentiment seems to give some explanations for the popularity of the technical analysis.

1.3 Stop Order

Another important reason for the persistence of market trend is the common usage of the stop order in financial market. It is highly important for the futures customer, and particularly a speculator whose interest in markets changes rapidly, to learn what is represented in a futures contract unit, how prices for each commodity are expressed, and the dollars and cents value of each minimum price fluctuation. It is also important that he learn how to enter orders properly, as failure to do so can lead to costly mistakes which might otherwise have been avoided. One of the most important orders is stop order as follows:

"buy 3 Feb. 1985 pork bellies 84.90 stop"
"sell 2 May 1985 Sugar #117.86 stop"

A Sell-Stop order is placed below the present market; it becomes effective only when the contract trades at or below, or is offered in the trading ring at or below, the stop price. A Buy-Stop order is placed above the present market; it becomes effective only when the contract trades at or above, or is bid at or above, the stop price. If either of these things happens, then an existing stop-order becomes a market order in the hands of a floor broker and is filled immediately thereafter at the best possible price. The actual execution of simple stop orders is not limited only to the trigger price. Such an order may be executed at any price, either above or below the stop-price,

which represents "the market price" at the moment after the stop-order is touched off. A stop order is often used to limit losses on long futures positions (a Sell-Stop order), or to limit losses on open short futures positions (a Buy-Stop order). Stop orders are also used by some traders to initiate buy or sell transactions in futures when the market penetrates key support or resistance points. This might sound illogical at first, but remember the normal circumstances under which a stop order is placed:

1. A stop order is used to limit losses if the market goes against an existing position. Thus, if a long position is held, the market would have to move lower before the trader would be convinced that the position is a losing one. His position would be liquidated only after the market had dropped to the predetermined loss level.

2. A stop order is used to protect profits on an existing position. Thus, if a trader had bought May wheat at $3.3 and it advanced to $3.43, rather than liquidate and take his 13 sent profit, the trader might decide to hold his position as long as the trend appears headed higher. His chart forecast might indicate that if the market sold down 13 cent to $3.3 again, the upward trend would no longer be intact and the position should be liquidated. He would therefore place an order to "sell May wheat at $3.3 stop, good 'til cancelled." Let us assume that the market continues to rise. The stop order was, therefore, not executed,

and the trader is still long the market. His stop order is still in effect, since the words "good 'til cancelled" were added. This means that the order to liquidate if May wheat sells down to 3.3 will be in effect every day until new instructions are issued by the trader. When May wheat reaches $3.5, the trader might cancel his old stop order and raise his protective stop to $3.4. If the market continues to rally, the trader could follow the advance by continuously raising his stop selling point, first to $3.45, then $3.50, then $3.55, etc. The trader is in this fashion able to take advantage of the continued rise in price, protecting his increasing profit by moving his stop point higher as prices continue climbing.

3. A stop order can be used to initiate a new position. One of the important uses of price charts is to determine at what price a market must trade to indicate the start of a new trend. Once the trend is underway, treaders are anxious to get into the market quickly. For example, suppose December copper is selling at 58.20 and the chart picture indicates that an upward trend is likely to take hold if the market can rally 120 points to 59.40. A chartist might place orders to "buy at 59.40 stop." In many instances traders are willing to pay more for the commodity if it is necessary to be more certain of the new trend.

A trader should understand that stop order does not guarantee that the price at which it is placed will be realized. Such a price will be realized only if the floor broker is able to obtain

it. When the stop price has been reached, a stop order becomes a market order. If the stop order cannot be executed immediately and the market goes beyond the stop price, the order will be executed as soon as a sale can be made. In a broad market goes beyond the stop price, the order will be executed as soon as a sale can be made. In a broad market with a large volume of trading at the time the stop price is reached, this is usually not of importance. But in a "thin" market, or one in which the trading limits for the day have been reached, it can mean that an execution of a stop order will perhaps be made at a price somewhat away from the price it specified; i.e., at a less favorable price.

Generally speaking, good traders will extend his upside profit potential and eliminate his downside risk. The stop order is obvious the best way to fulfill this goal. Another important point is that the speculator have to put more margin to maintain the short position when prices decline. The margin risk as well as the losses are both important factors to justify the Sell-Stop order.

Based on the discussion mention above, we know that both the psychological sentiment in the market and the stop order to reduce the downside risk and enlarge the upside profit can contribute to the temporary speculative trend.

1.4 Summary and Conclusions

We discussed some psychological aspects in the financial market and explained briefly the reason why fundamental method and equilibrium price can not be used solely to predict the price. Technical analysis works when there is a market trend which is the result of the market speculative activities.

Another important reason for the market trend is the widely used stop-order in the financial market to reduce the downside risk and let the upside profit go. This kind of trade order usually create a persisting trend in some "breaking point" of the price level.

It is also interesting to look into some financial market words of wisdom, such as "cut the risk and let the profit run", "when uncertain, stay aside", and "you don't go broke by taking profit." This kind of belief and aptitude of traders also creates the price trend in the financial market.

Chapter 2

Test of Market Trend

2.1 Introduction

Having discussed the general internal structure of futures market, the section will describe some rules of thumb used by technician.

There are all kinds of rules of thumb used by seasoned traders. They include the significance and interpretation of trendlines, chart configurations, and volume and open interest. More quantitaively, there are some calculation formula and rules to use these formula, such momentum, oscillators, relative strength index, bullish consensus, stochastic, and moving average. We will discuss volume and open interet in 2.2 and bullish consensus and stochastic in 2.3. We leave the oscillator, one of the most important rules in technical analysis, in Chapter 3 and 4, and compare it with our optimal stopping rules.

2.2 Volume, Open Interest, and Price Trend

If prices are the heartbeat of the market, trading volume and open interest are its temperature and blood pressure. Volume behavior provides clues to the actual supply and demand for commodity futures contracts. Analysis of the meaning of volume figures must be related to concomitant movement of prices. There are four possible situations, and each carries its own implication.

1. When volume of trading is increasing and prices are advancing, buying is aggressive and the market is judged to be technically strong.

2. When volume is increasing and prices are declining, the market is considered to be technically weak. This selling may be either long liquidation or new speculative short selling.

3. If the volume declines significantly while the prices are advancing, the market is considered to be technically weak because increasing demand is not evident.

4. If volume and prices are both declining, the implication is

that the internal technical condition of the market is improving.

Open interest is the number of contracts outstanding in a given market which have not yet been offset by an opposite futures transaction or by delivery of the actual commodity. Because there is a long for every short in the futures markets, open interest is the total number of longs or shorts--not both.

In working with open interest as a market indicator, the significant factor is the change in open interest in relation to the movements in price and volume. following is a review of the guidelines for interpreting open interest:

1. Open interest increases only when a new contract is made: that is, a new long is matched with a new short sale.

2. Open interest decreases when an old purchase (long) is liquidated by a sale, and the opposite side of the transaction represents short-covering by an old seller who is buying back his previous short position.

3. Open interest decreases when a short makes a delivery on a contract and a long accepts delivery.

4. No change in open interest occurs when a new long buys from an old long, or a new short sells to an old short. In each case, the new buyer or seller simply replaces the old one in the standings.

Based on the above, we can formulate some general rules of thumb for the analysis of changes in volume in relation to price changes:

1. When volume increases, the current price trend might be expected to continue;

2. When volume decreases, the current price trend might be expected to change.

As far as open interest is concern, it should be considered along with the price and volume to determine whether is a "short covering" or "profit taking". Volume is a measure of urgency. Market expectations are reflected in changes in trading volume. If volume increases and open interest increases while prices are advancing, buyers are apparently expecting higher prices and are willing to bid the market up. The expectation is that the advancing price trend will continue. On the other hand, if prices and volume are increasing while open interest is declining, it implies that knowledge longs may be distributing their holdings on a scale-up to shorts who are covering, and the advance may not have much farther to go. Caution is warranted when the trend of open interest is opposite to the trend of price and volume.

For example, some observers consider any sudden increase or decrease of 25 percent or more in the open interest to be significant,

signaling a probable shift in market sentiment by large commercial interests. This is particularly true if the change takes place while prices are within a trading range.

Since commercial hedging interests are the dominant force on the short side in many markets, open-interest statistics may suggest whether commercials are placing new hedges or retrieving short positions. An increase in open interest would mean that commercials are covering their shorts because they expect higher prices. If the commercial interests are more knowledgeable of the commodity markets, this situation should act as word form the wise.

2.3 Open/High/Low and Bullish Consensus

Besides the volume, open interest, and price, technicians also use open/high/low and market poll of bullish sentiment to test the market trend. We will discuss some rules of thumb dealing with this aspect as follows.

"Stochastic rules":

The stochastic rules is based on the assumptions that when the market is in a bullish mood, the closing price has a tendency to be near the recent (n periods) highest price level. On the other hand, when the market is in a bearish mood, the closing price tends to be near the recent lowest price level. The exact calculation is as follows:

$$Kt = \frac{pt - \min(pt-n+1, \ldots, pt)}{\max(pt-n+1, \ldots, pt) - \min(pt-n+1, \ldots, pt)}$$

$$SK = \frac{1}{m} \sum_{s=0}^{m-1} Kt-s$$

$$SD = \frac{1}{m} \sum_{s=0}^{m-1} SKt-s$$

Rules: Buy if SK > SD,

Sell if SK < SD.

n and m are selected based on the user's subjective judgement.

Bullish Consensus:

One of the key things for a successful trading is that you have to move earlier before everybody move. Quite often, when a consensus have been formed, we have a overbought/oversold market and it is time for a correction. One tool to test the market sentiment in futures market is "Bullish Consensus". Bullish Consensus is a market poll which shows the percentage of the traders being bullish in the current market. The rules of thumb for the Bullish Consensus is as follows:

Rules: Buy if Bullish Consensus is over 85 percent,
Sell if Bullish Consensus is under 25 percent.

One word of caution need to be noted: Traders use the Bullish Consensus figure only for reference purpose. They will be very cautious and watching for a price correction to happen. However, if there are fundamental reason and other technical rules point to the persistence of price trend. They will ignore the Bullish Consensus warning.

There is a similar index in stock market compiled by Investors' Intelligence. The company has been compiling data on the opinions of publishers of market letters. It might be expected that this group would be well informed and offer advice of a contrary nature by recommending acquisition of equities at market bottoms and offering selling advice at market tops. The evidence suggests that the advisory services in aggregate act in

a completely opposite manner and therefore represent a good proxy for majority opinion. In another word, the index shows that the advisory services follow the trend of equity prices by becoming most bullish near market tops and predominantly pessimistic around market bottoms. Investors would clearly find it more profitable to take a position contrary to that of the advisory service industry.

2.4 Data

To test the volume, open interest, and stochastic rules of thumb mentioned in previous sections, I chose to use three silver futures contracts, i.e., January 1980 contract, January 1982 contract, and January 1984 contract. I deliberately used these contract so that without having overlaps of market transaction period to avoid unnecessary confusions. The data were collected from COMEX silver futures market closing price and volume/open interest statistics.

Because Bullish Consensus is weekly published data, we used the weekly data of Silver, D-mark, and J-yen from 1980 to 1984 to test the correction hypothesis, i.e., buy if Bullish Consensus over 80 and sell if Bullish Consensus under 20.

2.5 Testing Results

We intend to test these rules of thumb by using the following setup. We basically calculate two conditional probabilities:

(1) $Prob\{P_{t+1} > P_t \mid P_t > P_{t-1} > P_{t-2}\}$,

(2) $Prob\{P_{t+1} > P_t \mid P_t > P_{t-1} > P_{t-1}, \text{rules of thumb}\}$.

If (2)>(1), this means the price trend prediction is improved by the use of the technical analysis. We apply the same methodology to the test of price trend correction test.

Our testing results concerning those volume and open interest rules of thumb are as follows:

1. We found that the combination of price advance and volume is very useful to predict the sustain of the price trend. As shown in TABLE 2.1, the conditional probabilities that the the upward (downward) trend of the price movement will not correct at next period given the the price and volume was advancing (declining) for the last two period are much larger than the conditional probabilities without considering volume. The test of the conditional probability of bullish trend (increasing price) showed that 66 percent out of 73 data increased given the price and volume increasing for two consecutive days. 69 percent out of 59 data decreased given the price and volume decreasing for two consecutive days.

2. It is not evident that the divergent movement of price and volume can be regarded as a signal to predict the correction of the market. Our testing results showed that in 82-83 sample period, the conditional probabilities of correction have been improved with volume. However, in 78-79 and 80-81 period, the conditional probabilities of correction are worse than the original probabilities.

3. Comparing with the results of the combination of volume and price, we found the combination of open interest, volume and price can further improve the conditional probabilities of price trend. In 1978-1979, the conditional probability has increased from 0.65 to 0.71. In 1980-1981, the conditional probability has increased from 0.63 to 0.67. In 1982-1983, the conditional probability has increased from 0.708 to 0.75. This seems to confirm the rules of thumb of the technical analysis.

4. Again, the conditional probabilities of market correction do not support the technician's rules of thumb, i.e., a correction come after the divergency of the open interest and price/volume. In 1978-1979, the conditional probability deteriorated further from 0.583 to 0.25. In 1780-1981, the conditional probability increased from 0.463 to 0.5. In 1982-1983, the conditional probability went down to 0.

Table 2.2 and Table 2.3 shows the results of the stochastic and Bullish Consensus.

1. We found that stochastic rules are helpful in terms of identifying the price trend. The conditional probabilities are obviously improved by the taking into account of stochastic rules. In the case of bullish market, i.e., upward price trend, the conditional probabilities in all period have improved slightly. In the case of bearish market, i.e., downward price trend, except for 1980-1981 period, the conditional probabilities have been improved. Further, it is important to note that all the conditional probabilites are above 50 percent.

2. We can not find any clear evidence to demonstrate that stochastic rules are helpful to predict the price correction. Our testing results showed that the conditional probabilites were not improved by the usage of stochastic rules. Specifically, in 1978-1979, the conditional probabilities was down from 0.405 to 0.395 in bullish correction and down from 0.583 to 0.414 in bearish correction. In 1980-1981, the conditional probabilities was up from 0.463 to 0.5 in bullish correction and was up 0.352 to 0.378 in bearish correction. In 1982-1983, the conditional probabilities was up from 0.48 to 0.54 in bullish correction and was up from 0.486 to 0.57.

3. Table 2.3 shows that, alhough the conditional probability of the correction can not justify the usage of Bullish Consensus, it is surprising that the magnitude of changes did support some arguments of Bullish Consensus correction prediction. Specifically, for silver, the mean of the price changes is -0.45 after the Bullish Consensus went over 80, and 0.6 after the Bullish Consensus went under 20. For D-mark, the mean of the price changes is -0.77 after the Bullish Consensus went over 80, and 0.16 after the Bullish Consensus went under 20. For J-yen, the mean of the price changes is -0.055 after the Bullish Consensus went over 80, and 0.049 after the Bullish Consensus went under 20.

TABLE 2.1
Conditional Probabilities of Price Trend and Correction
(Volume and Open Interest)

Conditional Probabilities*	SV0180	SV0182	SV0184
$P_{t+1} > P_t \mid P_t > P_{t-1} > P_{t-2}$	0.595	0.537	0.52
$P_{t+1} < P_t \mid P_t < P_{t-1} < P_{t-2}$	0.417	0.648	0.514
$P_{t+1} < P_t \mid P_t > P_{t-1} > P_{t-2}$	0.405	0.463	0.48
$P_{t+1} > P_t \mid P_t < P_{t-1} < P_{t-2}$	0.583	0.352	0.486
$P_{t+1} > P_t \mid P_t > P_{t-1} > P_{t-2}$ $\mid V_t > V_{t-1} > V_{t-2}$	0.65	0.63	0.708
$P_{t+1} < P_t \mid P_t < P_{t-1} < P_{t-2}$ $\mid V_t > V_{t-1} > V_{t-2}$	0.65	0.827	0.58
$P_{t+1} < P_t \mid P_t > P_{t-1} > P_{t-2}$ $\mid V_t < V_{t-1} < V_{t-2}$	0.33	0.44	0.8
$P_{t+1} > P_t \mid P_t < P_{t-1} < P_{t-2}$ $\mid V_t > V_{t-1} > V_{t-2}$	0.53	0.29	0.61
$P_{t+1} > P_t \mid P_t > P_{t-1} > P_{t-2}$ $\mid V_t > V_{t-1} > V_{t-2}$ $\mid O_t > O_{t-1} > O_{t-2}$	0.71	0.67	0.75
$P_{t+1} > P_t \mid P_t > P_{t-1} > P_{t-2}$ $\mid V_t > V_{t-1} > V_{t-2}$ $\mid O_t < O_{t-1} < O_{t-2}$	0.25	0.5	0.

* P_t stands for the price at time t.
  V_t stands for the volume at time t.
  O_t stands for the open interest at time t.

TABLE 2.2

Conditional Probabilities of Price Trend and Correction

(stochastic rules)

Conditional Probabilities*	SV0180	SV0182	SV0184
$P_{t+1} > P_t \mid P_t > P_{t-1} > P_{t-2}, K_t > D_t$	0.6	0.556	0.58
$P_{t+1} < P_t \mid P_t < P_{t-1} < P_{t-2}, K_t < D_t$	0.667	0.596	0.53
$P_{t+1} < P_t \mid P_t > P_{t-1} > P_{t-2}, K_t < D_t$	0.395	0.5	0.54
$P_{t+1} > P_t \mid P_t < P_{t-1} < P_{t-2}, K_t > D_t$	0.414	0.378	0.57

* K stands for SK and D stands for SD as defined in previous section.

TABLE 2.3

Means of Price Changes of Bullish Consensus

	Means of Price Changes		
	Silver	D-Mark	J-Yen
Bullish Consensus > 80	-0.45	-0.77	-0.055
Bullish Consensus < 20	0.6	0.16	0.049

Comments

It seems clear that the price trend is existing in the technical sense. However, the technical analysis does not provide a valid method in forecasting the correction of market trend. It might explain the widely used buy-stop and sell-stop order to eliminate the potential huge losses in trading.

The testing results imply very important results to apply the technical rule in the real trading. While the technical rules can increase the chance to catch the random market trend, the poor performance of the correction prediction also increase the risk to suffer a tremendous losses when the trend correct. The fact that you will gain in the trend and loss in the correct by used technical rule drives out the traders who don't have much to lose. It also explains the fact that even though the technical rules will make profit in the long run, no one would rely on the rules without any question.

Another important fact needs further explanation is that the "secret" of successful trading is to end a trading year with greater profits than losses. Not the number of profitable trades balanced against the number of losing trades, but the total dollars and cents taken as profits against the total dollars and cents taken as losses. It is common that for every 10 trades of a successful speculator at least half will be closed out at a loss. But the total amount of the profits are greater than the total amount of the losses, a trading cycle can end in success. By using technical rules, profits can be generated by the

occurrences of upward trend and downward trend. The profits of holding without any trade therefore balance out. On the other hand, the technical rules benefit both bullish and bearish market by changing a long position to a short position. The only losses is in the correction period. Further, it is well known that longer moving average or weekly data can generate larger profits in the long run because it can catch the long term trend. However, if a trader has to report his performance quarterly or annually, he should use shorter moving average and daily data to evade the large losses generated by the trend correction. In a one year period, it is very likely the moving average can not generate satifactory profits for the money manager's clients. This is also part of the reason why some traders can not stick into the technical rules consistantly.

According to our tests, Bullish Consensus is the only index which gave relatively good turning point signals for the price corrections. It is intereting to note that this might also have something to do with psychological reenforcement in the volatile financial market. People tend to be attracted to a buy or sell position when everyone else has already gained or lost. However, market always turn to opposite way when everyone try to jump to the same bandwagon.

2.7 Summary and Conclusions

The testing results of the previous studies that there is no general trend in the market price pattern have been used against the validity of technical analysis. However, they failed to realize that market sentiment and price pattern changes dramatically and there are bubbles in the general random walk type of price movement. Recent development in the test of speculative bubble and volatility has shown that temporary speculative trend can be formed. Experienced technicians are known to be able to identify the bubble by using some rules of thumb to filter the random noises out. We tested some most popular rules of thumb and found that there exists statistically significant price trend under the technical rules. However, I was unable to find the evidence that technical analysis can predict the correction in trend as the technician has claimed. Maybe the only possible exception is the Bullish Consensus.

Chapter 3.

Sequential Analysis and Oscillators

3.1 Introduction

While most of the traders in financial market believe that technical analysis is very helpful to catch the trend and correction of the market prices, it is surprising to note that there is no statistical method developed to justify any of these rules of thumb used by the traders.

The object of this chapter is to use optimal stopping rules of sequential analysis and develop a formal statistical method to forecast trend reversals, i.e., top and bottom, in futures prices. This detection method was first introduced by Neftci (1982) in forecasting the economic downturn and was followed by Palash and Radecki (1984) and de Leeuw, Missouri, and Robinson (1986). Different from the orignal design, we used the optimal stopping rules to forecast market trend, i.e., "bullish" or "bearish", and built a trading system to generate buy/sell signals.

3.2 Oscillators

There are all kinds of rules of thumb in technical analysis. In this paper, we use one of the most popular trading rules -- oscillator rules.

The oscillator value is the difference between two moving averages of market prices. Thus, two moving average lines need to be specified in the begining. Typically, the averages differ in the number of periods used, i.e., $MA(n)=1/n \sum_{k=0}^{n-1} Pt-k$, $MA(m)=1/m \sum_{k=0}^{m-1} Pt-k$, $m<n$. The oscillator is then found by subtracting the longer-term (more periods) moving average from the shorter-term average. When the shorter-term moving average is larger than longer-term moving average (the oscillator is larger than zero), the traders are supposed to be long (buy). When the shorter-term moving average is smaller than longer-term moving average (the oscillator is smaller than zero), the traders are supposed to be short (sell). The optimal period for longer-term and shorter-term depends on the market and period tested. Generally speaking, the longer period oscillator can catch the bigger move in the market (the blow-off type of price trend), the shorter period oscillator can catch the smaller move in the market.

It is interesting to note that the oscillator rules are nothing but the simpliest version of sequential analysis. We use the following example to demonstrate our point.

Suppose we have the following trading rules:

Go short, i.e., sell, as soon as MA(5) is smaller than MA(13)
Go long, i.e., buy, as soon as MA(5) is larger than MA(13).

Statistically, what the rules actually imply is that the mean of the price distribution for the latest 5 periods is larger than the mean of the price distribution for the latest 13 periods. From the sequential analysis point of view, the traders use the rules to decide whether the distribution of recent price trend is different from the previous one. Obviously, the oscillator is the simpliest sequential analysis without knowing the appropriate false alarm probability and the actual conditional distributions of price change in different market trend. The only variables they can change in the rules are the longer-term period and the shorter-term period used in the oscillator. The method the traders use to decide the "optimal" period is very naive. They will simulate the oscillator rules by using all the possible combinations, e.g., MA(1) vs. MA(3), MA(3) vs. MA(5), and MA(5) vs. MA(13). The pair of periods which can generate the highest rate of return from the historical test will be the "optimal" rules to trade. However, the experienced traders usually find that there are different "optimal" rules by using different testing period in different markets and the oscillator is too rigid to catch all the relevant information to identify the market trend. Obviously, most of the drawbacks of the oscillator can be overcome by developing a formal statistical model implementing the opimal stopping rules in sequential analysis.

3.3 The Optimal Stopping Rules

For the theoretical background of the optimal stopping rules, the reader should refer to Shiryayev (1978, 1974) and Neftci (1982). In this paper, We will only discuss the framework and applications of their studies.

The framework of the trading system is based on the assumptions that there are two stochastic processes {Yt} and {Xt}. Yt represents market sentiment, which will lead the price upward (bullish) or downward (bearish). We denote {Yt} is the so called "market trend". In this paper, Yt is a dichotomous variable. In another word,

Yt = 1 if market trend is "bullish",
= -1 if market trend is "bearish".

In addition, the shifting of Yt is sudden and unobservable. By the time Yt changes from 1 to -1, we say the market has reached the "top". By the time Yt changes from -1 to 1, we say the market has reach the "bottom". The sudden shift of market sentiment has been described by the observations that the abnormally high bullish consensus figure is regarded as the "overbought" area and the market is bound to have a correction. No trader in the market knows the actual trend, i.e., Yt, of the market. The only thing they can observe is the actual market price which will be affected by the trend and the random shocks in the market.

X_t represents observations on market price movement such as daily closing price or weekly closing price. Most importantly, the distribution of price movement, i.e., X_t, changes when the trend, i.e., Y_t, changes. The ultimate aim of the forecaster (market technician or trader) is to predict "top" or "bottom" of the market trend by the obervation of the process of the price movement in some optimal sense. From the statistical control theory point, we encounter problems in which the probabilistic characteristics of the variables being observed may change at a random moment of time. Below we propose a method for solving them based on the general theory of optimal stopping rules.

Let Z, an integer valued random variable represent the "top" or "bottom" of the market. This random variable has the property that when $\{Z=k\}$ the probability distribution of $\{X(k+j), j=0,1,2...\}$ will be different and independent of the distribution of $\{X_{k-j}, j=1,2,...\}$. Accordingly, for $\{Z=k, k<t\}$ we will have

$$P\{X_0 \leq x_0, \ldots, X_k \leq x_k, \ldots, X_t \leq x_t\}$$
$$= F^1\{x_0, \ldots, x_{k-1}\} * F^{-1}\{x_k, \ldots, x_t\}$$

where $F^1(.)$ and $F^{-1}(.)$ are two distribution functions which represent the probabilities associated with X_t during bull and bear regimes, respectively. Without loss of generality, we can assume that the distributions $F^i(.)$ have density $f^i(.)$, $i=1,-1$.

The value of Z -- i.e., the period during which distributions switch -- is not directly observed. Instead, inferences based on the X_t observed up to time t have to be used in order to see whether a top or bottom of the trend has started ($Z \leq t$) or not ($Z > t$).

The last component of the model is the existence of an a priori probability on when top or bottom is expected to occur. It is assumed that the traders who have observed past cyclical price trend have developed an a priori probability

$$P\{Z=k\}$$

representing the a priori beliefs on the period of the next bull or bear move in the market.

Given this framework, the problem of predicting the market trend can now be summarized. The objective is to forecast the value of Z after successive observations on X_t. Let this forecast be denoted by b. The $\{b=t\}$ will mean that the forecaster is signalling a top or bottom at time t, and b-Z would represent the prediction error. Every time period the trader faces two choices. Based upon the available information he can either "signal" a buy/sell or instead wait and take another observation on the process $\{X_t\}$. The first choice implies that the trader is predicting at time t, that $\{Z \leq t\}$; the second implies that he is instead opting for $\{Z > t\}$. The optimal decision will be made after comparing the cost of sounding a

"false alarm" represented by {b<Z} with the cost of announcing the downturn too late, i.e., of having a positive and "large" b-Z. This suggests that, in order to determine the "best" estimate, one first needs to define a class of stopping time -- i.e., a class of estimates having certain reasonable properties. Second, one needs to decide on an optimization criterion.

It can be proven that the optimal[2] stopping time to predict a shift of distributions can be obtained using the following formula[3]:

$$P_t = \frac{[P_{t-1} + A_t * (1 - P_{t-1})] * f^{-1}_t}{[(P_{t-1} + A_t * (1 - P_{t-1})] * f^{-1}_t + [(1 - P_{t-1}) * (1 - A_t)] * f^{1}_t}$$

where

P_t is this week's probability of an imminent peak, ie, turning to bearish, and P(t-1) is last week's probabilty of an imminent peak;

A_t is the a priori probability of a "top" occuring this week based solely on the length of the bull market to date, i.e.,

$A_t = P\{Z=t+1 \mid Z>t\}$;

f^{1}_t is the conditional density of X(t) during a bull market regimes;

f^{-1}_t is the conditional density of X(t) during a bear market regimes.

To implement this formula, the user should decide the risk, i.e., the probability of a false alarm, he want to take. For example, if he want no more than 5 percent probability of the

false signal, the opimal time he should predict a top or bottom of the price trend is when the Baysian formula is over 95 percent probability that the distribution of price percent change have shift from bull (bear) market to bear (bull) market. We will explain later how we tail this formular into a continuous signal generating trading system.

3.4 Summary and Conclusions

We introduced the oscillator rules and found out that the underlying rationale is similar to sequential analysis. General speaking, traders who use the oscillators are assuming the current distribution of price changes will be different from previous one when market correction happens. However, oscillator is only the simplest version without any statistical optimal properties. The optimal stopping rule can therefore be used to replace oscillator and give us more control and manupulation for the trading rules.

Chapter 4

Trading System and Estimates

4.1 Introduction

According to the sequential analysis and optimal stopping rules discussed in Chapter 3, we will proceed to develop a statistical trading system and simulate the trading results of the system. We used three futures, i.e., silver, J-yen, and D-mark as our sample and estimated all parameter needed in the trading system. We compared the trading results with the oscillators and discussd the outcomes.

4.2 Data

In this chapter, we used silver, D-mark, and J-yen futures market as our testing markets. Part of the reasons we chose these three futures markets were 1) precious metals are always the favorite financial market for the speculators to play their game; 2) foreign currencies were very bearish before 1985 and has been extremely bullish since G-5 meetings last year (esp. J-yen and D-mark). We therefore can test whether our trading system can catch different big move in the futures markets. As far as the data sources are concerned, we used COMEX silver futures weekly closing prices, IMM D-mark and J-yen futures weekly closing prices.

Additionally, we used the 1980-1984 period to estimate our statistical parameters and the 1985-1986 period as our out-of-sample testing period to see the stability of the forecasting ability of our trading system. For the first testing period (1980-1984) , because the futures contract of silver, D-mark, J-yen are less than two years, We collected weekly closing prices of December contract in 1980, 1981, 1982, 1983, and 1984. After the first December contract (e.g., Dec80 silver) expired, we began to collect the second December contract (e.g., Dec81 silver) and so on. For the second testing period (1985-1986), we collected the weekly closing prices of March '86 contract of silver, J-yen, and D-mark futures. Therefore, we tested from March 1985 to March 1986.

4.3 Trading System and Estimates

As discussed in previous chapter, in order to use the Bayesian formula in optimal stopping rules, we have to estimate some distributions in advance:

1. the density functions of price percent change distributions in both the bull and bear market;

2. the a priori probability of a top (bottom) occuring this week based solely on the length of the bull (bear) market to date.

To determine which period is a bullish or bearish market, we used the Bullish Consensus data, which are pollings of trader sentiment published by Market Vane. Generally speaking, high readings of Bullish Consensus are signs of market tops, low ones, market bottoms. A bulllish market usually is characterized by the Bullish Consensus from low readings to high readings. On the other hand, a bearish market usually is characterized by the Bullish Consensus from high readings to low readings. Therefore, we define a bullish market as the period when the Bullish Consensus readings increased and a bearish market as the period when the Bullish Consensus numbers decreased.

After we determine the periods for bull and bear market, we used the percent change in weekly closing prices as X_t. The histograms of the price percent change in bull and bear market for silver, J-yen, and D-mark are shown in Chart 4.1 - 4.3 (bull market), and Chart 4.4 - 4.6 (bear market). As the reader noted,

we can fit theoretical probability distributions to observed frequencies. For the reason of convinience, we used normal distribution with the parameters of sample mean and sample standard error. In another word, we used two normal density functions with different mean and standard error in our $f^1(.)$ and $f^{-1}(.)$ as mentioned previously.

$$f^i(.) = 1/(2\pi v_i)^{1/2} * \exp[-(x-u_i)^2/2v_i^2]$$

$i=1$ or -1

where

u_i = the mean of distribution of price percent change in bull ($i=1$) or bear ($i=-1$) market;

v_i = the standard error of distribution of price percent change in bull ($i=1$) or bear ($i=-1$) market;

To develop an a priori probability, we found the exponential distribution[4] can serve to fit the oberved distributions quite well (see Chart 4.7 - 4.12). In addition, the memoryless property of exponential distribution seems to satify the market's "looking forward" characteristic[5].

We can further prove that the a priori prabability is the same as the "hazard (failure) rate" in exponential distribution.

The hazard rate function r(t) is defined by

$$r(t)=\frac{f(t)}{1 - F(t)}$$

where f(x) is the probability density function, and F(x) is the cdf of exponential distribution.[6]

To interpret r(t), suppose that X (bull market) has survived for t weeks, and we desire the probability that X will not survive (i.e., turning to bear market) for an additional time dt. Because we are using weekly data for the testing, dt = 1 (week). Now, let's consider the following probability:

$$P\{ X=t+dt \mid X>t \} = \frac{P\{ X=t+dt \text{ , } X>t \}}{P\{ X>t \}}$$

$$= \frac{P\{ X=t+dt \}}{P \{ X>t \}}$$

$$= \frac{f(t)dt}{1 - F(t)} = r(t)dt.$$

That is, r(t) represents the conditional probability density that a t-week-old bull/bear market will fail. In this paper, because dt = 1, r(t) can be regard as the conditional probability in our testing period. In another word, our a priori probability can be calculated as the hazard rate in the exponential distribution. r(t) can give us an estimate of the conditional probability of the peak (in the bull market) or the bottom (in the bear market).

Suppose now that the lifetime distribution is exponential. Then, by the memoryless property, it follows that the distribution of remaining life for a t-week-old item is the same as for a new item. Hence r(t) should be a constant. This checks out since

$$r(t) = \frac{f(t)}{1 - F(t)}$$

$$= \frac{\lambda e^{-\lambda t}}{e^{-\lambda t}}$$

$$= \lambda \ .$$

Thus, the failure rate function for the exponential distribution is constant. The parameter is often referrred to as the rate of the distribution. (Note that the rate is the reciprocal of the mean, and vice versa.)

r(t)= 1/mean.

Therefore, our a priori probability is a constant.

Our estimates of the a priori probability and normal distribution parameters for Silver, J-yen, and D-mark are shown in Table 4.1. As the reader will note that the bull market failure rate estimates for D-mark is highest, i.e., 0.58. One of the reasons is European currencies were depreciating dramatically because of the strong dollar during the testing period.

After we find the probability density functions for the distribution of previous price percent change in both bullish and bearish market and the a priori probability of the bull/bear market expansion, we can calculate the baysian probability of the turning point. To implement the results for the market trading, we decided to use 95/90 percent probability for our turning point

forecasting. Whenever we predict more than 95/90 percent probability in a bull market to turn to bear market, the model will give us a sell signal. At the same time, the model assigns an a priori probability to turn to bull market and begin to detect the turning point for the upturn of the price trends. The process will continue from the first weekly closing price to the very end and generate continous buy/sell signals. We assigned +1 for each buy signal and -1 to each sell signal. The price percent changes and the corresponding buy/sell signals are shown in Chart 4.13 - 4.15.

As the reader might note, the signals fit the price pattern quite well in the long run (esp. for the consistent price trends). We will compare the testing results for three strategies, i.e., holding, oscillator, and optimal stopping rules in next section.

TABLE 4.1

A Priori, Mean, Standard Error

	SILVER	J-YEN	D-MARK
BULL	mean = 1.85 std = 5.63 r = 0.535	mean = 0.48 std = 1.62 r = 0.49	mean = 0.34 std = 2.05 r = 0.58
BEAR	mean = -2.39 std = 6.19 r = 0.446	mean = -0.57 std = 1.12 r = 0.423	mean = -0.68 std = 1.38 r = 0.38

CHART 4-1

Bull Market

silver

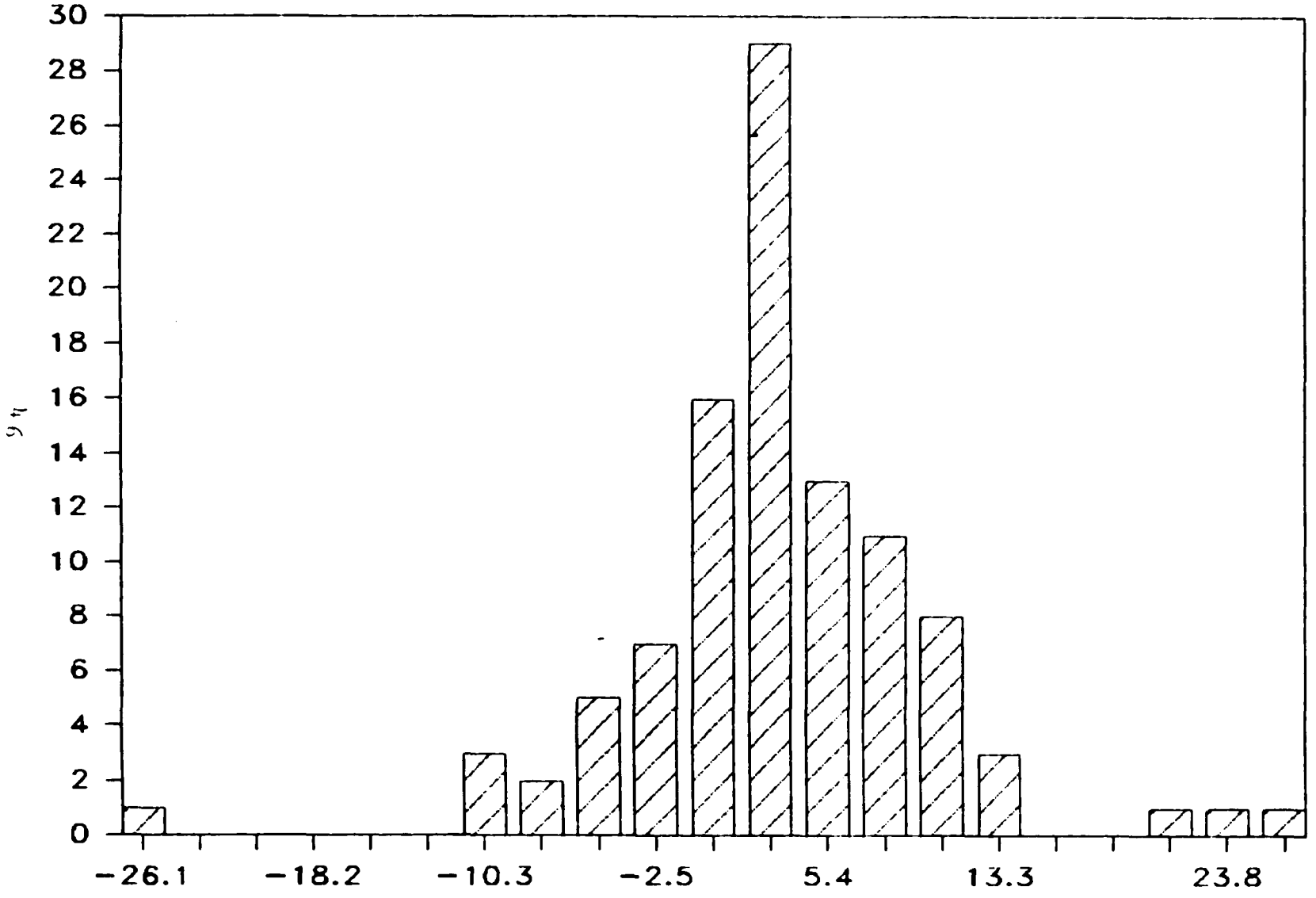


CHART 4-2

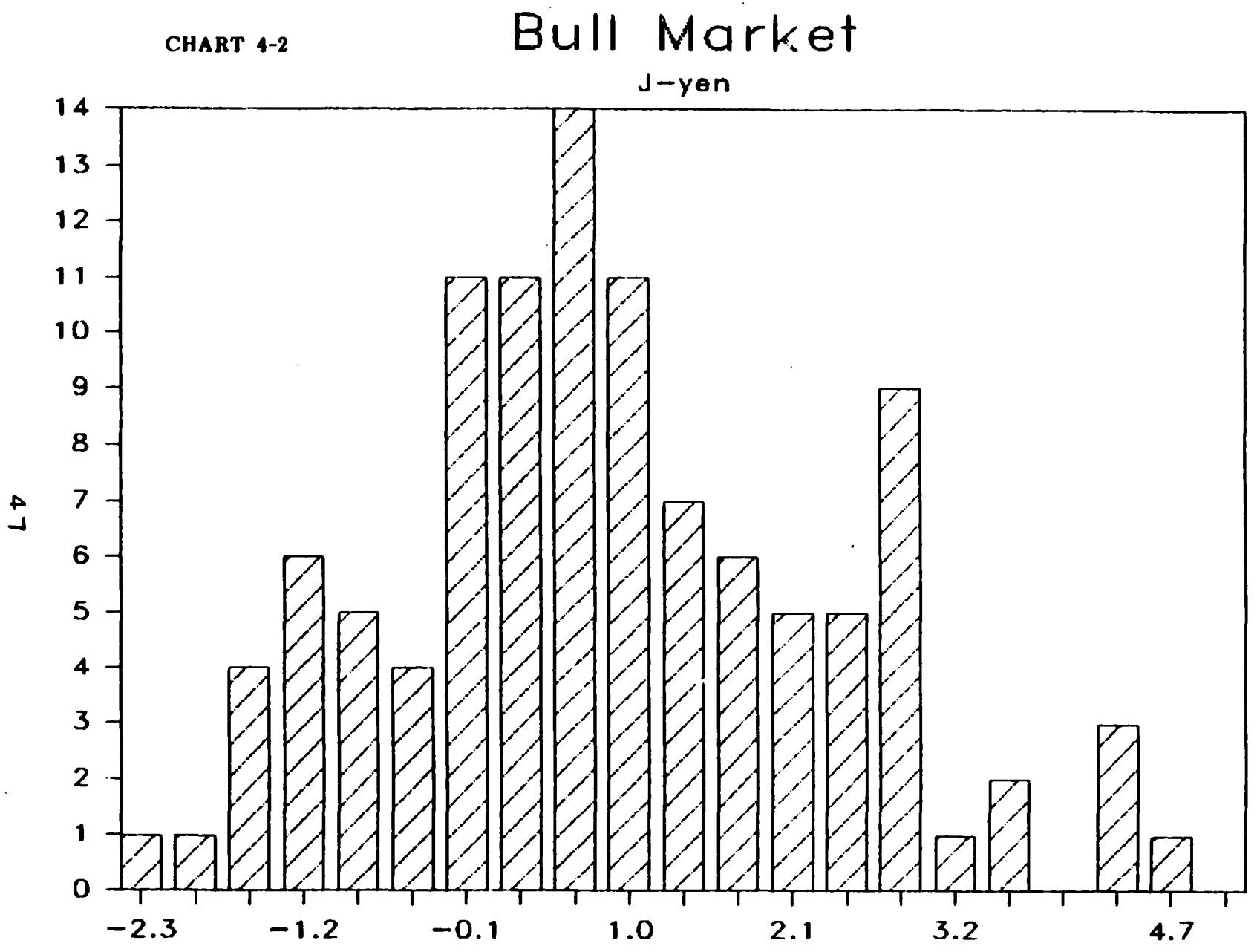

Bull Market
J-yen
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
47
-2.3
-1.2
-0.1
1.0
2.1
3.2
4.7

CHART 4-3

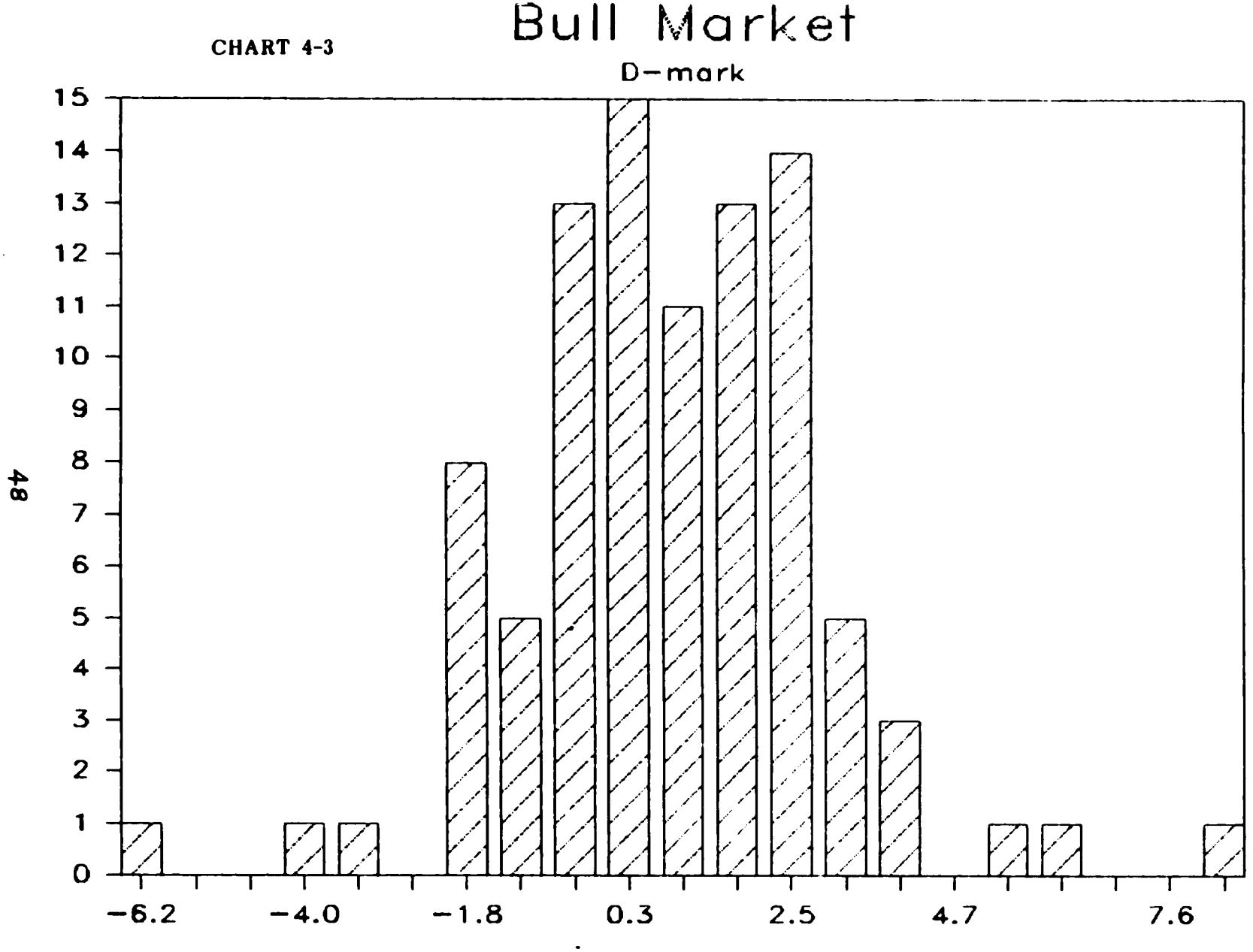

Bull Market
D-mark
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
48
-6.2
-4.0
-1.8
0.3
2.5
4.7
7.6

CHART 4-4

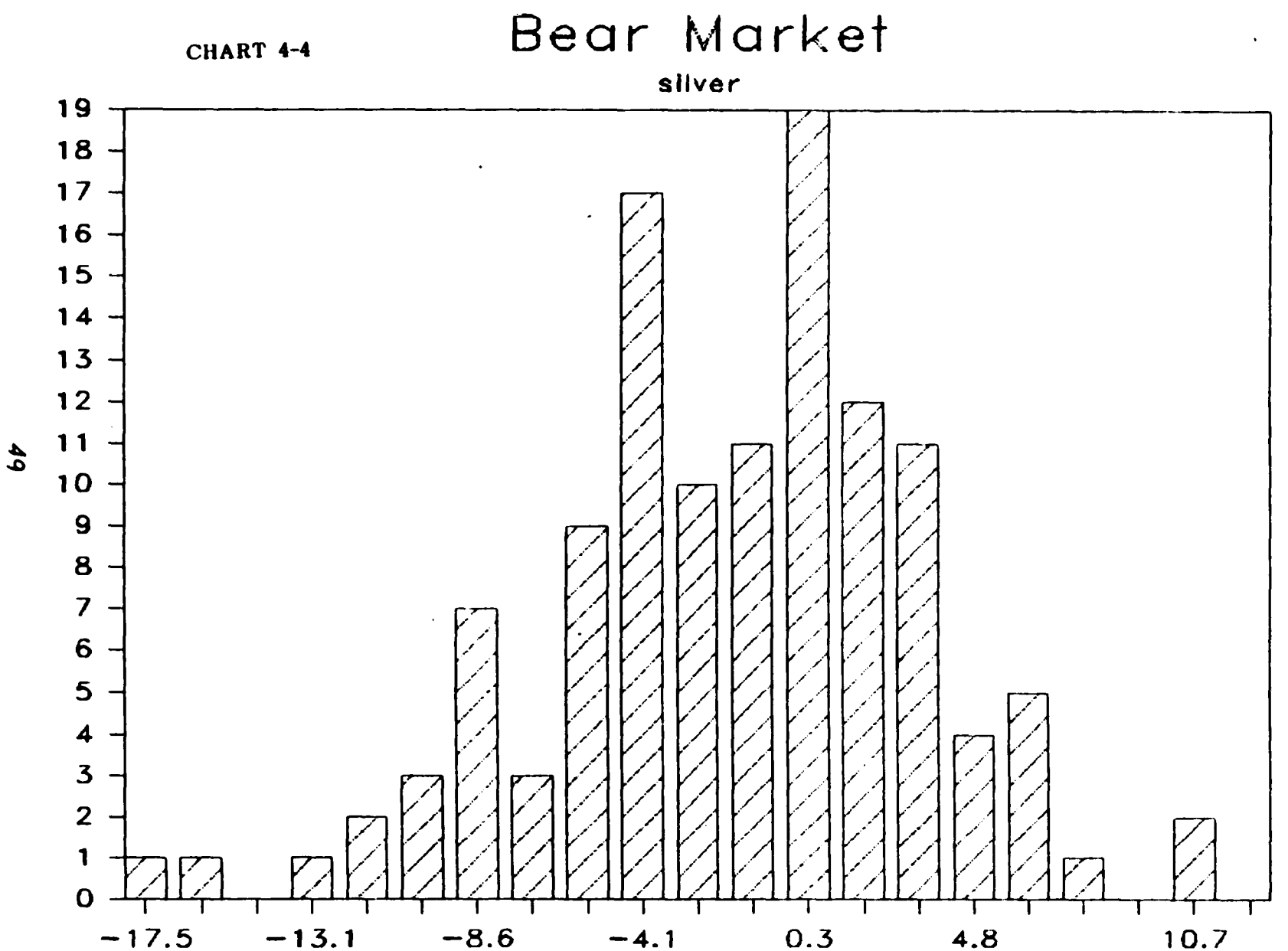

Bear Market
silver
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-17.5
-13.1
-8.6
-4.1
0.3
4.8
10.7

CHART 4-5

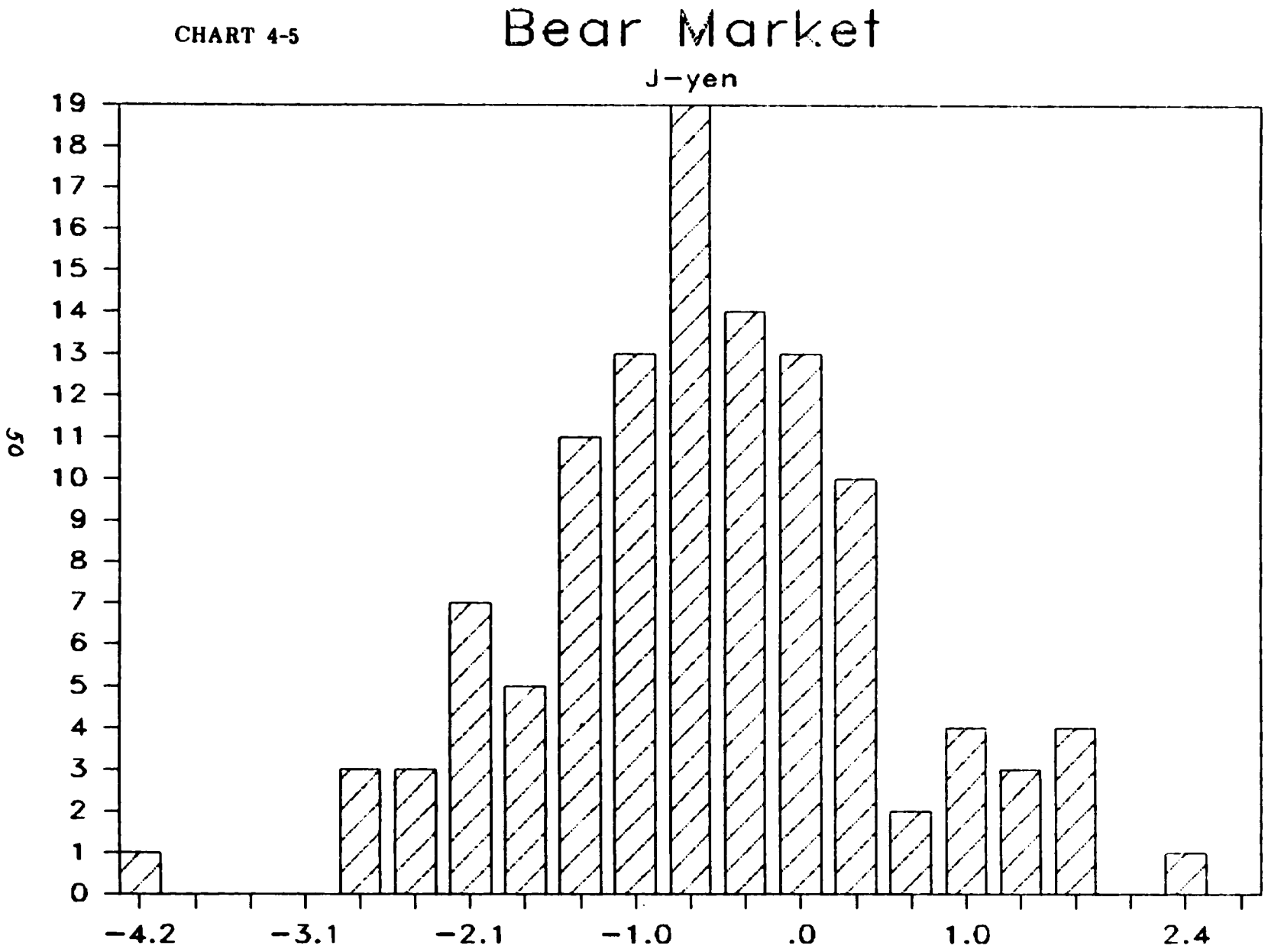

Bear Market
J-yen
50
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-4.2
-3.1
-2.1
-1.0
.0
1.0
2.4

CHART 4-6

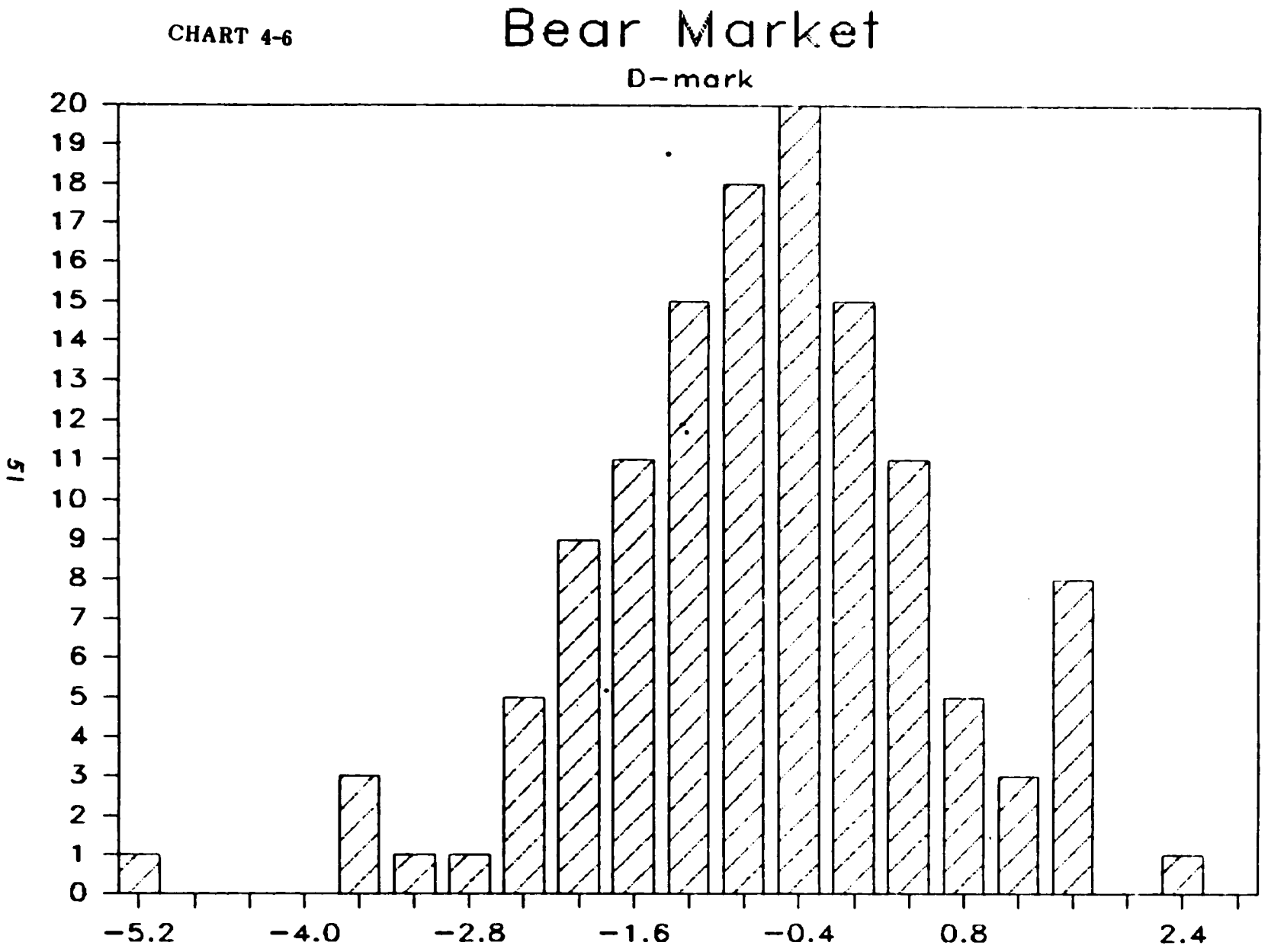
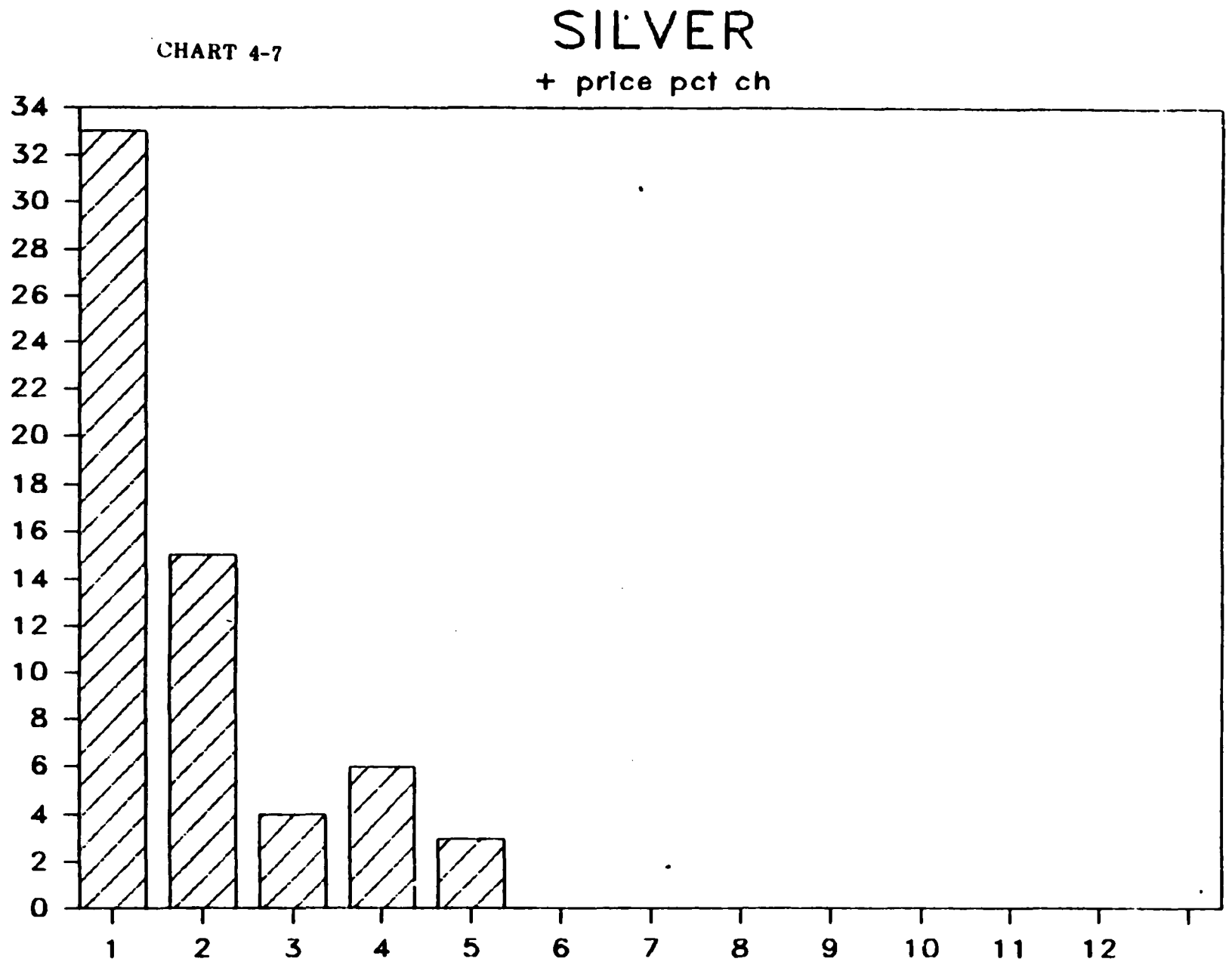

Bear Market
D-mark
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-5.2
-4.0
-2.8
-1.6
-0.4
0.8
2.4

CHART 4-7


SILVER
+ price pct ch
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
1
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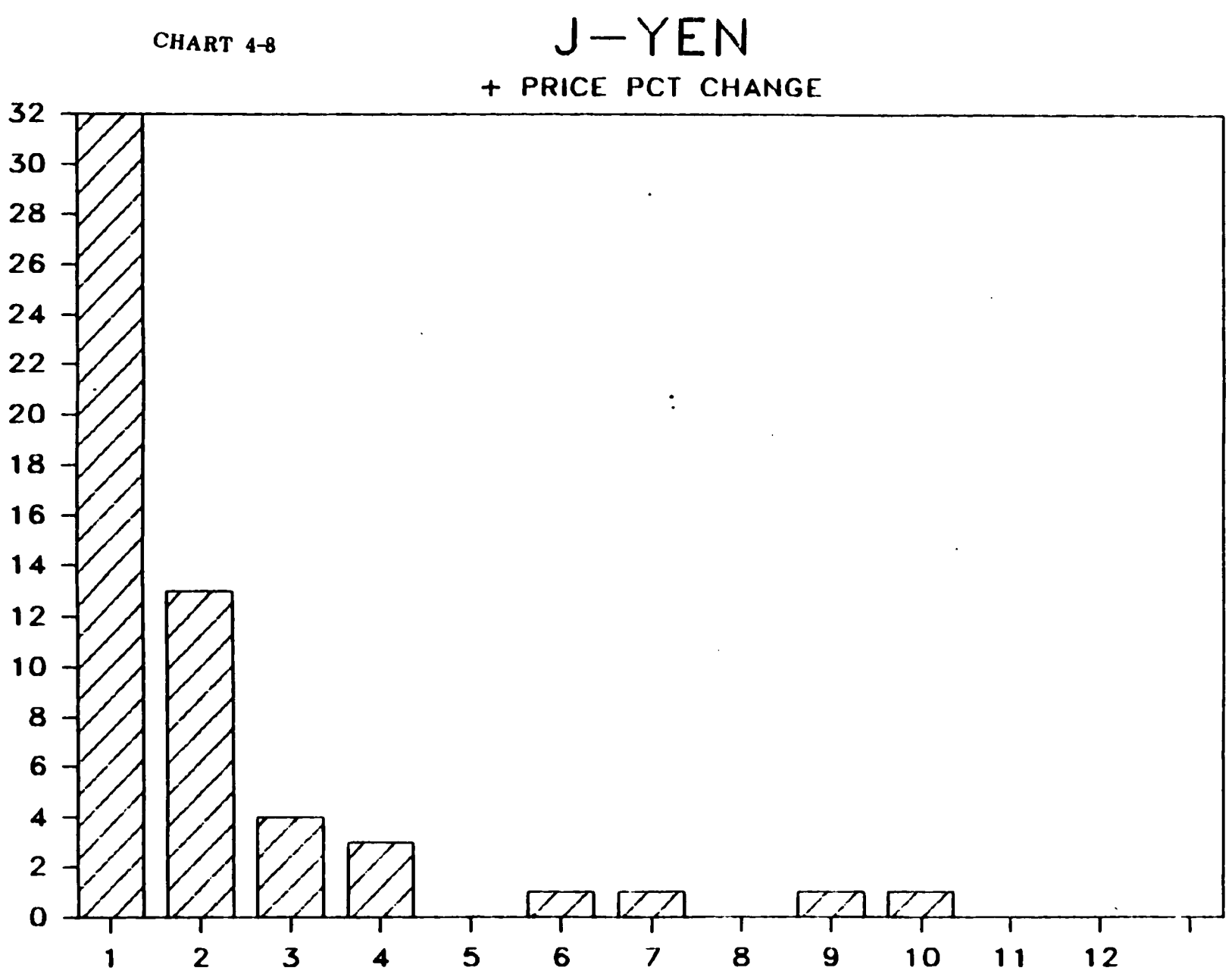
12

CHART 4-8


J—YEN
+ PRICE PCT CHANGE
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
1
2
3
4
5
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7
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9
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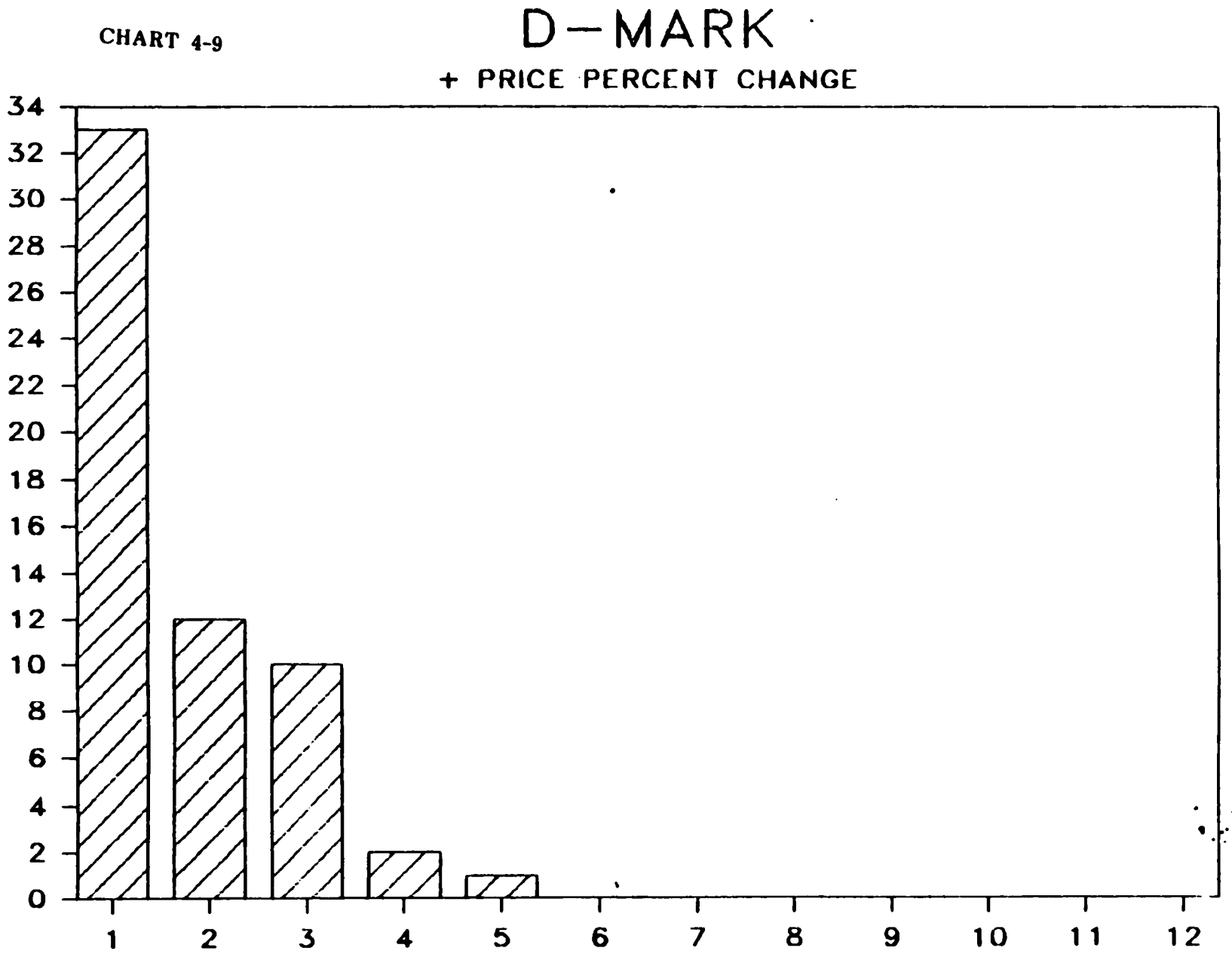
11
12

CHART 4-9


D-MARK
+ PRICE PERCENT CHANGE
34
32
30
28
26
24
22
20
18
16
14
12
10
8
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4
2
0
1
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3
4
5
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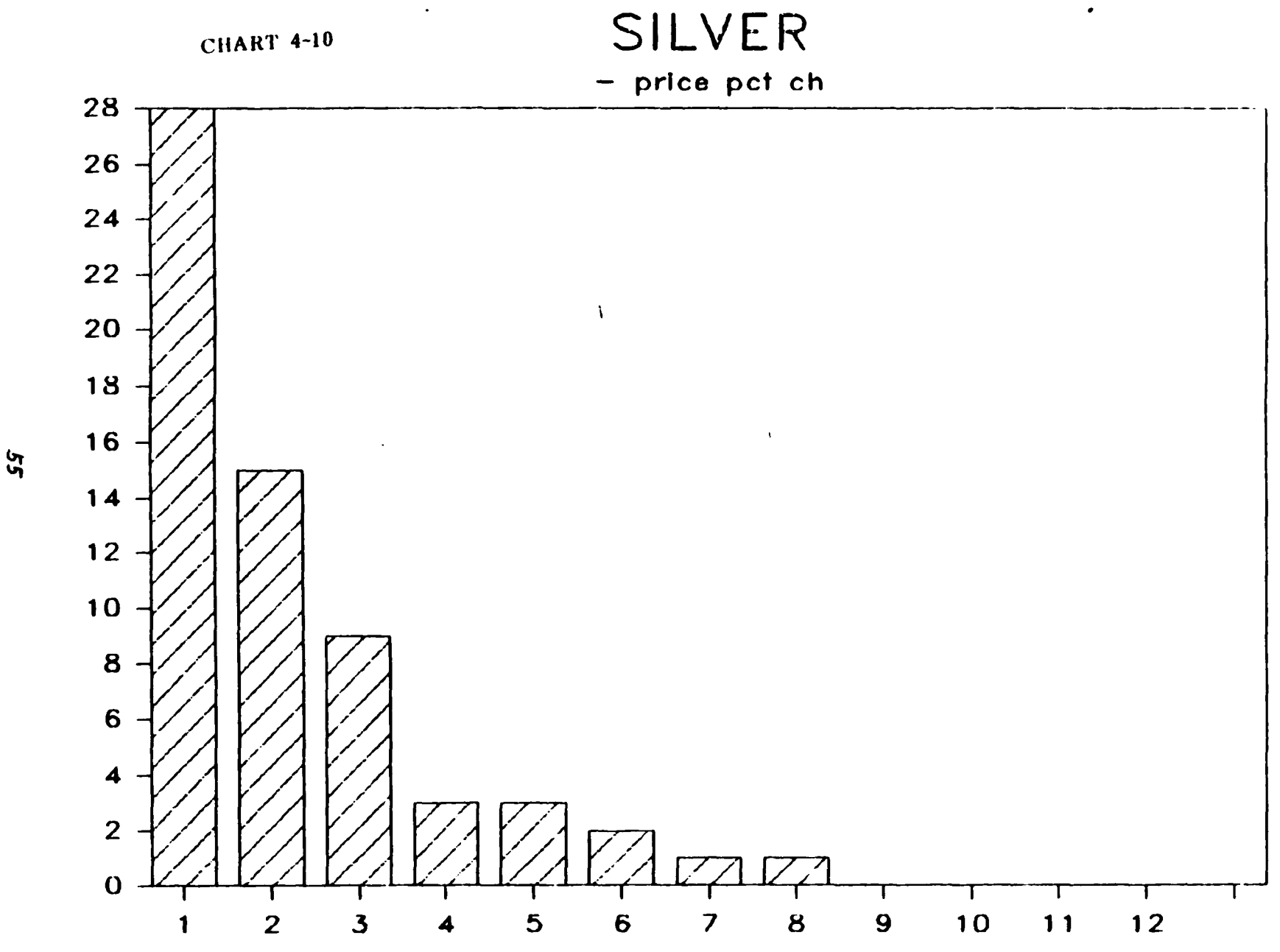
CHART 4-10


SILVER
– price pct ch
28
26
24
22
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18
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14
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10
8
6
4
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4
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7
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9
10
11
12

CHART 4-11

J—YEN

– PRICE PCT CHANGE

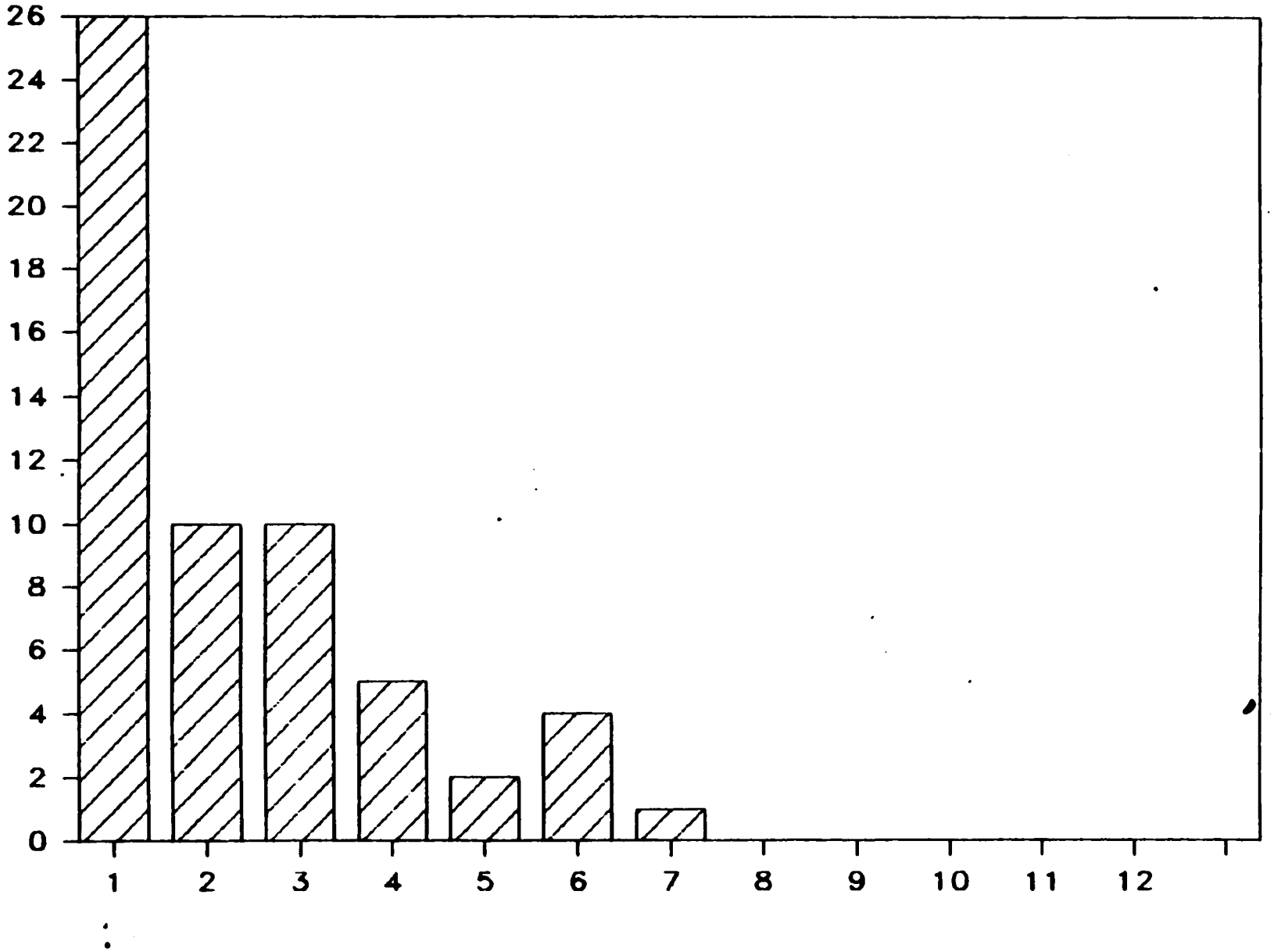
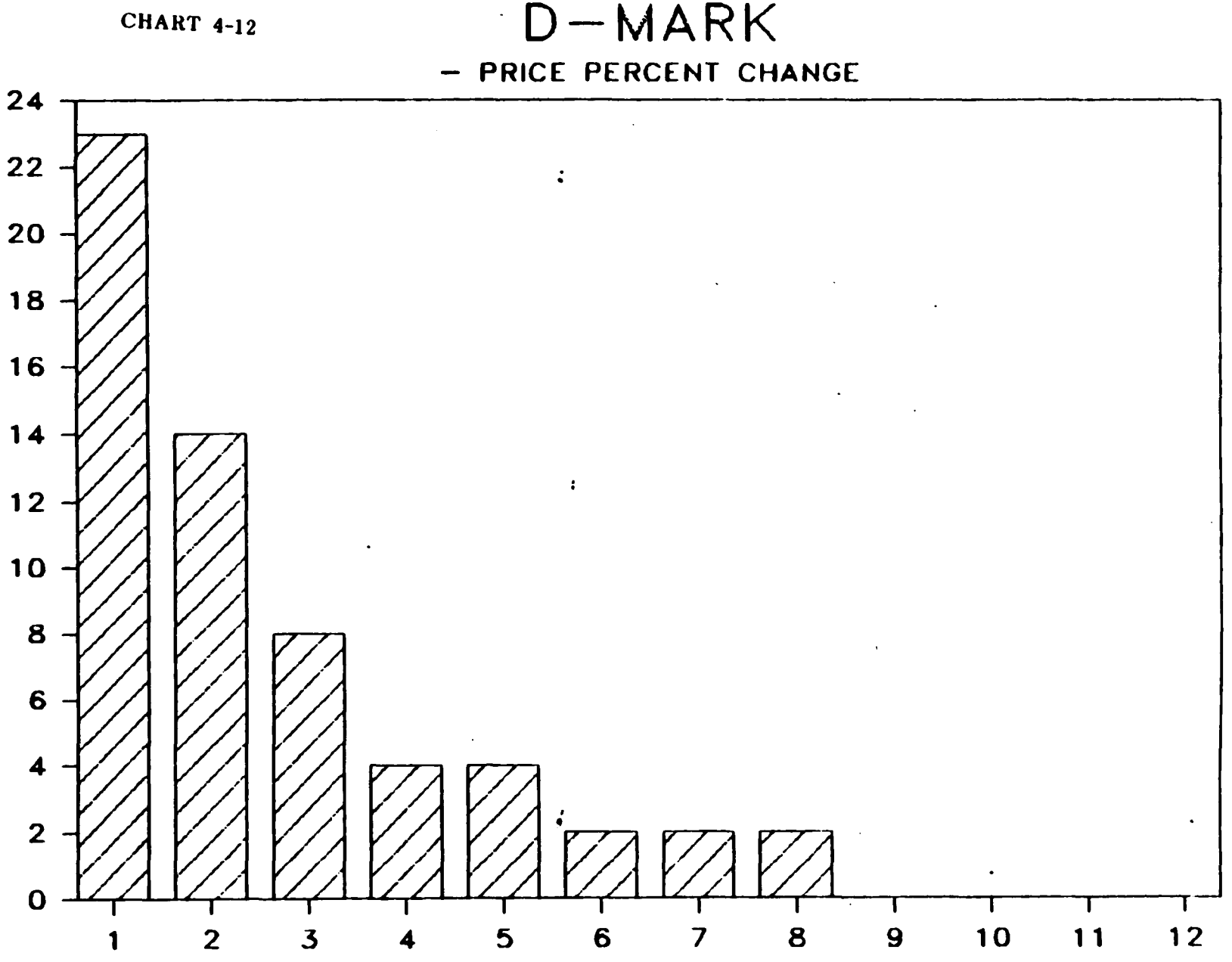


CHART 4-12


D—MARK
— PRICE PERCENT CHANGE
24
22
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12
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CHART 4-13

SILVER

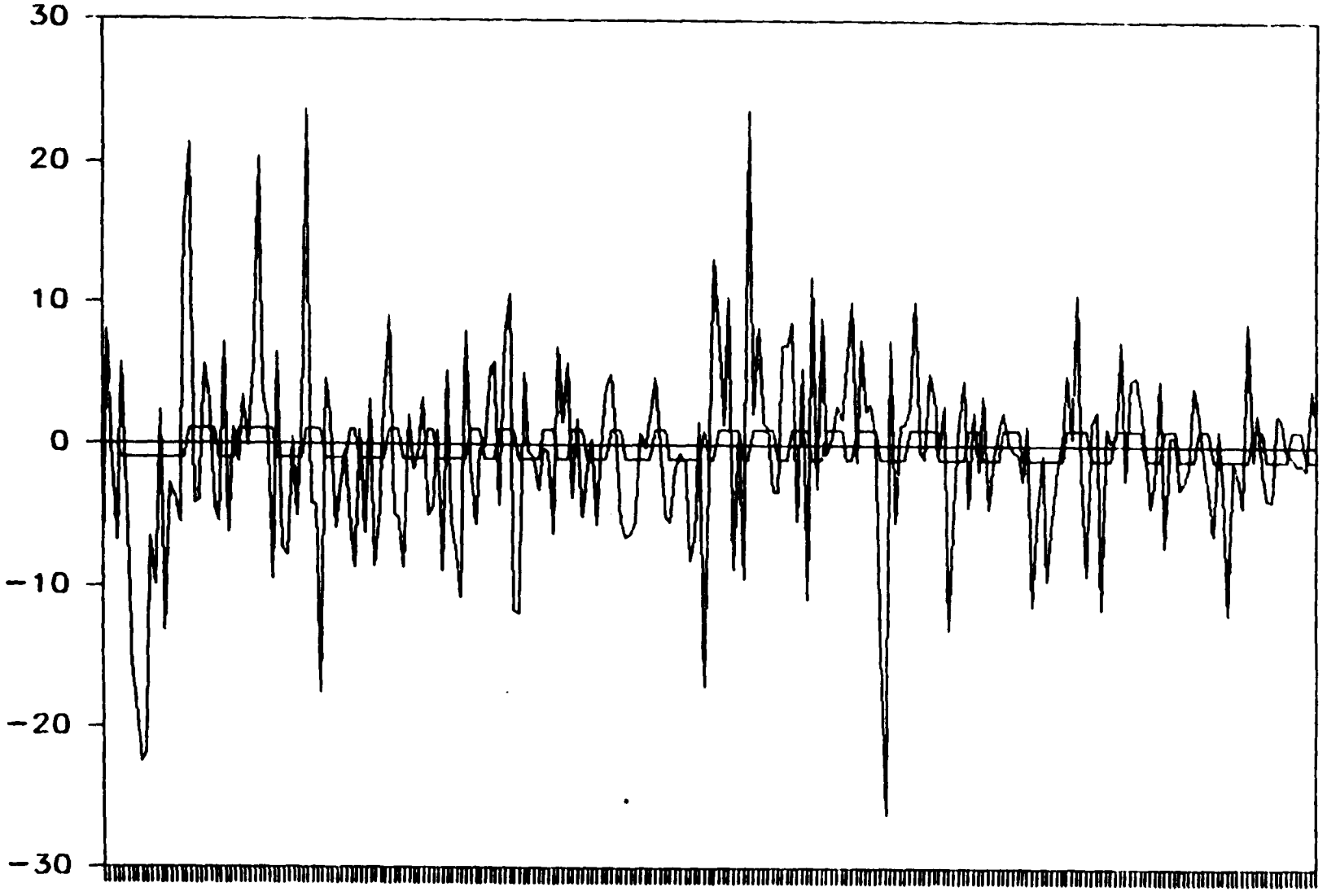


CHART 4-14

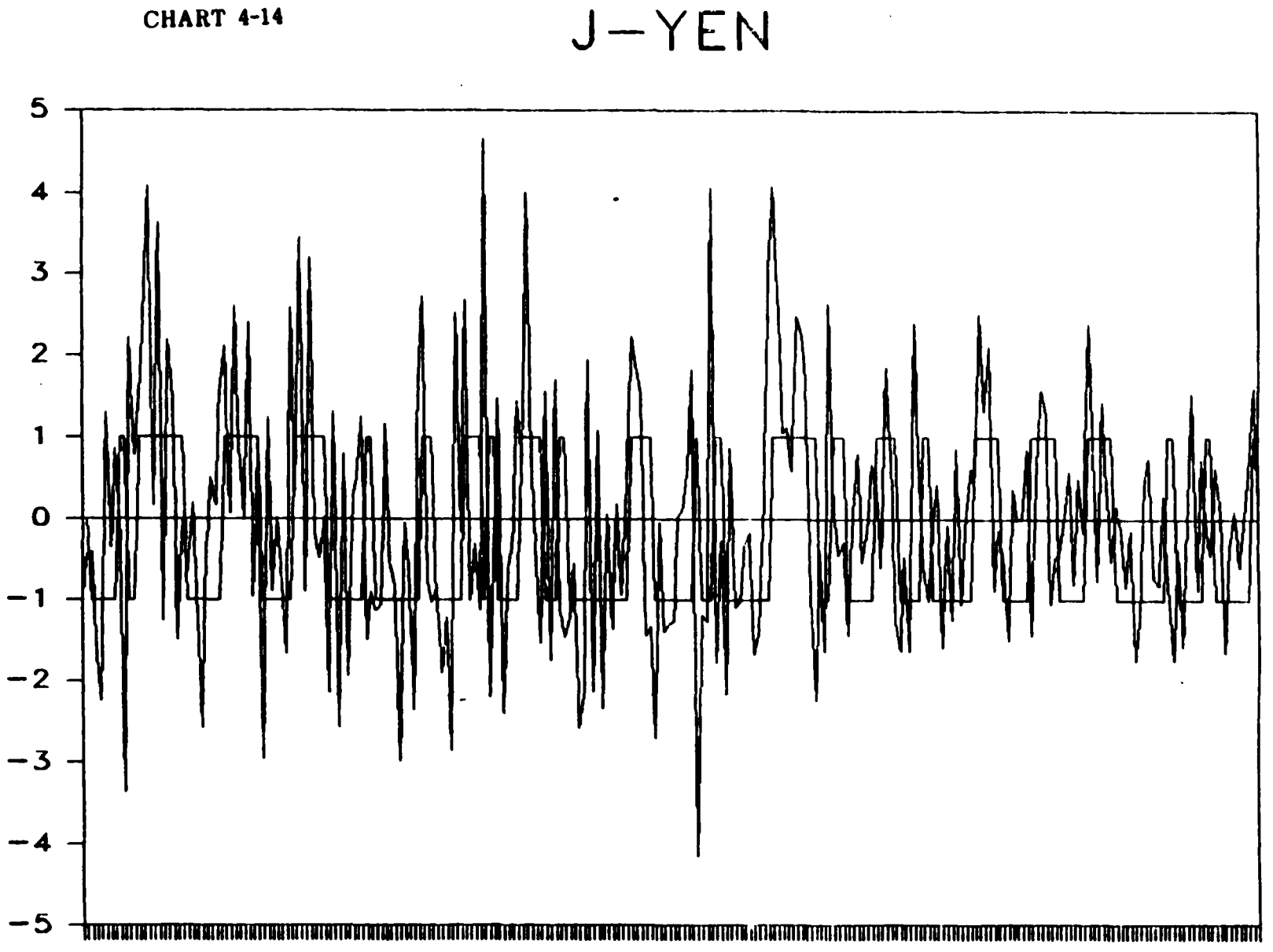
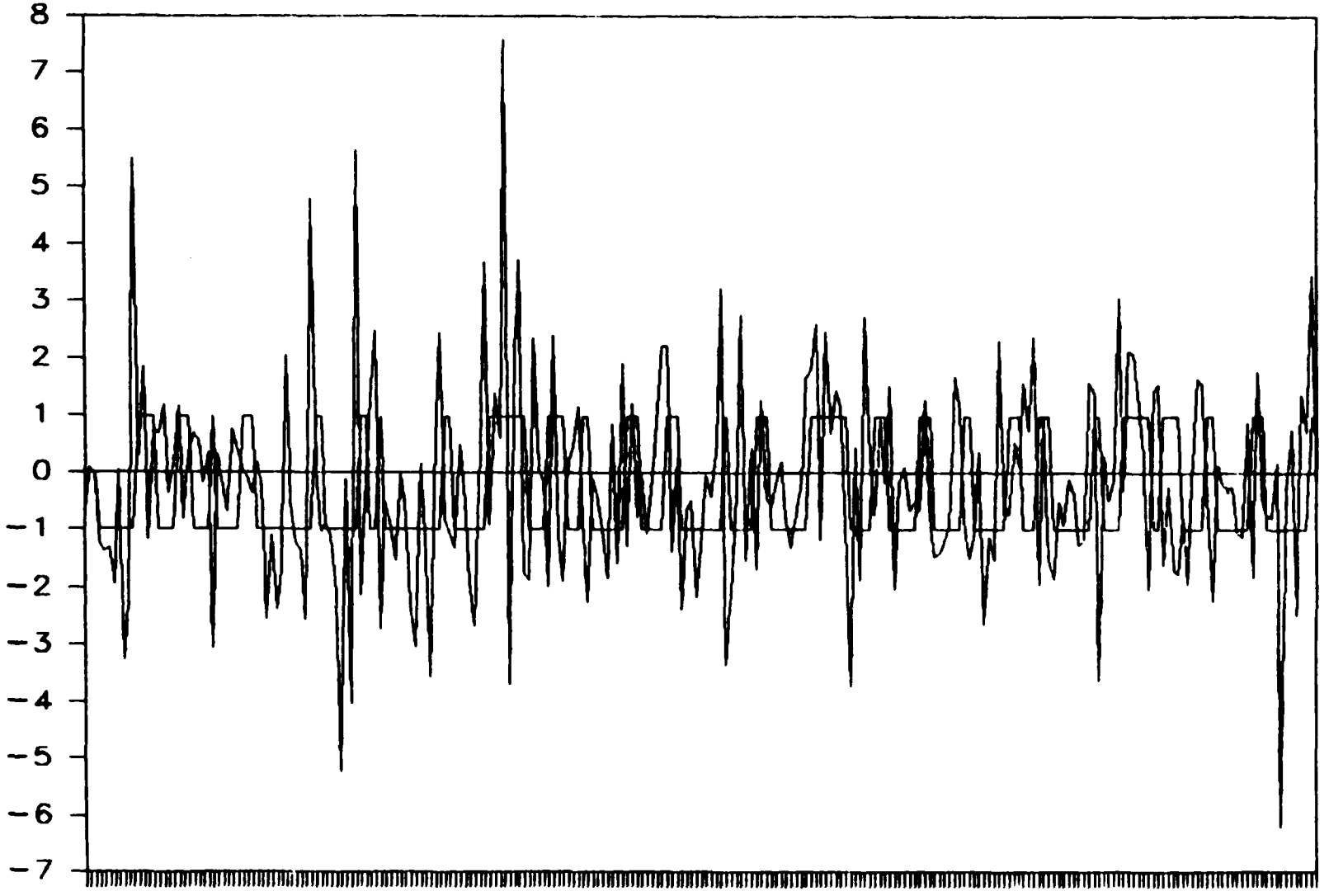


CHART 4-15

D—MARK



4.4 Testing Results

Table 4.2 shows the rate of returns for both optimal stopping rule and oscillator. The reader should note that the initial margin call payments to buy or sell futures can yield normal interest so that the rate of return in Table II in some sense should be regarded as the risk premium for the speculator (except for the case of holding).

Table 4.3 shows our out-of-sample test for 1985-1986 period. In this test, we used March 86 contract for silver, J-yen, and D-mark. As the reader will note that the longer oscillator has a better performance than the shorter oscillator in foreign currency market because of the big bull move since G-5 meetings last September. We mentioned in the previous section that the longer term oscillator can catch bigger move than the shorter term oscillator. Compared with the oscillator, our optimal stopping rules had a relatively stable and better performance, though the testing gave a mixed results and the optimal stopping rules did not perform in the 1985-86 period as good as in the 1980-84 period.

TABLE 4.2
Rate of Return
(Jan. 1980 - Dec. 1984)

		holding	Bayesian	13/5 ma	5/3 ma	3/1 ma
SV	(%)	-50	116* (122)**	-12	-29	59
JY	(%)	-3	62 (68)	-34	5	57
DM	(%)	-41	22 (29)	21	27	32

* numbers not in parentheses are calculated by assuming 90 percent confidence interval.

** numbers in parentheses are calculated by assuming 95 percent confidence interval.

TABLE 4.3
Rate of Return
(Mar. 1985 - Mar. 1986)

		holding	Bayesian	13/5 ma	5/3 ma	3/1 ma
SV	(%)	-33	23* (31)**	12	-17	31
JY	(%)	39	22 (27)	33	3	31
DM	(%)	34	11 (13)	25	7	4

* numbers not in parentheses are calculated by assuming 90 percent confidence interval.

** numbers in parentheses are calculated by assuming 95 percent confidence interval.

4.5 Comments

Some comments on the applications of optimal stopping rules are necessary.

1. the market price change distribution may not be stable. Specifically, our assumption of normal distribution for each bull and bear market should be studied further so that we can have better grasp of the price change pattern. Different distribution may be used for differnt market at different time. According to our experience, the accurate estimation of the distribution density function is crucial for the success of our trading rule. The testing results were very sensitive to the estimates of parameters and the assigned false alarm Bayesian probability.

2. we should be able to assign the neutral condition when the price trend is uncertain so that we can avoid the risk of being "wipsawed" in the jittery market situation. Waiting or further confirmation for future development, the market price movement is uncertain and lack of consistent pattern. On this occasion, the best decision for the trader is to stay on the side line and wait the market to form its trend. Because of its dichonomous property, our trading system can not generate the neutral signal for the trader (neither can oscillator).

3. There are a lot of factors can be taken into account to detect the market trend. For example, the traders will look at the volume, open interest, open/high/low, volitility, and bullish consensus number before making their own subjective judgements according to the market pattern. the price movement has only limited information about the overall market trend.

4. The statistical properties of the optimal stopping rules obviously are much more flexible than the oscillator. By controlling the false alarm probability and assigning a priori belief, the traders can measure the risk involved and combine the objective trading rules with the subjective judgement.

5. By using this one-dimentional normal density function, we were actually assuming X_0, X_1,... are mutually independent with respect to each of the domains., i.e.,

$$f^i(x_0,\ldots,x_n) = f^i(x_0)\ldots f^i(x_n), \qquad i=1,-1.$$

By implementing the multinormal distribution into the trading system, the optimal stopping rules will be able to identify the trend better.

4.6 Summary and Conclusions

While most of the traders use the technical analysis to forecast the market trend, no statistical justification has been studied for the rules of thumb in the trading system. In this chapter, we tried to find the statistical rationale behind one of the most popular trading rules, the oscillator rules, and present a Bayesian trading system with the assumptions that underlying financial market trends are subject to shifts in their distributions at random time points.

Our results showed that the technical analysis is just a simpliest version of the sequential analysis. By studying the properties of the market price distributions, we can apply the optimal stopping rules to the technical system and manupulate it according to our own belief (the a priori probability) and risk preference (the Baysian probability). Although we do not claim we create a profit-making money machine, it is interesting to note that our results. showed most of the time optimal stopping rules have better and stable performances than the ocillator rules. With further study of the distributions of price movement and take into account other market factors, the opimal stopping rules should be the better approach than the rules of thumb in the technical analysis.

Footnotes

1. It is also interesting to note that the sudden shifting of market sentiment is not necessarily associated with the random fundamental shocks. In the case of the speculative bubble, the bubble burst because of endogenous psychological forces.

2. By "optimal", we mean it satisfy the following condition:

$$E[\max(b^*-Z,0)] \leq E[\max(b-Z,0)]$$

where E(.) is the conditional expectation operator given a information set. Accordingly, b* will be the optimal estimate, if for a given false alarm probability, "the average delay" in reporting the downturn is minimized.

3. As the reader will note the formula was derived recursively from the basic Baysian formula:

In this paper, the posterior density of Y, given $x_1,\ldots,x_n$, equals

$$f(Y=-1|x_1,\ldots,x_n)=\frac{f^{-1}(x_1,\ldots,x_n)f(Y=-1)}{\sum_i f^i(x_1,\ldots,x_n)f(Y=i)}$$

i=1,-1.

4. A continuous random variable X is said to be an exponential distribution with parameter λ , $\lambda>0$ if it probability density function is given by

$$f(x) = \lambda e^{-\lambda x}, \quad x\geq 0$$

$$= 0 \quad , \quad x<0$$

5. A random variable X is said to be memoryless, if

$P\{X>s+t|X>t\}=P\{X>s\}$ for all $s,t \geq 0$.

This condition is equivalent to

$$\frac{P\{X>s+t, X>t\}}{P\{X>t\}} = P\{X>s\}$$

or

$$P\{X>s+t\} = P\{X>s\}\, P\{X>t\}.$$

When X is exponentially distributed, $e^{-\lambda(s+t)} = e^{-\lambda t}e^{-\lambda t}$.
It follows that exponentially distributed random variables are memoryless.

6. $F(x) = \int_{-\infty}^{x} f(y)dy = 1 - e^{-\lambda x}, \quad x \geq 0$
$= 0, \quad x < 0$

APPENDIX

When we used the weekly silver, J-yen, and D-mark data to estimate our trading system, we also tested some interesting statistical properties of our data. Not surprisingly, we found the serial covariances of the price percent changes are close to zero. As we mentioned before, the general market effenciency does not prevent the short-term local speculative trend. By looking into the price change patterns, we found the same results as mentioned by Niederhoffer and Osborne (1966) in stock prices. Table V shows the interesting results:

CONDITIONAL PROBABILITIES OF PRICE CHANGES

	P{+¦+,+}	P{+¦+,-}	P{-¦-,-}	P{-¦-,+}
SV	0.47	0.44	0.58	0.54
JY	0.59	0.44	0.62	0.57
DM	0.39	0.37	0.62	0.58

As the reader noted that the trend probabilities , i.e., P{+¦+,+} and P{-¦-,-}, were always slightly higher than random walk probabilites, i.e., P{+¦+,-} and P{-¦-,+}. These results seem to support the existing of the local trend.

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