

Corridor analysis for detection of significant breakout movements
by Mahadevan Krishnamoorthi

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Mechanical & Industrial Engineering
Montana State University
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Abstract:
Time series form patterns during their movements and have been continuously analyzed for relevance to forecasting. A neutral corridor is one of many patterns formed by time series. Neutral corridors, when broken, result in significant upward or downward movements of time series. Therefore, it is imperative that a forecaster be able to detect such significant movements. Research was undertaken to identify a quantitative technique for the detection of such significant breakout movements.

Three techniques were analyzed for possible use. The techniques are cusum control charts, nonparametric tests for location and trends, and a new empirical method developed by the author. Neutral corridors were identified from historical data corresponding to market securities. Rules were formed to define significant breakout movements and each test was performed on all sets of data. A signal of positive or negative trend (breakout movements) was verified by comparison to the actual plot of the data. Accuracy of a signal was determined based on the actual direction of movement and the time of movement.

The cusum control charts and the nonparametric tests gave erratic signals of positive and negative trends and were not confirmed by the actual plot of the time series. Hence these tests cannot be recommended for the purpose of detecting significant breakout movements. The new empirical method illustrated a high accuracy of above 90 percent correct breakout calls, and therefore, is highly recommended for detection of significant movements away from neutral corridors.

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This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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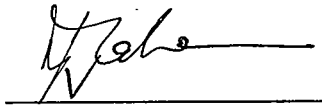
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ABSTRACT

Time series form patterns during their movements and have been continuously analyzed for relevance to forecasting. A neutral corridor is one of many patterns formed by time series. Neutral corridors, when broken, result in significant upward or downward movements of time series. Therefore, it is imperative that a forecaster be able to detect such significant movements. Research was undertaken to identify a quantitative technique for the detection of such significant breakout movements.

Three techniques were analyzed for possible use. The techniques are cusum control charts, nonparametric tests for location and trends, and a new empirical method developed by the author. Neutral corridors were identified from historical data corresponding to market securities. Rules were formed to define significant breakout movements and each test was performed on all sets of data. A signal of positive or negative trend (breakout movements) was verified by comparison to the actual plot of the data. Accuracy of a signal was determined based on the actual direction of movement and the time of movement.

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CHAPTER 1

INTRODUCTION

Time series form patterns during their movements. These patterns have been continuously analyzed for relevance to forecasting. By studying the nature of previous turning points, it is possible to develop some characteristics that can help identify movements of time series. Studies of patterns for purposes of forecasting are based on the assumption that history repeats itself. *The art of forecasting - for it is an art - is to identify trend changes at an early stage and to maintain a posture until the weight of evidence indicates that the trend has reversed* [Pring, 11]. It is worthwhile to note that time series never duplicate their performance exactly, but the recurrence of similar characteristics is sufficient to enable forecast analysts to identify important junctures.

Here, data obtained from market securities have been used for analysis. Reasons for using data from market securities are fourfold:

1. Ease of availability
2. Accurate and timely information
3. Availability of real time data, for verification.
4. Reluctance of business people to release privy information.

Movements of market securities can be classified as long (primary), intermediate, and short term. Primary movements typically work out in a period of 1 to 3 years. Intermediate movements usually develop over a period of 3 weeks to as many months,

sometimes longer. Short term movements last less than 3 weeks. Studies presented in this paper are primarily confined to identification of intermediate term movements in the market securities.

As in a court of law or when testing a hypothesis, a trend in presumed innocent (continuing) until proven otherwise. The "evidence" is the objective element in forecasting. The evidence is derived from the use of one or more forecasting techniques. Not all of them work for all situations. The "art" consists of combining forecasting techniques into an overall picture and recognizing the resemblance of that picture to market patterns.

Corridors

Corridors, are one of the most important and often analyzed patterns. Corridors could be classified as neutral, positive or negative corridors depending on the direction of movement of the time series within a corridor. A neutral corridor (or sideways trend) is essentially horizontal or transitional, which usually separates two major market movements. To the forecaster, the neutral corridor has great significance because it marks the turning point between major market movements. The phenomenon of neutral corridors and their formation is described below. Figure 1 illustrates a typical neutral corridor formed by a market security.

Suppose a time series moving in the upward direction reaches the top at point *A* (Figure 1) and then starts moving down. The point A corresponds to the highest value, the market security reached within that trading period (usually a day). Now, if the time series



Figure 1. Neutral Corridor formed by Market Security 8

reaches point *B* and reverses its direction of movement, to go up, a neutral corridor is likely to be formed. The point B corresponds to the lowest value the market security reached in that trading period. The formation of the neutral corridor is confirmed only some time after this picture, including points A and B, is formed. Now, if the time series, while moving up, does not go above point A, but changes direction and moves past the center of the vertical distance between points A and B, point *A* is called a "valid top." A line (1-1 in Figure 1), is drawn parallel to the X axis from point *A* and termed the "upper boundary" [Schillings, 12]. When the time series once again changes direction from a downward to an upward movement moving past the center line, we are permitted to draw a line from point *B*. The second line, (2-2 in Figure 1) is also drawn parallel to the X axis, and is termed the "lower boundary." The point B is now called a "valid bottom." Appendix A illustrates more examples of neutral corridors formed using the above method.

Neutral corridors sometimes include micro corridors within their boundaries. These micro corridors may exhibit positive, negative or sideways trends. However, for purposes of analysis one can assume randomness of the oscillations within the boundaries of a neutral corridor.

Neutral corridors are broken only by significant movements of the time series. A significant movement is defined as "a movement outside the boundary in either direction, culminating at a distance of more than the width of the corridor." The culmination of a movement is observed when the time series retracts by more than half of the total distance moved in the primary direction of movement. Understanding the concept of significant movements is imperative because time series often cross the boundaries of corridors

momentarily and then move back into the corridors. Such moves are quite misleading and may result in incorrect decisions. Figure 9 shown in Appendix A illustrates temporary movements out of a corridor.

Research was undertaken to eliminate subjectivity in detecting significant movements away from neutral corridors. Here, an effort has been made to formulate a quantitative technique to consistently identify significant movements. This research may be classified as part of the continuing search for the "holy grail" or perfect technique.

Three techniques have been analyzed for possible use to detect significant movements. The techniques are cusum control charts, nonparametric tests for location and trends, and an empirical method developed by the author.

CHAPTER 2

LITERATURE REVIEW

A neutral corridor is one of many time series patterns that are often analyzed by forecasters. Although patterns resembling neutral corridors have been observed and considered for many years, the author and Schillings [Schillings, 12] found no published material that analyzed quantitative aspects for the detection of significant breakout movements. It is worth mentioning that the patterns studied in this paper were referred to for the first time, as *neutral corridors,* by Schillings. Pring [Pring, 11] calls these patterns *transition zones* or *rectangles*.

Currently, there is one technique used for analyzing patterns resembling neutral corridors which concentrates on the position of the time series values and corridor lengths. If a neutral corridor is formed at a market top, then the time series is usually expected to undergo a reversal and revert to a negative trend [Pring, 11]. If the corridor is formed at the bottom, then the time series is expected to revert to a positive trend. Analysis based on the length of the corridor leads to an estimate of how far the time series will go up or down after the breakout.

Pring finds that some practitioners (references not cited) define a movement away from a rectangle by a three percent penetration of either boundary as "significant." This filters out only some of the misleading moves, but does not ensure consistency in detection of statistically significant breakout movements. A movement of half the width of the corridor

away from either boundary is also termed "significant." Both rules are only heuristics followed by some forecasters.

The review of published literature related to corridor analysis, as defined in this paper, does not indicate the availability of a quantitative technique. Hence, research was undertaken to formulate a quantitative technique for the detection of statistically significant breakout movements from time series neutral corridors.

CHAPTER 3

CONCEPTS OF STATISTICAL TESTING

Tests, usually called hypothesis tests or significance tests, often play a major part in statistical investigations. The basic idea of most statistical techniques is to increase our knowledge about populations using information in samples taken from them. In statistical testing, we are concerned with examining the truth, or otherwise, of hypotheses about some feature(s) of one or more populations. A statistical hypothesis is a statement about a population; for example its form or shape, or some aspect thereof; the numerical value of one or more parameters; and so forth [Gibbons, 4]. A hypothesis set consists of two statements, called the null hypothesis, H_0 and the alternative hypothesis, H_1. These statements must be mutually exclusive.

Whether or not particular hypotheses are eventually assessed to be reasonable, will depend on the weight of evidence contained in the sample data taken from population(s). In hypotheses testing, we never claim to *prove* anything completely (beyond doubt) by means of statistical test: we simply pronounce a judgement based on the available evidence, and give an assessment of the strength of that evidence [Neave, 9]. Sometimes, the evidence may be so overwhelming that a hypothesis may be regarded as proved (or disproved) "for all practical purposes."

Approach to Hypothesis Testing

For example, if the null hypothesis is stated as "The populations under consideration do not differ in persistence", then an alternative could be stated as "A motivated population exhibits more persistence for a task than a population with no motivation." As a mathematical statement, if μ_1 and μ_2 are parameters representing average persistence for the populations with motivation and without motivation, respectively, then the null hypothesis is $\mu_1 = \mu_2$ and the alternative is $\mu_1 > \mu_2$. The alternative hypothesis here is called one-sided (or one-tailed or right-tailed), because it states a particular direction of inequality. When the alternative is stated as $\mu_1 < \mu_2$, it is called left-tailed and when it is stated as μ_1 not equal to μ_2, then it is called two sided.

A decision to accept or reject any hypothesis is made on sample evidence according to some *statistical test procedure* and *test statistic*. The test procedure may also be called one-sided or two-sided, according to whether the alternative is one-sided or two-sided. One-sided tests are either left-tailed or right-tailed, depending on the direction of the alternative hypothesis, H_1. The test statistic should be consistent with, and appropriate for, the type of alternative, the data available for analysis, and the assumptions the investigator is willing to make about the population. By central limit theorem, the sampling distribution of the sample mean (test statistic in this case) is a normal distribution.

Once the test statistic is chosen, its value is calculated for the data obtained. Then the investigator can use this value and the sampling distribution of the test statistic to determine a quantity called the *P-value*, or the *associated probability*. The P-value is the probability,

when H_0 is true, of obtaining a value of the test statistic which is equal to or "more extreme" in the appropriate direction than its critical value [Gibbons, 4].

When the investigator wishes to make a statistical decision, whether to reject or accept H_0, the decision can be based on the magnitude of the P-value in the following method. Because the P-value is found from the probability distribution of the test statistic under the null hypothesis, a very small P-value implies that a sample result this extreme, when H_0 is true, occurs only very rarely, by chance phenomena. Sampling error is primarily due to two causes: (1) sample does not encompass the entire population, and (2) each member of the population is not equally accessible to the sample. When the P-value is critically small, then the investigator can state that the data do not support the null hypothesis, that rejection is "statistically significant ." When the P-value is less than 0.05 the result is *probably* significant and if it is less than 0.01 then the result is *highly* significant. In both cases the statistical decision is to "Reject the null hypothesis, H_0 ."

Suppose that the P-value is large, then the sample result offers no convincing evidence that the statement made in H_0 about the population is false. In other words, the data do not deny the null hypothesis. The statistical decision is "Fail to reject the null hypothesis, H_0 ."

Errors Associated with Hypothesis Testing

It is imperative that we properly address the question "How rare is the rare event?", while discussing the decision process. The probability value taken as the cutoff between a rare event and a likely occurrence is frequently called the *level of significance* of the test

[Gibbons, 4]. The value for the cutoff is primarily a matter of personal choice, but it should reflect the investigator's feeling about the cost and the consequence of error.

Two types of error may occur. The first error occurs when the null hypothesis is rejected, while it is actually true and is called, Type I error, α. The second error, called Type II error, β occurs, when the null hypothesis is accepted while it is actually false. These definitions are summarized below.

Table 1. Summary of Type I and Type II Errors

Actual Situation

Decision Taken	**H_0 TRUE (Probability)**	**H_0 False (Probability)**
Accept H_0	Correct Acceptance (1-α)	Type II Error (β)
Reject H_0	Type I Error (α)	Correct Rejection (1-β)

If rejecting a true hypothesis would be considered a serious mistake, a small value for α would be appropriate. However, a very small value of α may not be good either, because Type I error and Type II errors interact. When the probability of one type of error decreases, the probability of the other increases, but disproportionately because of the non-linearity of the distribution function. This is to be distinguished from the trivial case at μ_0, where $\alpha + \beta = 1.0$. Thus if a Type II error has serious consequences, a larger α value might be advisable. Once the value for α is chosen and the test result gives a P-value, the null hypothesis H_0 is rejected if $P <= \alpha$, but not otherwise. It is important to note that in statistical analysis, P-values can be an aid to making a research conclusion, but only in concert with the judgement and intelligence of the investigator.

CHAPTER 4

INVESTIGATION OF CUSUM CONTROL CHARTS

Process Behavior and Control Charts

A process is set of causes and conditions that repeatedly come together to transform inputs into outcomes [Moen, 8]. The inputs may include people, methods, material, equipment, environment, and information. The outcome is some product or service. Process behaviours are often studied with the use of control charts. Control charts are graphical displays of statistics plotted according to the order of their observation [Devor, 2]. A process is said to be in statistical control if there are only random patterns on a control chart. A succession of data emanating from a process, which is under statistical control, will exhibit variability due to a constant set of causes that are inherent in the process. These causes, usually called *common* causes, can also be thought of as causes leading to variability in the process.

Data observed from processes, often fall into a predictable pattern of variation, such as a normal distribution, easily described by simple statistical measures, namely, a mean and a standard deviation. These measures serve as a model to predict process behavior, when the process is subject only to a set of common causes. When a process is subject only to a set of common causes, data observed from the process will fall within the control limits of the

process. Control limits are boundaries constructed on either side of the mean of the process, usually at a distance of three standard deviations.

For process control, data collected over time may be used to develop a statistical model as long as the data are collected while the process is subject to a set of common causes. Hence, if we can develop a model for the process measurements, then, when a major disturbance or an abnormal situation affects the process, the ensuing data will not conform to that model. The data from the abnormal situation will stand out clearly from the common-cause variability pattern. To be able to distinguish abnormal data from data generated during normal operating conditions, we should consider the process as it evolves over time.

Adoption to Forecasting

Data within a neutral corridor can be thought of as data generated by a process. Chi-squared tests for normality, were performed on sets of data and the results show that data within neutral corridors exhibit normality. All chi-square tests were performed at five percent level of significance and the results of some of them are listed in Appendix B. A mean and a standard deviation can now be computed and used to construct control charts for visual analysis of existence of special causes. If nonrandom patterns or the existence of data generated by abnormal situations are observed, then it is concluded that all the data points in the given set no longer fall within a neutral corridor.

A particular control chart that can be effectively used for purposes of predicting movements out of the boundaries of the neutral corridors is the cusum chart, where "cusum" stands for "cumulative sum ."

Cusum Charts

Cusum charts are becoming widely used in the industry because they are powerful, versatile, and have the ability to quickly detect small changes in a process mean [Lucas, 7]. The use of cumulative sums of sample data for on-line process control was developed by E. S. Page [Page, 10] and G. A. Barnard. The principle behind these charts is based on a method using the sequential likelihood ratio test [Wald, 13], where, as each new sample becomes available, a test is conducted to determine whether the process mean deviates by at least a specified amount from the target value.

Advantages of Cusum Charts

The most fundamental advantages of cusum charts are threefold:

i. Ease with which changes in mean level can be detected, either by observing points that lie outside the control limits or by a change in the slope of the chart.

ii. Ability to locate a point of change on a chart as that point at which the change in slope occurs.

iii. Efficiency over the standard control chart (Shewhart control chart) for changes of about 0.5σ and 2.0σ, which means that in this region changes can be detected approximately twice as quickly, when compared with Shewhart control charts [Ewan, 3]. These advantages make the cusum charts suited to analyze processes expected to have small and sustained deviations in the mean.

Traditional Cusum Charts

Common to all cusum control charts that are developed according to the sequential likelihood ratio is the idea of hypothesis testing between two alternative quality levels, one acceptable and the other rejectable. These cusum charts are usually referred to as *traditional cusum charts* [Devor, 2]. To construct traditional cusum charts both acceptable and rejectable quality levels must be specified. The necessity to specify the shifts (acceptable and rejectable quality levels) in advance, presents a serious concern in the application of these charts. However, the success of traditional cusum control charts depends mainly on the accurate estimation of both the target process parameter value and the size of the shift the control chart is designed to detect. Therefore, the use of traditional cusum charts is suited only when accurate estimation of target process parameter and shift are possible. Instead a modified version of the traditional cusum chart called the *standardized cusum chart* can be used. The method of preparation and analysis of the standardized cusum chart will be discussed later.

The traditional cusum control chart is developed according to the concept of hypothesis testing, where the hypotheses, for a one-sided cusum chart, are stated as follows:

$$H_0: \mu = \mu_0$$

$$H_1: \mu = \mu_1 \qquad (\mu_1 > \mu_0),$$

where μ is the mean of X and both Type I and Type II errors are specified beforehand. H_1 is accepted only if there is a significant rejection of H_0. If rejection is not significant then H_0 stands unrejected.

The likelihood ratio can be expressed in terms of α and β as,

$$\frac{\beta}{1-\alpha} < \text{likelihood ratio of the data} < \frac{1-\beta}{\alpha}$$

The above equation can be used to construct a one-sided cusum control chart for detecting upward shifts in the mean. If we have a time ordered sequence of independent sample observations, $X_1, X_2, \ldots, Xt$, from a normal population with variance σ_x^2 and an uncertain mean μ, it can be shown that the ratio will take the form

$$\frac{\sigma_x^2}{\Delta_1} \ln \frac{\beta}{1-\alpha} < S_t < \frac{\sigma_x^2}{\Delta_1} \ln \frac{1-\beta}{\alpha}$$

where $\Delta_1 = \mu_1 - \mu_0$ is the difference between the two hypotheses means or the shift in the process mean from μ_0, and

$$S_t = \sum [X_i - (\mu + \frac{\Delta_1}{2})]$$

is the cumulative sum of the sample deviations of the data from the average of the two means. However, when it is desirable to detect a process mean shift in either direction from the target, as with predictions of significant movements away from neutral corridors, one could use a pair of one-sided cusum charts to monitor the process for upward and downward shifts, separately. Let the two off-target mean values of interest be denoted by $\mu_1 > \mu_0$ and $\mu_2 < \mu_0$ with a Type II error β and a Type I error 2α. Note, that the Type II errors for the

upward and downward shifts can be different, but with the neutral corridors, the selection of two different β values is not meaningful.

By combining two one-sided decision criteria, it can be shown that the upper and lower control limits for the centered cumulative sum, $\Sigma(X_i - \mu)$, are

$$UCL = \frac{\sigma^2_x}{\Delta_1} \ln\left(\frac{1-\beta}{\alpha}\right) + t\left(\frac{\Delta_1}{2}\right)$$

$$LCL = \frac{\sigma^2_x}{\Delta_2} \ln\left(\frac{1-\beta}{\alpha}\right) + t\left(\frac{\Delta_2}{2}\right)$$

where $\Delta_1 = \mu_1 - \mu_0$ and $\Delta_2 = \mu_2 - \mu_0$. Because the equations for the control limits are functions of the sample size t, the upper and lower control limits are linear trend lines for the cusum chart. An example of the resulting cusum chart is shown in Figure 3 and the corresponding neutral corridor is shown in Figure 2.

The general model for the cusum chart above is that of a sequential sampling scheme shown in Figure 3. There are two alternative hypotheses for rejection of the null hypothesis:

$$H_0: \mu = \mu_0$$

$$H_1: \mu = \mu_0 + \Delta_1,$$

and $$H_2: \mu = \mu_0 + \Delta_2.$$

Only the upper and lower trend lines are used for the detection of shifts in the mean. In every case cusums are cumulative sums of sample deviations from the target process mean μ_0, where μ_0 for a neutral corridor as defined earlier, is the value of the center line of the neutral corridor.

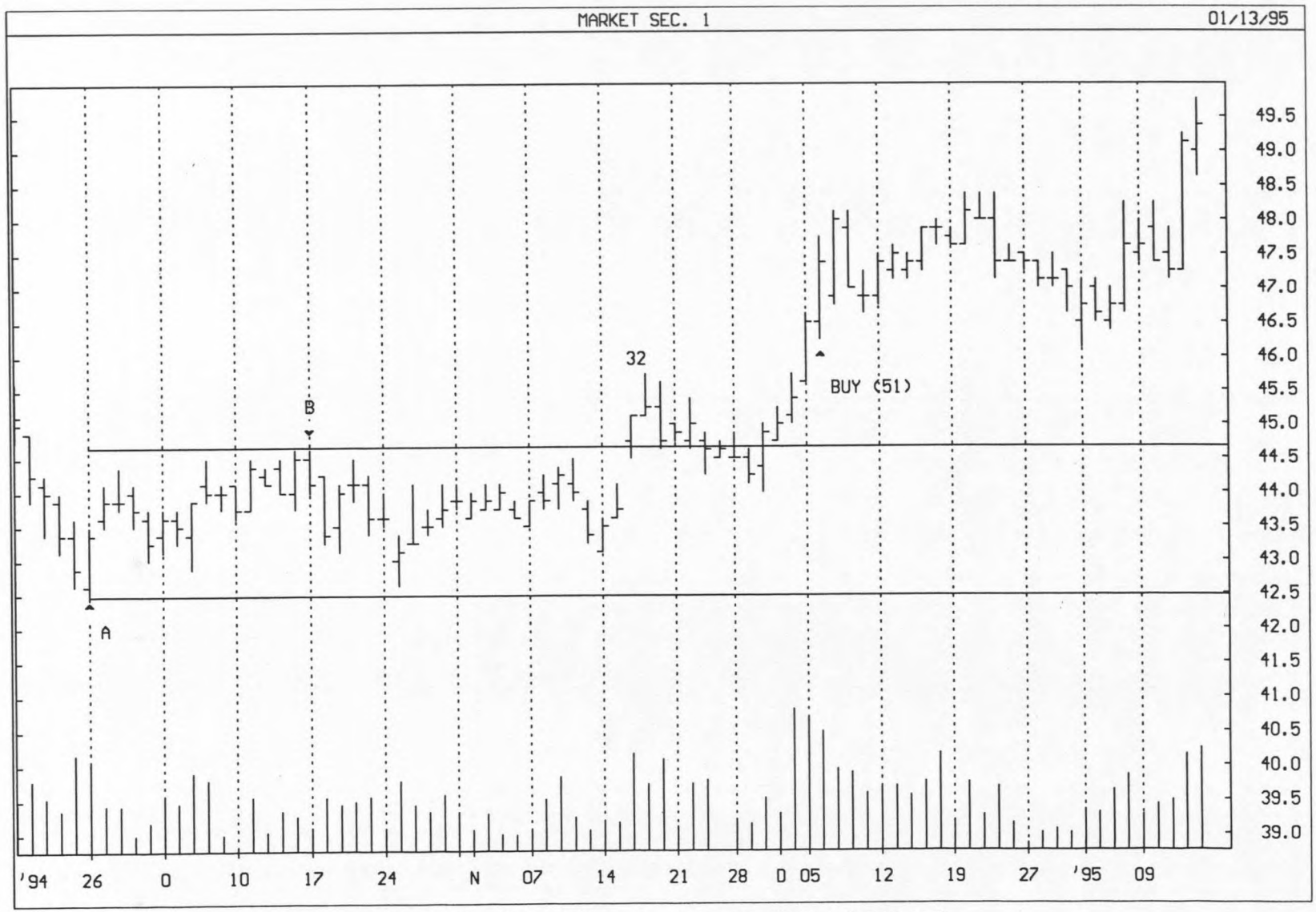


Figure 2. Neutral Corridor formed by Market Security 1

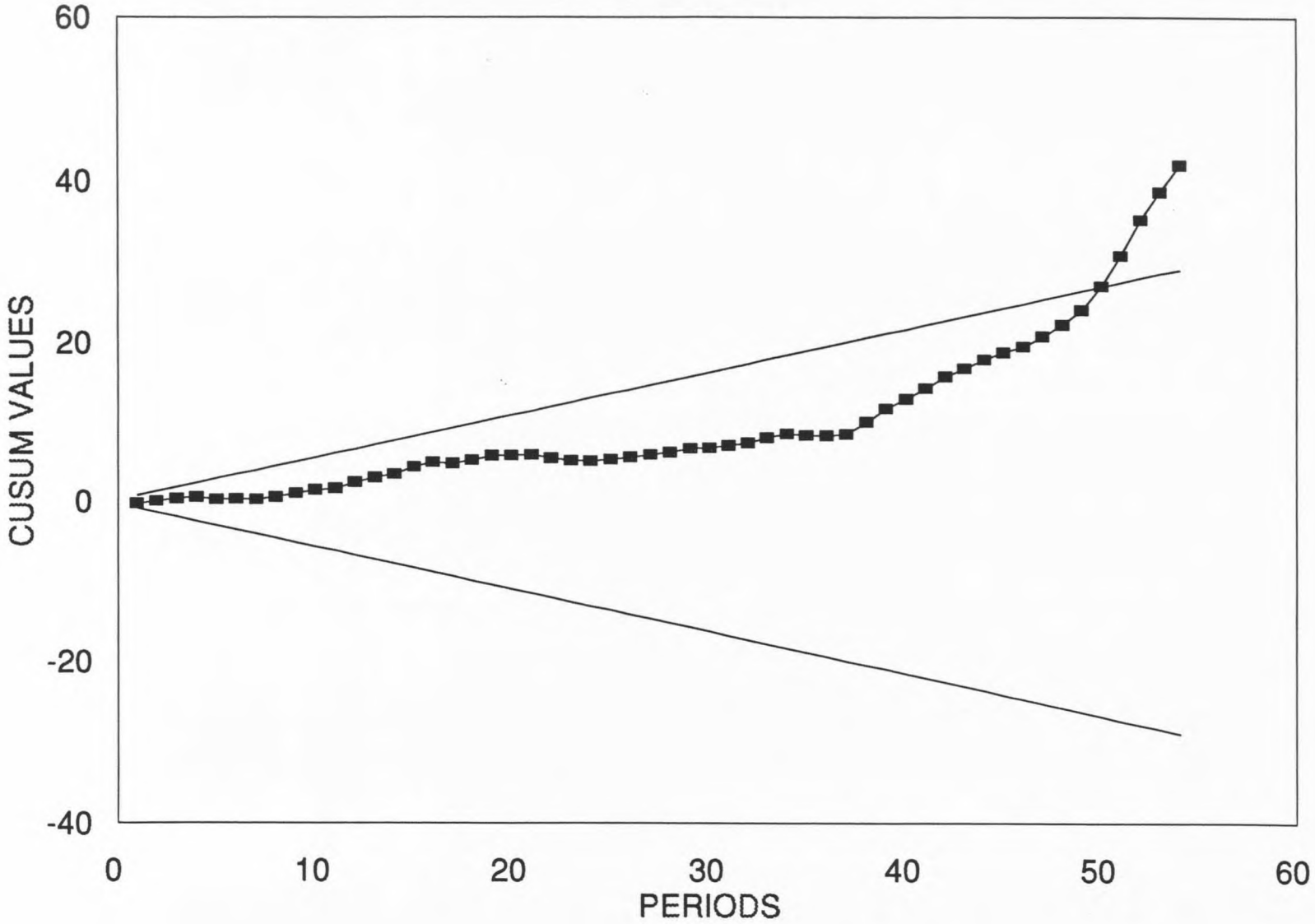


Figure 3. Traditional Cusum Chart for Market Security 1

Standardized Cusum Chart

Cusum charts can be used for individual measurements, when these measurements exhibit a normal distribution with mean μ and standard deviation σ. Given the individual measurements, X_i, $i = 1, 2, 3, \ldots, t$, we can standardize them by applying the transformation

$$Z_i = \frac{X_i - \mu}{\sigma}$$

The sum of Z's will have a normal distribution with mean = 0 and variance = t {since the variance of each Z_i is 1.0, the variance of t independent Z_i's will be (t)(1.0) = t [Devor, 2]}. We can write the cusum as follows:

$$S_t^* = \frac{\Sigma Z_i}{\sqrt{t}}$$

where, S_t^* also follows a normal distribution. This allows us to plot the S_t^* on a control chart with constant control limits (usually $\pm$ 3) and a centerline of zero. Thus a control chart simpler than the traditional cusum control chart can be constructed for the cusum defined above. Figure 4 shows a standardized cusum chart which has been plotted on the same neutral corridor data (Figure 2) used for plotting the traditional cusum chart.

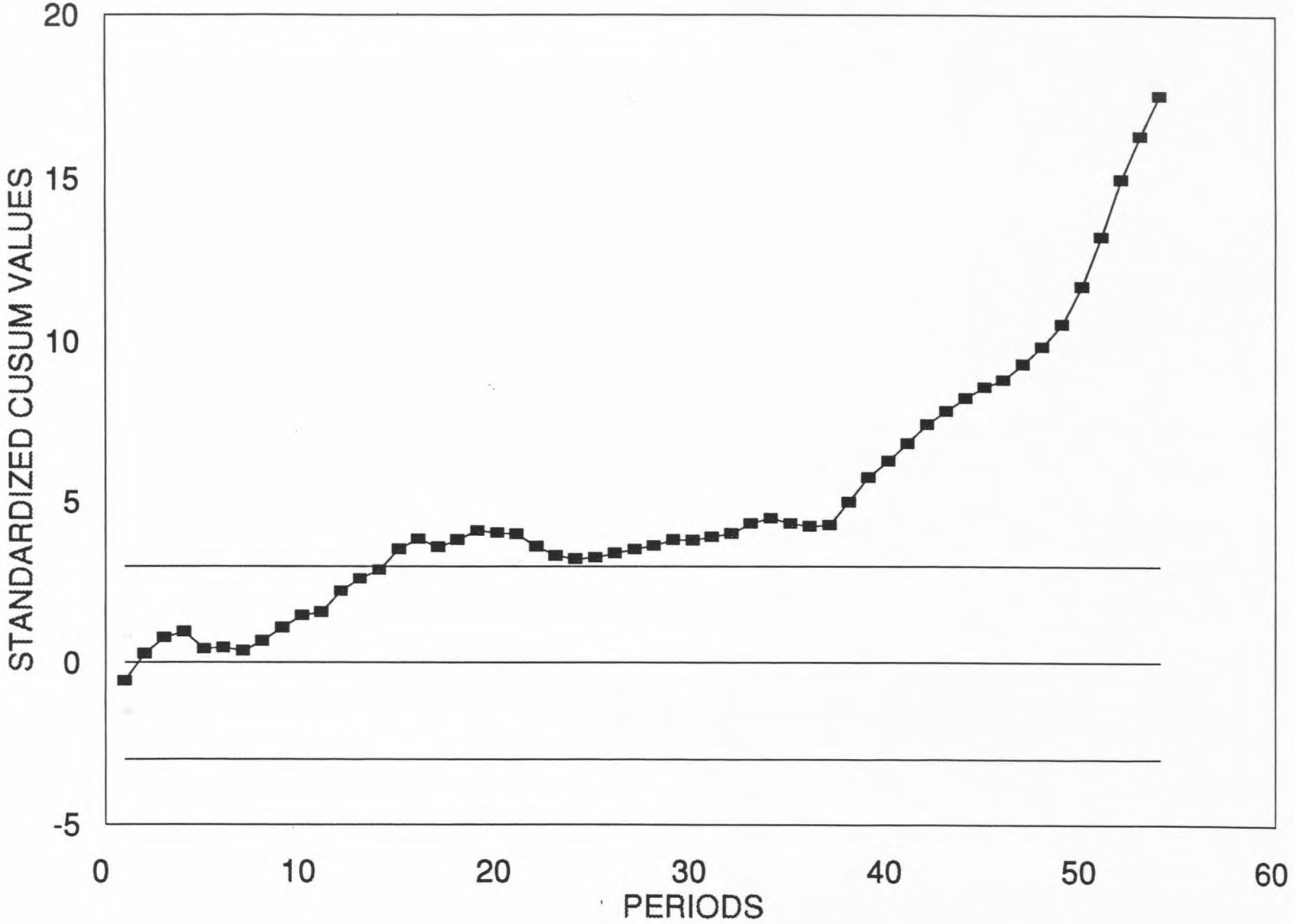


Figure 4. Standardized Cusum Chart for Market Security 1

Construction of the Standardized Cusum Chart

i. Compute X-bar and s_x from the data. These are used as point estimators of the true mean and true standard deviation of the X's respectively.

$$Xbar = \frac{\Sigma X_i}{k}$$

$$s_x = \left[\frac{\Sigma (X_i - Xbar)^2}{k-1} \right]^{1/2}$$

ii. Standardize all the X's into Z's for i = 1, 2, 3, . . . , k:

$$Z_i = \frac{(X_i - Xbar)}{s_x}$$

iii. Sum the Z's cumulatively for each t, where t = 1, 2, 3, . . . , k:

$$sum_t = \Sigma Z_i$$

iv. Obtain the standardized cusum for each t, where t = 1, 2, 3, . . . , k:

$$S_t^* = \frac{sum_t}{\sqrt{t}}$$

v. Plot the S_t^* on the standardized cusum chart, where

Centerline = 0

UCL = 3

LCL = -3

vi. Interpret the chart, looking especially for possible trends in the sums.

Tests with Cusum Control Charts on Neutral Corridors

More than 15 neutral corridors have been tested for possible indications of significant movements away from one of the boundaries (upper or lower boundary) of the neutral corridor (abnormal situations), using the traditional and standardized cusum charts. One set of data, which was tested using the traditional cusum chart is shown in Figure 2. These data represent a neutral corridor formed by open, high, low and close prices of a market security. The data used to plot the cusum charts, the X_i's, correspond to the closing prices of that particular security.

The value of the center line of the neutral corridor was taken as μ_0, and the values of upper and lower boundaries of the neutral corridor were set equal to μ_1 and μ_2, respectively. The standard deviation of the closing prices within the neutral corridor was used for all calculations. Type I error values, α, are set to 0.05 and Type II error values, β, are set to 0.10.

Results

The traditional cusum chart shown in Figure 1 has a number of points that lie outside the upper control limit, indicating a significant movement away from the upper boundary of

the neutral corridor starting from the forty-third time period. The corresponding significant movement can be seen in Figure 2, the actual neutral corridor.

Signal, for significant movement away from the upper boundary, was given by the standardized cusum chart at time period 32. Figure 2 shows a temporary movement away from the upper boundary during time periods 31 and 32. However, movement in time periods 31 and 32 can be considered valid because a significant movement occurs in the same direction within a short period of time, say, within 12 periods. Therefore, points falling outside the upper control limit, on the standardized cusum chart gave a valid signal.

In the standardized cusum chart points between the eighth and thirteenth time period fall outside the upper control limit indicating a significant movement away from the neutral corridor. Comparing this indication of significant movement to the neutral corridor (Figure 2), it is obvious, that the signal is false. Appendix D shows cusum charts which are examples of both successful and failed signals of movements away from neutral corridors.

Conclusion

Signals, of movements away from neutral corridors, were given by traditional and standardized cusum charts, when there was actually no significant movement. The author considers these erroneous movements contradictory, which leads to the failure of the concept that cusum control charts could be used to detect significant movements away from neutral corridors.

CHAPTER 5

INVESTIGATION OF NONPARAMETRIC TESTS

Usually statistical inferential procedures contain *parametric procedures* which depend upon certain distributional assumptions about population(s). Some widely used parametric tests are t-test, ANOVA, and regression analysis. Because the population(s) does not always meet the underlying assumptions for parametric tests, inferential procedures are needed whose validity does not depend on rigid assumptions. In many instances, *nonparametric statistical procedures* fill this need.

Statistical inferences not concerned with parameter values are called *nonparametric*. Inferences whose validity does not depend on a specific probability model, such as a binomial or normal, is called *distribution-free*. While nonparametric and distribution-free are not synonymous, and in fact refer to two different aspects of a statistical inference, procedures of either type are frequently known as nonparametric methods.

Advantages of Nonparametric Statistics

- Often nonparametric procedures are computationally simple because they exist for the measurement scales of nominal and ordinal only.
- Most nonparametric procedures depend on very few assumptions.
- Assumptions are often "weaker" than those of parametric procedures.

Disadvantages of Nonparametric Statistics

- When a parametric is appropriate, using a nonparametric test is less efficient.
- Some procedures are computationally demanding.

Two types of nonparametric tests have been considered for possible use to detect significant movements away from neutral corridors. The two types are tests for location and tests against trend.

Tests for Location

A measure of central tendency in the population is a location parameter. The best known location parameters are the mean and the median. Both represent a "typical" or "average" value of a sample variable, or a central value of a distribution, but typify different concepts of centrality. For a finite population, the mean is determined by summing all the values and dividing by the number of elements, while the median is the middle case of the ordered values. Therefore, by definition, the probability that a variable exceeds its median is equal to the probability that the variable is exceeded by the median.

The mean is influenced by extreme values, since each possible value directly affects the mean, while only ordering affects the median. The statistics that correspond to these location parameters are the sample mean and the sample median. In nonparametric statistics, the median is often the sample measure of central tendency that has desirable distribution properties.

The value of the center line of the neutral corridor is selected as the sample measure of central tendency. For a symmetric distribution, inferences concerning the value of the center line can be considered equivalent to inferences concerning the median and mean. However, in the case of neutral corridors, due to non-symmetry, the value of the center line is more meaningful than the mean or the median. The study of inferences concerning the chosen measure of central tendency was conducted using two tests for location. They are the ordinary sign test and the Wilcoxon signed rank test.

Ordinary Sign Test

The sign test is a quick and simple test for the location parameter. Here, the numerical data are dispensed with and only limited information, summarized by '+' and '-' signs, is retained. Hence the sign test involves very little computation and is found suitable to make quick inferences concerning location parameters. The assumptions for the sign test are:

i. The measurement scale is at least nominal.

ii. The observations can be classified into non-overlapping sets while set union exhausts all possibilities. The sets are labeled '+' and '-'.

Suppose there are *n* independent observations, which are later classified into two categories according to their relative magnitudes. After classification the data will consist of n dichotomous observations. These two categories are termed as "success", denoted by '+' and "failure", denoted by '-'. The data to be analyzed are the frequencies in the two categories.

The occurrences of success (+) or failure (-) are assumed to follow a Bernoulli process [Gibbons, 4]. The only population parameters relevant are the probability of success, denoted by P_+, and the probability of failure, P_-. The ordinary sign test can be used for the following types of inference concerning these parameters. Let C_0 denote the initial value of the center line of the neutral corridor and C the value of the center line calculated after the observation of additional data. The hypothesis set to be tested is one of the following:

H_0: $C = C_0$

H_1: $C > C_0$, to check whether or not the time series has moved away from the upper boundary of the neutral corridor.

or

H_0: $C = C_0$

H_1: $C < C_0$, to check whether or not the time series has moved away from the lower boundary of the neutral corridor.

Suppose we have *n* observations in the period of analysis, each point is classified as a '+' or '-' depending on the location of the observation. If an observation is above the center line then it is classified as '+' and if the observation is below to center line it is classified as '-'. Points falling on the center line (give zero differences) are omitted from all calculations. These derived data can be regarded as random samples drawn from a dichotomous population of plus and minus signs. The test statistics are defined as follows:

S_+ = Number of plus signs among the $(X_i - C_0)$

S_- = Number of minus signs among the $(X_i - C_0)$.

Because the sampling distributions of S_+ and S_- are each binomial with parameter $\theta = 0.5$ if H_0 is true, the P-Values could be found from the appropriate binomial distribution. The P-values are found using the binomial distribution when $n \leq 20$ and the normal approximation when $n > 20$. Table 2 lists the results of the sign test performed on the data shown in Figure 2.

Wilcoxon Signed Rank Test

Because the sign test for location utilizes only the signs of the differences between each observation and the measure of central tendency (center line of neutral corridors), the magnitudes of the differences are not considered. If this information is available from the data measured on a ratio scale, a test procedure that takes into account the size of relative magnitudes might be expected to give better performance [Gibbons, 4]. The Wilcoxon signed rank test statistic uses both the signs and the magnitudes of differences to influence the inference. The only additional assumption required is that of symmetry about the true measure of central tendency. Because data from a neutral corridor belong to the ratio scale, the Wilcoxon signed rank test can be applied.

For C_0, the center line value of a neutral corridor, the hypotheses set to be tested is one of the following:

H_0: $C = C_0$

H_1: $C > C_0$, to check whether or not the time series has moved away from the upper boundary of the neutral corridor, or

Table 2. Results of the Ordinary Sign Test

Data pertains to ==> MARKET SECURITY 1

Points in neutral corridor ==> 16

Upper boundary => 44.625 Lower boundary => 42.5

TOTAL POINTS	NON-ZERO POINTS	POINTS ABOVE	POINTS BELOW	PROB./ ZVAL	RECOMMENDATION
17	17	13	4	0.9936	POSITIVE TREND !
18	18	14	4	0.9962	POSITIVE TREND !
19	19	15	4	0.9978	POSITIVE TREND !
20	20	16	4	0.9987	POSITIVE TREND !
21	21	17	4	2.8587	POSITIVE TREND !
22	22	17	5	2.5797	POSITIVE TREND !
23	23	17	6	2.3145	POSITIVE TREND !
24	24	17	7	2.0617	POSITIVE TREND !
25	25	18	7	2.2200	POSITIVE TREND !
26	26	19	7	2.3730	POSITIVE TREND !
27	27	20	7	2.5211	POSITIVE TREND !
28	28	21	7	2.6646	POSITIVE TREND !
29	29	22	7	2.8040	POSITIVE TREND !
30	30	23	7	2.9394	POSITIVE TREND !
31	31	24	7	3.0713	POSITIVE TREND !
32	32	25	7	3.1997	POSITIVE TREND !
33	33	26	7	3.3249	POSITIVE TREND !
34	34	27	7	3.4471	POSITIVE TREND !
35	35	27	8	3.2285	POSITIVE TREND !
36	36	27	9	3.0167	POSITIVE TREND !
37	37	28	9	3.1400	POSITIVE TREND !
38	38	29	9	3.2607	POSITIVE TREND !
39	39	30	9	3.3787	POSITIVE TREND !
40	40	31	9	3.4943	POSITIVE TREND !
41	41	32	9	3.6076	POSITIVE TREND !
42	42	33	9	3.7187	POSITIVE TREND !
43	43	34	9	3.8277	POSITIVE TREND !
44	44	35	9	3.9347	POSITIVE TREND !
45	45	36	9	4.0398	POSITIVE TREND !
46	46	37	9	4.1431	POSITIVE TREND !
47	47	38	9	4.2447	POSITIVE TREND !
48	48	39	9	4.3446	POSITIVE TREND !
49	49	40	9	4.4429	POSITIVE TREND !
50	50	41	9	4.5396	POSITIVE TREND !
51	51	42	9	4.6349	POSITIVE TREND !
52	52	43	9	4.7288	POSITIVE TREND !
53	53	44	9	4.8214	POSITIVE TREND !
54	54	45	9	4.9126	POSITIVE TREND !

H_0: $C = C_0$

H_1: $C < C_0$, to check whether or not the time series has moved away from the lower boundary of the neutral corridor.

Suppose we have *n* observations in the period of analysis, each point is classified as a '+' or '-' depending on the location of the observation. If an observation is above the center line then it is classified as '+', and if it is below the center line it is classified as '-'. Points which lie on the center line (zero differences) are omitted from all calculations.

To compare the absolute magnitude values of the differences $D_i = X_i - C_0$, we temporarily ignore the signs and rank the absolute values $|D_1|, |D_2|, \ldots, |D_n|$ according to relative magnitude. In other words, rank 1 is given to the smallest absolute difference $|D_i|$, rank 2 to the second smallest, . . . and rank *n* to the largest. The sum of the ranks assigned to the absolute values of those differences whose original sign is plus, called positive ranks, should be approximately equal to the sum of the ranks of those absolute differences that are originally minus, called negative ranks [Gibbons, 4].

Clearly, if H_0 is true, we would expect that sums of the ranks of the negative and positive differences to be roughly equal. If the sum of positive ranks is much larger than the sum of negative ranks, most of the ranks belong to positive differences, and the data support the alternative H_1: $C > C_0$. A larger sum of positive ranks indicate that more observations lie above the center line and have higher magnitudes of differences. This situation is analogous to a higher momentum of the time series towards or away from the upper boundary of the neutral corridor.

Similarly, a large sum of negative ranks reflects the situation in which large ranks are associated primarily with negative differences, and the data support H_1: $C < C_0$. A larger sum of negative ranks indicates that more observations lie below the center line and have higher magnitudes of differences. This situation is analogous to a higher momentum towards or away from the lower boundary of the neutral corridor.

The Wilcoxon test statistic is defined as either

T_+ = sum of positive ranks

T_- = Sum of negative ranks.

Note, that T_+ and T_- are both defined as nonnegative integers, and

$$T_+ + T_- = n(n+1)/2.$$

Tables that provide the critical values [Harter, 5] are available and have been used for determining the P-values. The P-values are found using the null distribution for a Wilcoxon signed rank test when $n \leq 50$ and the normal approximation when $n > 50$. Table 3 lists results of Wilcoxon signed rank test performed on data shown in Figure 2.

Tests Against Trend

There are two types of trends: *upward trend and downward trend.* A series of observations is said to exhibit an upward trend if the magnitudes of the later observations tend to be greater than those of the earlier observations. The data exhibit a downward trend if the earlier observations tend to be larger than the later observations. This simple

Table 3. Results of Wilcoxon Signed Rank Test

Data pertains to ==> MARKET SECURITY 1

Number of points in neutral corridor = 16

Value of Center Line = 43.5625

Periods	Nonzero Diff.	Sum '+' Ranks	Sum '-' Ranks	Recommendation
17	17	134	19	Positive Trend
18	18	152	19	Positive Trend
19	19	171	19	Positive Trend
20	20	187.5	22.5	Positive Trend
21	21	205	26	Positive Trend
22	22	212	41	Positive Trend
23	23	222.5	53.5	Positive Trend
24	24	238	62	Positive Trend
25	25	259	66	Positive Trend
26	26	283	68	Positive Trend
27	27	308	70	Positive Trend
28	28	334	72	Positive Trend
29	29	362.5	72.5	Positive Trend
30	30	386.5	78.5	Positive Trend
31	31	415.5	80.5	Positive Trend
32	32	445.5	82.5	Positive Trend
33	33	478.5	82.5	Positive Trend
34	34	512	83	Positive Trend
35	35	533.5	96.5	Positive Trend
36	36	558.5	107.5	Positive Trend
37	37	591	112	Positive Trend
38	38	629	112	Positive Trend
39	39	668	112	Positive Trend
40	40	708	112	Positive Trend
41	41	749	112	Positive Trend
42	42	791	112	Positive Trend
43	43	834	112	Positive Trend
44	44	878	112	Positive Trend
45	45	923	112	Positive Trend
46	46	969	112	Positive Trend
47	47	1016	112	Positive Trend
48	48	1064	112	Positive Trend
49	49	1113	112	Positive Trend
50	50	1163	112	Positive Trend
51	51	1214	112	Positive Trend
52	52	1266	112	Positive Trend
53	53	1319	112	Positive Trend
54	54	1373	112	Positive Trend

idea has been used to construct some tests against trend. Here, three tests have been studied to determine their possible use for detection of significant movements away from neutral corridors.

Cox-Stuart Test

The Cox-Stuart test for trend, is a modification of the sign test. To use it, we pair one of the earlier observations with one of the later observations. When the later observations exceed the earlier observation, we replace the pair by a minus sign. When the earlier observation is greater than the later observation, we replace the pair by a plus sign. A preponderance of plus signs suggests a downward trend, and a preponderance of minus signs suggests an upward trend [Daniel, 1]. If positive and negative signs occur in equal number, no trend is present. The hypothesis set to be tested is one of the following:

H_0: There is no upward trend

H_1: There is an upward trend

or

H_0: There is no downward trend

H_1: There is a downward trend

Suppose the time series has a set of observations denoted by $X_1, X_2, \ldots, X_n$. Pairs are first formed as

$$(X_1, X_{1+c}), (X_2, X_{2+c}), \ldots, (X_{n-c}, X_n) \quad \text{where,}$$

$C = n/2$ when n is an even number, and $C = (n+1)/2$ when n is an odd number. For example, if $n = 6$, $X_1 = 2$, $X_2 = 3$, $X_3 = 5$, $X_4 = 8$, $X_5 = 9$, and $X_6 = 10$, then $C =$

6/2 = 3. The pairs in this case are (2,8), (4,10), (6,12). If n = 7, and we add the observation $X_7 = 12$ to the other six observations, then C = (7+1)/2 = 4. The pairs in this case are (2, 9), (4,10), (6,11). Note that the middle term, 8 is not used. This is always the case when n is an odd number. A plus sign replaces each pair (X_i, X_{i+c}) for which X_i is greater than for which X_{i+c} is greater than X_i [Daniel, 1]. Pairs leading to zero differences are omitted from the analysis. The number of pairs yielding to nonzero differences is equal to *m*.

The test statistic depends on the hypotheses being tested. The test statistic for the first hypotheses set is the number of plus signs, and the test statistic for the second set of hypotheses is the number of minus signs. The probabilities of observing the number of plus or minus signs is obtained from the binomial distribution. Table 4 lists the result of the Cox-Stuart test performed on the data shown in Figure 2.

Modified Cox-Stuart Test

A slight modification was made to the Cox-Stuart test to increase the sensitivity of the test, permitting the magnitudes of the differences to influence the test statistic. This method combines the principles of the Cox-Stuart test and the Wilcoxon signed rank test. The hypotheses sets used here, are the same as the hypotheses sets used for the Cox-Stuart test.

Similar to the Wilcoxon signed rank test, the absolute magnitude values of the differences between the elements in each pair are ranked according to relative magnitude. While ranking, signs of the differences are temporarily ignored and all differences are

Table 4. Results of the Cox-Stuart Test

Data pertains to ==> MARKET SECURITY 1

Initial Sample size = 54

Number of points in neutral corridor = 16

POINTS	+ SIGNS	- SIGNS	PROB./ZVAL	RECOMMENDATION
16	1	7	0.035	Positive Trend !
17	1	7	0.035	Positive Trend !
18	2	6	0.145	
19	2	6	0.145	
20	2	8	0.055	
21	2	8	0.055	
22	4	7	0.274	
23	4	7	0.274	
24	5	7	0.387	
25	5	7	0.387	
26	7	6	0.500	
27	7	6	0.500	
28	7	5	0.387	
29	7	5	0.387	
30	8	5	0.291	
31	8	5	0.291	
32	11	4	0.059	
33	11	4	0.059	
34	11	5	0.105	
35	11	5	0.105	
36	12	3	0.018	Negative Trend !
37	12	3	0.018	Negative Trend !
38	10	7	0.315	
39	10	7	0.315	
40	7	10	0.315	
41	7	10	0.315	
42	10	10	0.588	
43	10	10	0.588	
44	10	12	-0.405	
45	10	12	-0.405	
46	5	16	-2.379	Positive Trend !
47	5	16	-2.379	Positive Trend !
48	3	16	0.002	Positive Trend !
49	3	16	0.002	Positive Trend !
50	3	19	-3.390	Positive Trend !
51	3	19	-3.390	Positive Trend !
52	3	21	-3.654	Positive Trend !
53	3	21	-3.654	Positive Trend !
54	4	23	-3.637	Positive Trend !

treated as a single array of numbers. The sum of the ranks assigned to the absolute values of those differences whose original sign is plus, called positive ranks, should be approximately equal to the sum of the ranks of those absolute differences that are originally minus, called negative ranks. The distribution of the test statistic is the same as the Wilcoxon signed rank test. The author suggested this modification and tested it. Table 5 lists the results of the modified Cox-Stuart test performed on the data shown in Figure 2.

Kendall's test for trend

Here we arrange the data in the ascending order of their magnitude and rank them as $T_1, T_2, \ldots, T_n$. After ranking all observations, each rank is compared to the time order of that observation. Suppose it is believed that the observed data gradually increase over the period in consideration, the null hypothesis will be stated as "There is no trend in the data over the period of observation". The alternative hypothesis will be stated as "There is an upward trend in the data over the period of observation". The existence of such a trend would increase the probability of arrangements of the ranks $T_1, T_2, \ldots, T_n$, where large values of T_i, would occur later.

Under the alternatives large values of T_i will occur for large values of i and small values of T_i for small values of i, so that the differences $(T_i - i)^2$ will tend to be small. This means that the differences between the rank of the observations and the time of observation will be reduced. The distribution for the test statistic has been tabled for $n \leq$

Table 5. Results of the Modified Cox-Stuart Test

DATA PERTAINS TO ==> MARKET SECURITY 1

INITIAL SAMPLE SIZE = 54

NUMBER OF POINTS IN NEUTRAL CORRIDOR = 16

PERIODS	NONZERO DIFF..	SUM '+' RANKS	SUM '-' RANKS	RECOMMENDATION
17	8	1.5	34.5	Positive Trend
18	8	4.5	31.5	Positive Trend
19	8	4.5	31.5	Positive Trend
20	10	8.5	46.5	Positive Trend
21	10	8.5	46.5	Positive Trend
22	11	22	44	
23	11	22	44	
24	12	38	40	
25	12	38	40	
26	13	50	41	
27	13	50	41	
28	12	45.5	32.5	
29	12	45.5	32.5	
30	13	64	27	
31	13	64	27	
32	15	95.5	24.5	Negative Trend
33	15	95.5	24.5	Negative Trend
34	16	87.5	48.5	
35	16	87.5	48.5	
36	15	88.5	31.5	
37	15	88.5	31.5	
38	17	97.5	55.5	
39	17	97.5	55.5	
40	17	72	81	
41	17	72	81	
42	20	87	123	
43	20	87	123	
44	22	77.5	175.5	
45	22	77.5	175.5	
46	21	40.5	190.5	Positive trend
47	21	40.5	190.5	Positive trend
48	19	20.5	169.5	Positive trend
49	19	20.5	169.5	Positive trend
50	22	25.5	227.5	Positive trend
51	22	25.5	227.5	Positive trend
52	24	20	280	Positive trend
53	24	20	280	Positive trend
54	27	27	351	Positive trend

Table 6. Results of the Kendall's Test

DATA PERTAINS TO ==> MARKET SECURITY 1

Initial Sample size = 54

PERIODS	TEST STAT.	RECOMMENDATION
17	392.5	Positive trend !
18	442.5	Positive trend !
19	472	Positive trend !
20	737.5	Positive trend !
21	1032	
22	1494	
23	1979.5	
24	2410	
25	2765.5	
26	3043.5	
27	3341.5	
28	3660	
29	3860	
30	4462	
31	4853.5	
32	5268.5	
33	5346.5	
34	5621	
35	6647.5	
36	7639	
37	8429	
38	8429	
39	8429	
40	8435	
41	8445	Positive trend !
42	8459	Positive trend !
43	8489	Positive trend !
44	8529.5	Positive trend !
45	8615	Positive trend !
46	8829.5	Positive trend !
47	8879	Positive trend !
48	8922.5	Positive trend !
49	8922.5	Positive trend !
50	8922.5	Positive trend !
51	8922.5	Positive trend !
52	8922.5	Positive trend !
53	8928.5	Positive trend !
54	8940.5	Positive trend !

11 [Harter, 5]. For sufficiently large n, the distribution is approximately normal [Lehman, 6]. Table 6 lists the results of the test performed on the data shown in Figure 2.

Results

From Table 2, it can be seen that the ordinary sign test gave a signal indicating a positive trend from the seventeenth period. The data illustrated in Figure 2, lies within the neutral corridor until the fiftieth period. Comparing the signal and the plot of the data it was concluded that the signal for positive trend is false. Table 3, results of Wilcoxon signed rank test, also gave a signal for positive trend from seventeenth period. This is also a false signal because the plot shows that the data lie within the neutral corridor until period 50. Hence we know that both tests for location gave false signals for the data set, corresponding to market security 1.

Results of Cox-Stuart test (Table 4) gave signals for positive trends at the sixteenth and seventeenth time periods and also from the forty-sixth time period. There were also signals for negative trends at the thirty-sixth and thirty-seventh time periods. Data shown in Figure 1 lie within the neutral corridor until time period 50. This proves that the first signal for positive trend and the signal for negative trend are false. Table 5, results of the modified Cox-Stuart test, also gave two signals for positive trends and a signal for negative trend between these positive signals. Comparing with the plot of the data and using the same logic, it can be seen that the signals for the first positive trend and the negative trend are false.

Results of Kendall's test, (Table 5), gave signals of positive trends from the seventeenth to the twentieth periods. A signal for positive trend was also given starting from the forty-first period. Comparing these signals with the plot of the data (Figure 2) it was concluded that the signal for the first positive trend was false.

All nonparametirc tests discussed above were tested on more than 15 sets of data (neutral corridors), where erratic signals were received on 12 sets of data. Appendices E, F, G, H and I, show the results of the nonparametric tests performed on selected sets of data.

Conclusion

All nonparametric tests gave erratic signals of positive and negative trends when there were none. This ratio of false signals to correct signals was very high (12 to 3). The mixture of positive and negative signals and improper timing of the correct signals (positive trend for data in Figure 2) led to the failure of these tests. Therefore, the author concludes that these nonparametric tests should not be used to detect significant movements away from neutral corridors.

CHAPTER 6

THE NEW EMPIRICAL METHOD

Failure of the cusum charts and all nonparametric tests led to a change in thinking. Traditional methods were not found suitable, but the concept of hypotheses testing was considered important and promising. The concept of hypotheses testing has been used to venture into a pristine zone and an empirical method has been developed to identify a quantitative approach to detect significant breakout movements away from neutral corridors.

Hypotheses used in this test are similar to the hypotheses stated for the cusum control chart procedure. The hypotheses are

$$H_0: \mu = \mu_0$$

$$H_1: \mu = \mu_0 + \Delta_1,$$

and $$H_2: \mu = \mu_0 - \Delta_2 \text{ where,}$$

μ_0 represents the center line of the neutral corridor; $\mu_0 + \Delta_1$ represents the upper boundary of the corridor; $\mu_0 - \Delta_2$ represents the lower boundary of the corridor.

The magnitudes of distances between each data point and the hypothetical center line of the neutral corridor were monitored. These magnitudes were calculated separately for points above and points below the center line. The sum of the magnitudes of distances from the center line indicates the cumulative strength of the time series in each direction.

The cumulative sum might also be considered as an *index of momentum* in that particular direction. Steps to calculate the momentum index and a corresponding threshold value, similar to a critical value, are listed below:

- Identify neutral corridor and values of upper and lower boundaries using the method described in Chapter 1.
- Count the number of periods that elapsed before the upper and lower boundaries were formed. This count will henceforth be called the "number of points in the neutral corridor." For example, points A and B form the upper and lower boundaries in Figure 2, and the number of points in the neutral corridor is sixteen.
- Compute the half width of the neutral corridor. The half width of the corridor in Figure 1 is calculated as

$$HW = (\text{difference between point A and point B}) / 2$$

- Classify the data, closing prices of the market security, into two groups. The first group consists of points above the center line and the other consists of points below. If an observation lies on the center line that observation is ignored. Classification of the data in Figure 2 until the seventeenth time period gave 13 observations above the center line (first group) and 4 observations below center line (second group).
- Calculate the differences between each observation and the value of the center line.

- Compute the ratio between the differences and the half width of the corridor. The ratio indicates the measure of how far away an observation is from the center line. These differences are termed a_i's. Let 0.1875 be the difference between the first observation and the center line. Note that the first observation is below the center line and hence belongs to the second group. The ratio for the first observation is calculated as $P_1 = a_i / HW$.
- Calculate the momentum index for each group of points using the formula

$$\sum a_i * P_i^{1.5}$$

The value of *1.5* for the exponential power was determined empirically after tests on several neutral corridors.

- Calculate threshold value using the formula

$$HW * n^{1.5}$$

where, n = number of points in the group (above or below center line). The concept of threshold value was derived based on the assumption that the momentum index attains a maximum, when all points in a group lie on the boundary, given that no point has crossed the boundary. Suppose the momentum index is being calculated for the group of points above the center line. Here, the maximum possible value of the momentum index will be attained when all points lie on the upper boundary.

- Compute the ratio of the momentum index and the threshold value for that group of observations.
- It can be concluded that the group of points have gained enough momentum to cross the corresponding boundary, when the ratio is greater than 1.

Confirmation using Volume of Transaction

The above method considers only the momentum attained by the closing prices. Studies show a definite relation between the price movements and the volume of transaction. Volume shows the intensity of changes in human attitudes and fears. Volume moves up when prices move up or down indicating interest from the major buyers and sellers. For example, the level of enthusiasm implied by a price rise on low volume is not nearly as strong as that implied by a similar price advance accompanied by very high volume [Pring, 11]. The concept of volume of price relation is used here to obtain a confirmation.

Information on the volume of transactions is available only for securities of individual companies. Therefore, the confirmation of high volume transactions can be obtained only for such securities. For example in Figure 2 it was observed that sixteen observations were needed to form the boundaries of the corridor (represented by points A and B). The median volume is identified from the set of the first sixteen volumes of transactions. A value of 150 percent of this median volume has been considered a "substantial increase in volume" and the value of "150 percent of the median volume"

was also empirically determined after analyzing several market securities. The median volume for the data shown in Figure 2 is 671,950 units.

Another aspect of price-volume relationship is also helpful in confirming significant breakout movements. Volume often leads the price movement and serves as a warning for imminent price movements. If there is a substantial increase in volume (150 % of median volume), one or two periods before a signal is received from the price momentum, such increases are also considered valid confirmations of significant breakout movements.

Both price momentum and volume increase were used to detect significant breakout movements away from neutral corridors. The price momentum was used to detect significant movements when information on volumes of transaction was unavailable for securities like market indices and mutual funds.

Results

Table 7 shows the results of the test performed on the corridor in Figure 2. The data shown in Figure 2 correspond to an individual company. Therefore, information on volume was available and used to obtain a confirmation. A signal for positive trend was given starting from time period 51. Observation of the plot of data (Figure 2) shows that the time series started the significant breakout movement from the forty-eighth period of observation. From the comparison it was concluded that the empirical method gave a correct and timely signal.

Twenty one corridors obtained from historical market data were studied. Nineteen tests gave signals in the correct direction and at the right time. The accuracy of these tests was verified by comparing the signals to actual movements of the time series.

Table 7: Results of New Empirical Method on Market Security 1

Points in neutral corridor ==> 16

Upper boundary => 44.625 Lower boundary => 42.5

NUMBER OF POINTS	TEST STATISTIC RATIO	SIGNAL
51	1.476549	Positive trend !
52	2.271212	Positive trend !
53	2.647483	Positive trend !
54	2.970027	Positive trend !

Conclusions

The new empirical method gave nineteen correct signals out of the 21 tests, placing the accuracy of the method at 90 percent. Although, a 90 percent accuracy is considered high, any new testing method can be accepted for use, only if it performs consistently over a wide range of conditions. To verify the consistency in performance, tests are being conducted with real-time data from the market. Neutral corridors that are currently being analyzed include market securities that do not contain information on volume of transaction.

CHAPTER 7

RESULTS AND DISCUSSION

Three techniques were investigated for possible use in the detection of significant breakout movements away from neutral corridors. They were cusum control charts, nonparametric tests for location and trend, and a new empirical method developed by the author. An accurate result was defined as the availability of a signal indicting a positive or negative trend at the right time. Comparison and a brief discussion of the results are presented below.

Discussion on False signals

Incorrect signals were of two types. The first type of false signal was the indication of a positive or negative trend when there was none. The other false signal was the indication of a positive or negative trend much before or after the actual movement occurred.

Traditional Cusum Charts

Traditional cusum charts also gave similar false signals. Appendix C shows selected plots of traditional cusum charts constructed on data corresponding to market securities. Charts plotted on data from market securities 3 and 5 gave signals of positive

trends very early compared to the actual movement of the time series. Thus the two signals were considered false. A plot of the data from market security 6 gave no signals. However, it can be seen from the plot of the actual data (Figure 7, Appendix A) that the times series attained a significant movement starting from period 97. Although traditional cusum charts gave correct and timely signals for market securities 1, 2, 4 and 7, the ratio of false signals to correct signals was quite high. Ten out of the 15 traditional cusum charts gave false signals. Hence, traditional cusum charts cannot be used for detection of significant breakout movements.

Standardized Cusum charts

Standardized cusum charts constructed for market securities 2 and 7 (shown in Appendix D) gave accurate and timely signals. However most of the standardized cusum charts shown in Appendix D and the chart shown in Chapter 3, gave out of control signals indicating positive or negative trends. These false signals were often received much before the time series actually moved in that direction. However, the direction of movement indicated by these standardized cusum charts was correct, the time of movement indicated did not match with the actual time of movement. Plots of neutral corridors, not shown here, twelve out of fifteen, also gave erratic signals. Therefore, the author concluded that standardized cusum charts cannot be used to detect significant breakout movements away from neutral corridors.

Ordinary Sign Test

Appendix E lists selected results of sign tests conducted on market securities. The sign test often gave signals of significant movements much earlier than actual movements. Such false signals were encountered in data corresponding to market securities 1, 2, 3, 4, 5, and 6. The test performed on data from market security 7 gave the only correct and timely signal, leading to a very low accuracy. More than twelve out of the fifteen tests gave false signals. Hence, the author concluded that the ordinary sign test can not be used for detection of significant movements away from neutral corridors.

Wilcoxon Signed Rank Test

Wilcoxon signed rank tests also gave false signals in many instances. Appendix F lists selected results of tests performed on market securities. From the results we can see that signals of significant movements were given before the actual movements of the time series. These results are similar to the results of ordinary sign tests. Therefore, the possibility of using Wilcoxon signed rank test was also ruled out.

Cox-Stuart Test

Appendix G shows selected results of the Cox-Stuart tests performed on market securities. Positive and negative signals were received within the period of analysis for data corresponding to market securities 1 and 2. Results on market securities 3, 4, 5, and 6 gave signals of significant movement before the actual movement of times series. Thus, the accuracy of the Cox-Stuart test also fell below expectations which led to rejection.

Modified Cox-Stuart Test

Appendix H lists selected results of the modified Cox-Stuart tests. Results of the tests were very similar to the results obtained during Cox-Stuart tests. The signal from tests on market security 7 was the only correct signal. Hence, this test was also rejected.

Kendall's Test

Appendix I lists selected results of the Kendall's tests. Results on market security 7 was a correct and timely signal. The movement signals on all other market securities were either very early or were a mixture of positive and negative trends leading to a very low accuracy. Therefore, the Kendall's test cannot be used to detect significant breakout movements away from neutral corridors.

Results of the New Empirical Method

Twenty-one neutral corridors were analyzed using the new empirical method. Nineteen of them gave accurate and timely signals. The neutral corridors were formed from historical data corresponding to market securities. Data that were tested by cusum charts and nonparametric tests were included in the twenty-one tests to facilitate comparison of the techniques.

Appendix J shows selected results of the new empirical method. Results of tests on market security 6 gave signals of positive trend before a positive trend actually started. Tests on all other market securities shown in Appendix A gave accurate and timely

signals. The accuracy of the new empirical method can be computed as 90 percent (19/21), and therefore was concluded to be the best method.

Conclusions

Acceptance of any method depends on the robustness of the method. Robustness is defined as the ability to consistently perform over a variety of situations. Here, the consistency has to be tested over different types of time series. Tests are currently being conducted with real-time data obtained from market indices and mutual funds. Note, that these data sets do not contain information on volume of transactions. In addition to these sets of data, more neutral corridors formed for market securities of individual companies are also being analyzed. Results from the ongoing tests will help to confirm the accuracy of results derived from historical data.

Although the accuracy has been determined as 90 percent, the results depend largely on proper identification of neutral corridors. Improper identification of the upper and lower boundaries could result in inflated or deflated boundary values. The inflation or deflation of the boundary values will affect the sensitivity of the empirical method. Thus proper identification of neutral corridors is imperative for accuracy.

As a conclusion to this research, the author wants the reader to understand and assimilate the following quote from Pring, a leading market analyst [Pring, 11].

"The continual search for the "holy grail" or a perfect indicator, will undoubtedly continue, but it is unlikely that such an indicator will ever be developed. Even if it were, news of its discovery would soon be disseminated and the technique will gradually be discounted."

APPENDICES

APPENDIX A

PLOTS OF NEUTRAL CORRIDORS

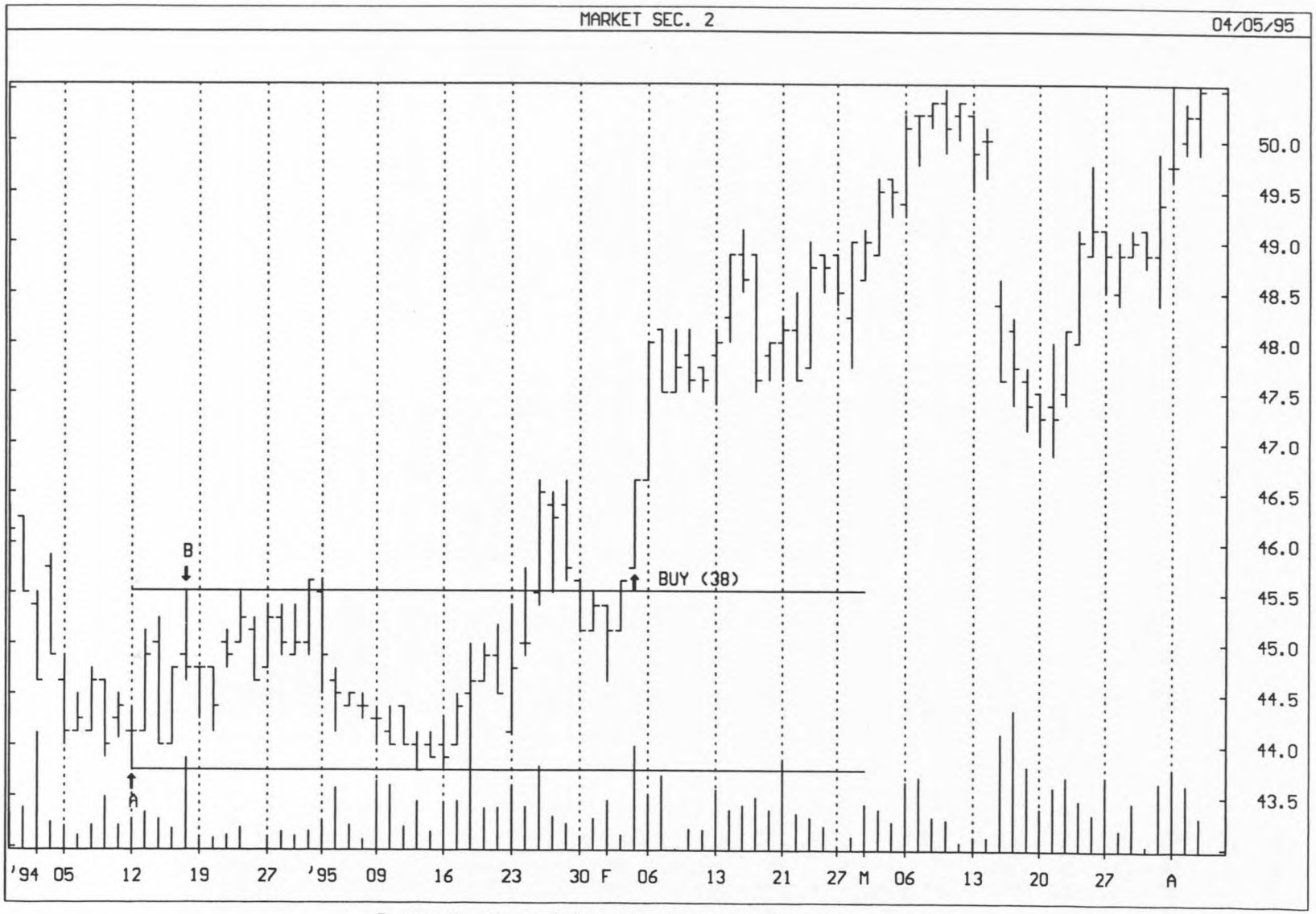


Figure 5. Neutral Corridor formed by Market Security 2

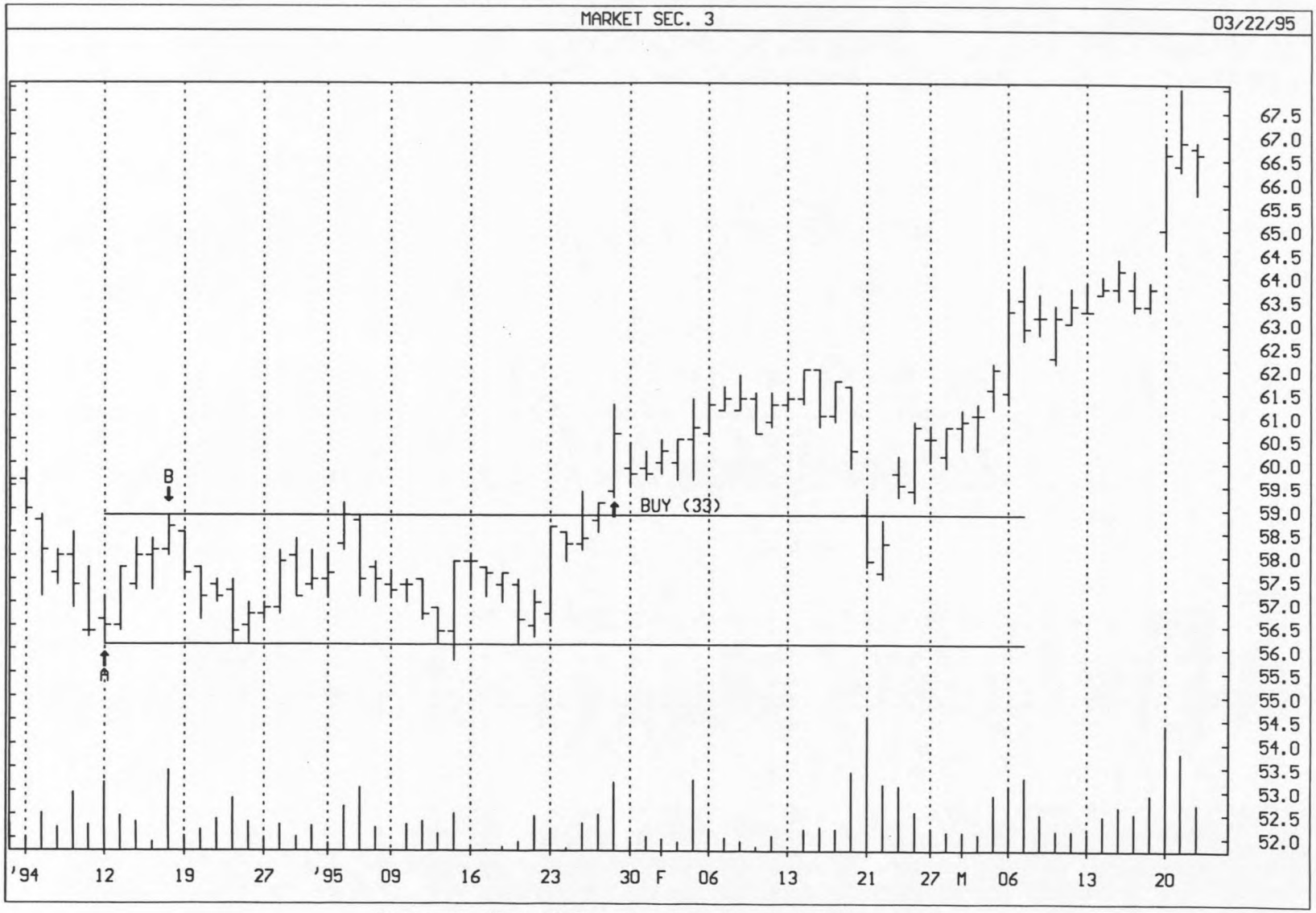


Figure 6. Neutral Corridor formed by Market Security 3

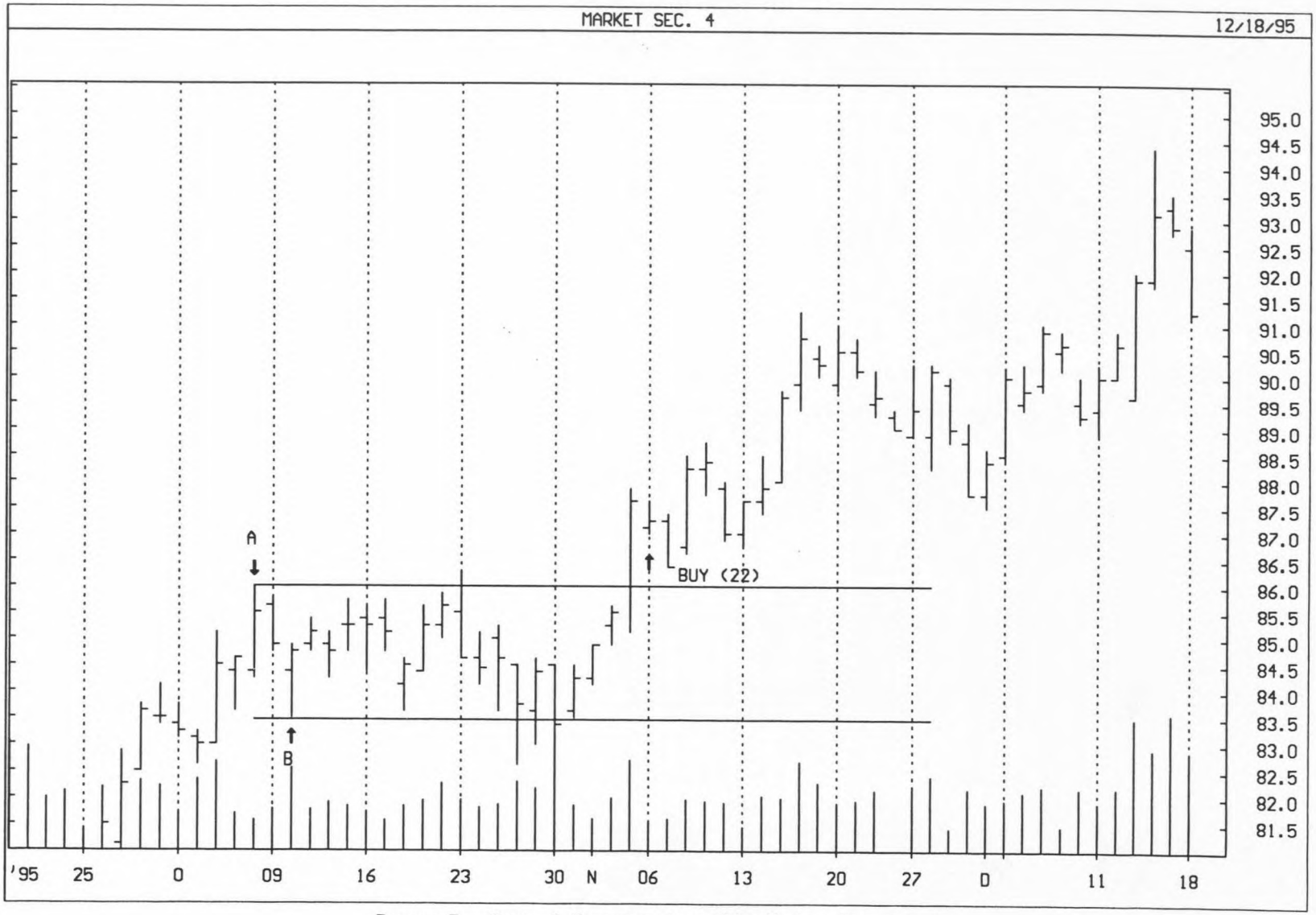


Figure 7. Neutral Corridor formed by Market Security 4

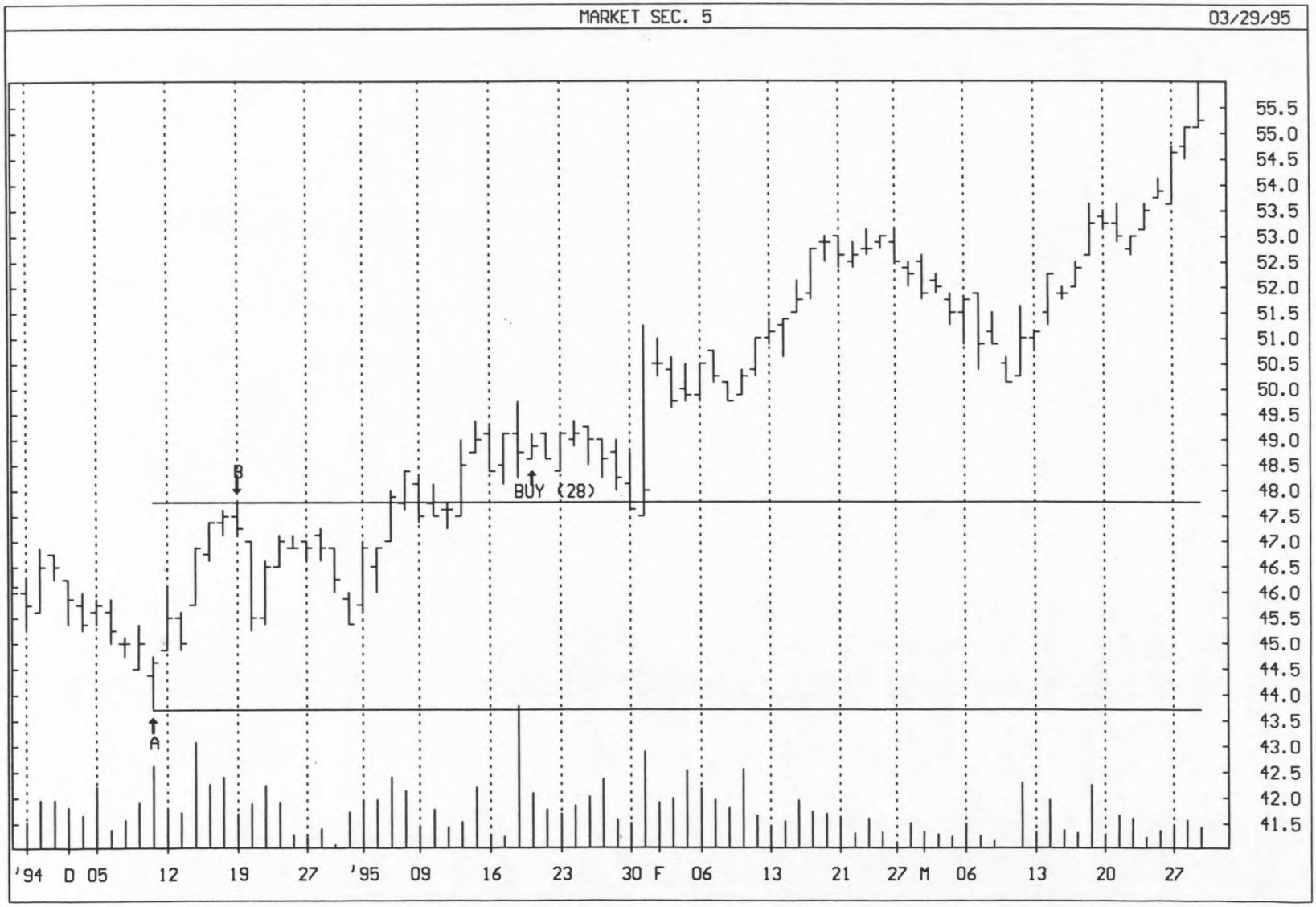


Figure 8. Neutral Corridor formed by Market Security 5

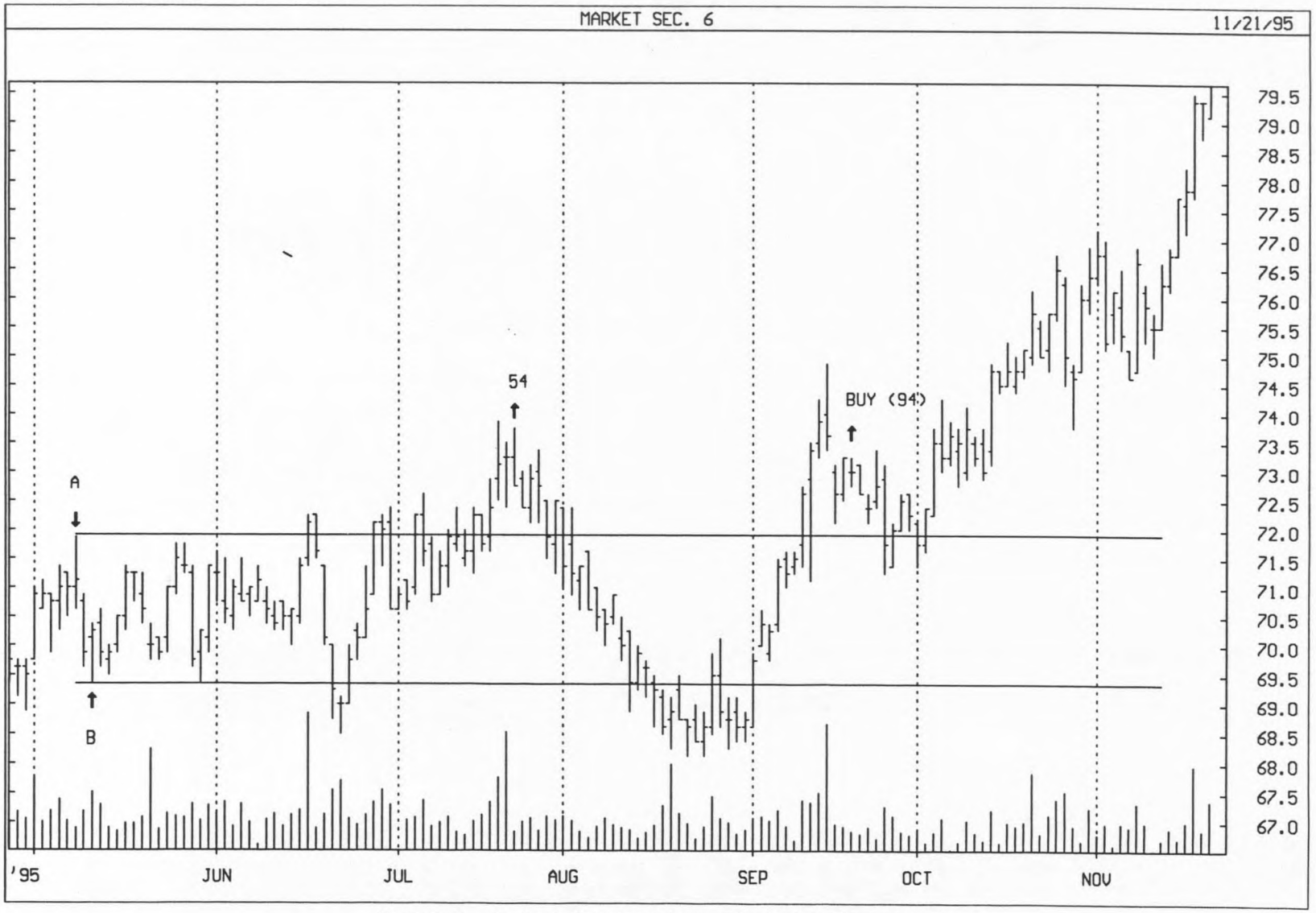


Figure 9. Neutral Corridor formed by Market Security 6



Figure 10. Neutral Corridor formed by Market Security 7

APPENDIX B

RESULTS OF NORMALITY TESTS

Table 8. Results of Normality Tests

Market Security	No. of Observations	P-value
1	37	0.118677
2	37	0.199360
3	32	0.512036
4	20	0.943950 **
5	41	0.261792
6	90	0.647873
7	20	0.802360 **

Note:

** Indicates insufficient degrees of freedom for Chi-Square test.

K-S test was performed.

APPENDIX C

TRADITIONAL CUSUM CHARTS

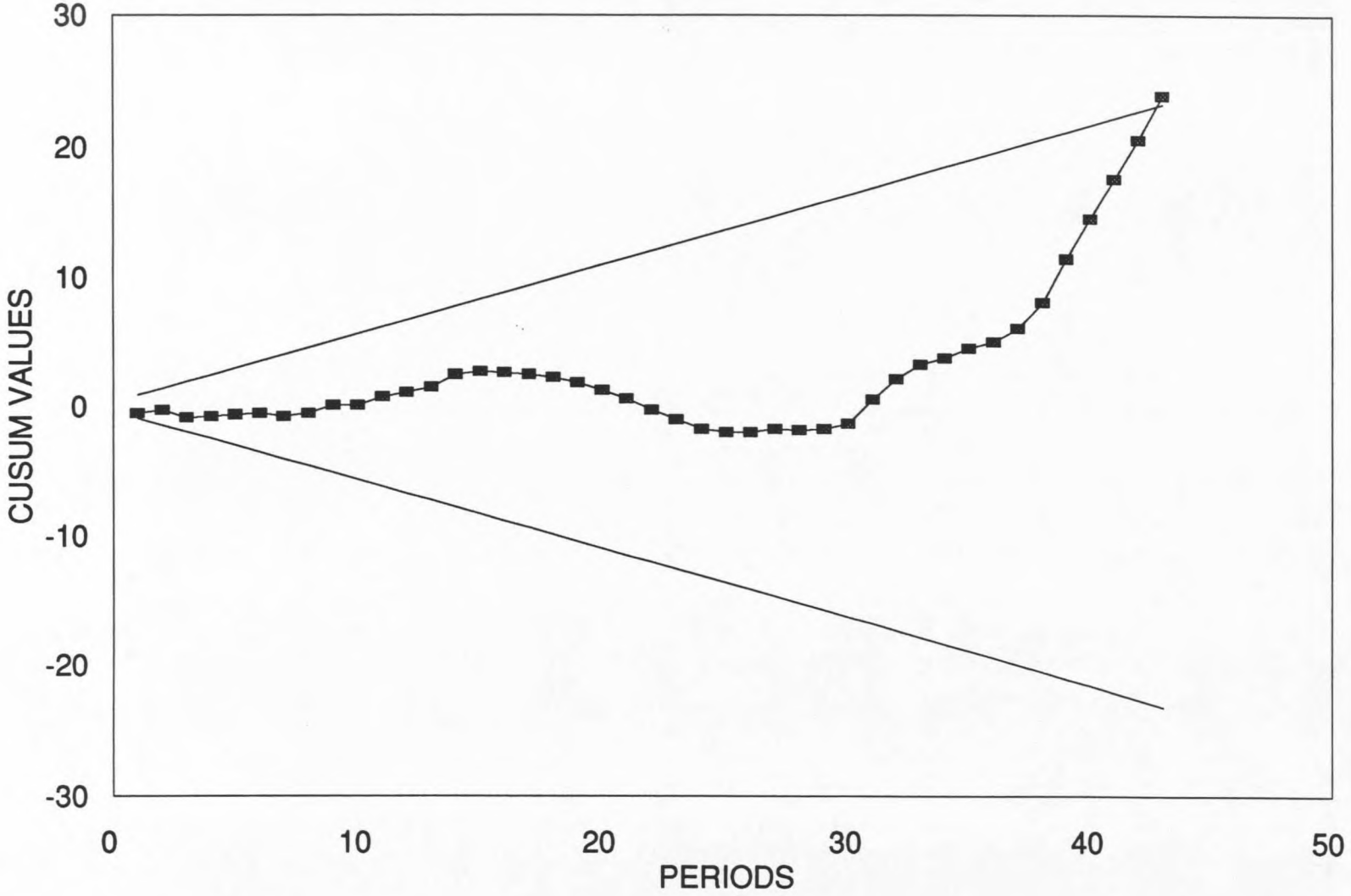


Figure 11. Traditional Cusum Chart for Market Security 2

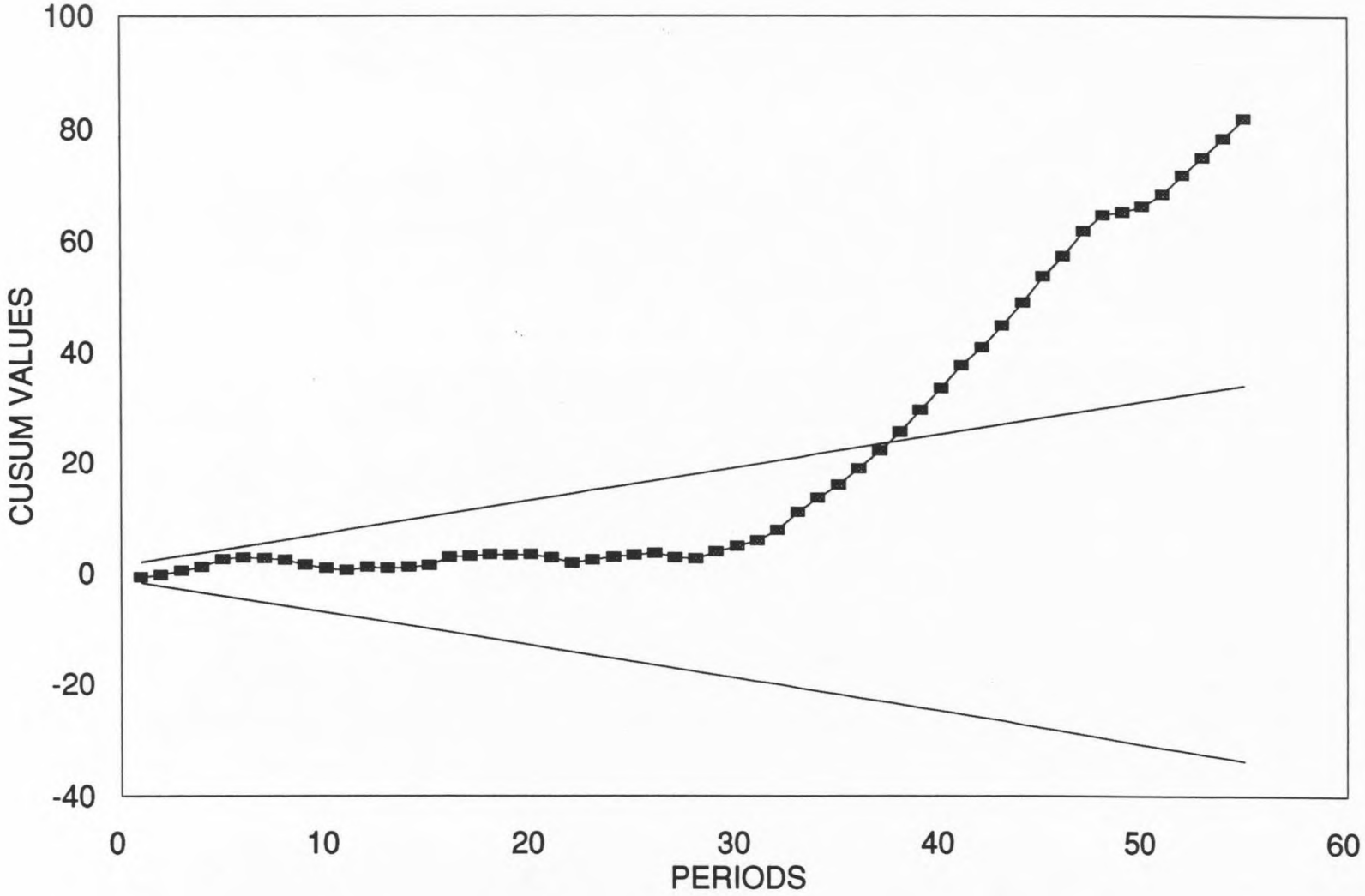


Figure 12. Traditional Cusum Chart for Market Security 3

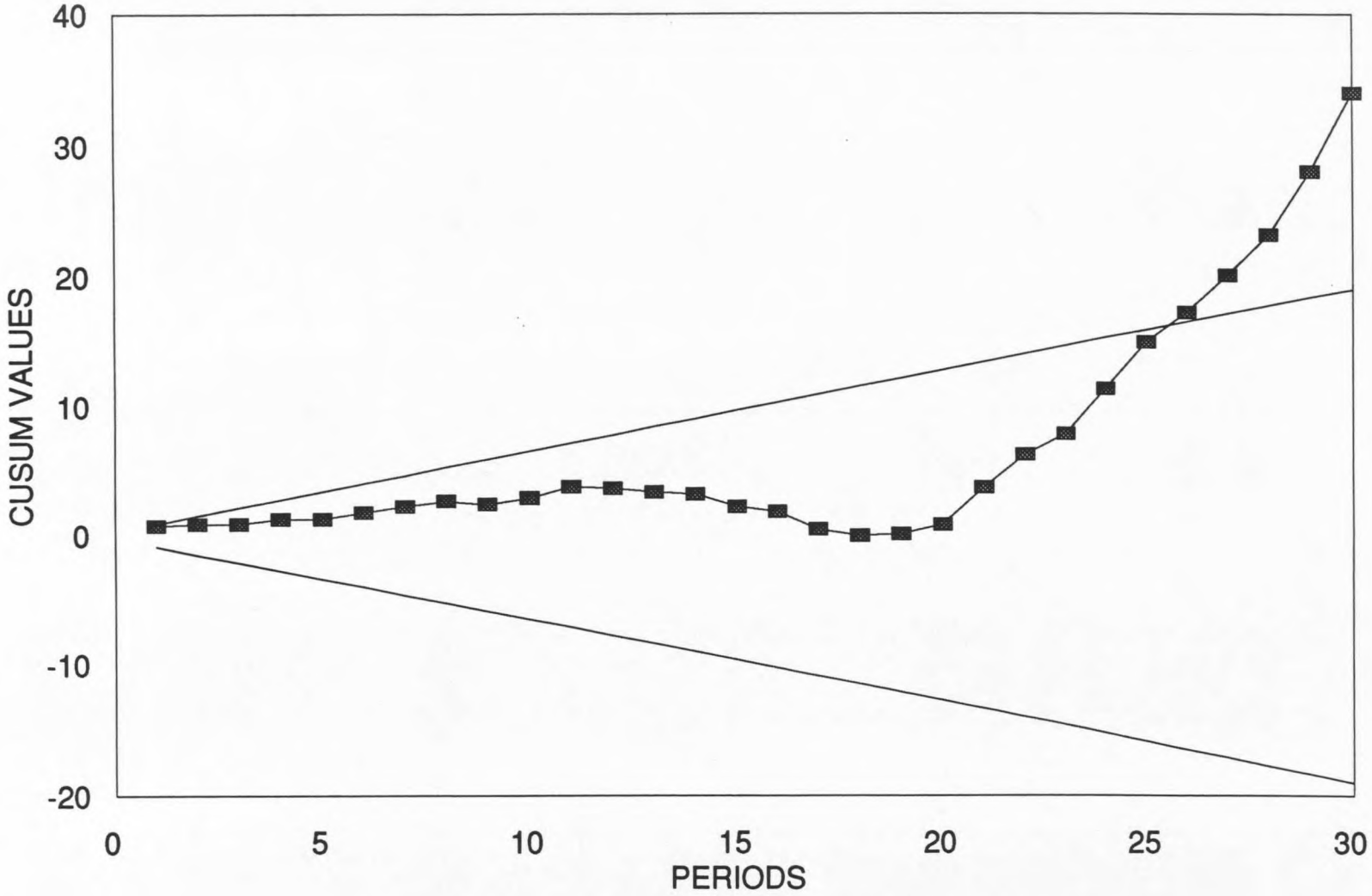


Figure 13. Traditional Cusum Chart for Market Security 4

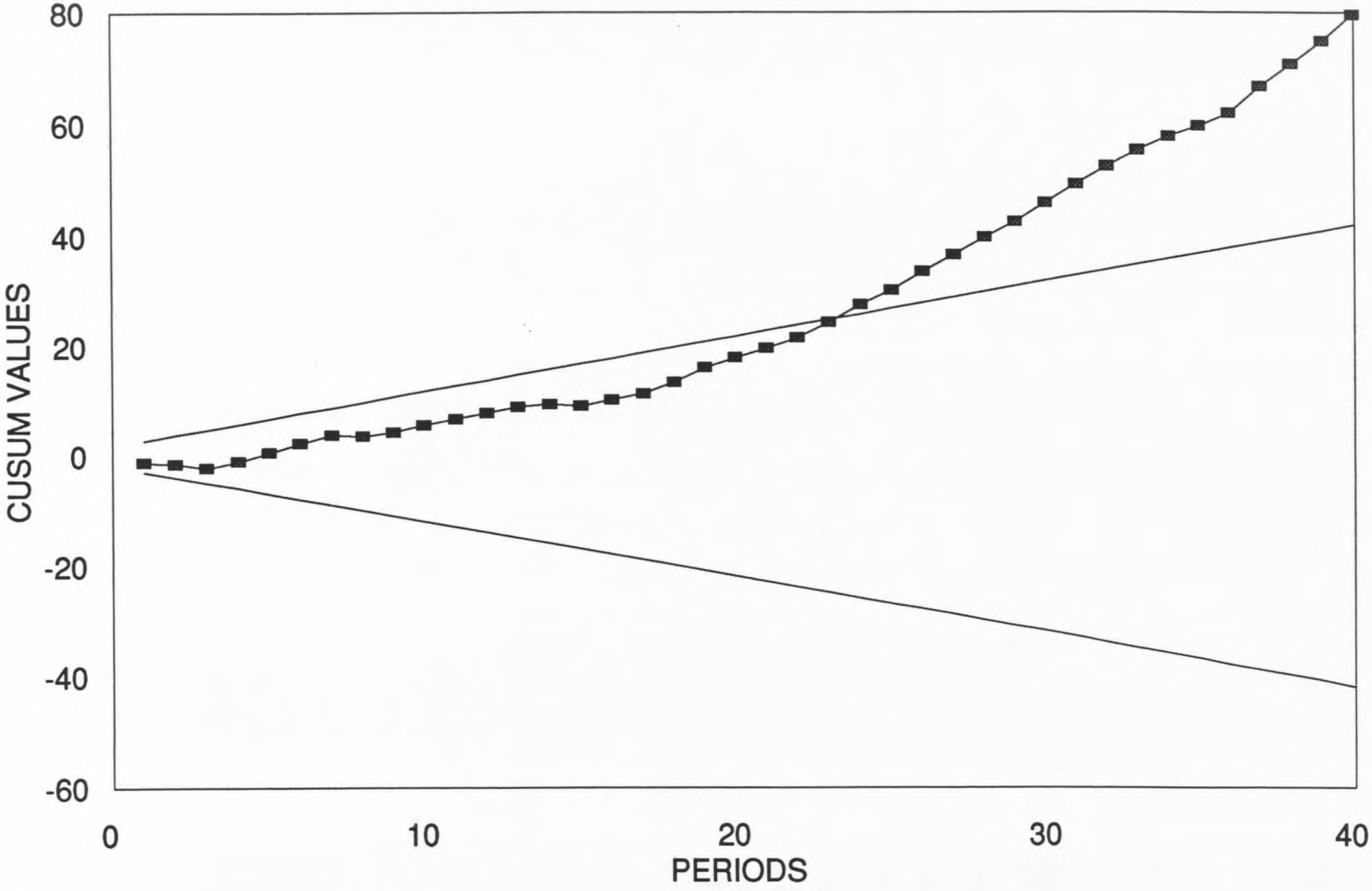


Figure 14. Traditional Cusum Chart for Market Security 5

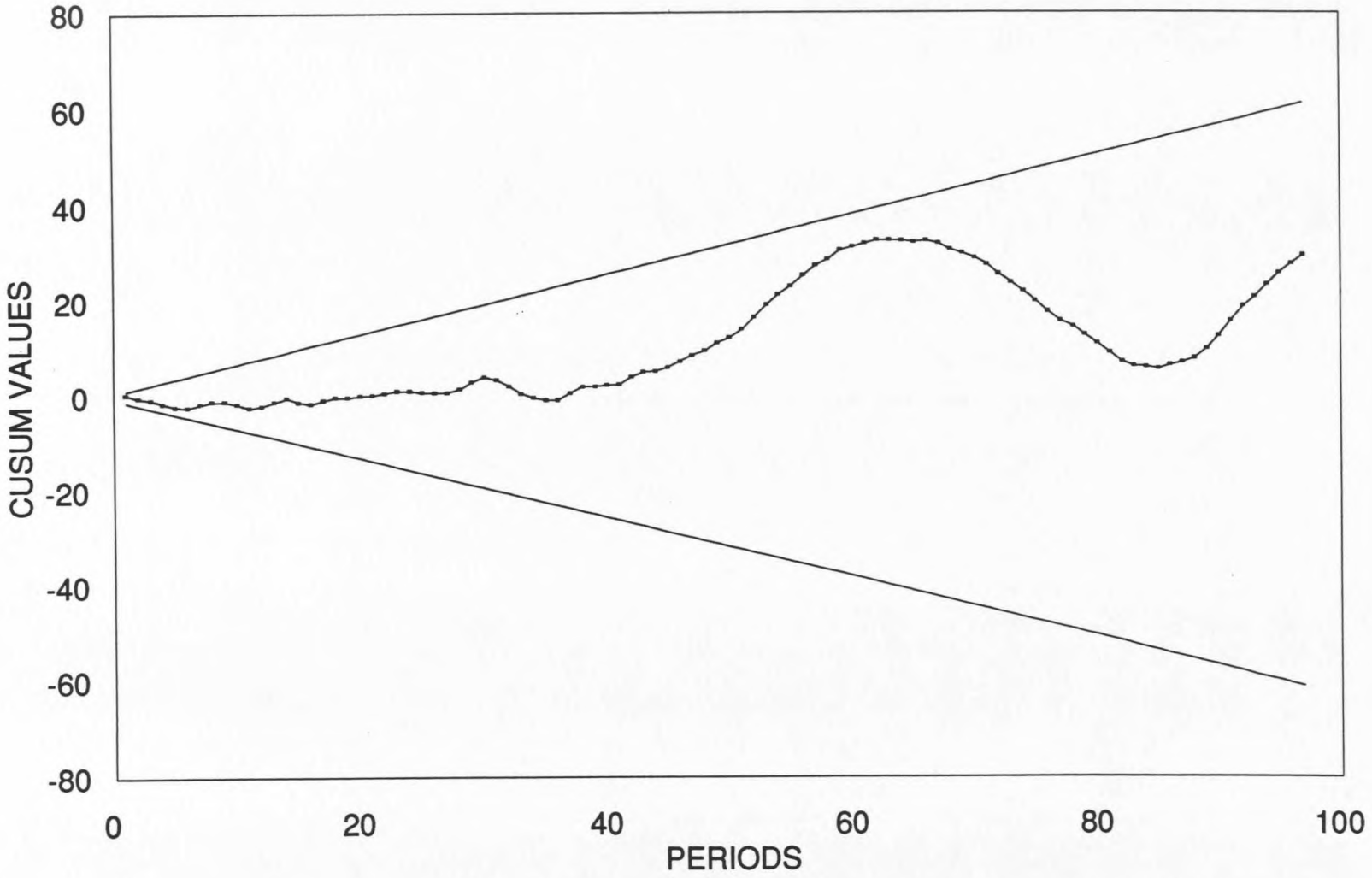


Figure 15. Traditional Cusum Chart for Market Security 6

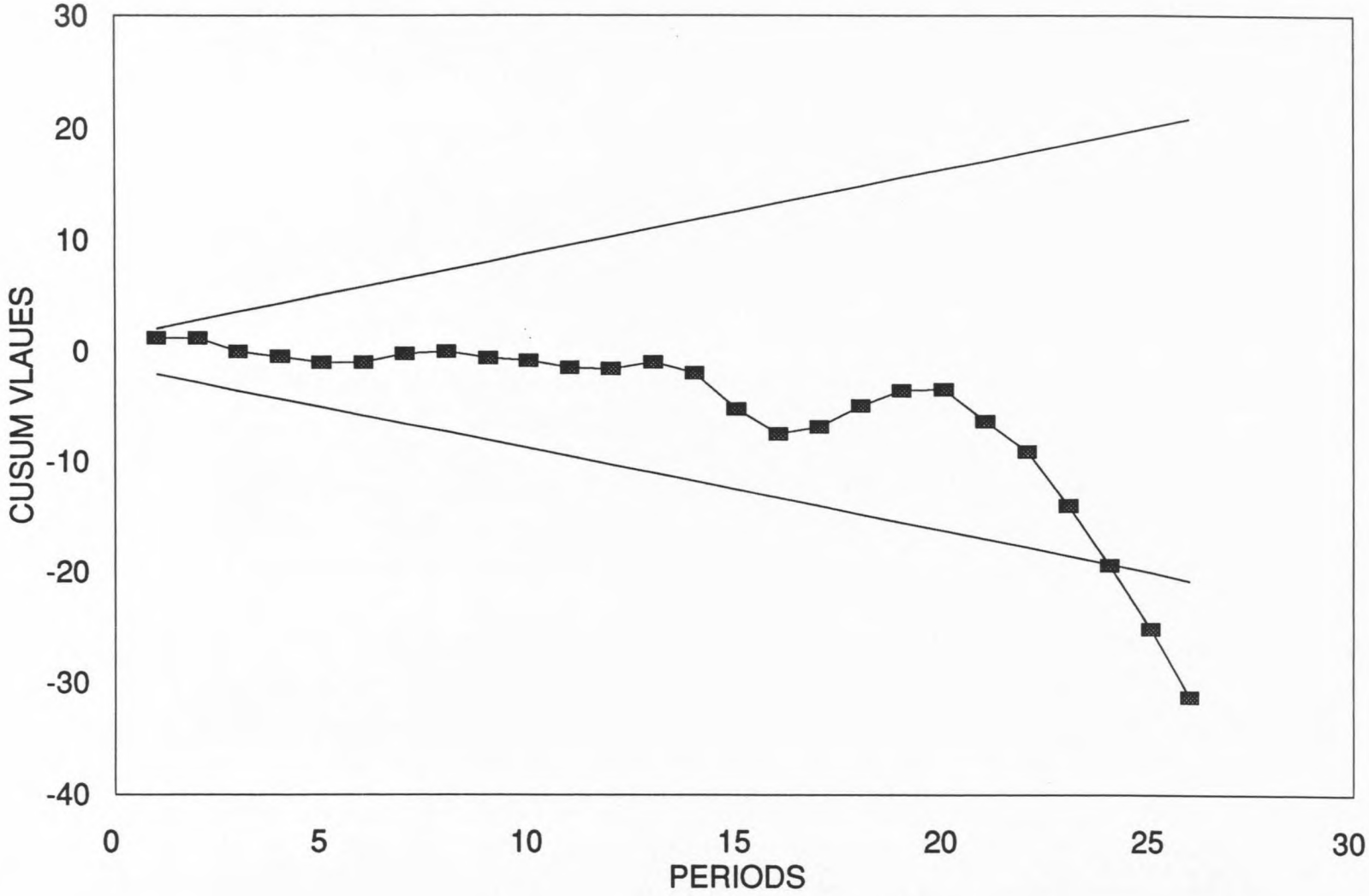


Figure 16. Traditional Cusum Chart for Market Security 7

APPENDIX D

STANDARDIZED CUSUM CHARTS

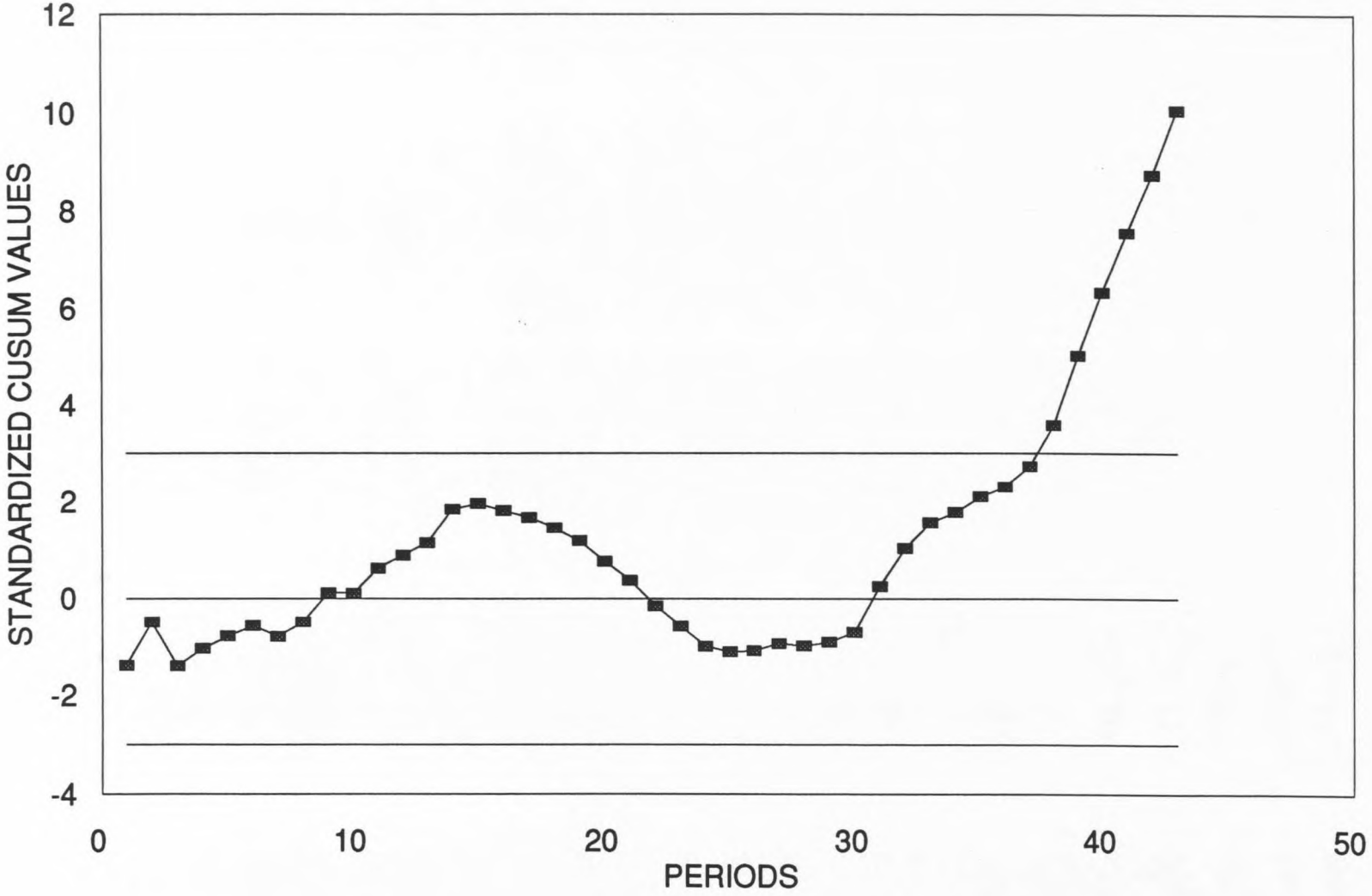


Figure 17. Standardized Cusum Chart for Market Security 2

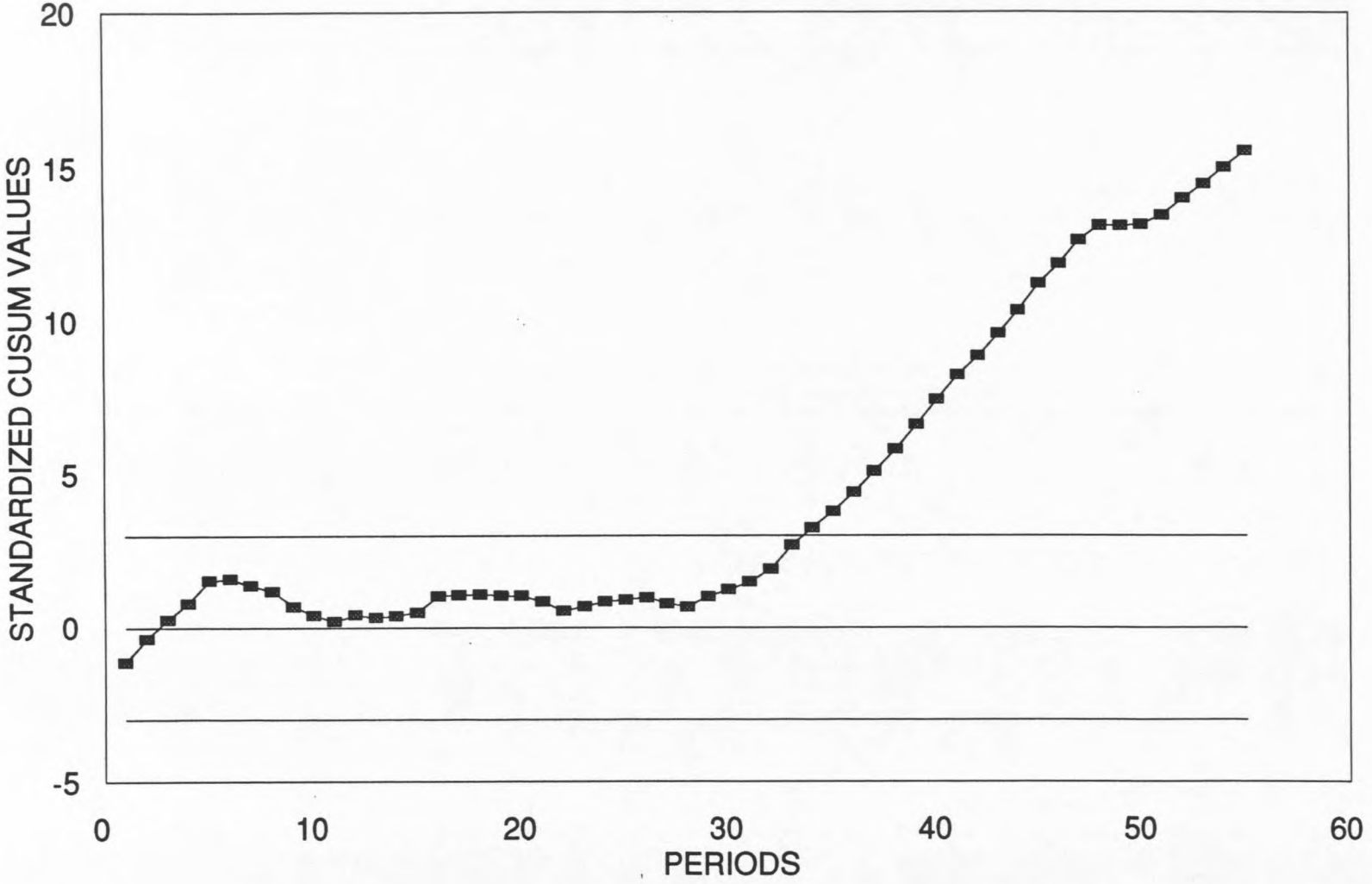


Figure 18. Standardized Cusum Chart for Market Security 3

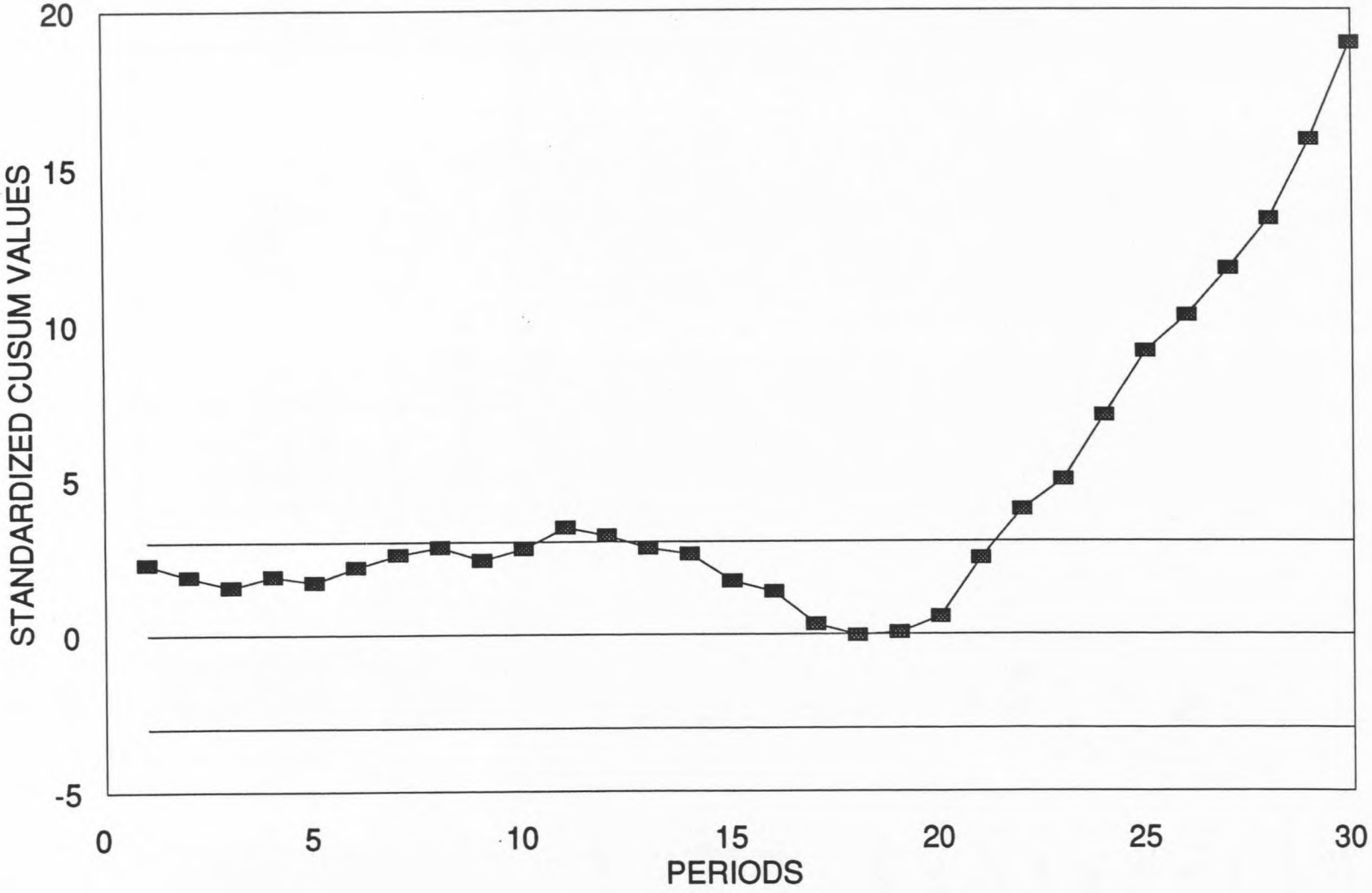


Figure 19. Standardized Cusum Chart for Market Security 4

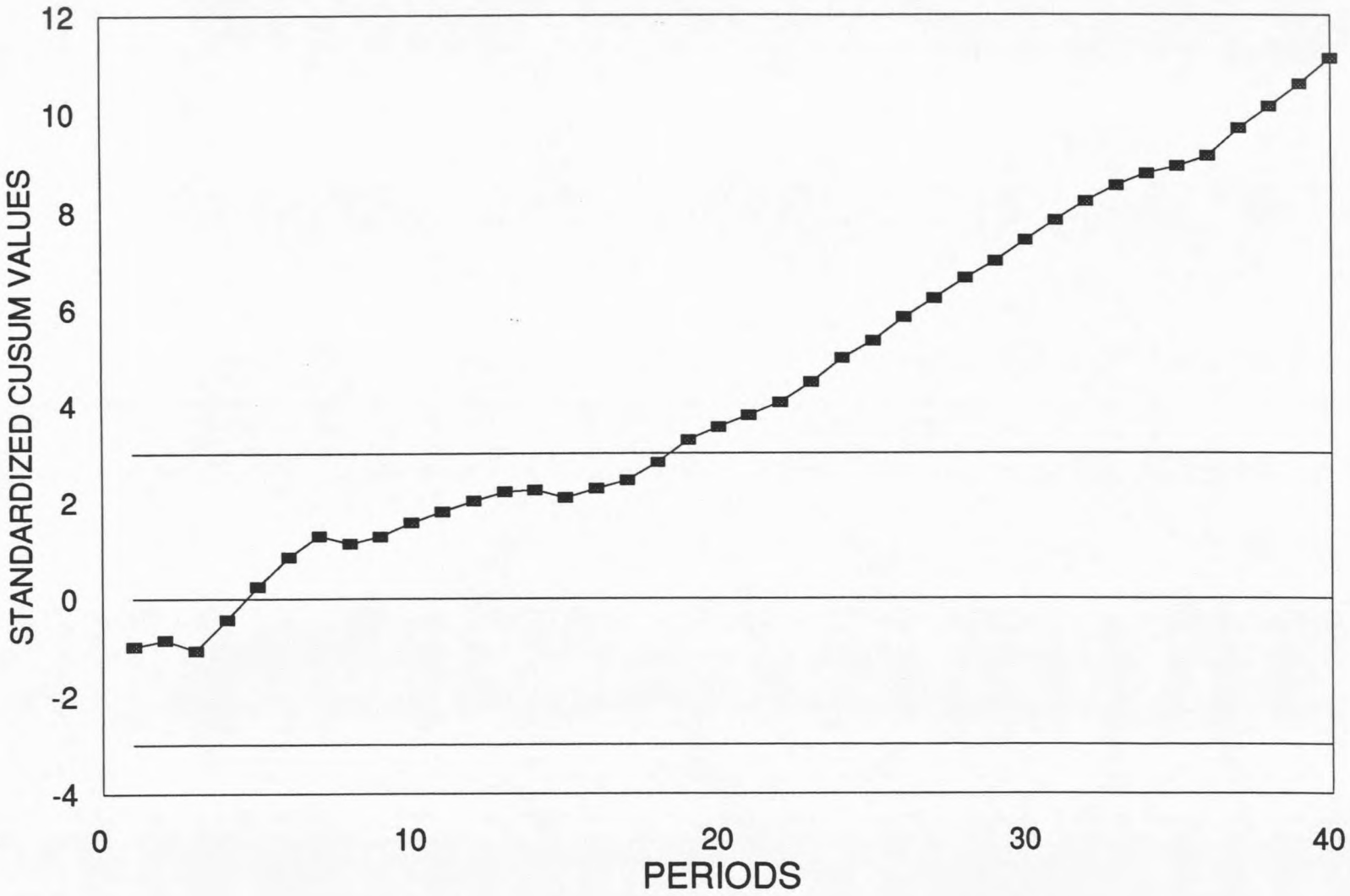


Figure 20. Standardized Cusum Chart for Market Security 5

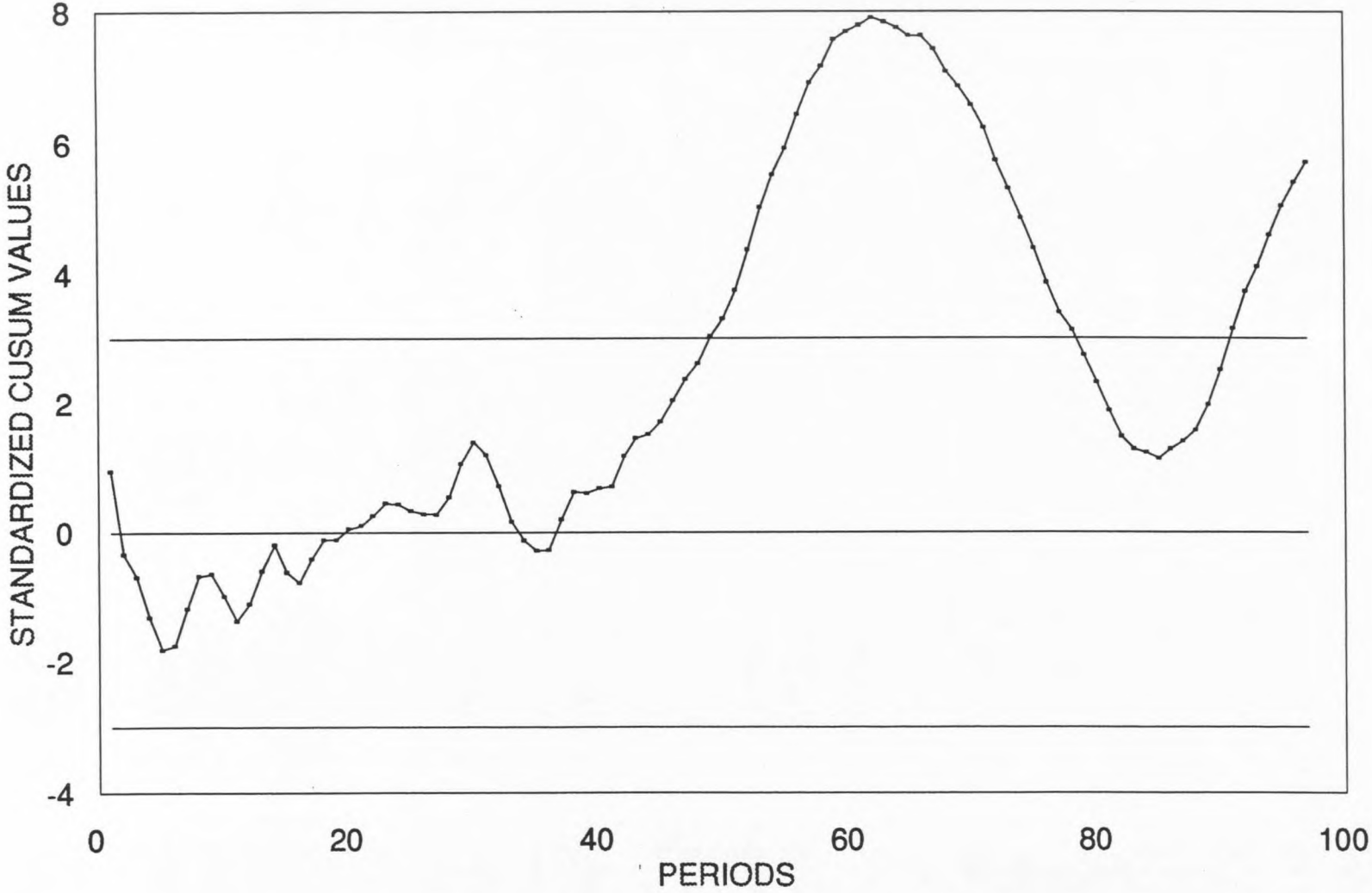


Figure 21. Standardized Cusum Chart for Market Security 6

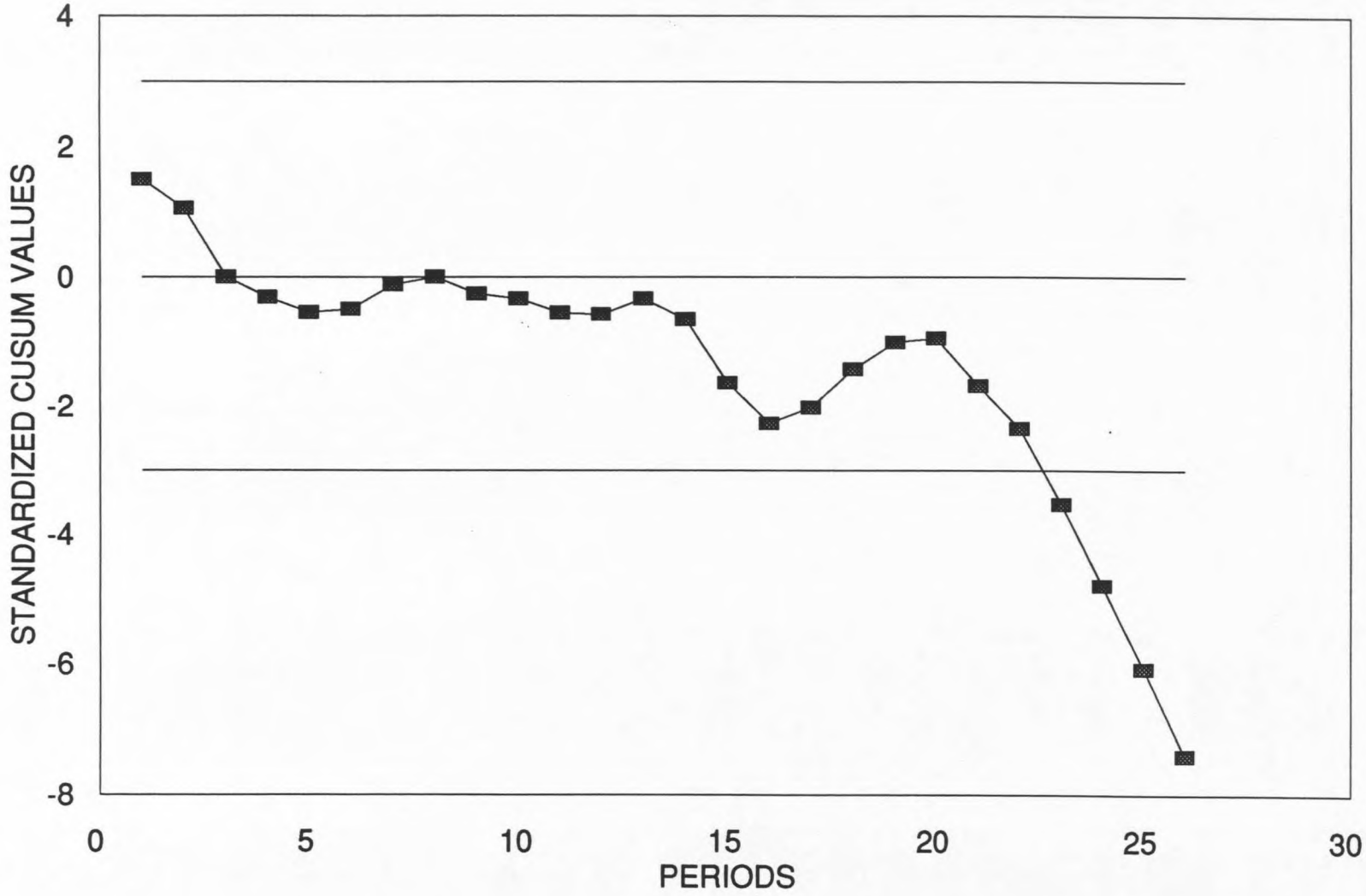


Figure 22. Standardized Cusum Chart for Market Security 7

APPENDIX E

RESULTS OF ORDINARY SIGN TESTS

Table 9. RESULTS OF ORDINARY SIGN TEST ON MARKET SECURITY 2

Points in neutral corridor ==> 5

Upper boundary => 45.5 Lower boundary => 43.75

TABULATION OF RESULTS

TOTAL POINTS	NON-ZERO POINTS	POINTS ABOVE	POINTS BELOW	PROB./ ZVAL	RECOMMENDATION
6	6	4	2	0.8906	
7	7	4	3	0.7734	
8	8	5	3	0.8555	
9	9	6	3	0.9102	
10	9	6	3	0.9102	
11	10	7	3	0.9453	
12	11	8	3	0.9673	POSITIVE TREND !
13	12	9	3	0.9807	POSITIVE TREND !
14	13	10	3	0.9888	POSITIVE TREND !
15	14	11	3	0.9935	POSITIVE TREND !
16	15	11	4	0.9824	POSITIVE TREND !
17	16	11	5	0.9616	POSITIVE TREND !
18	17	11	6	0.9283	
19	18	11	7	0.8811	
20	19	11	8	0.8204	
21	20	11	9	0.7483	
22	21	11	10	0.2400	
23	22	11	11	0.0213	
24	23	11	12	0.2294	
25	24	11	13	0.4287	
26	24	11	13	0.4287	
27	25	12	13	0.2200	
28	26	12	14	0.4118	
29	27	13	14	0.2117	
30	28	14	14	0.0189	
31	29	15	14	0.2043	
32	30	16	14	0.3834	
33	31	17	14	0.5568	
34	32	18	14	0.7248	
35	33	19	14	0.8878	
36	34	20	14	1.0461	
37	35	21	14	1.2001	
38	36	22	14	1.3500	
39	37	23	14	1.4960	

Table 10. RESULTS OF ORDINARY SIGN TEST ON MARKET SECURITY 3

Points in neutral corridor ==> 5

Upper boundary => 58.5 Lower boundary => 56.125

TABULATION OF RESULTS

TOTAL POINTS	NON-ZERO POINTS	POINTS ABOVE	POINTS BELOW	PROB./ ZVAL	RECOMMENDATION
6	6	5	1	0.9844	POSITIVE TREND !
7	7	5	2	0.9375	
8	8	5	3	0.8555	
9	9	5	4	0.7461	
10	10	5	5	0.6230	
11	11	5	6	0.7256	
12	12	6	6	0.6128	
13	13	6	7	0.7095	
14	14	7	7	0.6047	
15	15	8	7	0.6964	
16	16	9	7	0.7728	
17	17	10	7	0.8338	
18	18	11	7	0.8811	
19	19	11	8	0.8204	
20	20	12	8	0.8684	
21	21	12	9	0.6765	
22	22	12	10	0.4477	
23	23	13	10	0.6464	
24	24	14	10	0.8369	
25	25	15	10	1.0200	
26	26	16	10	1.1963	
27	27	16	11	0.9815	
28	28	16	12	0.7748	
29	29	17	12	0.9470	
30	30	18	12	1.1137	
31	31	19	12	1.2752	
32	32	20	12	1.4319	
33	33	21	12	1.5841	
34	34	22	12	1.7321	POSITIVE TREND !
35	35	23	12	1.8762	POSITIVE TREND !
36	36	24	12	2.0167	POSITIVE TREND !
37	37	25	12	2.1536	POSITIVE TREND !
38	38	26	12	2.2873	POSITIVE TREND !
39	39	27	12	2.4179	POSITIVE TREND !
40	40	28	12	2.5456	POSITIVE TREND !

Table 10. RESULTS OF ORDINARY SIGN TEST ON MARKET SECURITY 3
-Continued

Points in neutral corridor ==> 5

Upper boundary => 58.5 Lower boundary => 56.125

TABULATION OF RESULTS

TOTAL POINTS	NON-ZERO POINTS	POINTS ABOVE	POINTS BELOW	PROB./ ZVAL	RECOMMENDATION
41	41	29	12	2.6706	POSITIVE TREND !
42	42	30	12	2.7929	POSITIVE TREND !
43	43	31	12	2.9127	POSITIVE TREND !
44	44	32	12	3.0302	POSITIVE TREND !
45	45	33	12	3.1454	POSITIVE TREND !
46	46	34	12	3.2585	POSITIVE TREND !
47	47	35	12	3.3695	POSITIVE TREND !
48	48	36	12	3.4785	POSITIVE TREND !
49	49	37	12	3.5857	POSITIVE TREND !
50	50	38	12	3.6911	POSITIVE TREND !
51	51	39	12	3.7948	POSITIVE TREND !
52	52	40	12	3.8968	POSITIVE TREND !
53	53	41	12	3.9972	POSITIVE TREND !
54	54	42	12	4.0961	POSITIVE TREND !
55	55	43	12	4.1935	POSITIVE TREND !

Table 11. RESULTS OF ORDINARY SIGN TEST ON MARKET SECURITY 4

Points in neutral corridor ==> 3

Upper boundary => 86 Lower boundary => 83.5

TABULATION OF RESULTS

TOTAL POINTS	NON-ZERO POINTS	POINTS ABOVE	POINTS BELOW	PROB./ ZVAL	RECOMMENDATION
4	3	3	0	1.0000	POSITIVE TREND !
5	3	3	0	1.0000	POSITIVE TREND !
6	4	4	0	1.0000	POSITIVE TREND !
7	5	5	0	1.0000	POSITIVE TREND !
8	6	6	0	1.0000	POSITIVE TREND !
9	7	6	1	0.9922	POSITIVE TREND !
10	8	7	1	0.9961	POSITIVE TREND !
11	9	8	1	0.9980	POSITIVE TREND !
12	10	8	2	0.9893	POSITIVE TREND !
13	11	8	3	0.9673	POSITIVE TREND !
14	12	8	4	0.9270	
15	13	8	5	0.8666	
16	14	8	6	0.7880	
17	15	8	7	0.6964	
18	16	8	8	0.5982	
19	17	9	8	0.6855	
20	18	10	8	0.7597	
21	19	11	8	0.8204	
22	20	12	8	0.8684	
23	21	13	8	1.1129	
24	22	14	8	1.3005	
25	23	15	8	1.4805	
26	24	16	8	1.6534	POSITIVE TREND !
27	25	17	8	1.8200	POSITIVE TREND !
28	26	18	8	1.9808	POSITIVE TREND !
29	27	19	8	2.1362	POSITIVE TREND !
30	28	20	8	2.2867	POSITIVE TREND !

Table 12. RESULTS OF ORDINARY SIGN TEST ON MARKET SECURITY 5

Points in neutral corridor ==> 7

Upper boundary => 47.75 Lower boundary => 43.75

TABULATION OF RESULTS

TOTAL POINTS	NON-ZERO POINTS	POINTS ABOVE	POINTS BELOW	PROB./ ZVAL	RECOMMENDATION
8	8	4	4	0.6367	
9	9	5	4	0.7461	
10	10	6	4	0.8281	
11	11	7	4	0.8867	
12	12	8	4	0.9270	
13	13	9	4	0.9539	POSITIVE TREND !
14	14	10	4	0.9713	POSITIVE TREND !
15	15	10	5	0.9408	
16	16	11	5	0.9616	POSITIVE TREND !
17	17	12	5	0.9755	POSITIVE TREND !
18	18	13	5	0.9846	POSITIVE TREND !
19	19	14	5	0.9904	POSITIVE TREND !
20	20	15	5	0.9941	POSITIVE TREND !
21	21	16	5	2.4222	POSITIVE TREND !
22	22	17	5	2.5797	POSITIVE TREND !
23	23	18	5	2.7315	POSITIVE TREND !
24	24	19	5	2.8782	POSITIVE TREND !
25	25	20	5	3.0200	POSITIVE TREND !
26	26	21	5	3.1575	POSITIVE TREND !
27	27	22	5	3.2909	POSITIVE TREND !
28	28	23	5	3.4206	POSITIVE TREND !
29	29	24	5	3.5468	POSITIVE TREND !
30	30	25	5	3.6697	POSITIVE TREND !
31	31	26	5	3.7897	POSITIVE TREND !
32	32	27	5	3.9068	POSITIVE TREND !
33	33	28	5	4.0212	POSITIVE TREND !
34	34	29	5	4.1331	POSITIVE TREND !
35	35	30	5	4.2427	POSITIVE TREND !
36	36	31	5	4.3500	POSITIVE TREND !
37	37	32	5	4.4552	POSITIVE TREND !
38	38	33	5	4.5584	POSITIVE TREND !
39	39	34	5	4.6597	POSITIVE TREND !
40	40	35	5	4.7592	POSITIVE TREND !

Table 13. RESULTS OF ORDINARY SIGN TEST ON MARKET SECURITY 6

Points in neutral corridor ==> 3

Upper boundary => 71.875 Lower boundary => 69.375

TABULATION OF RESULTS

TOTAL POINTS	NON-ZERO POINTS	POINTS ABOVE	POINTS BELOW	PROB./ ZVAL	RECOMMENDATION
4	4	1	3	0.9375	
5	5	1	4	0.9688	NEGATIVE TREND !
6	6	1	5	0.9844	NEGATIVE TREND !
7	7	2	5	0.9375	
8	8	3	5	0.8555	
9	8	3	5	0.8555	
10	9	3	6	0.9102	
11	10	3	7	0.9453	
12	11	4	7	0.8867	
13	12	5	7	0.8062	
14	13	6	7	0.7095	
15	14	6	8	0.7880	
16	15	6	9	0.8491	
17	16	7	9	0.7728	
18	17	8	9	0.6855	
19	17	8	9	0.6855	
20	18	9	9	0.5927	
21	19	10	9	0.6762	
22	20	11	9	0.7483	
23	21	12	9	0.6765	
24	21	12	9	0.6765	
25	22	12	10	0.4477	
26	23	12	11	0.2294	
27	23	12	11	0.2294	
28	24	13	11	0.4287	
29	25	14	11	0.6200	
30	26	15	11	0.8041	
31	27	15	12	0.5966	
32	28	15	13	0.3969	
33	29	15	14	0.2043	
34	30	15	15	0.0183	
35	31	15	16	0.1976	
36	31	15	16	0.1976	
37	32	16	16	0.0177	
38	33	17	16	0.1915	

Table 13. RESULTS OF ORDINARY SIGN TEST ON MARKET SECURITY 6 - Continued

Points in neutral corridor ==> 3

Upper boundary => 71.875 Lower boundary => 69.375

TABULATION OF RESULTS

TOTAL POINTS	NON-ZERO POINTS	POINTS ABOVE	POINTS BELOW	PROB./ ZVAL	RECOMMENDATION
39	33	17	16	0.1915	
40	34	18	16	0.3601	
41	35	19	16	0.5240	
42	36	20	16	0.6833	
43	37	21	16	0.8384	
44	38	22	16	0.9896	
45	39	23	16	1.1369	
46	40	24	16	1.2807	
47	41	25	16	1.4212	
48	42	26	16	1.5585	
49	43	27	16	1.6927	POSITIVE TREND !
50	44	28	16	1.8241	POSITIVE TREND !
51	45	29	16	1.9528	POSITIVE TREND !
52	46	30	16	2.0789	POSITIVE TREND !
53	47	31	16	2.2026	POSITIVE TREND !
54	48	32	16	2.3238	POSITIVE TREND !
55	49	33	16	2.4429	POSITIVE TREND !
56	50	34	16	2.5597	POSITIVE TREND !
57	51	35	16	2.6745	POSITIVE TREND !
58	52	36	16	2.7874	POSITIVE TREND !
59	53	37	16	2.8983	POSITIVE TREND !
60	54	38	16	3.0074	POSITIVE TREND !
61	55	39	16	3.1148	POSITIVE TREND !
62	56	40	16	3.2205	POSITIVE TREND !
63	56	40	16	3.2205	POSITIVE TREND !
64	57	40	17	3.0597	POSITIVE TREND !
65	58	40	18	2.9019	POSITIVE TREND !
66	59	41	18	3.0074	POSITIVE TREND !
67	60	41	19	2.8531	POSITIVE TREND !
68	61	41	20	2.7016	POSITIVE TREND !
69	62	41	21	2.5527	POSITIVE TREND !
70	63	41	22	2.4064	POSITIVE TREND !
71	64	41	23	2.2625	POSITIVE TREND !
72	65	41	24	2.1210	POSITIVE TREND !

Table 13. RESULTS OF ORDINARY SIGN TEST ON MARKET SECURITY 6 - Continued

Points in neutral corridor ==> 3

Upper boundary => 71.875 Lower boundary => 69.375

TABULATION OF RESULTS

TOTAL POINTS	NON-ZERO POINTS	POINTS ABOVE	POINTS BELOW	PROB./ ZVAL	RECOMMENDATION
73	66	41	25	1.9818	POSITIVE TREND !
74	67	41	26	1.8448	POSITIVE TREND !
75	68	41	27	1.7099	POSITIVE TREND !
76	69	41	28	1.5771	
77	70	41	29	1.4462	
78	71	41	30	1.3173	
79	72	41	31	1.1903	
80	73	41	32	1.0651	
81	74	41	33	0.9416	
82	75	41	34	0.8198	
83	76	41	35	0.6997	
84	77	41	36	0.5812	
85	78	41	37	0.4642	
86	79	42	37	0.5738	
87	80	43	37	0.6820	
88	81	44	37	0.7889	
89	82	45	37	0.8945	
90	83	46	37	0.9989	
91	84	47	37	1.1020	
92	85	48	37	1.2040	
93	86	49	37	1.3048	
94	87	50	37	1.4045	
95	88	51	37	1.5031	
96	89	52	37	1.6006	
97	90	53	37	1.6971	POSITIVE TREND !

Table 14. RESULTS OF ORDINARY SIGN TEST ON MARKET SECURITY 7

Points in neutral corridor ==> 5

Upper boundary => 63.75 Lower boundary => 60.75

TABULATION OF RESULTS

TOTAL POINTS	NON-ZERO POINTS	POINTS ABOVE	POINTS BELOW	PROB./ ZVAL	RECOMMENDATION
6	4	1	3	0.9375	
7	5	2	3	0.8125	
8	6	3	3	0.6563	
9	7	3	4	0.7734	
10	8	3	5	0.8555	
11	9	3	6	0.9102	
12	10	3	7	0.9453	
13	11	4	7	0.8867	
14	12	4	8	0.9270	
15	13	4	9	0.9539	NEGATIVE TREND !
16	14	4	10	0.9713	NEGATIVE TREND !
17	15	5	10	0.9408	
18	16	6	10	0.8949	
19	17	7	10	0.8338	
20	18	8	10	0.7597	
21	19	8	11	0.8204	
22	20	8	12	0.8684	
23	21	8	13	1.1129	
24	22	8	14	1.3005	
25	23	8	15	1.4805	
26	24	8	16	1.6534	NEGATIVE TREND !

APPENDIX F

RESULTS OF WILCOXON SIGNED RANK TESTS

Table 15. RESULTS OF WILCOXON SIGNED RANK TEST ON MARKET SECURITY 2

Initial Sample size = 39

Number of points in neutral corridor = 5

Value of Center Line = 44.625

Periods	Nonzero Diffs.	Sum '+' Ranks	Sum '-' Ranks	Recommendation
6	6	10	11	
7	7	10.5	17.5	
8	8	16	20	
9	9	24.5	20.5	
10	9	24.5	20.5	
11	10	34	21	
12	11	43	23	
13	12	53	25	
14	13	66	25	
15	14	77.5	27.5	
16	15	87	33	
17	16	96.5	39.5	
18	17	103	50	
19	18	107	64	
20	19	109	81	
21	20	111	99	
22	21	112	119	
23	22	113	140	
24	23	114	162	
25	24	120.5	179.5	
26	24	120.5	179.5	
27	25	136	189	
28	26	146.5	204.5	
29	27	161	217	
30	28	181.5	224.5	
31	29	210.5	224.5	
32	30	240.5	224.5	
33	31	271.5	224.5	
34	32	297	231	
35	33	328	233	
36	34	355.5	239.5	
37	35	390.5	239.5	
38	36	426.5	239.5	
39	37	463.5	239.5	Positive Trend

Table 16. RESULTS OF WILCOXON SIGNED RANK TEST ON MARKET SECURITY 3

Initial Sample size = 55

Number of points in neutral corridor = 5

Value of Center Line = 57.3125

Periods	Nonzero Diffs.	Sum '+' Ranks	Sum '-' Ranks	Recommendation
6	6	16.5	4.5	
7	7	21.5	6.5	
8	8	26.5	9.5	
9	9	27.5	17.5	
10	10	30.5	24.5	
11	11	34	32	
12	12	43.5	34.5	
13	13	49.5	41.5	
14	14	58	47	
15	15	69	51	
16	16	85	51	
17	17	96.5	56.5	
18	18	109	62	
19	19	120	70	
20	20	132.5	77.5	
21	21	137	94	
22	22	139	114	
23	23	158	118	
24	24	178	122	
25	25	197	128	
26	26	217	134	
27	27	220.5	157.5	
28	28	230.5	175.5	
29	29	259.5	175.5	
30	30	288.5	176.5	
31	31	319.5	176.5	
32	32	351.5	176.5	
33	33	384.5	176.5	Positive Trend
34	34	418.5	176.5	Positive Trend
35	35	453.5	176.5	Positive Trend
36	36	489.5	176.5	Positive Trend
37	37	526.5	176.5	Positive Trend
38	38	564.5	176.5	Positive Trend
39	39	603.5	176.5	Positive Trend
40	40	643.5	176.5	Positive Trend

Table 16. RESULTS OF WILCOXON SIGNED RANK TEST ON MARKET SECURITY 3 - Continued

Initial Sample size = 55

Number of points in neutral corridor = 5

Value of Center Line = 57.3125

Periods	Nonzero Diffs.	Sum '+' Ranks	Sum '-' Ranks	Recommendation
41	41	684.5	176.5	Positive Trend
42	42	726.5	176.5	Positive Trend
43	43	769.5	176.5	Positive Trend
44	44	813.5	176.5	Positive Trend
45	45	858.5	176.5	Positive Trend
46	46	904.5	176.5	Positive Trend
47	47	951.5	176.5	Positive Trend
48	48	999.5	176.5	Positive Trend
49	49	1043.5	181.5	Positive Trend
50	50	1092.5	182.5	Positive Trend
51	51	1143.5	182.5	Positive Trend
52	52	1195.5	182.5	Positive Trend
53	53	1248.5	182.5	Positive Trend
54	54	1302.5	182.5	Positive Trend
55	55	1357.5	182.5	Positive Trend

Table 17. RESULTS OF WILCOXON SIGNED RANK TEST ON MARKET SECURITY 4

Initial Sample size = 30

Number of points in neutral corridor = 3

Value of Center Line = 84.75

Periods	Nonzero Diffs.	Sum '+' Ranks	Sum '-' Ranks	Recommendation
4	3	6	0	Positive Trend
5	3	6	0	Positive Trend
6	4	10	0	Positive Trend
7	5	15	0	Positive Trend
8	6	21	0	Positive Trend
9	7	26	2	Positive Trend
10	8	34	2	Positive Trend
11	9	43	2	Positive Trend
12	10	50.5	4.5	Positive Trend
13	11	57.5	8.5	Positive Trend
14	12	65	13	Positive Trend
15	13	65	26	
16	14	71	34	
17	15	71	49	
18	16	74.5	61.5	
19	17	84.5	68.5	
20	18	100.5	70.5	
21	19	119.5	70.5	
22	20	139.5	70.5	
23	21	160.5	70.5	
24	22	182.5	70.5	Positive Trend
25	23	205.5	70.5	Positive Trend
26	24	229.5	70.5	Positive Trend
27	25	254.5	70.5	Positive Trend
28	26	280.5	70.5	Positive Trend
29	27	307.5	70.5	Positive Trend
30	28	335.5	70.5	Positive Trend

Table 18. RESULTS OF WILCOXON SIGNED RANK TEST ON MARKET SECURITY 5

Initial Sample size = 40

Number of points in neutral corridor = 7

Value of Center Line = 45.75

Periods	Nonzero Diffs.	Sum '+' Ranks	Sum '-' Ranks	Recommendation
8	8	25.5	10.5	
9	9	33	12	
10	10	43	12	
11	11	53.5	12.5	Positive Trend
12	12	65	13	Positive Trend
13	13	77.5	13.5	Positive Trend
14	14	89.5	15.5	Positive Trend
15	15	99.5	20.5	Positive Trend
16	16	115	21	Positive Trend
17	17	131.5	21.5	Positive Trend
18	18	149.5	21.5	Positive Trend
19	19	168.5	21.5	Positive Trend
20	20	188.5	21.5	Positive Trend
21	21	209.5	21.5	Positive Trend
22	22	231.5	21.5	Positive Trend
23	23	254.5	21.5	Positive Trend
24	24	278.5	21.5	Positive Trend
25	25	303.5	21.5	Positive Trend
26	26	329.5	21.5	Positive Trend
27	27	356.5	21.5	Positive Trend
28	28	384.5	21.5	Positive Trend
29	29	413.5	21.5	Positive Trend
30	30	443.5	21.5	Positive Trend
31	31	474.5	21.5	Positive Trend
32	32	506.5	21.5	Positive Trend
33	33	539.5	21.5	Positive Trend
34	34	573.5	21.5	Positive Trend
35	35	608.5	21.5	Positive Trend
36	36	644.5	21.5	Positive Trend
37	37	681.5	21.5	Positive Trend
38	38	719.5	21.5	Positive Trend
39	39	758.5	21.5	Positive Trend
40	40	798.5	21.5	Positive Trend

Table 19. RESULTS OF WILCOXON SIGNED RANK TEST ON MARKET SECURITY 6

Initial Sample size = 97

Number of points in neutral corridor = 3

Value of Center Line = 70.625

Periods	Nonzero Diffs.	Sum '+' Ranks	Sum '-' Ranks	Recommendation
4	4	2	8	
5	5	2	13	
6	6	3	18	
7	7	7	21	
8	8	12	24	
9	8	12	24	
10	9	13	32	
11	10	13	42	
12	11	18.5	47.5	
13	12	30.5	47.5	
14	13	41.5	49.5	
15	14	42	63	
16	15	47.5	72.5	
17	16	60.5	75.5	
18	17	72	81	
19	17	72	81	
20	18	83	88	
21	19	93.5	96.5	
22	20	106.5	103.5	
23	21	121.5	109.5	
24	21	121.5	109.5	
25	22	132.5	120.5	
26	23	144	132	
27	23	144	132	
28	24	165	135	
29	25	190	135	
30	26	216	135	
31	27	226	152	
32	28	227	179	
33	29	227	208	
34	30	229.5	235.5	
35	31	239.5	256.5	
36	31	239.5	256.5	
37	32	270.5	257.5	
38	33	302	259	

Table 19. RESULTS OF WILCOXON SIGNED RANK ON MARKET SECURITY 6 - Continued

Initial Sample size = 97

Number of points in neutral corridor = 3

Value of Center Line = 70.625

Periods	Nonzero Diffs.	Sum '+' Ranks	Sum '-' Ranks	Recommendation
39	33	302	259	
40	34	322.5	272.5	
41	35	342.5	287.5	
42	36	378	288	
43	37	413	290	
44	38	437.5	303.5	
45	39	470.5	309.5	
46	40	508.5	311.5	
47	41	547.5	313.5	Positive Trend
48	42	587.5	315.5	Positive Trend
49	43	630	316	Positive Trend
50	44	672	318	Positive Trend
51	45	717	318	Positive Trend
52	46	763	318	Positive Trend
53	47	810	318	Positive Trend
54	48	858	318	Positive Trend
55	49	907	318	Positive Trend
56	50	957	318	Positive Trend
57	51	1008	318	Positive Trend
58	52	1058	320	Positive Trend
59	53	1111	320	Positive Trend
60	54	1159	326	Positive Trend
61	55	1205.5	334.5	Positive Trend
62	56	1255.5	340.5	Positive Trend
63	56	1255.5	340.5	Positive Trend
64	57	1294.5	358.5	Positive Trend
65	58	1331.5	379.5	Positive Trend
66	59	1376.5	393.5	Positive Trend
67	60	1405.5	424.5	Positive Trend
68	61	1420	471	Positive Trend
69	62	1444	509	Positive Trend
70	63	1462.5	553.5	Positive Trend
71	64	1475	605	Positive Trend
72	65	1480	665	Positive Trend
73	66	1487	724	Positive Trend

Table 19. RESULTS OF WILCOXON SIGNED RANK ON MARKET SECURITY 6 - Continued

Initial Sample size = 97

Number of points in neutral corridor = 3

Value of Center Line = 70.625

Periods	Nonzero Diffs.	Sum '+' Ranks	Sum '-' Ranks	Recommendation
74	67	1492.5	785.5	Positive Trend
75	68	1497.5	848.5	Positive Trend
76	69	1500	915	Positive Trend
77	70	1505	980	Positive Trend
78	71	1521.5	1034.5	Positive Trend
79	72	1528.5	1099.5	Positive Trend
80	73	1534	1167	Positive Trend
81	74	1539	1236	Positive Trend
82	75	1544.5	1305.5	Positive Trend
83	76	1565	1361	Positive Trend
84	77	1602.5	1400.5	Positive Trend
85	78	1637	1444	Positive Trend
86	79	1694.5	1465.5	Positive Trend
87	80	1749.5	1490.5	Positive Trend
88	81	1813	1508	Positive Trend
89	82	1892	1511	Positive Trend
90	83	1975	1511	Positive Trend
91	84	2059	1511	Positive Trend
92	85	2144	1511	Positive Trend
93	86	2227	1514	Positive Trend
94	87	2314	1514	Positive Trend
95	88	2402	1514	Positive Trend
96	89	2488	1517	Positive Trend
97	90	2569	1526	Positive Trend

Table 20. RESULTS OF WILCOXON SIGNED RANK TEST ON MARKET SECURITY 7

Initial Sample size = 26

Number of points in neutral corridor = 5

Value of Center Line = 62.25

Periods	Nonzero Diffs.	Sum '+' Ranks	Sum '-' Ranks	Recommendation
6	4	3.5	6.5	
7	5	7.5	7.5	
8	6	10.5	10.5	
9	7	12.5	15.5	
10	8	15	21	
11	9	17	28	
12	10	20	35	
13	11	29	37	
14	12	30	48	
15	13	30	61	
16	14	30	75	
17	15	40	80	
18	16	54	82	
19	17	69	84	
20	18	77.5	93.5	
21	19	77.5	112.5	
22	20	77.5	132.5	
23	21	77.5	153.5	
24	22	77.5	175.5	
25	23	77.5	198.5	Negative trend
26	24	77.5	222.5	Negative trend

APPENDIX G

RESULTS OF COX-STUART TESTS

Table 21. RESULTS OF COX-STUART TEST ON MARKET SECURITY 2

Initial Sample size = 39

Number of points in neutral corridor = 5

POINTS	+ SIGNS	- SIGNS	PROB./ZVAL	RECOMMENDATION
5	2	0	0.250	
6	1	2	0.500	
7	1	2	0.500	
8	1	3	0.313	
9	1	3	0.313	
10	2	3	0.500	
11	2	3	0.500	
12	1	4	0.188	
13	1	4	0.188	
14	0	7	0.008	Positive Trend !
15	0	7	0.008	Positive Trend !
16	2	6	0.145	
17	2	6	0.145	
18	2	7	0.090	
19	2	7	0.090	
20	4	6	0.377	
21	4	6	0.377	
22	6	4	0.377	
23	6	4	0.377	
24	9	3	0.073	
25	9	3	0.073	
26	10	2	0.019	Negative Trend !
27	10	2	0.019	Negative Trend !
28	12	2	0.006	Negative Trend !
29	12	2	0.006	Negative Trend !
30	12	3	0.018	Negative Trend !
31	12	3	0.018	Negative Trend !
32	11	4	0.059	
33	11	4	0.059	
34	9	6	0.304	
35	9	6	0.304	
36	8	7	0.500	
37	8	7	0.500	
38	8	10	0.407	
39	8	10	0.407	

Table 22. RESULTS OF COX-STUART TEST ON MARKET SECURITY 3

Initial Sample size = 55

Number of points in neutral corridor = 5

POINTS	+ SIGNS	- SIGNS	PROB./ZVAL	RECOMMENDATION
5	0	2	0.250	
6	1	2	0.500	
7	1	2	0.500	
8	3	1	0.313	
9	3	1	0.313	
10	4	1	0.188	
11	4	1	0.188	
12	4	2	0.344	
13	4	2	0.344	
14	5	2	0.227	
15	5	2	0.227	
16	6	2	0.145	
17	6	2	0.145	
18	4	4	0.637	
19	4	4	0.637	
20	3	7	0.172	
21	3	7	0.172	
22	5	5	0.623	
23	5	5	0.623	
24	5	6	0.500	
25	5	6	0.500	
26	6	6	0.613	
27	6	6	0.613	
28	9	5	0.212	
29	9	5	0.212	
30	8	7	0.500	
31	8	7	0.500	
32	7	9	0.402	
33	7	9	0.402	
34	5	12	0.072	
35	5	12	0.072	
36	4	14	0.015	Positive Trend !
37	4	14	0.015	Positive Trend !
38	5	13	0.048	Positive Trend !
39	5	13	0.048	Positive Trend !
40	6	13	0.084	
41	6	13	0.084	
42	6	15	-1.942	Positive Trend !
43	6	15	-1.942	Positive Trend !

Table 22. RESULTS OF COX-STUART TEST ON MARKET SECURITY 3 - Continued

Initial Sample size = 55

Number of points in neutral corridor = 5

POINTS	+ SIGNS	- SIGNS	PROB./ZVAL	RECOMMENDATION
44	4	18	-2.963	Positive Trend !
45	4	18	-2.963	Positive Trend !
46	4	19	-3.107	Positive Trend !
47	4	19	-3.107	Positive Trend !
48	3	20	-3.524	Positive Trend !
49	3	20	-3.524	Positive Trend !
50	3	21	-3.654	Positive Trend !
51	3	21	-3.654	Positive Trend !
52	2	23	-4.180	Positive Trend !
53	2	23	-4.180	Positive Trend !
54	0	27	-5.177	Positive Trend !
55	0	27	-5.177	Positive Trend !

Table 23. RESULTS OF COX-STUART TEST ON MARKET SECURITY 4

Initial Sample size = 30

Number of points in neutral corridor = 3

POINTS	+ SIGNS	- SIGNS	PROB./ZVAL	RECOMMENDATION
3	1	0	0.500	
4	1	1	0.750	
5	1	1	0.750	
6	2	1	0.500	
7	2	1	0.500	
8	1	2	0.500	
9	1	2	0.500	
10	2	3	0.500	
11	2	3	0.500	
12	3	3	0.656	
13	3	3	0.656	
14	5	2	0.227	
15	5	2	0.227	
16	6	2	0.145	
17	6	2	0.145	
18	8	1	0.020	Negative Trend !
19	8	1	0.020	Negative Trend !
20	7	3	0.172	
21	7	3	0.172	
22	8	3	0.113	
23	8	3	0.113	
24	7	5	0.387	
25	7	5	0.387	
26	6	7	0.500	
27	6	7	0.500	
28	4	10	0.090	
29	4	10	0.090	
30	4	11	0.059	

Table 24. RESULTS OF COX-STUART TEST ON MARKET SECURITY 5

Initial Sample size = 40

Number of points in neutral corridor = 7

POINTS	+ SIGNS	- SIGNS	PROB./ZVAL	RECOMMENDATION
7	0	3	0.125	
8	1	3	0.313	
9	1	3	0.313	
10	2	3	0.500	
11	2	3	0.500	
12	2	3	0.500	
13	2	3	0.500	
14	3	3	0.656	
15	3	3	0.656	
16	3	4	0.500	
17	3	4	0.500	
18	3	5	0.363	
19	3	5	0.363	
20	4	6	0.377	
21	4	6	0.377	
22	3	8	0.113	
23	3	8	0.113	
24	1	10	0.006	Positive Trend !
25	1	10	0.006	Positive Trend !
26	1	11	0.003	Positive Trend !
27	1	11	0.003	Positive Trend !
28	0	13	0.000	Positive Trend !
29	0	13	0.000	Positive Trend !
30	0	14	0.000	Positive Trend !
31	0	14	0.000	Positive Trend !
32	0	16	0.000	Positive Trend !
33	0	16	0.000	Positive Trend !
34	0	17	0.000	Positive Trend !
35	0	17	0.000	Positive Trend !
36	0	18	0.000	Positive Trend !
37	0	18	0.000	Positive Trend !
38	0	19	0.000	Positive Trend !
39	0	19	0.000	Positive Trend !
40	0	20	0.000	Positive Trend !

Table 25. RESULTS OF COX-STUART TEST ON MARKET SECURITY 6

Initial Sample size = 97

Number of points in neutral corridor = 3

POINTS	+ SIGNS	- SIGNS	PROB./ZVAL	RECOMMENDATION
3	1	0	0.500	
4	1	0	0.500	
5	1	0	0.500	
6	1	1	0.750	
7	1	1	0.750	
8	1	3	0.313	
9	1	3	0.313	
10	1	4	0.188	
11	1	4	0.188	
12	0	5	0.031	Positive Trend !
13	0	5	0.031	Positive Trend !
14	1	5	0.109	
15	1	5	0.109	
16	4	4	0.637	
17	4	4	0.637	
18	3	5	0.363	
19	3	5	0.363	
20	3	5	0.363	
21	3	5	0.363	
22	3	7	0.172	
23	3	7	0.172	
24	4	8	0.194	
25	4	8	0.194	
26	5	7	0.387	
27	5	7	0.387	
28	5	8	0.291	
29	5	8	0.291	
30	5	9	0.212	
31	5	9	0.212	
32	4	12	0.038	Positive Trend !
33	4	12	0.038	Positive Trend !
34	7	10	0.315	
35	7	10	0.315	
36	9	8	0.500	
37	9	8	0.500	
38	9	9	0.593	
39	9	9	0.593	
40	6	12	0.119	

Table 25. RESULTS OF COX-STUART TEST ON MARKET SECURITY 6 - Continued

Initial Sample size = 97

Number of points in neutral corridor = 3

POINTS	+ SIGNS	- SIGNS	PROB./ZVAL	RECOMMENDATION
41	6	12	0.119	
42	7	14	-1.506	
43	7	14	-1.506	
44	9	12	-0.633	
45	9	12	-0.633	
46	9	14	-1.022	
47	9	14	-1.022	
48	8	16	-1.613	
49	8	16	-1.613	
50	6	19	-2.580	Positive Trend !
51	6	19	-2.580	Positive Trend !
52	8	18	-1.942	Positive Trend !
53	8	18	-1.942	Positive Trend !
54	8	18	-1.942	Positive Trend !
55	8	18	-1.942	Positive Trend !
56	8	19	-2.098	Positive Trend !
57	8	19	-2.098	Positive Trend !
58	7	22	-2.767	Positive Trend !
59	7	22	-2.767	Positive Trend !
60	6	23	-3.138	Positive Trend !
61	6	23	-3.138	Positive Trend !
62	7	23	-2.903	Positive Trend !
63	7	23	-2.903	Positive Trend !
64	9	22	-2.317	Positive Trend !
65	9	22	-2.317	Positive Trend !
66	6	27	-3.638	Positive Trend !
67	6	27	-3.638	Positive Trend !
68	5	28	-3.986	Positive Trend !
69	5	28	-3.986	Positive Trend !
70	5	30	-4.209	Positive Trend !
71	5	30	-4.209	Positive Trend !
72	8	27	-3.195	Positive Trend !
73	8	27	-3.195	Positive Trend !
74	10	27	-2.778	Positive Trend !
75	10	27	-2.778	Positive Trend !
76	11	26	-2.450	Positive Trend !
77	11	26	-2.450	Positive Trend !

Table 25. RESULTS OF COX-STUART TEST ON MARKET SECURITY 6 - Continued

Initial Sample size = 97

Number of points in neutral corridor = 3

POINTS	+ SIGNS	- SIGNS	PROB./ZVAL	RECOMMENDATION
78	13	24	-1.792	Positive Trend !
79	13	24	-1.792	Positive Trend !
80	17	22	-0.785	
81	17	22	-0.785	
82	19	22	-0.453	
83	19	22	-0.453	
84	21	21	0.015	
85	21	21	0.015	
86	25	16	-1.390	
87	25	16	-1.390	
88	25	18	-1.052	
89	25	18	-1.052	
90	23	21	-0.286	
91	23	21	-0.286	
92	23	22	-0.134	
93	23	22	-0.134	
94	23	24	-0.131	
95	23	24	-0.131	
96	23	24	-0.131	
97	23	24	-0.131	

Table 26. RESULTS OF COX-STUART TEST ON MARKET SECURITY 7

Initial Sample size = 26

Number of points in neutral corridor = 5

POINTS	+ SIGNS	- SIGNS	PROB./ZVAL	RECOMMENDATION
5	2	0	0.250	
6	2	1	0.500	
7	2	1	0.500	
8	1	2	0.500	
9	1	2	0.500	
10	2	3	0.500	
11	2	3	0.500	
12	3	3	0.656	
13	3	3	0.656	
14	4	3	0.500	
15	4	3	0.500	
16	5	3	0.363	
17	5	3	0.363	
18	5	4	0.500	
19	5	4	0.500	
20	6	4	0.377	
21	6	4	0.377	
22	5	6	0.500	
23	5	6	0.500	
24	9	3	0.073	
25	9	3	0.073	
26	10	3	0.046	Negative Trend !

APPENDIX H

RESULTS OF MODIFIED COX-STUART TESTS

Table 27. RESULTS OF MODIFIED COX-STUART TEST ON MARKET SECURITY 2

INITIAL SAMPLE SIZE = 39

NUMBER OF POINTS IN NEUTRAL CORRIDOR = 5

PERIODS	NONZERO DIFFS.	SUM '+' RANKS	SUM '-' RANKS	RECOMMENDATION
6	3	1	5	
7	3	1	5	
8	4	1.5	8.5	
9	4	1.5	8.5	
10	5	3.5	11.5	
11	5	3.5	11.5	
12	5	1	14	
13	5	1	14	
14	7	0	28	Positive Trend
15	7	0	28	Positive Trend
16	8	6	30	
17	8	6	30	
18	9	12	33	
19	9	12	33	
20	10	23.5	31.5	
21	10	23.5	31.5	
22	10	35	20	
23	10	35	20	
24	12	58	20	
25	12	58	20	
26	12	61	17	Negative trend
27	12	61	17	Negative trend
28	14	89.5	15.5	Negative trend
29	14	89.5	15.5	Negative trend
30	15	108.5	11.5	Negative trend
31	15	108.5	11.5	Negative trend
32	15	86	34	
33	15	86	34	
34	15	68.5	51.5	
35	15	68.5	51.5	
36	15	60.5	59.5	
37	15	60.5	59.5	
38	18	68.5	102.5	
39	18	68.5	102.5	

Table 28. RESULTS OF MODIFIED COX-STUART TEST ON MARKET SECURITY 3

INITIAL SAMPLE SIZE = 55

NUMBER OF POINTS IN NEUTRAL CORRIDOR = 5

PERIODS	NONZERO DIFFS.	SUM '+' RANKS	SUM '-' RANKS	RECOMMENDATION
6	3	1	5	
7	3	1	5	
8	4	6	4	
9	4	6	4	
10	5	12	3	
11	5	12	3	
12	6	17.5	3.5	
13	6	17.5	3.5	
14	7	24	4	
15	7	24	4	
16	8	24	12	
17	8	24	12	
18	8	16.5	19.5	
19	8	16.5	19.5	
20	10	22	33	
21	10	22	33	
22	10	27.5	27.5	
23	10	27.5	27.5	
24	11	28	38	
25	11	28	38	
26	12	31	47	
27	12	31	47	
28	14	49.5	55.5	
29	14	49.5	55.5	
30	15	55	65	
31	15	55	65	
32	16	57	79	
33	16	57	79	
34	17	41.5	111.5	
35	17	41.5	111.5	
36	18	39	132	Positive trend
37	18	39	132	Positive trend
38	18	30	141	Positive trend
39	18	30	141	Positive trend
40	19	26	164	Positive trend
41	19	26	164	Positive trend
42	21	25.5	205.5	Positive trend
43	21	25.5	205.5	Positive trend

Table 28. RESULTS OF MODIFIED COX-STUART TEST ON MARKET SECURITY 3 - Continued

INITIAL SAMPLE SIZE = 55

NUMBER OF POINTS IN NEUTRAL CORRIDOR = 5

PERIODS	NONZERO DIFFS.	SUM '+' RANKS	SUM '-' RANKS	RECOMMENDATION
44	22	19.5	233.5	Positive trend
45	22	19.5	233.5	Positive trend
46	23	18	258	Positive trend
47	23	18	258	Positive trend
48	23	10.5	265.5	Positive trend
49	23	10.5	265.5	Positive trend
50	24	12.5	287.5	Positive trend
51	24	12.5	287.5	Positive trend
52	25	9	316	Positive trend
53	25	9	316	Positive trend
54	27	0	378	Positive trend
55	27	0	378	Positive trend

Table 29. RESULTS OF MODIFIED COX-STUART TEST ON MARKET SECURITY 4

INITIAL SAMPLE SIZE = 30

NUMBER OF POINTS IN NEUTRAL CORRIDOR = 3

PERIODS	NONZERO DIFFS.	SUM '+' RANKS	SUM '-' RANKS	RECOMMENDATION
4	2	2	1	
5	2	2	1	
6	3	3	3	
7	3	3	3	
8	3	3	3	
9	3	3	3	
10	5	6	9	
11	5	6	9	
12	6	11	10	
13	6	11	10	
14	7	19	9	
15	7	19	9	
16	8	28	8	
17	8	28	8	
18	9	39	6	Negative Trend
19	9	39	6	Negative Trend
20	10	46.5	8.5	Negative Trend
21	10	46.5	8.5	Negative Trend
22	11	39.5	26.5	
23	11	39.5	26.5	
24	12	38	40	
25	12	38	40	
26	13	28.5	62.5	
27	13	28.5	62.5	
28	14	18	87	Positive trend
29	14	18	87	Positive trend
30	15	14	106	Positive trend

Table 30. RESULTS OF MODIFIED COX-STUART TEST ON MARKET SECURITY 5

INITIAL SAMPLE SIZE = 40

NUMBER OF POINTS IN NEUTRAL CORRIDOR = 7

PERIODS	NONZERO DIFFS.	SUM '+' RANKS	SUM '-' RANKS	RECOMMENDATION
8	4	1	9	
9	4	1	9	
10	5	3	12	
11	5	3	12	
12	5	5	10	
13	5	5	10	
14	6	7.5	13.5	
15	6	7.5	13.5	
16	7	9	19	
17	7	9	19	
18	8	10	26	
19	8	10	26	
20	10	16	39	
21	10	16	39	
22	11	14	52	
23	11	14	52	
24	11	3	63	Positive trend
25	11	3	63	Positive trend
26	12	1	77	Positive trend
27	12	1	77	Positive trend
28	13	0	91	Positive trend
29	13	0	91	Positive trend
30	14	0	105	Positive trend
31	14	0	105	Positive trend
32	16	0	136	Positive trend
33	16	0	136	Positive trend
34	17	0	153	Positive trend
35	17	0	153	Positive trend
36	18	0	171	Positive trend
37	18	0	171	Positive trend
38	19	0	190	Positive trend
39	19	0	190	Positive trend
40	20	0	210	Positive trend

Table 31. RESULTS OF MODIFIED COX-STUART TEST ON MARKET SECURITY 6

INITIAL SAMPLE SIZE = 97

NUMBER OF POINTS IN NEUTRAL CORRIDOR = 3

PERIODS	NONZERO DIFFS.	SUM '+' RANKS	SUM '-' RANKS	RECOMMENDATION
4	1	1	0	
5	1	1	0	
6	2	2	1	
7	2	2	1	
8	4	3	7	
9	4	3	7	
10	5	2	13	
11	5	2	13	
12	5	0	15	
13	5	0	15	
14	6	3	18	
15	6	3	18	
16	8	17	19	
17	8	17	19	
18	8	14.5	21.5	
19	8	14.5	21.5	
20	8	11	25	
21	8	11	25	
22	10	8	47	Positive Trend
23	10	8	47	Positive Trend
24	12	19	59	
25	12	19	59	
26	12	27	51	
27	12	27	51	
28	13	33.5	57.5	
29	13	33.5	57.5	
30	14	22	83	Positive Trend
31	14	22	83	Positive Trend
32	16	28.5	107.5	Positive Trend
33	16	28.5	107.5	Positive Trend
34	17	68.5	84.5	
35	17	68.5	84.5	
36	17	78.5	74.5	
37	17	78.5	74.5	
38	18	70	101	
39	18	70	101	
40	18	65	106	

Table 31. RESULTS OF MODIFIED COX-STUART TEST ON MARKET SECURITY 6 - Continued

INITIAL SAMPLE SIZE = 97

NUMBER OF POINTS IN NEUTRAL CORRIDOR = 3

PERIODS	NONZERO DIFFS.	SUM '+' RANKS	SUM '-' RANKS	RECOMMENDATION
41	18	65	106	
42	21	85.5	145.5	
43	21	85.5	145.5	
44	21	93.5	137.5	
45	21	93.5	137.5	
46	23	112	164	
47	23	112	164	
48	24	93.5	206.5	
49	24	93.5	206.5	
50	25	85.5	239.5	Positive Trend
51	25	85.5	239.5	Positive Trend
52	26	88.5	262.5	Positive Trend
53	26	88.5	262.5	Positive Trend
54	26	78.5	272.5	Positive Trend
55	26	78.5	272.5	Positive Trend
56	27	59.5	318.5	Positive Trend
57	27	59.5	318.5	Positive Trend
58	29	54	381	Positive Trend
59	29	54	381	Positive Trend
60	29	62	373	Positive Trend
61	29	62	373	Positive Trend
62	30	70.5	394.5	Positive Trend
63	30	70.5	394.5	Positive Trend
64	31	74.5	421.5	Positive Trend
65	31	74.5	421.5	Positive Trend
66	33	64	497	Positive Trend
67	33	64	497	Positive Trend
68	33	64	497	Positive Trend
69	33	64	497	Positive Trend
70	35	72	558	Positive Trend
71	35	72	558	Positive Trend
72	35	108	522	Positive Trend
73	35	108	522	Positive Trend
74	37	188.5	514.5	Positive Trend
75	37	188.5	514.5	Positive Trend
76	37	233.5	469.5	Positive Trend
77	37	233.5	469.5	Positive Trend

Table 31. RESULTS OF MODIFIED COX-STUART TEST ON MARKET SECURITY 6 - Continued

INITIAL SAMPLE SIZE = 97

NUMBER OF POINTS IN NEUTRAL CORRIDOR = 3

PERIODS	NONZERO DIFFS.	SUM '+' RANKS	SUM '-' RANKS	RECOMMENDATION
78	37	255	448	Positive Trend
79	37	255	448	Positive Trend
80	39	342.5	437.5	
81	39	342.5	437.5	
82	41	413.5	447.5	
83	41	413.5	447.5	
84	42	464.5	438.5	
85	42	464.5	438.5	
86	41	447.5	413.5	
87	41	447.5	413.5	
88	43	494.5	451.5	
89	43	494.5	451.5	
90	44	483	507	
91	44	483	507	
92	45	472	563	
93	45	472	563	
94	47	511	617	
95	47	511	617	
96	47	486.5	641.5	
97	47	486.5	641.5	

Table 32. RESULTS OF MODIFIED COX-STUART TEST ON MARKET SECURITY 7

INITIAL SAMPLE SIZE = 26

NUMBER OF POINTS IN NEUTRAL CORRIDOR = 5

PERIODS	NONZERO DIFFS.	SUM '+' RANKS	SUM '-' RANKS	RECOMMENDATION
6	3	4	2	
7	3	4	2	
8	3	2	4	
9	3	2	4	
10	5	5	10	
11	5	5	10	
12	6	8	13	
13	6	8	13	
14	7	17	11	
15	7	17	11	
16	8	26	10	
17	8	26	10	
18	9	28	17	
19	9	28	17	
20	10	32.5	22.5	
21	10	32.5	22.5	
22	11	45	21	
23	11	45	21	
24	12	63.5	14.5	Negative Trend
25	12	63.5	14.5	Negative Trend
26	13	77	14	Negative Trend

APPENDIX I

RESULTS OF KENDALL'S TESTS

Table 33. RESULTS OF KENDALL'S TEST ON MARKET SECURITY 2

Initial Sample size = 39

PERIODS	TEST STAT.	RECOMMENDATION
6	26	
7	48	
8	53.5	
9	53.5	
10	105.5	
11	107	
12	115	
13	127.5	Positive trend !
14	127.5	Positive trend !
15	178	Positive trend !
16	344	Positive trend !
17	534.5	
18	765	
19	1039	
20	1401.5	
21	1801	
22	2263	
23	2767	Negative trend !
24	3313.5	Negative trend !
25	3753	Negative trend !
26	4142.5	Negative trend !
27	4347.5	Negative trend !
28	4829	Negative trend !
29	5198	
30	5343.5	
31	5343.5	
32	5345.5	
33	5351.5	
34	5499.5	
35	5559.5	
36	5735	
37	5787.5	Positive trend !
38	5787.5	Positive trend !
39	5787.5	Positive trend !

Table 34. RESULTS OF KENDALL'S TEST ON MARKET SECURITY 3

Initial Sample size = 55

PERIODS	TEST STAT.	RECOMMENDATION
6	20	
7	50	
8	90.5	
9	162.5	
10	232.5	
11	316.5	
12	364.5	
13	466	
14	570	
15	676.5	
16	676.5	
17	825	
18	990.5	
19	1184.5	
20	1400.5	
21	1745	
22	2193.5	
23	2332	
24	2479.5	
25	2729	
26	2996	
27	3600	
28	4166	
29	4215.5	
30	4295.5	
31	4381.5	
32	4381.5	
33	4381.5	
34	4383.5	Positive trend !
35	4388	Positive trend !
36	4394	Positive trend !
37	4402	Positive trend !
38	4402	Positive trend !
39	4402	Positive trend !
40	4402	Positive trend !
41	4402.5	Positive trend !
42	4431	Positive trend !
43	4444.5	Positive trend !
44	4450	Positive trend !
45	4450	Positive trend !
46	4498	Positive trend !

Table 34. RESULTS OF KENDALL'S TEST ON MARKET SECURITY 3 - Continued

Initial Sample size = 55

PERIODS	TEST STAT.	RECOMMENDATION
47	4502	Positive trend !
48	4675.5	Positive trend !
49	5516.5	Positive trend !
50	6114	Positive trend !
51	6450	Positive trend !
52	6605.5	Positive trend !
53	6873	Positive trend !
54	7063.5	Positive trend !
55	7253.5	Positive trend !

Table 35. RESULTS OF KENDALL'S TEST ON MARKET SECURITY 4

Initial Sample size = 30

PERIODS	TEST STAT.	RECOMMENDATION
4	14	
5	31.5	
6	41.5	
7	54	
8	77.5	
9	149.5	
10	173	
11	173	
12	299	
13	455	
14	622.5	
15	832.5	Negative trend !
16	1070.5	Negative trend !
17	1342.5	Negative trend !
18	1640.5	Negative trend !
19	1829	Negative trend !
20	1865.5	Negative trend !
21	1865.5	
22	1867.5	
23	1873.5	
24	1873.5	
25	1873.5	
26	1897.5	Positive trend !
27	1913	Positive trend !
28	1927	Positive trend !
29	1927	Positive trend !
30	1927	Positive trend !

Table 36. RESULTS OF KENDALL'S TEST ON MARKET SECURITY 5

Initial Sample size = 40

PERIODS	TEST STAT.	RECOMMENDATION
8	33.5	
9	61.5	
10	85.5	
11	124	
12	171.5	
13	228.5	
14	326.5	
15	484.5	
16	575.5	
17	677	
18	677	
19	677	Positive trend !
20	696.5	Positive trend !
21	721	Positive trend !
22	735	Positive trend !
23	735	Positive trend !
24	735	Positive trend !
25	746.5	Positive trend !
26	746.5	Positive trend !
27	754.5	Positive trend !
28	766.5	Positive trend !
29	788.5	Positive trend !
30	792	Positive trend !
31	796.5	Positive trend !
32	822	Positive trend !
33	891.5	Positive trend !
34	1053.5	Positive trend !
35	1288	Positive trend !
36	1502	Positive trend !
37	1502	Positive trend !
38	1504	Positive trend !
39	1508	Positive trend !
40	1510.5	Positive trend !

Table 37. RESULTS OF KENDALL'S TEST ON MARKET SECURITY 6

Initial Sample size = 97

PERIODS	TEST STAT.	RECOMMENDATION
4	15.5	
5	30	
6	40	
7	40	
8	40.5	
9	62.5	
10	114.5	
11	199.5	
12	239.5	
13	239.5	
14	241.5	Positive trend !
15	451.5	
16	580	
17	590.5	
18	630	
19	763.5	
20	895	
21	1053	
22	1215.5	
23	1359	
24	1601.5	
25	1933.5	
26	2277	
27	2599	
28	2652.5	
29	2652.5	Positive trend !
30	2654.5	Positive trend !
31	3306.5	Positive trend !
32	4298.5	
33	5354.5	
34	6451	
35	7298.5	
36	7912.5	
37	7920	
38	7940	
39	8662.5	
40	9308.5	
41	10008	
42	10008	
43	10072.5	
44	10856	

Table 37. RESULTS OF KENDALL'S TEST ON MARKET SECURITY 6 - Continued

Initial Sample size = 97

PERIODS	TEST STAT.	RECOMMENDATION
45	11095	Positive trend !
46	11171	Positive trend !
47	11255.5	Positive trend !
48	11375	Positive trend !
49	11381.5	Positive trend !
50	11505.5	Positive trend !
51	11505.5	Positive trend !
52	11505.5	Positive trend !
53	11505.5	Positive trend !
54	11511.5	Positive trend !
55	11527	Positive trend !
56	11541	Positive trend !
57	11563.5	Positive trend !
58	11831	Positive trend !
59	11877	Positive trend !
60	12594	Positive trend !
61	13651	Positive trend !
62	14459.5	Positive trend !
63	16691	Positive trend !
64	19345.5	Positive trend !
65	22237	Positive trend !
66	24305.5	Positive trend !
67	27870	Positive trend !
68	32284	Positive trend !
69	36391	Positive trend !
70	41067	Positive trend !
71	45921.5	Positive trend !
72	51033.5	
73	56287.5	
74	61685.5	
75	67232	
76	72932	
77	78773.5	
78	84521.5	
79	90635	
80	96908.5	
81	103356.5	
82	109929	Negative trend !
83	116202.5	Negative trend !

Table 37. RESULTS OF KENDALL'S TEST ON MARKET SECURITY 6 - Continued

Initial Sample size = 97

PERIODS	TEST STAT.	RECOMMENDATION
84	121067	Negative trend !
85	126268.5	Negative trend !
86	128226	Negative trend !
87	130789	Negative trend !
88	132475.5	
89	132821.5	
90	132821.5	
91	132821.5	
92	132823.5	
93	133225	
94	133283.5	
95	133479.5	
96	133940	
97	134600.5	

Table 38. RESULTS OF KENDALL'S TEST ON MARKET SECURITY 7

Initial Sample size = 26

PERIODS	TEST STAT.	RECOMMENDATION
6	46	
7	58	
8	74	
9	134	
10	186	
11	277.5	
12	349.5	
13	385.5	
14	545.5	
15	755.5	
16	993.5	Negative trend !
17	1049	
18	1049	
19	1051	
20	1165	
21	1573	
22	2019	
23	2525	
24	3077	
25	3677	Negative trend !
26	4327	Negative trend !

APPENDIX J

RESULTS OF NEW EMPIRICAL METHOD

Table 39. RESULT OF TEST WITH NEW EMPIRICAL METHOD ON MARKET SECURITY 2

Points in neutral corridor ==> 5

Upper boundary => 45.5 Lower boundary => 43.75

NUMBER OF POINTS	TEST STATISTIC RATIO	SIGNAL
38	1.208636	Positive trend !
39	2.426475	Positive trend !

Table 40. RESULT OF TEST WITH NEW EMPIRICAL METHOD ON MARKET SECURITY 3

Points in neutral corridor ==> 5

Upper boundary => 58.5 Lower boundary => 56.125

NUMBER OF POINTS	TEST STATISTIC RATIO	SIGNAL
33	1.099998	Positive trend !
34	1.32438	Positive trend !
35	1.52925	Positive trend !
36	1.866536	Positive trend !
37	2.264048	Positive trend !
38	2.725309	Positive trend !
39	3.365859	Positive trend !
40	4.018759	Positive trend !
41	4.626633	Positive trend !
42	4.905608	Positive trend !
43	5.393173	Positive trend !
44	5.901108	Positive trend !
45	6.6604	Positive trend !
46	6.964272	Positive trend !
47	7.536541	Positive trend !
48	7.594529	Positive trend !
51	7.146586	Positive trend !
52	7.324341	Positive trend !
53	7.433609	Positive trend !
54	7.596066	Positive trend !
55	7.781936	Positive trend !

Table 41. RESULT OF TEST WITH NEW EMPIRICAL METHOD ON MARKET SECURITY *4*

Points in neutral corridor ==> 3

Upper boundary => 86 Lower boundary => 83.5

NUMBER OF POINTS	TEST STATISTIC RATIO	SIGNAL
22	1.254642	Positive trend !
23	1.306354	Positive trend !
24	2.150102	Positive trend !
25	2.961543	Positive trend !
26	3.048129	Positive trend !
27	3.340749	Positive trend !
28	3.704159	Positive trend !
29	5.090116	Positive trend !
30	7.359515	Positive trend !

Table 42. RESULT OF TEST WITH NEW EMPIRICAL METHOD ON MARKET SECURITY 5

Data correspond to ===> MARKET SECURITY 5

Points in neutral corridor ==> 7

Upper boundary => 47.75 Lower boundary => 43.75

NUMBER OF POINTS	TEST STATISTIC RATIO	SIGNAL
28	1.136184	Positive trend !
29	1.192074	Positive trend !
30	1.292359	Positive trend !
31	1.384931	Positive trend !
32	1.458309	Positive trend !
33	1.49471	Positive trend !
34	1.503407	Positive trend !
35	1.48166	Positive trend !
36	1.477168	Positive trend !
37	1.702656	Positive trend !
38	1.82248	Positive trend !
39	1.948561	Positive trend !
40	2.141253	Positive trend !

Table 43. RESULT OF TEST WITH NEW EMPIRICAL METHOD ON MARKET SECURITY 6

Data correspond to ===> MARKET SECURITY 6

Points in neutral corridor ==> 3

Upper boundary => 71.875 Lower boundary => 69.375

NUMBER OF POINTS	TEST STATISTIC RATIO	SIGNAL
54	1.042072	Positive trend !
55	1.08077	Positive trend !
56	1.176833	Positive trend !
57	1.250869	Positive trend !
58	1.243901	Positive trend !
59	1.28476	Positive trend !
92	1.764774E+10	Positive trend !
93	1.728758E+10	Positive trend !
94	1.694183E+10	Positive trend !
95	1.660963E+10	Positive trend !
96	1.629022E+10	Positive trend !
97	1.598286E+10	Positive trend !

Table 44. RESULT OF TEST WITH NEW EMPIRICAL METHOD ON MARKET SECURITY 7

Data correspond to ===> MARKET SECURITY 7

Points in neutral corridor ==> 5

Upper boundary => 63.75 Lower boundary => 60.75

NUMBER OF POINTS	TEST STATISTIC RATIO	SIGNAL
16	1.102831	Negative trend !
22	1.722097	Negative trend !
23	3.073235	Negative trend !
24	4.58988	Negative trend !
25	6.201894	Negative trend !
26	7.920076	Negative trend !

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