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Much of the progress that researchers in strategic management, organization theory, marketing and industrial organization economics have achieved in understanding the determinants of firm performance has been based on comparative studies. Typically in these studies, performance as a dependent variable has been characterized by its average magnitude. A few studies have also incorporated a measure of the dispersion of performance (i.e. its variance or standard deviation). The present paper shows how these approaches to performance measurement are seriously flawed. An alternative approach is proposed and illustrated. This alternative is tied directly to the concept of uncertainty as encountered in both economic and organization theories. The managerial relevance of the alternative approach is established. Spectral methods are used to operationalize the alternative approach.

Conceptual Overview

The usual approach to comparative studies of performance has been to use some form of linear statistical model (often multiple regression) with the magnitude of performance as the dependent variable. Independent variables have included various market structure, organizational, strategy and marketing variables. Typical of such studies are Schendel and Patton (1978), Hambrick (1983), Stigler (1963), Hall and Weiss (1967) and Rumelt (1974). In spite of the popularity of this approach it ignores the risk associated with the performance measures. This is obviously a severe simplification since, for example, of two equal returns the one with less risk will be preferred. More generally, the concept of stochastic dominance can be applied to compare different performance distributions (Mahajan, Wind & Bradford, 1983). Some researchers have incorporated risk into their models by using the variation of average performance, measured by the variance or standard deviation as an ex post risk measure (e.g., Winn, 1975; Bettis and Hall, 1982; Armour and Teece, 1978; Fisher and Hall, 1969; Bowman, 1980).

Whereas, comparative studies of performance at the level of accounting data have generally ignored risk considerations, financial economists have developed sophisticated models of risk and return at the security market level. These models represent a promising approach for some research. However, they cannot fully replace accounting level studies but only supplement them for a number of reasons. Most large firms are substantially diversified. This makes it extremely difficult to measure the impact any one particular business has on the firm's stock price. The problem is magnified when it is necessary to study an industry the constituents of which are all parts of the various diversified firms. The popularity of the PIMS database reflects the utility of accounting level data in such situations. At the other end of the spectrum, many firms are privately held and hence do not have a stock price. Furthermore, in many countries of the world, state owned enterprise is the major ownership arrangement.

On a more pragmatic level, it can be argued that accounting returns are more directly under the control of management than market returns. Furthermore, as Beaver, Kettler and Scholes (1970) have shown, accounting and market performance measures are correlated. Hence, study at one level supplements study at the other level. Studies using either type of performance measure have a place.

Having established the nature of performance measurement in strategic management, marketing, and industrial organization economics, a discussion of some serious flaws in the standard measurement methodology will now be developed. In particular, the problems with the use of magnitude and variation measures for return and risk will be discussed.

Magnitude and Variation Approach

As discussed above the typical performance study has used an average magnitude (e.g., ROA, ROE, profits) and a few have also used a variation measure of risk which is usually the variance or standard deviation of the average magnitude measure. For several reasons this mean/variance approach is in error.

The mean/variance approach assumes implicitly that performance measurement is path independent and this is obviously not the case. Consider Figure 1 where four separate time series of eight observations each of some assumed performance variable are plotted. In this figure, examples "A" and "B" have the same mean and variance. "A" is a positively sloped relation over time while "B" is negatively sloped (same slope). Both "A" and "B" have the same mean and variance, but does this mean that they display identical performance? Surely by any reasonable definition "B" has a higher risk profile and a lower performance level. Consider also examples "C" and "D" in Figure 1. Here again the mean and variance are identical but the nature of performance would seem to be substantially different. There is a substantial qualitative (and it will turn out quantitative) difference here in performance that escapes the mean/variance approach. It is interesting to note that a complete random time history of performance could be constructed with mean and variance identical to either pair of examples. Furthermore, consider the managerial problems raised by these four different time series. Certainly, from a managerial viewpoint the four histories are substantially different. For example, management of a positive trend ("A") is obviously different from the management to rapidly fluctuating performance ("C"). Although these examples are obviously contrived they are illustrative of the general principles involved. (Later in the paper examples from actual firms will be presented to show that these dramatic differences do occur.)

As will be discussed below, adjacent values are often autocorrelated in firm performance variables such as profits. This autocorrelation significantly biases the uses of the sample mean and variance (or standard deviation) as performance measures. If the data have positive autocorrelation and if they are above the mean, they are likely to continue above the mean for some period of time and the same can be said for observations below the mean at a particular time. Thus we have runs of consecutive observations away from the mean. This may bias a sample estimate of the mean and will generally spread out the distribution of estimates of the mean around its expected value, biasing the estimates of variance. (For negative autocorrelation, quite the opposite situation is true, but this does not seem to occur in most performance measurements.) Overall, the important result to remember is that the mean/variance approach by ignoring autocorrelation derives biased estimates of performance.

Time Series Data

Time series data and the associated statistical models vary significantly from the data and models that are typically encountered in classical statistics. (The mean/variance approach is derived from classical statistics.) Because of this it will be useful to establish the general nature of the differences before proceeding to a discussion of an alternative to the mean/variance approach.

Time series are observed in connection with a wide range of phenomena. Among the most prominent are a wide range of economic data.

It is possible to describe a wide range of time series by using stochastic processes. Possible values of the times series at a given time t are assumed to be described by a random variable X (t) and its associated probability distribution. The observed value x (t) of the time series at time t is then regarded as one of an infinity of values that the random variable X (t) might have taken at time t. The behavior of the time series can at all times be described by a set of random variables $\{X(t)\}$ where the time variable t can take on any value from $+\infty$ to $-\infty$. Time series can in practice be either discrete or continuous with economic time series usually being discrete. From this basic model of a time series as a stochastic process powerful statistical techniques have been developed, some of which are discussed below.

Time series are said to be either stationary or non-stationary. Qualitatively, a stationary series is one which is in statistical equilibrium, in the sense that it contains no trends, whereas a non-stationary series is such that its properties change with time. More precisely, a stationary process will have mean and variance that do not change with time and the covariance between two values of the process at two time points will depend only on the distance between these time points and not on time itself. Most statistical techniques require stationary series. However, there are various techniques for converting non-stationary series into stationary series without significant loss or distortion of information. Also, many statistics are relatively robust to the presence of some non-stationarity.

In classical statistics observed values can normally be assumed to be independent. If the probability distribution associated with the measurements is normal (or if the Central Limit Theorem applies) it can be completely characterized by its mean and variance (or standard deviation). This is the basis for most of classical statistics. This is the basis of the mean/variance approach to performance measurement discussed above. Such is <u>not</u> the case for most time series. In general, neighboring values of a time series will be correlated. Hence in addition to specifying the mean and variance, it is necessary to specify the dependence among values. By not specifying this dependence among values, the mean/variance approach ignores an important parameter of the data.

Trend, Cyclical, Stochastic Approach

Given the foregoing discussion of the basic properties of time series, it is now possible to discuss an alternative approach to measuring performance: the trend, cyclical, stochastic approach. The motivation behind this approach is twofold. First, an alternative approach should consider the underlying dependency among the values in a time series. In operational terms this means that the approach should be able to discriminate among series such as those in Figure 1. Second, the alternative approach should have theoretical and managerial relevance. Here, as we shall see below, it would be useful to determine the "amount" of uncertainty in a performance measurement. This follows from the central role that uncertainty plays in both economic and organization theories.

The general approach is to decompose the time series into a deterministic pattern or patterns and a stationary stochastic process. More specifically we seek to decompose a performance measurement into its trend, cyclical, and stochastic components. We will refer to this as the "TCS approach" in contrast to the mean/variance approach. Then verbally one can decompose performance as (assuming an additive relationship):

Performance = Trend + Deterministic Cycles + Stationary Stochastic Process

The first component of the model is <u>trend</u>. This will usually be linear trend, but it need not be linear. For example, it could be quadratic. (Notice that the removal of trend eliminates a significant source of non-stationarity.) The second component of the model consists of <u>deterministic cycles</u>. These are sinusoids that have <u>relatively</u> precise and stationary cyclicities. Actually here the distinction between deterministic and non-deterministic is more a matter of degree than kind. As a later discussion will show, it will be relatively easy to distinguish the two cases with actual data. Examples of deterministic cycles in performance data might include a seasonal cycle (in quarterly data) or the business cycle. The final component is a <u>stationary stochastic process</u>. Here the underlying dependence between values (i.e. the autocorrelation) structure becomes a parameter as discussed above.

Proceeding beyond verbal description, the alternative approach can be specified mathematically as the following additive model:

$$X_t = T_t + C_{t1} + C_{t2} + \dots C_{tn} + S_t$$

where X_t is the time series value at time t,

T_t is the trend component at period t

$C_{t1}, C_{t2}, \dots C_{tn}$ are the n cyclical components at time t, and

S_t is the stationary stochastic component at time t.

Furthermore, if we assume a linear trend, the trend and cyclical components can be specified as:

$$T_t = A \cdot t + B,$$

$$C_t = D \cdot \sin(2\pi ft + \phi),$$

where A, B, D, and ϕ are parameters that can be estimated from the data, and f is the frequency in cycles per unit time. Furthermore, D and ϕ will in general be functions of f.

Figure 2 illustrates graphically how a time series can be reprsented as the sum of trend, cyclical, and stochastic components. As will be shown below it is methodologically possible and meaningful to perform this decomposition on real data.

It should be noted that decompostions of this sort are not new. As Makridakis, Wheelwright and McGee (1983:131) note, decompostion methods are among the oldest forecasting approaches, having been used in the beginning of this century by economists studying the business cycles. Furthermore, decomposition methods are widely used in forecasting today. The use of decomposition methods in the present paper is aimed at goals somewhat different from those of forecasting.

The TCS approach as discussed and illustrated above has certain advantages over the mean/variance approach. The TCS approach overcomes the path independence problems with the mean/variance approach. The TCS approach will discriminate significantly among the four examples shown in Figure 1. It considers the underlying autocovariance structure of performance measures which the mean/variance approach ignores. Finally it separates qualitatively different performance components that are theoretically and managerially relevant. Furthermore, important managerial tasks in a particular firm will be a function of the relative proportions of each particular component. These final points require further comment.

Table 1 shows how the three TCS components are likely to affect some important managerial dimensions: forecastability, market valuation, key risk, key decision, and key strategic variable. For a particular firm the managerial dimensions vary in relationship to the amounts of trend, cyclical and stochastic components in the earning stream.

Forecastability will obviously be high for the trend and will tend to be a bit less so for the cyclical component. However, it will generally be much less so for the stochastic component. What little forecastability there is in the stochastic component will derive from the presence of a detectable autocorrelation structure. This variability in forecastability is obviously merely a variation in uncertainty or risk across the three TCS components. (Higher forecastability implies lower uncertainty.) The concept of risk or uncertainty is a central component of modern economic theory. (See, for example, Arrow, 1974.) Economic theory suggests that, ceteris parabis, because of risk aversion, individuals will demand higher returns for holding riskier assets (i.e. assets with more uncertain or less forecastable returns). Building on this result, theorists in financial economics have developed an elegant theory relating uncertainty and returns in the capital markets (e.g., Copeland and Weston, 1983). This suggests that the TCS approach is particularly useful because it allows a separation of performance measures into certainty and uncertainty components which can then be tied back to the theory of risky assets such as valuation of the firm.

The variation in forecastability or uncertainty results in a variation in market valuation of the firm. Investors are interested in forecastability of performance. Because investors are risk averse, they will pay a premium for the uncertainty reduction that increased forecastability brings. As Salter and Weinhold put it:

> Managers should not forget the intuitively obvious point that future cash flows that can be forecast with greater confidence will be less severely discounted by the marketplace and have a higher market value (1979, p. 107).

Hence, ceteris parabis, trend will provide a positive premium (even if negative the forecastability will increase value above similarly poor but unforecastable results) in the value of the stock. The cyclical component will provide a similar premium but less so, while the stochastic is likely to decrease value.

With trend the key risk points are barriers to entry and exit. For a positive trend barriers to entry are important because stable and increasing performance are likely to attract new entrants who could potentially compete away the profits. For a negative trend barriers to exit come into play because here it is important to be able to exit an industry that is becoming increasingly unattractive. For the cyclical component cash flow is an important risk point because by definition of a performance cycle there will be periods of high and low cash flow. (In highly cyclical business (e.g., agriculture) bank loans are often used to bridge the cash troughs.) For the stochastic component again cash flow is important to bridge unanticipated reductions of earnings. Here because of the inherent inability to forecast, the risk is likely to be significantly higher than with the cyclical component.

With positive trend the key decision is obviously the timing and size of capacity additions, while with negative trend it is the timing and size of capacity reductions. For the cyclical component the key decision is what cost structure will be used. A heavily fixed cost structure can be used with a "level production/build for inventory" manufacturing strategy while a variable cost structure can be used with manufacturing strategy to "chase demand." (See Buffa and Miller, 1979, for a complete description of these strategies.) There are numerous intermediate choices. With the stochastic component the key decision focuses on the cost of holding slack resources versus choosing not to and perhaps foregoing profit opportunities. (In this discussion of key decisions it was implicitly assumed that performance fluctuations reflect sales fluctuations. This assumption may <u>not</u> hold under all circumstances but the authors believe it reflects the vast majority of circumstances. This assumption is also extended into the following discussion of key strategic variables.)

For the trend component it would seem that the growth rate compared to the industry growth rate is the key strategic variable for a positive trend while the decline rate compared to industry decline rate would be key for a negative trend. Here it is generally important to grow at least as fast as the industry or to decline no faster than the industry in order to avoid losing market share although a harvest strategy would run the other way. In either case the focus is on comparison to industry performance. For the cyclical component the key strategic variable is both size and cost structure of capacity. This will determine the strategy for responding to ups and downs as discussed earlier. For the stochastic component it is key to have adequate flexibility to respond to unforecastable future performance developments.

Having conceptually discussed the TCS approach and its merits vis-a-vis the mean/variance approach, it is now necessary to discuss a methodology for operationalizing the TCS approach.

Operationalizing the TCS Approach

In order to operationalize the TCS approach it is necessary to find a methodology to decompose a performance history into its trend, cyclical and stochastic components as shown in Figure 2. Such a decomposition should provide at least a rough estimate of the importance of each of the three components.

The methodology discussed below is one in which the trend is estimated and removed by regression analysis and then cyclical and stochastic components are examined by using spectral analysis.

Estimating and Removing Trend

A straight forward approach to estimating and removing trend is to use a simple regression against time. Since trend can be nonlinear, various powers or polynomials of time could be used in addition to a simple linear model. (Examination of numerous time histories suggest to the authors that for profits a simple linear regression will provide an appropriate estimate in many if not most cases.) Using simple regression, the coefficient of determination (R^2) can be used to measure how important trend is, since it measures the percentage of variance explained by the regression. For example, a coefficient of determination of .80 (meaning 80% of the variance is trend) obviously suggests that trend is the dominant component, while a coefficient of .20 (meaning 20% of the variance is trend) suggests that trend is only a small proportion of the variance.

Having run the regression, the trend can be removed from the time series. The resulting residuals can be used to estimate cyclical and stochastic components.

Estimating Cyclical and Stochastic Components

In order to discuss the estimation of cyclical and stochastic components, it is necessary to develop some fundamental concepts of spectral analysis. This discussion will necessarily be brief. The reader interested in a more complete discussion should consult one of the standard references (e.g., Chatfield, 1980; Jenkins and Watts, 1968; Koopmans, 1974; Bloomfield, 1976). The concept of spectral analysis has its foundation in Fourier techniques to which we now turn.

The analytic techniques developed by Jean-Baptiste-Fourier (1768-1830) have played a crucial role in the development of modern mathematics. Fourier was able to show that any function could be represented as a sum of weighted sines and cosines. (This is in itself a rather amazing result.) Figure 3 shows a sine wave with amplitude A, frequency f, period T which is equal to 1/f, and phase ϕ. This sine wave can be described by the expression:

$$X(t) = A \sin (2\pi ft + \phi)$$

A cosine wave could be similarly represented except that it would be displaced by 90% (or 1/4 T) from a sine wave of the same freqency, and phase. The Fourier representation of a function is simply a sum of sine and cosine waves. Specifically, given a set of n observations of a time series, the purpose of Fourier analysis is to compute m coefficients a_o, a_1, ..., a_k and b_1, b_2, ..., b_k, where k = (m-1)/2 which satisfy the equation:

$$x(t) = \frac{a_o}{2} + \sum_{f=1}^{k} \left[a_f \cos \left(\frac{2\pi ft}{m} \right) + b_f \sin \left(\frac{2\pi ft}{m} \right)\right].$$

Once the coefficients have been computed, they are converted into amplitudes and phase angles for each of the k frequencies. For present purposes, we are more interested in the amplitude than the phase, and hence the important output is a plot of the amplitude as a function of frequency.

Spectral analysis can be described as the result of applying Fourier methods to the statistical analysis of time series. Conceptually, the difference between Fourier analysis and spectral analysis is that we are dealing with an underlying process and hence are estimating coefficients instead of exactly specifying them. The practical result of spectral analysis is a plot of the spectral density (which is a function of the amplitude) versus frequency. Spectral density roughly corresponds to probability density in standard statistics since the integral of both is equal to one.

If a regular cyclical component is present in a time series, then since by definition it occurs at a single frequency, it will show up as a sharp spike at that frequency. By contrast when there are no regular typical components in a time series, the spectrum will tend to be a smooth function of frequency with no sharp spikes. Therefore, for the present purposes, deterministic cycles in performance data can be detected as spikes in the spectrum. It will turn out that, at least visually, it will be a simple matter to isolate the cyclical component from the stochastic component in performance data using spectral analysis.

With this conceptual discussion of the TCS approach in mind we now turn to a specific discussion of the methodology, hypotheses and data employed to illustrate and study the application of the TCS approach.

Hypotheses, Data and Methodology

In order to test the applicability of the TCS approach a sample of 36 firms were drawn from the Fortune 500. More specifically the sample was drawn as a subsample of Rumelt's (1974, 1977) sample. This was done since Rumelt's random sample is well documented. Furthermore, it was decided that only firms that had not changed diversification strategy during the time period of the study should be included. This was done because a change of diversification strategy was judged, based on the work of Rumelt (1974, 1977), Montgomery (1979) and Bettis (1981), to substantially alter the performance in terms of both risk and return. (It should be noted that this sample was used primarily to test the applicability of the TCS approach and not primarily to study diversification strategy.)

As a performance measure the authors decided to use profits. The choice was somewhat arbitrary.[1] Measures such as return on equity or return on assets could also have been used.

Quarterly earnings were used as the specific profit measure and were collected for the period 1959 through 1982. This resulted in 92 observations per firm which was substantially more than the analysis required. (A minimum of about 60 data points are required for the spectral analysis.) The sample size resulted from the intersection of those firms for which the required quarterly profit figures were available and those firms which had retained the same diversification strategy from 1959 till 1982. The sample summarized in Table 2 included 3 single business firms, 12 dominant business firms, 17 related business firms and 4 unrelated business firms. (See Table 2 for a breakdown into diversification subcategories. The attached appendix gives a brief description of these diversification categories suggested by Rumelt.)

The hypotheses to be examined were, given the innovative nature of the methodology, exploratory in nature. The first hypothesis (H1) was designed to examine whether the TCS approach overcame some shortcomings of the magnitude/variation approach.

> H1: The TCS approach will detect significant differences in performance where the magnitude/variation approach does not.

The second hypothesis (H2) was designed to take advantage of the stratification of the database across diversification strategies. The magnitude/variation approach has been used to detect differences in performance across related and unrelated diversification strategies by Bettis and Hall (1982). Following directly from this the second hypothesis was formulated as:

> H2: Systematic variation in the TCS components will be found across diversification strategies.

In order to examine these two hypotheses, the method of operationalizing the TCS approach described above was used. The first step was to run linear regressions against time for all of the sample firms. The slope and adjusted R^2 of these regressions appear in Table 2.

The residuals from these regressions were then analyzed to estimate the power spectral density content. In accomplishing this a Parzen spectral window (see Jenkins and Watt:240-257) was utilized. Plots of some of the spectral density functions appear in Figures 4-11.

Results

Table 2 shows the overall means and standard deviations across the time series of quarterly profits for each individual firm. This table also gives the adjusted R^2 for the linear regression fitted to each firm's profit history.[2] As this table shows the percent of variance explained by trend varies from 19% (U.S. Steel) to 85% (Crown Cork and Seal) with an overall average of 62%. These results suggest that on the average over long time periods, a linear trend explains the majority of profit fluctuations for large firms such as those in the sample. Furthermore, the results show that the magnitude/variation approach in using the variance (or standard deviation) as a measure of variation is on the average primarily measuring a forecastable trend instead of an uncertainty or risk component since on average 62% of the variance was trend.

Table 3 breaks down the results of the trend analysis by diversification categories. Because of the limitations of the sample only five categories out of Rumelt's eight are represented and representation is highly uneven across categories. These limitations place some restrictions on the conclusions that can be drawn from this table. In particular, the fact that three of the categories are represented by fewer than five firms, statistical comparisons across categories is not likely to be useful. However, the authors do believe that the results are suggestive of some tentative conclusions. Trend appears to be the dominant component for the single business and constrained (dominant and related) categories, accounting for more than 70% of the variance, while the cyclical and stochastic components are equally important for the vertically integrated and unrelated firms where they account for about 50% of the variance. Therefore, given Rumelt's (1974, 1977) conclusions about diversification category and performance, it would appear that firms in high performing diversification categories (as defined by Rumelt) tend to have profits that primarily and consistently grow on trend, whereas for firms in low performing diversification categories the sum of the cyclical and stochastic components of profits tend to be as important as trend.

This result is in sharp contrast to what might have been expected on normative grounds. Normatively, one would have expected that increasing diversification would have reduced the relative importance of the cyclical and stochastic components, since they would tend to cancel out as different businesses are pooled together in a diversified firm. In fact, in financial economics, using market returns, the construction of portfolios of stocks reduces the random component of risk (unsystematic risk) so that only the component correlated to overall market returns (systematic risk) is left.

Returning to our first hypothesis (H1), that the TCS approach will detect significant differences where the magnitude/variation will not, we need to find a minimum of two firms with which to test this. Koppers and Allis Chalmers are such firms. As shown in Table 2, Koppers' mean quarterly profit level is 8% higher than that of Allis Chalmers while the standard deviation of profits is 2% lower, making the firms almost identical from the perspective of the magnitude/ variation approach. However, notice that trend accounts for 58% of the variance in Koppers' profit history but only 22% of the variance in Allis-Chalmers' profit history. In other words, trend accounts for over half of the variance in Koppers' profits but less than one-fourth of the variance in Allis-Chalmers' profits. From this we can immediately surmize that Allis-Chalmers is more risky although the magnitude/variation approach would roughly equate the riskiness of the two firms.

Furthermore, Figure 4.5 shows plots of spectral density for these two firms.[3] As the figure shows Koppers has a sharply pronounced peak at a frequency of .25 (period of 4 quarters) corresponding to a seasonal cyclicality. By contrast Allis-Chalmers has a much less pronounced (broader) peak at frequencies of .50 (period of 2 quarters) and approximately .21. This leads us to conclude that for Allis-Chalmers the stochastic component dominates while for Koppers trend dominates with a strong seasonal (annual) cycle but with relatively little stochastic content. Hence the TCS approach does provide a measure of significant and substantial differences in the profit histories of these two firms that the magnitude/variation approach does not detect. Furthermore, the TCS approach suggests that the management tasks will vary widely in these two firms as summarized in Table 1.

Similar to Figures 4 and 5 spectrum plots were generated for each of the firms in the sample. These were then examined to determine systematic differences across diversification strategies. A thorough examination of these plots failed to detect any systematic differences. This combined with the earlier discussion about the importance of trend across diversification categories (Table 3) suggests that the second hypothesis cannot be adequately supported by the current study. However this examination of the spectral content of firms in the sample did produce some interesting insights to which we now turn.

Figures 6-8 illustrate the presence of cyclical components across various diversification categories. Figure 6 shows Maytag's (trend = 72% of variance) spectrum with a strong seasonal cycle (period = 4) and a second strong cycle at a period of about 5 years (20 quarters) which probably corresponds to the business cycle and/or the consumer durable cycle. Hence Maytag represents a single business firm the profit history of which is dominated by trend but which also has a couple of strong cycles. By contrast Figure 7 shows Olin (trend = 26% of variance), an unrelated diversifier, also with a strong seasonal cycle which dominates the spectrum. At an intermediate level of diversification (related-constrained) Figure 8 shows General Foods (trend = 73% of variance) with a strong seasonal cycle and a strong cycle of about 6 1/2 years. These three spectra illustrate that cyclical components can be present and be strong across diversification strategies.

Figures 9-11 illustrate situations where the stochastic component dominates the spectrum. Figure 9 shows Revlon (trend = 75% of variance) a dominant constrained firm, with virtually no significant periods and with only 25% of the variance in the stochastic component. Figure 10 shows the spectrum of Kimberly-Clark (trend = 38% of variance), a dominant vertical firm, with virtually no distinguishable periods but substantial (62%) of the variance in the stochastic component. Forecasting profits for this firm would indeed be a difficult task. Finally, Figure 11 shows Minnesota Mining and Manufacturing (trend = 83% of variance), a related-linked firm, with virtually no distinguishable periods and with only 17% of the variance in the stochastic component.

In sum, these eight spectra (Figures 5-11) illustrate the broad range of spectra found in the sample. The relative proportions of the three TCS components can vary widely among firms.

Discussion

Overall, the present paper demonstrates the usefulness of the TCS approach to performance measurement. The magnitude/variation approach, a clear improvement over the use of a magnitude measure only, is conceptually flawed because it fails to separate trend from the variance as a stability measure (Remember that for the sample of firms trend accounted for more than 50% of the variance.) and does not in general consider the autocorrelation structure present in most time series. Furthermore, conceptually, the TCS approach can be argued to be more managerially relevant as summarized in Table 1. The TCS approach is a clearly superior conceptual approach.

On an empirical level the paper has demonstrated that the TCS approach can be operationalized. There is one serious limitation here. In general, about 15 years (60 quarters) of data are required to do the spectral analysis. In some cases, the length of this time series is likely to be a serious constraint. Here the authors believe that at a minimum the removal of trend before the calculation of a stability measure will improve results over previous approaches. Furthermore, the authors believe that in many studies 60 data points is not a serious constraint. Overall, further work needs to be done to refine the methodology for applying the TCS approach. Such work could examine nonlinear trends, trends in the variance about the trend, the use of shortened (less than 60 points) time series, and modeling the autocorrelation structure within the stochastic component.

The results of applying the TCS approach to the sample of diversified firms was suggestive but not conclusive. It appears that the percent of variance accounted for by trend may vary across diversification categories. It also appears that diversified firms are no more effective than relatively undiversified firms in eliminating or minimizing cyclical and stochastic components. In fact there is some evidence that the highest level of diversification (unrelated firms) was the least effective.

The authors believe that the TCS approach could be useful in studying the relationships between accounting rates of return and market rates of return. The one major study in this area (Beaver, Kettler, and Scholes, 1970) primarily used a magnitude/variation approach although some refinements were introduced to study the impact of accounting performance on the systematic and unsystematic risk components of market returns.

The authors also believe that the TCS approach could also be useful in studies of organization design and process when applied to environmental variables. For example the concept of stable vs. turbulent environments, as pioneered by Emery and Trist (1965), could potentially be refined and quantified using the TCS approach and variables such as the demand for the organization's services or products (sales in the case of a for-profit enterprise), the time history of customer complaints, the time history of applicants for jobs in the organization, and the time history of public sentiment about the organization (as in the case of a government institution). It might also be interesting to examine perceptions of environmental uncertainty (e.g., Lawrence and Lorsch, 1967; and Duncan, 1972) as they relate to the three TCS components in the just mentioned variables. Such studies could result in a better quantification of environmental variables and ultimately a better understanding of the relationships between organization and environment.

Appendix

Rumelt's Diversification Categories:

<u>Single Business</u>: A firm deriving more than 95% of annual revenues from the base business.

<u>Dominant Business</u>: A firm deriving 70-95% of annual revenues from the base business.

<u>Dominant Vertical</u>: A dominant firm that is vertically integrated.

<u>Dominant Constrained</u>: A dominant firm in which all component businesses are directly related to the base business.

<u>Dominant Linked</u>: A dominant firm in which all component businesses are related but are not all related to the base business.

<u>Dominant Unrelated</u>: A dominant firm in which the component businesses are not related to the base business.

<u>Related Business</u>: A firm deriving less than 70% of revenues from the base business and where diversification has been achieved by "relating" new activities to old. This relatedness is defined in terms of markets served, distribution systems, production technologies, or the exploitation of science-based research.

<u>Related Constrained</u>: A related firm in which all component businesses are directly related to the base business.

<u>Related Linked</u>: A related firm in which component businesses are not all directly related to the base business.

<u>Unrelated Business</u>: A firm deriving less than 70% of revenues from the base business and where diversification is unrelated.

<u>Multibusiness</u>: Any unrelated firm containing a few large unrelated businesses.

<u>Unrelated-Portfolio</u>: Any unrelated firm containing many unrelated businesses.

Table 1

Managerial Significance of Trend, Cyclical and Stochastic Components

	Trend	Cyclical	Stochastic
Forecastability	high	high to moderate	low to moderate depending on autocorrelation structure
Market Valuation	positive premium for risk reduction	positive premium but less so	negative
Key Risk	barriers to entry/exit	cash flow	cash flow
Key Decision	timing and size of capacity expansion/contraction	fixed versus variable costs	slack resources versus risk of foregone demand
Key Strategic Variable	growth/decline rate compared to industry	size and structure of capacity	degree of flexibility

Table 2

Linear Trend Analysis

Rumelt Diversification Category	Firm	Profit		Trend	
		Average	Standard deviation	Slope	Adjusted R^2
Single-Business	Crown Cork & Seal	7581.14	5681.86	196.37	.85
	Maytag	5984.86	2715.95	6.42	.72
	William Wrigley	4815.83	2208.18	71.17	.74
Dominant Constrained	Caterpillar Tractor	59426.47	17911.29	1556.89	.75
	John Deere	30627.67	26202.90	773.28	.62
	Ralston Purina	18039.42	13434.91	459.34	.83
Dominant Vertical	Revlon	13275.07	12722.76	414.35	.75
	Aluminium Company of America	36006.97	33934.37	915.13	.51
	Diamond International	8309.71	3941.21	112.55	.58
	Kimberly-Clark	20736.93	22869.87	533.27	.38
	Phillips Petroleum	78683.98	76579.76	2290.58	.63
	Scott Paper	15769.35	11912.44	301.69	.45
	U.S. Steel	86417.76	92079.84	1526.46	.19
	Weyerhauser	42731.08	34656.82	1023.29	.62
Dominant Unrelated	Philip Morris	43258.11	49848.06	1624.27	.75
Related Constrained	Abbot Labs	16437.41	17193.30	539.22	.70
	Corning Glass W.	14151.76	8863.80	242.72	.53
	Eastman Kodak	124236.34	89117.64	2957.93	.78
	General Foods	32369.18	15436.90	495.56	.73
	Gillette	17004.22	6930.58	225.64	.75
	Ingersoll Rand	18515.59	12301.43	409.68	.79
	Johnson & Johnson	33770.18	33908.32	1143.43	.81
Related Linked	Allis-Chalmers	7154.15	8186.92	147.41	.22
	Borg-Warner	16146.20	10766.54	313.55	.60
	DuPont	123632.21	64774.50	1357.27	.31
	General Electric	155396.30	114707.14	3697.53	.74
	Koppers	7754.13	8001.26	230.17	.58
	McGraw Edison	8761.99	4426.05	137.28	.68
	3-M	65882.61	49944.73	1708.73	.83
	PPG Industries	22775.28	16152.99	504.87	.69
	Texas Instruments	15396.24	14309.37	457.71	.73
	Westinghouse	43117.36	28110.45	928.28	.78
Unrelated Passive	Curtis-Wright	3545.56	3695.30	73.27	.27
	Midland Ross	3972.76	2928.13	58.80	.65
	Olin	12990.33	6510.22	125.56	.26
	TRW	18421.37	16616.81	550.74	.78

Table 3

Variance Explained by Trend*

Category	Average Adjusted R^2	M	% of companies with r^2 less than .4	% of companies with r^2 greater than .8
Single business	0.77	3	0.00	0.33
Dominant Constrained	0.73	3	0.00	0.33
Dominant Vertical	0.51	8	0.25	0.00
Related Constrained	0.73	7	0.00	0.14
Related Linked	0.62	10	0.20	0.10
Unrelated	0.49	4	0.50	0.00

*Philip Morris, the only firm listed as dominant unrelated in Table 2, is excluded. During the analysis period, the firm changed its strategy to related constrained.

Figure 1

Example Performance Histories

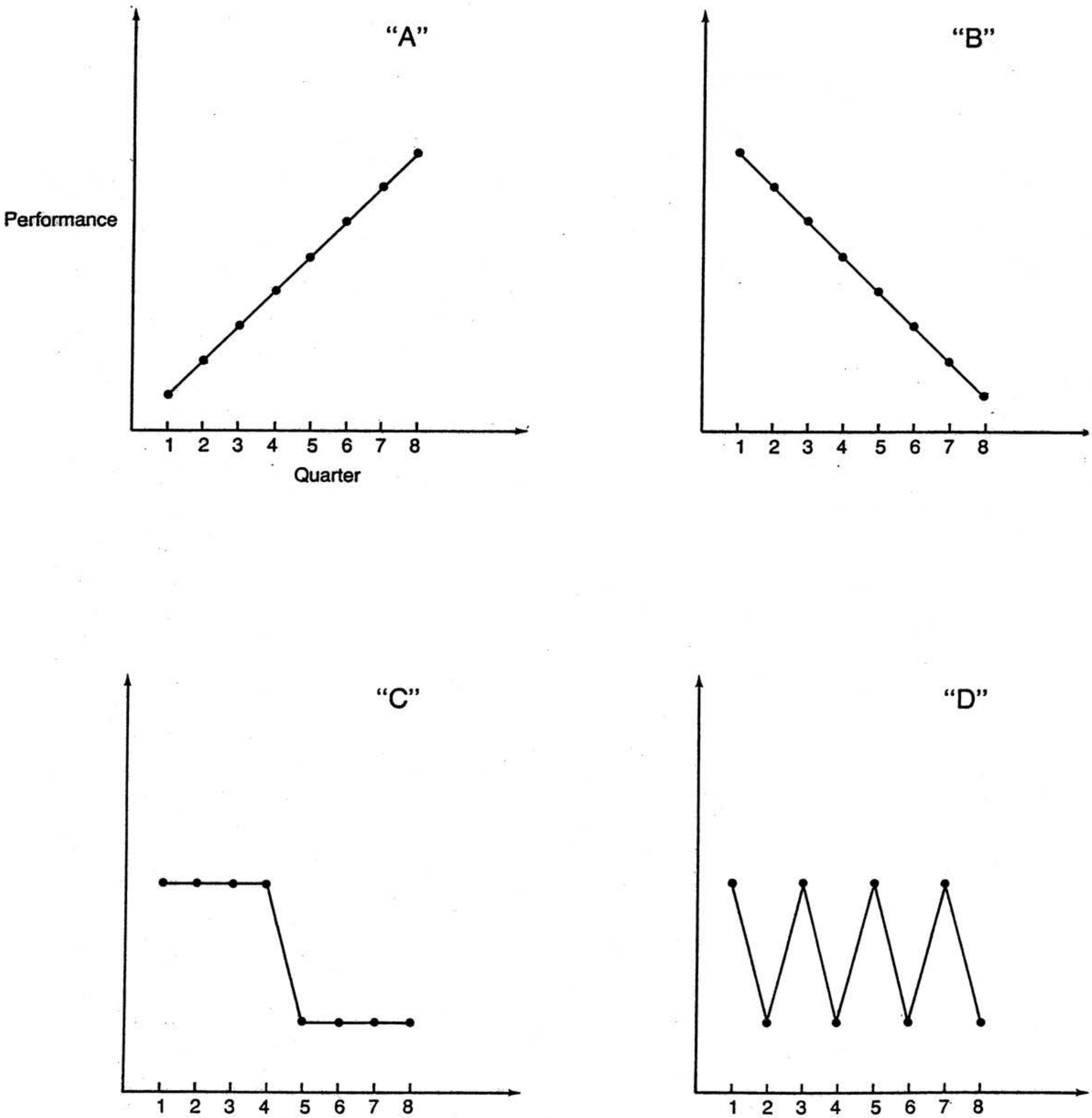


Figure 2

Performance Components

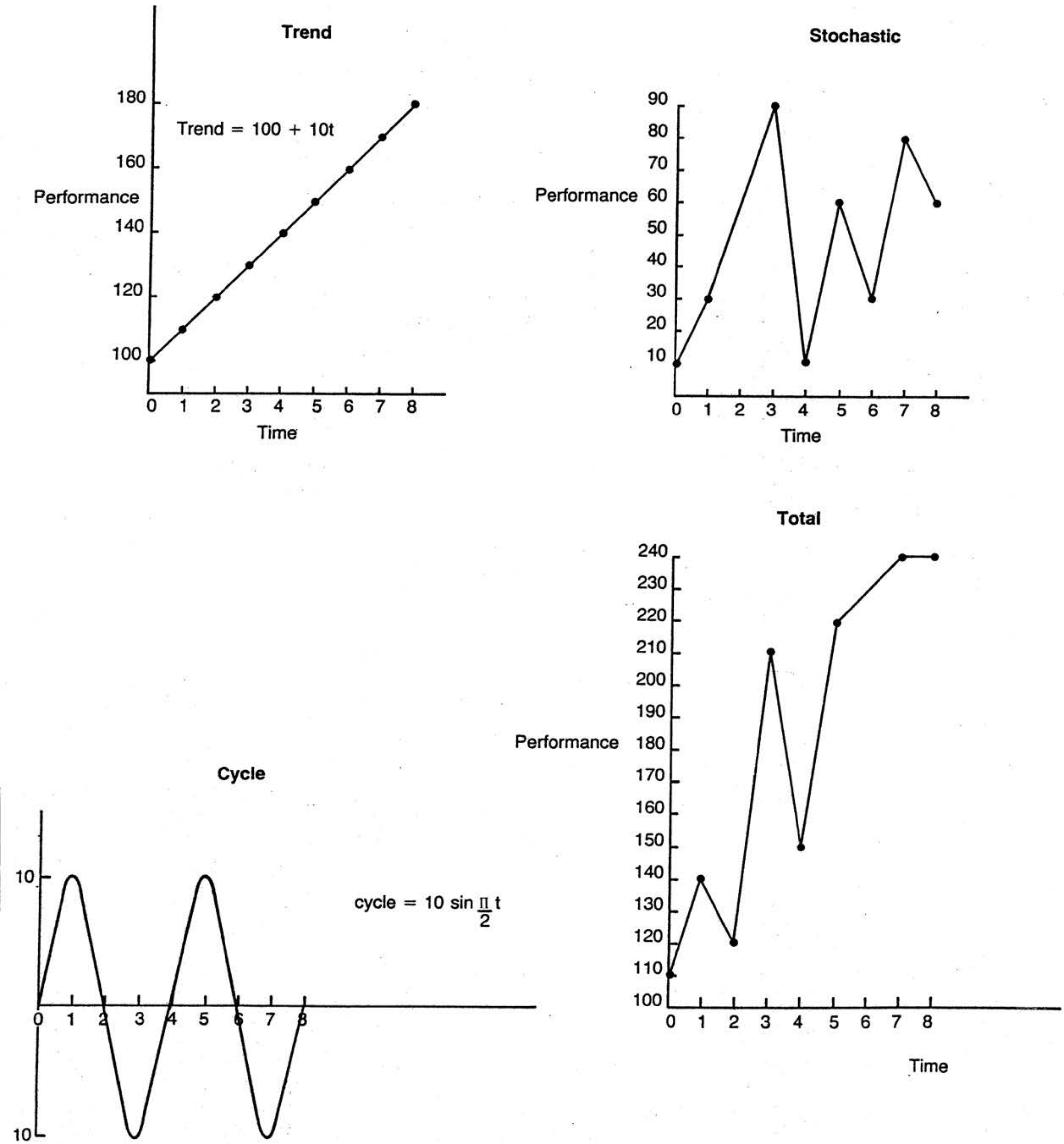


Figure 3

Example of a Sine Wave

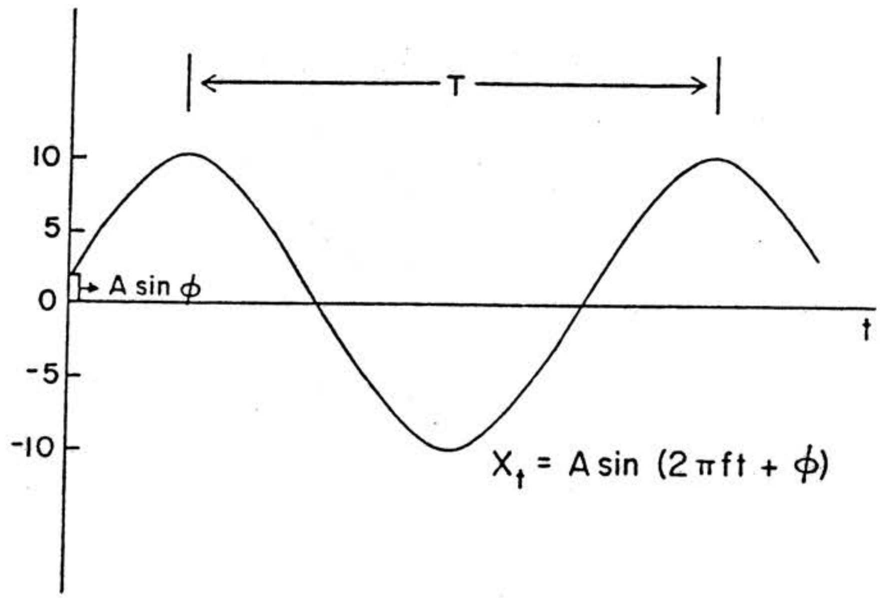


Figure 4

Spectral Density Plot for Koopers

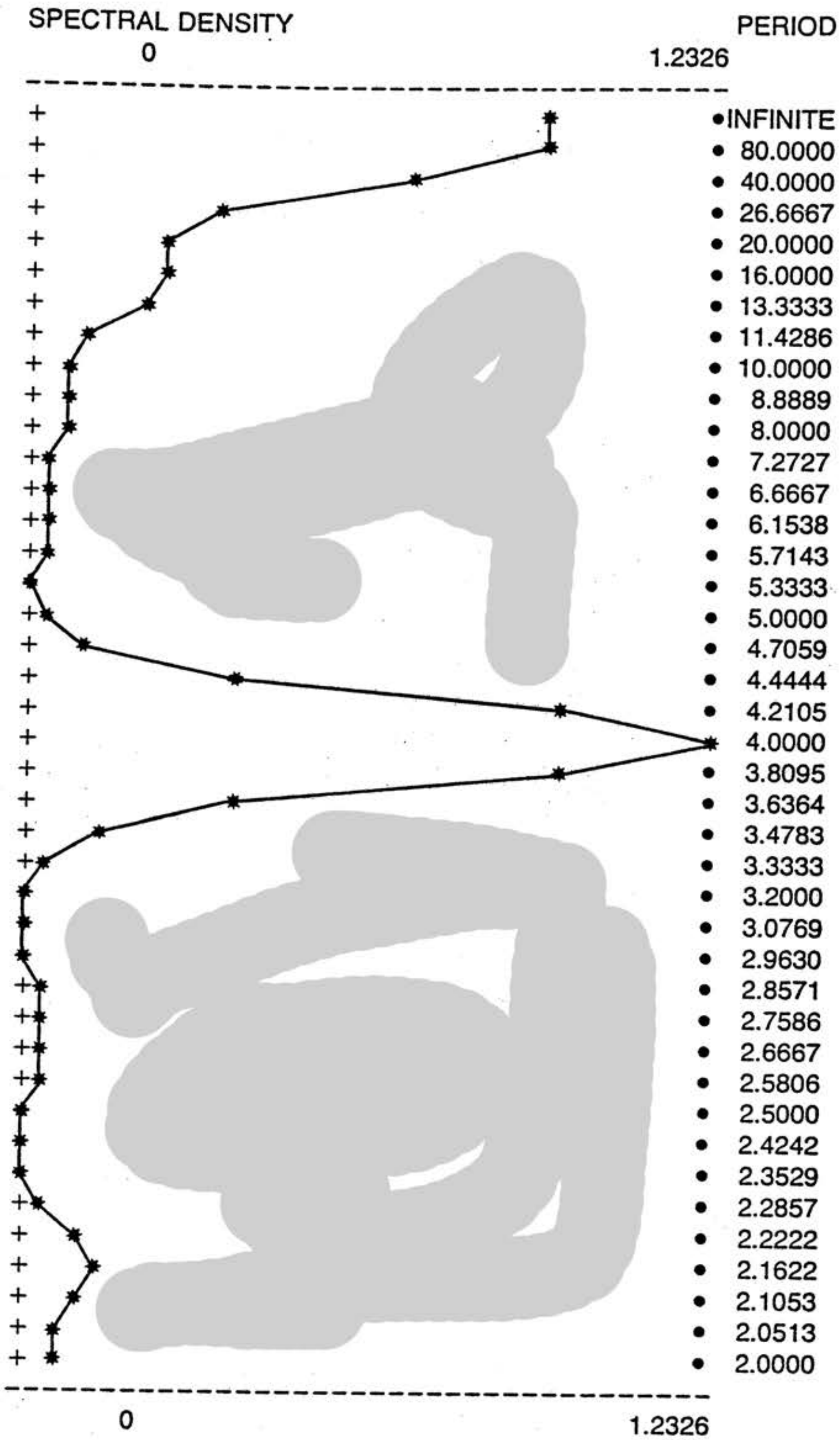


Figure 5

Spectral Density Plot for Allis-Chalmers

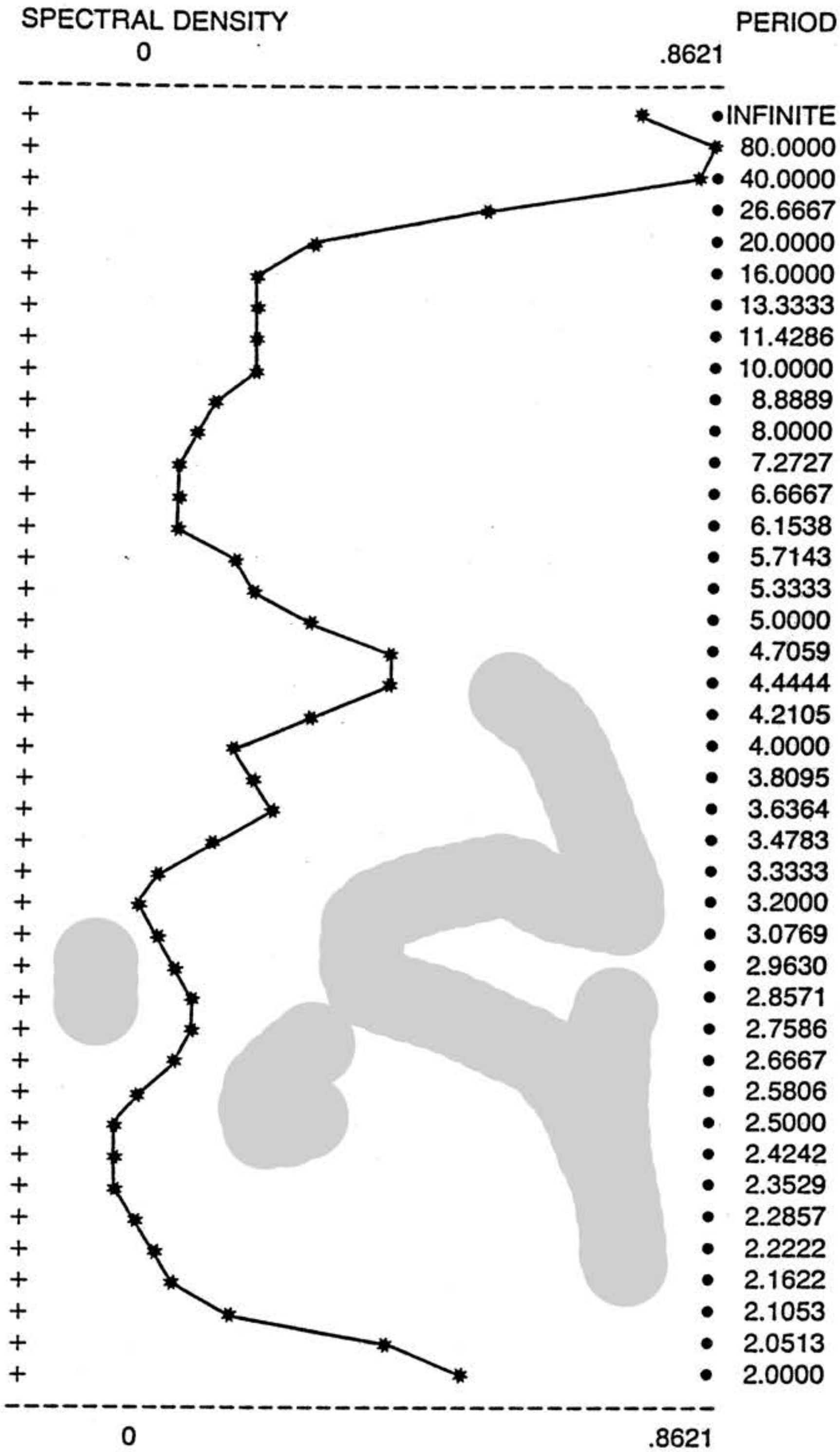


Figure 6

Spectral Density Plot for Maytag

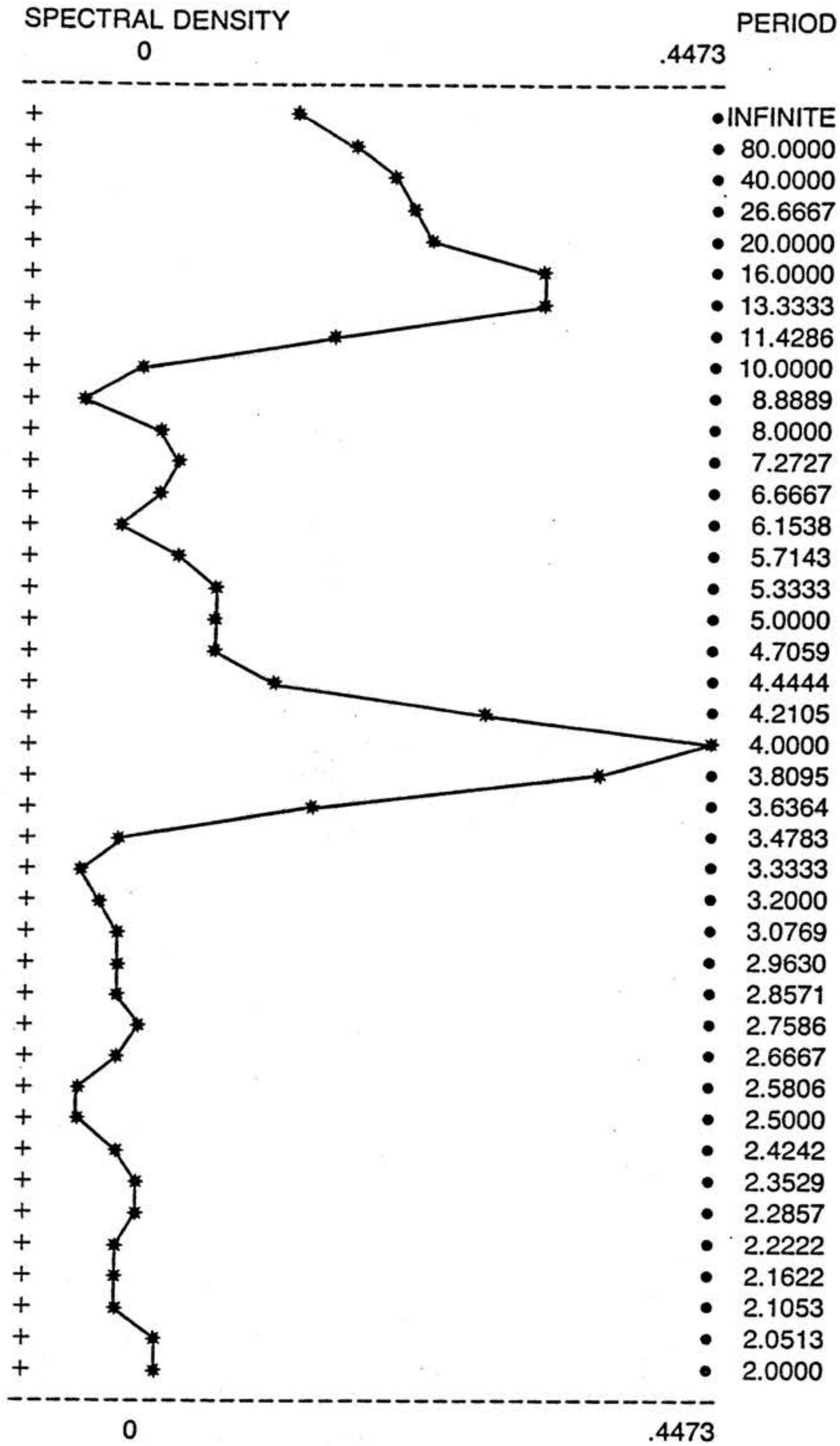


Figure 7

Spectral Density Plot for Olin

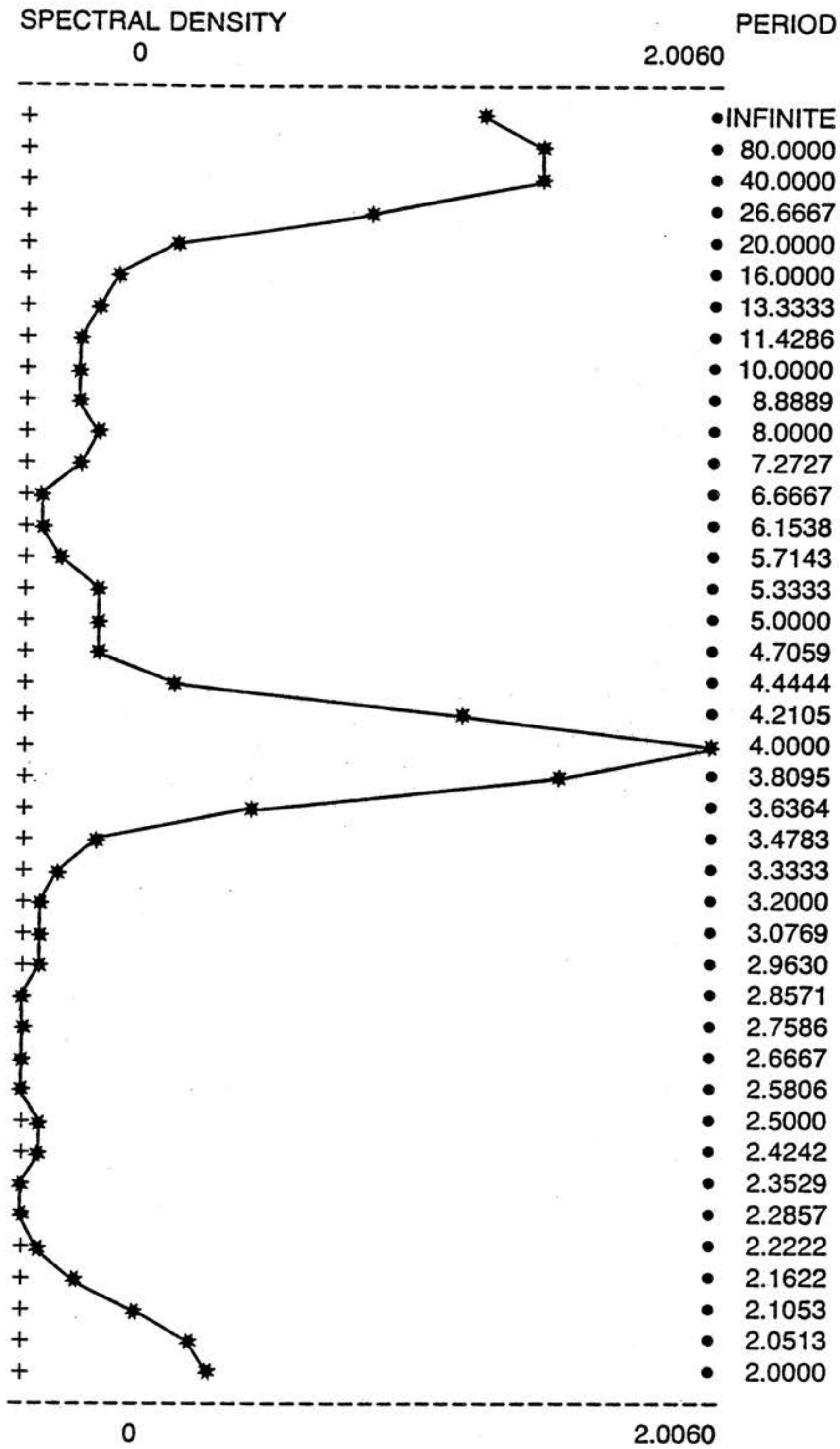


Figure 8

Spectral Density Plot for General Foods

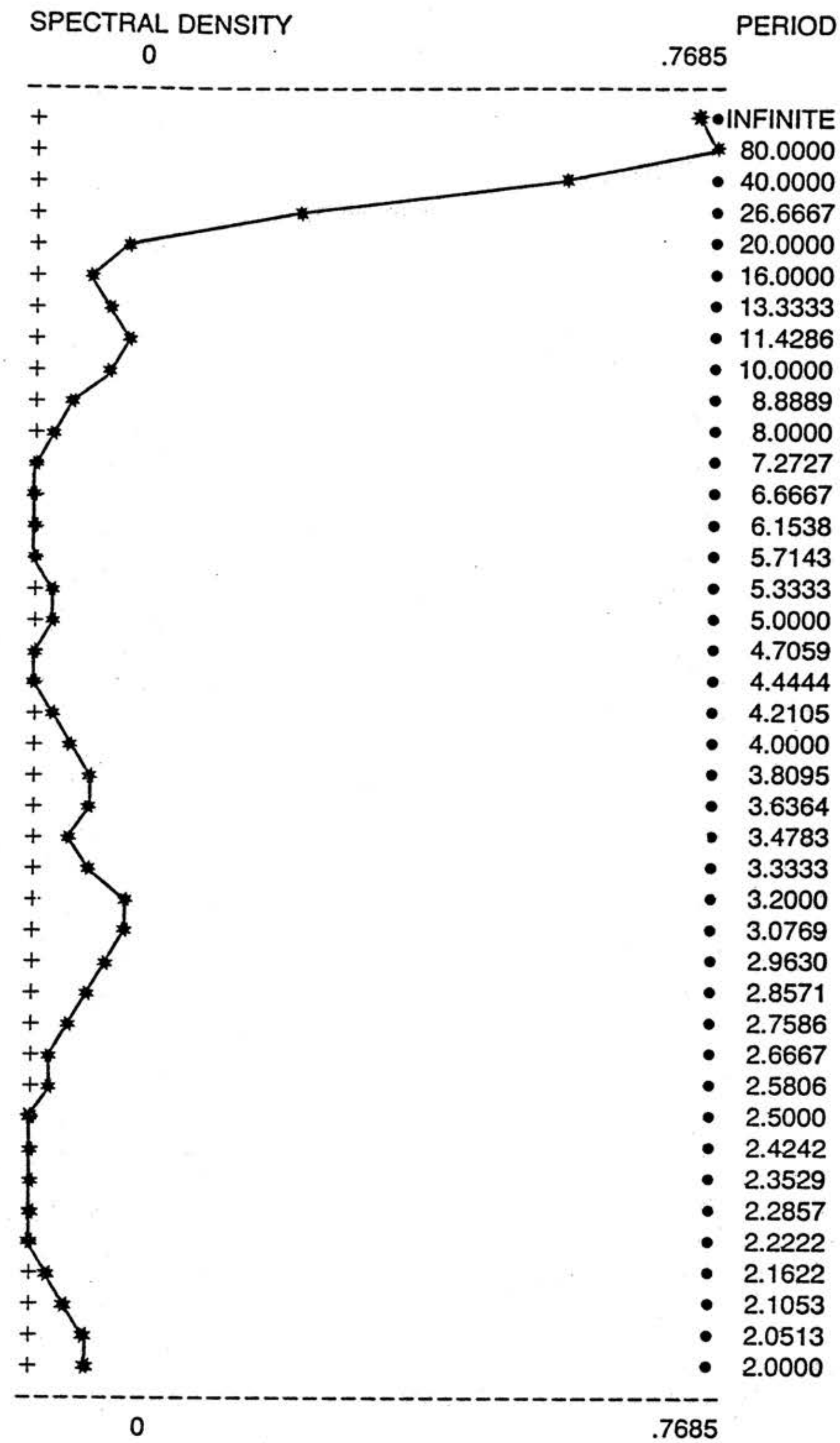


Figure 9

Spectral Density Plot for Revlon

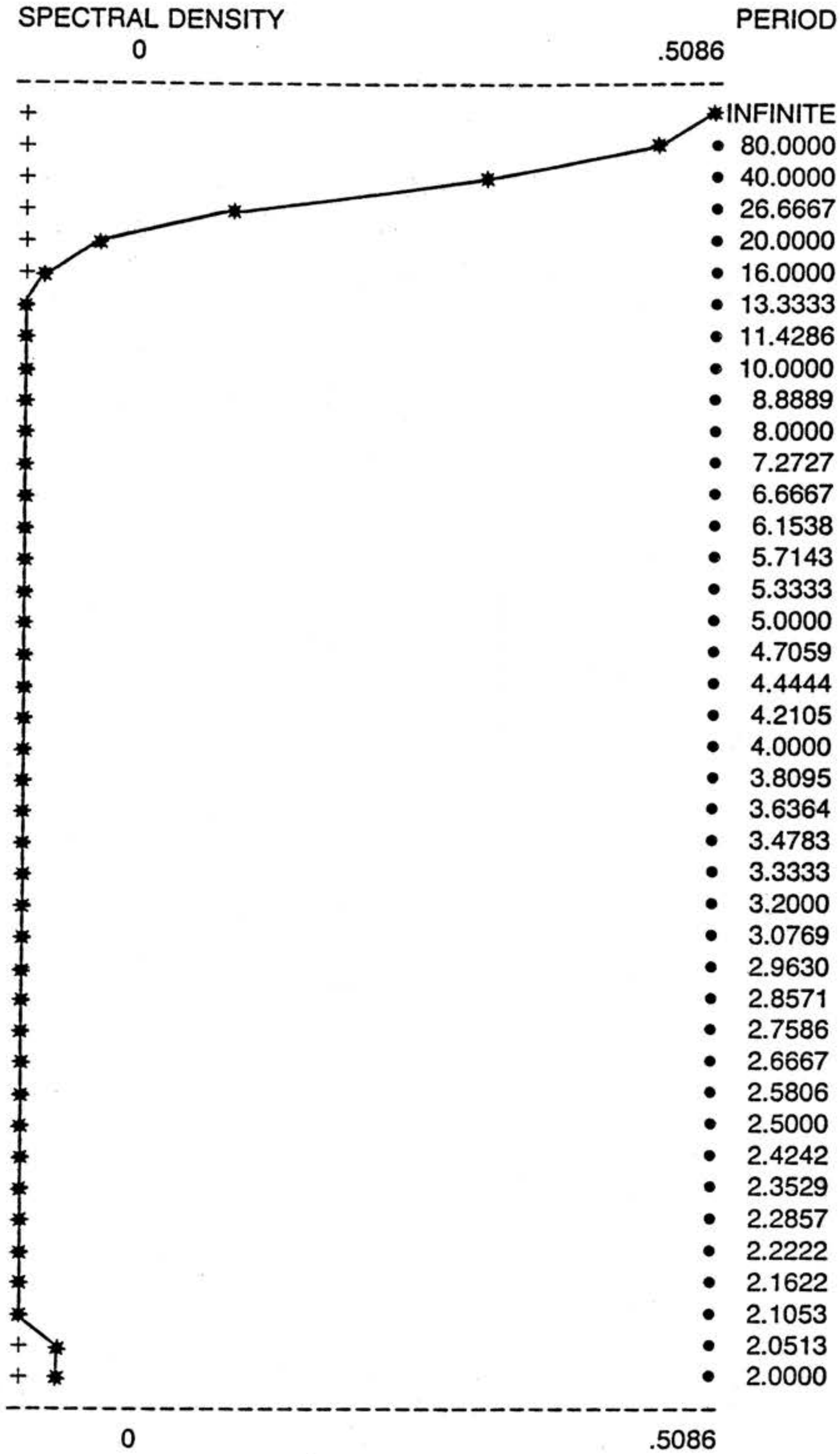


Figure 10

Spectral Density Plot for Kimberly-Clark

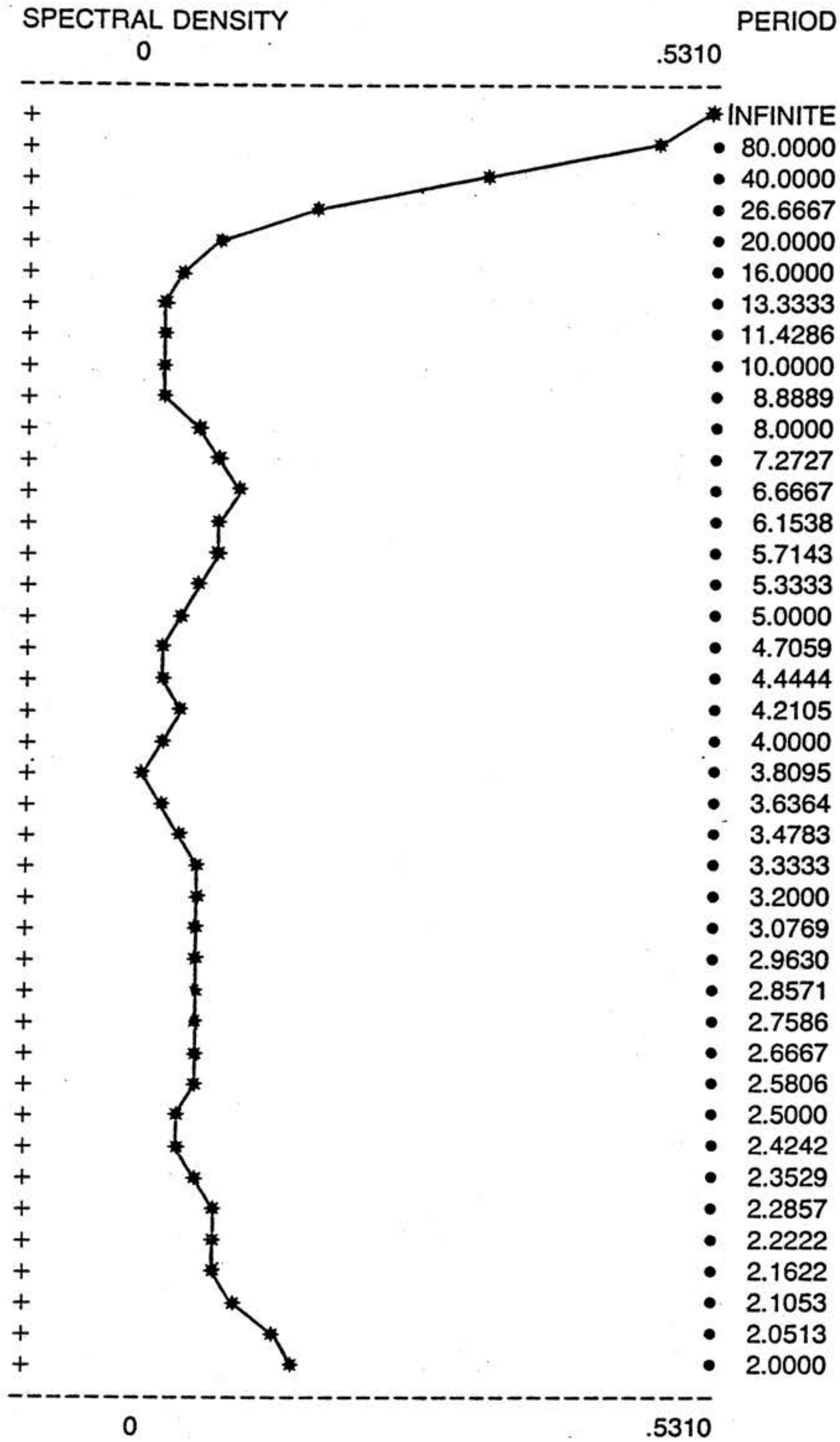
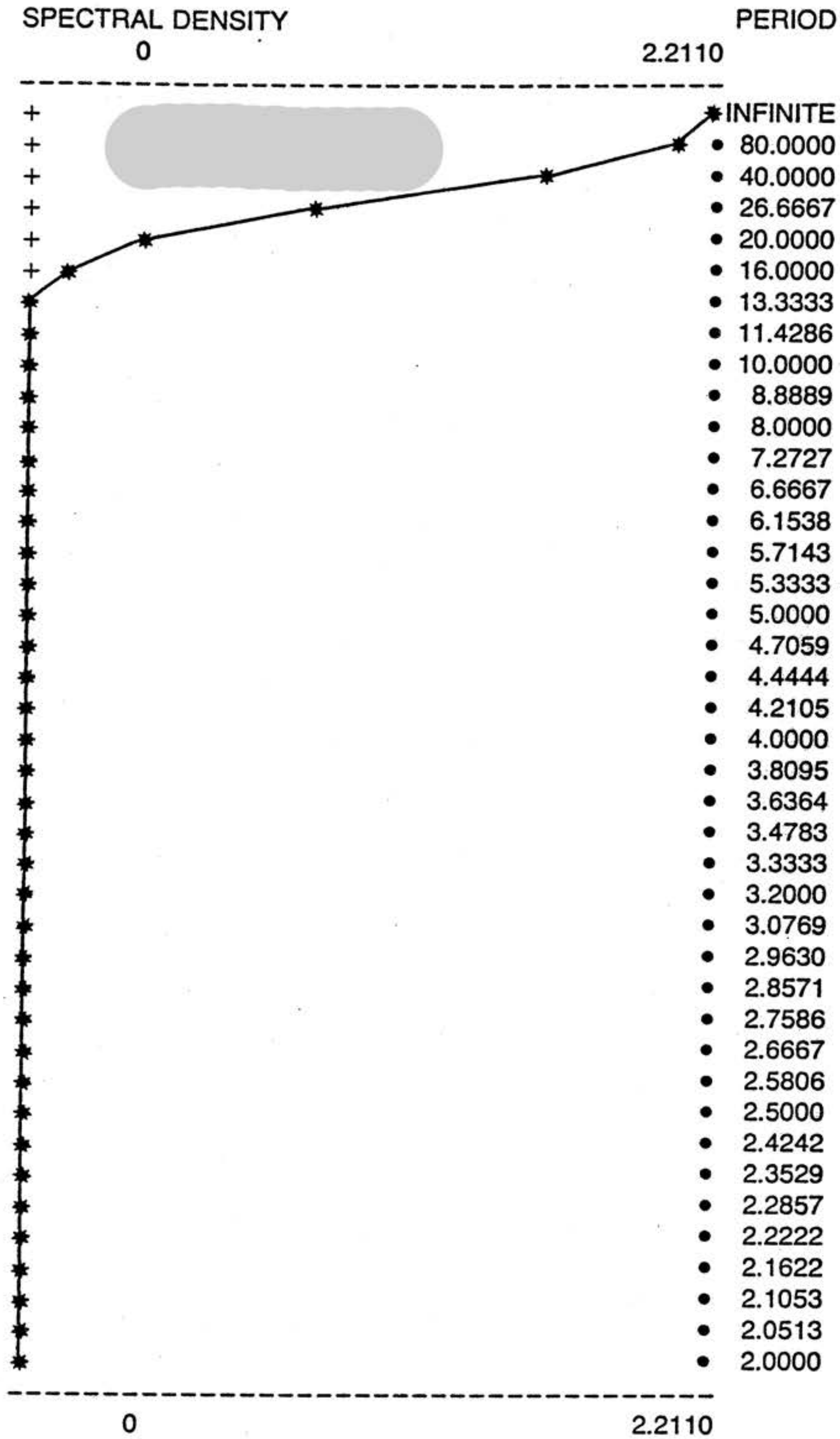


Figure 11

Spectral Density Plot for 3M



Footnotes

[1]It should be noted that the empirical analysis here is constructed merely as an example of the TCS approach. In this sense the use of profits was arbitrary as was the particular sample used and the hypotheses examined. The empirical work is intended primarily to illustrate the TCS approach.

[2]The profit figures were not corrected for inflation. This undoubtedly introduces some bias into the data and results. However, only for about one-quarter of the sample years was the inflation rate high. The major consequence here is that the slope of the detected linear trend may have been exaggerated by a small amount. The authors have thoroughly examined the data and do not believe that substantial bias was introduced.

[3]In almost all of the spectra that were studied, there is a sharp increase at very low frequencies (near an infinite period). This is due to a small amount of remaining nonstationarity in the data (intuitively many nonstationarities would have an infinite period since they never repeat). Such results are normal with most economic time series.

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