# Seasonal and Cyclic Forecasting for the Small Firm

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*This paper discusses the practical role of sales forecasting for the small business concern. Although a smaller firm may have limited resources to use in making future sales estimates, there are still techniques and procedures available for use by the firm. Such a procedure is discussed from a realistic perspective by noting circumstances which do come up in the real world and how one may adjust one's forecast methodology to account for such situations. For clarity of discussion, the methodology is discussed in the context of an actual business case.*

## INTRODUCTION

The selection and implementation of the proper sales forecast methodology has always been an important planning and control issue for most profit maximizing firms and agencies. Often, the financial well-being of the entire business operation may rely on the accuracy of the forecast since such information will likely be used to make interrelated budgetary and operative decisions in areas of personnel management, purchasing, marketing and advertising, capital financing, etc. Any significant over-or-under sales forecast error may cause the firm to be overly burdened with excess inventory carrying costs or else create lost sales revenue through unanticipated item stockouts. When demand is fairly stable (e.g., unchanging or else growing or declining at a known constant rate), making an accurate forecast is less difficult. If, on the other hand, the firm has historically experienced an up-and-down sales pattern, then the complexity of the forecasting task is compounded.

Ideally, businesses which can afford to do so will usually assign crucial forecast responsibilities to those departments and/or individuals that are best qualified and have the necessary resources at hand to make such sales estimations under complicated demand patterns. Clearly, a firm with a large ongoing operation and a technical staff comprised of statisticians, management scientists, computer analysts, etc. is in a much better position to select and make proper use of sophisticated forecast techniques than is a company with more limited resources. Notably, the bigger firm, through its larger resources, has a competitive edge over an unwary smaller firm and can be expected to be very diligent and detailed in estimating future sales (although between the two, it is usually the smaller firm which can least afford miscalculations in new sales levels). Below we discuss an effective forecasting approach which can be used by any size firm.

## METHODOLOGY

There are two main approaches to forecasting. Either the estimate of future sales is based on an analysis of factors which are believed to influence new sales (the explanatory method) or else the prediction is based on an inferred study of past general sales behavior over time (the extrapolation method). For example, the belief that the sale of doll clothing will increase from current levels because of a recent advertising blitz rather than proximity to Christmas illustrates the difference between the two philosophies. It is possible that both approaches will lead to the creation of accurate and useful sales forecasts, but it must be remembered that even for a modest degree of desired accuracy the former method is often more difficult to implement and validate than the latter approach. Because of this reason, our discussion focuses on the extrapolation or time series approach to forecasting. Assuming that there is some sort of regularity in sales over time (though perhaps not well understood or measured in detail), we present a forecasting methodology that is generally applicable to situations where useful future sales estimates are desired. The following procedure is scientifically valid yet easy-to-follow and implement. It requires only that the forecasting manager possess a general mathematical background.

For reasons of clarity and uniformity, points of significance and mathematical procedures are discussed and shown in the context of a business case typical of most firms. Our case example involves a subsidiary operation of WOMETCO corporation in the Tidewater region of Virginia. While the parent company would not likely be considered small in size, its different regional and product divisions function largely as decentralized units; therefore we can view WOMETCO's Tidewater vending sundries group as a modest sized firm. Although not having as much financial and technical expertise to support its sales forecasts, the smaller firm often does have the advantage of more control and better communication flow among its various departments and managerial staff. Reliable intracompany data (not having been 'passed' through as many hands as in a larger centralized business concern), good communication, cooperation, and trust are important prerequisites for accurate and useable sales forecasts, especially in situations of changing sales levels.

From an objective stance, the forecaster needs only the sales time series data from relevant periods. Table 1 gives the past data in dollars for WOMETCO's vending sundries in the local Tidewater region.[1] In this example, the manager believes that the recent three years of 1982, 1983, and 1984 most accurately reflect the current business situation and expects these sales patterns to continue into 1985. This case is especially easy to analyze initially as the company divides its sales time unit into 4 week periods rather than months. Monthly sales are awkward to study as the number of operation days often varies. Thus, it is best at the outset to reorganize one's sales information into equal intervals (i.e., 4 week periods rather than monthly, or 12 week periods rather than quarterly).

TABLE 1: WOMETCO VENDING MACHINE SUNDRIES SALES FOR TIDEWATER REGION

| period | 1982 sales | 1983 sales | 1984 sales |
|---|---|---|---|
| 1 | $171 422 | $170 006 | $189 863 |
| 2 | 191 003 | 196 112 | 205 745 |
| 3 | 193 991 | 200 181 | 213 248 |
| 4 | 207 399 | 211 874 | 228 480 |
| 5 | 205 494 | 219 528 | 231 781 |
| 6 | 197 367 | 215 573 | 237 120 |
| 7 | 208 396 | 232 726 | 254 384 |
| 8 | 214 413 | 236 883 | 253 862 |
| 9 | 200 260 | 221 034 | 232 810 |
| 10 | 187 900 | 216 940 | 226 728 |
| 11 | 182 203 | 206 932 | 223 668 |
| 12 | 180 789 | 198 068 | 218 328 |
| 13 | 171 892 | 189 484 | 209 008 |

* Each period equals one 4-week interval.
** Annual sales data is ordered January to December.
*** Tidewater, Va. consists of the Norfolk—Virginia Beach Greater Metropolitan Area.

Recalling the old adage that a picture is worth a thousand words, we plot the given sales data (of Table 1) in Figure 1 and note the following characteristics of the data.

- Within each year, there seems to be an initial period of sales growth followed in turn by an interval of decline with some minor up-and-down sales movement.
- Between the given years, sales seem to generally increase overall.
- Mid-1982 sales data vary somewhat from the generally similar time series patterns for years 1983 and 1984.

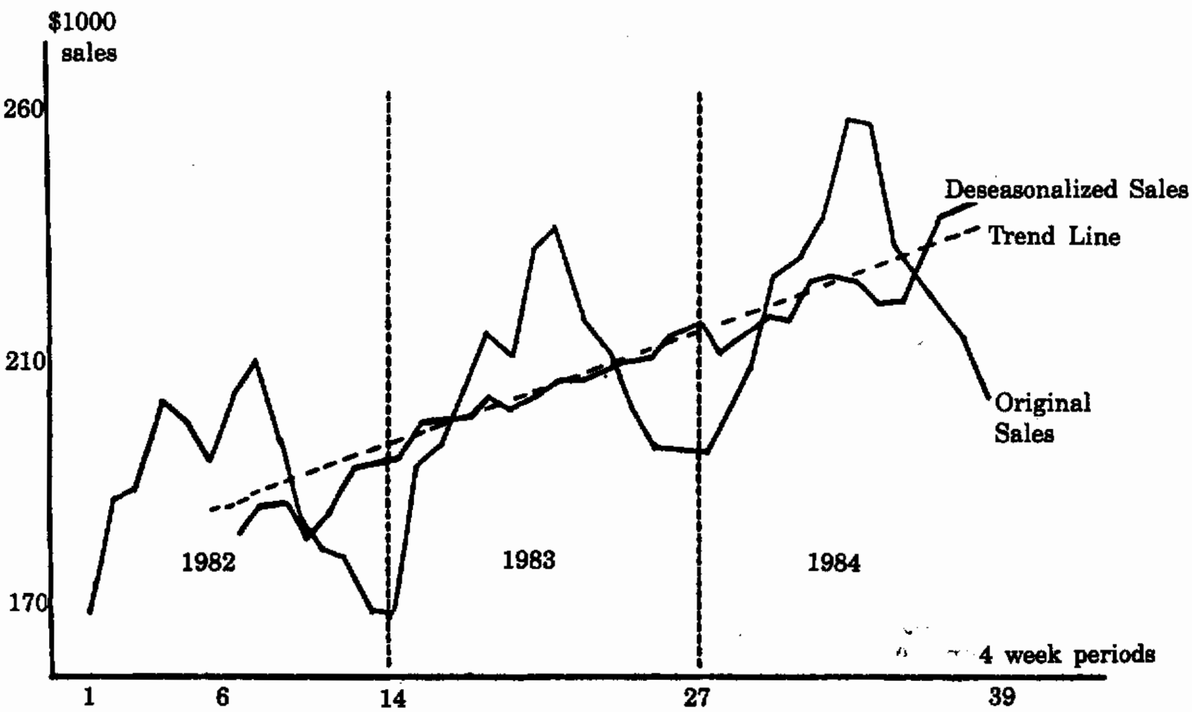


FIGURE 1: WOMETCO VENDING MACHINE SUNDRIES SALES (DESEASONALIZED AND TREND EFFECTS)

## OUTLIER CONSIDERATIONS

The first two noted characteristics of the time series plot are found in many normal business situations. The third point requires closer scrutiny of the data. In checking the firm's recent past history, management recalls that an unusual contractual incident occurred in period 6 of 1982. As this sharp decline in sales is believed to be a unique occurrence, it should not be considered when making new forecasts. Whenever sales levels are thought to be too high or low for normal business levels, we call such points *outliers*. A mathematical reason to adjust for such occurrences is that the majority of forecast techniques (including the one in this paper) are based on sales averaging. It is well known that arithmetic averages are very sensitive to outlier values; therefore, some alteration should be made in the data before continuing. In our case, we have two choices. One alternative is to replace the outlier by the average of the two sales levels for the periods which immediately come before and after the period in question (here, average the sales in periods 5 and 7 in 1982 and put this number in place of the outlier). This idea is useful if outliers occur in the middle or recent part of the data. As our outlier is located early or in the oldest part of the data, we may follow a second alternative which is to simply throw away the sales data up to and including the outlier (here, period 1-6 sales). Note that we still have most of the original data which we believe to now be purged of all extreme sales levels.

## DECOMPOSING THE SALES DATA

General analysis of the Figure 1 time series plot shows that a variety of things are likely influencing sales. It is very important in the study that these different influences or sales components be separated or decomposed out of the 'raw' sales levels in Table 1. In general, there are four types of sales components in time series analysis.

1) *Seasonalities* are regular sales fluctuations which are repeated from year to year with about the same timing and level of intensity.
2) *Growth or Decay Trends* are tendencies for sales to increase or decrease fairly steadily over time.
3) *Cyclic Oscillations* are general up-and-down sales changes due to changes in the overall economic environment (not caused by seasonal effects).
4) *Irregularities* are any sales fluctuations not classified as one of the above.

To be able to make a proper sales forecast, we must know to what extent each of the above sales components is present in the sales data. Hence, to understand and measure these components, the forecast procedure involves initially removing the component effects from the sales data (decomposition). After the effects are measured, making a sales forecast involves putting back the components on new sales estimates (recomposition).

## DESEASONALIZING THE SALES DATA

The first step of a times series decomposition is to remove seasonal effects in the data. Without deseasonalizing the sales information, we may, for example, incorrectly infer that recent sales growth patterns will continue indefinitely (i.e., a growth trend is present) when actually the increase is 'just because it is that time of the year' (i.e., due to regular seasonal peaks). To measure seasonal effects, we calculate a series of seasonal indexes. A practical and widely used method to compute these indexes is the ratio-to-moving-average approach. From such indexes, we may quantitatively measure how far above or below a given period stands in comparison to the expected or 'business as usual' sales period (the expected sales are represented by a seasonal index of 100%, or 1.0). The procedure for calculation of the seasonal indexes and deseasonalized data is summarized below.

Step 1: Compute a centered 13-period moving average[2] for all possible periods for all given years.
Step 2: Compute the ratio of actual sales in each period to the moving average from Step 1.
Step 3: Average the above ratios for periods 1-13 for all given years.
Step 4: Correct the averaged ratios from Step 3 for possible roundoff error to get the 13 period seasonal index set.
Step 5: Divide the original sales by the seasonal indexes to get the deseasonalized sales levels.

Sample Step 1 and Step 2 calculations for the WOMETCO case are shown in Table 2. Step 3-5 calculations for the example are given in Table 3. The strength of the seasonal effect on the original sales data can be seen in column (f) of Table 3 which depicts a plus(+) or minus(−) for each period's seasonal index which is above or below expected sales level (=seasonal index of 100%), respectively. This table column clearly shows an annual seasonal pattern of below average sales in the beginning periods followed by an interim time interval of above average sales and ending each year with another below average sales group. These uninterrupted highs and lows in the seasonal index set represent a very strong seasonal effect in the data. By removing this influence, we can now further study the sales data for other component effects. The removal of seasonality from the data is depicted in Figure 1. Note that the deseasonalized sales do not oscillate as widely as the original sales levels. Any remaining up-and-down movement must therefore be due to trend, cyclic, or irregular effects.

## MEASURING THE SALES TREND

Using the deseasonalized data, we now wish to consider the growth trend as noted in our initial inspection of the time series in Figure 1. Measurement of the trend component is done by fitting a line to the Table 1 sales data for all given years. This fitted line is calculated by the

TABLE 2: RATIO TO MOVING AVERAGE CALCULATIONS FOR SELECTED PERIODS (WOMETCO CASE)

| period | (a) Sales (from Table 1) | (b) 13-period Moving Total | (c) = (b)/13 13-period Moving Average | (d) = (a)/(c) Ratio to Moving Average (%) |
|---|---|---|---|---|
| 1982: | | | | |
| ⋮ | | | | |
| 7 | 208 396 | | | |
| 8 | 214 413 | | | |
| 9 | 200 260 | | | |
| 10 | 187 900 | | | |
| 11 | 182 203 | | | |
| 12 | 180 789 | | | |
| 13 | 171 892 | 2 559 127 | 196 855.9 | 87.3 |
| 1983: | | | | |
| 1 | 170 006 | 2 583 457 | 198 727.5 | 85.5 |
| 2 | 196 112 | ⋮ | ⋮ | ⋮ |
| 3 | 200 181 | | | |
| 4 | 211 874 | | | |
| 5 | 219 528 | | | |
| 6 | 215 573 | | | |
| 7 | 232 726 | | | |
| ⋮ | | | | |

method of least squares represents the overall linear trend of the sales growth over time. The trend line equation is of the form below.

$$Y = A + BX$$

where $Y$ = predicted sales level (due to the trend effect) occurring in period $X$,

$A$ = vertical intercept of the trend line equation,

$B$ = sales growth rate per period (i.e., slope of the trend line equation).

The trend line parameters A and B may be calculated through mathematical formulas[3] although this is unnecessary if one has a basic electronic calculator (eg., Texas Instrument SR-51), many of which have simple-to-use preprogrammed routines for least square line fits. The trend line equation for the WOMETCO case is found to be

$$Y = 186731.2 + 1450.74\ X.$$

To illustrate how the above equation is used, suppose that we are interested in the predicted sales level accorded by trend for period 3 of 1983. This period corresponds in the equation to $X = 10$ (recalling that we dropped the first 6 periods of 1982, we then count the remaining 7 periods of 1982 + the first 3 periods of 1983 to get $X = 10$). Thus, predicted sales

**TABLE 3: SEASONAL INDEX AND DESEASONALIZED SALES FOR SELECTED PERIODS CALCULATIONS (WOMETCO CASE)**

| period | (a) ratio to moving avg. 1982 | (b) 1983 | (c) 1984 | (d) = avg. of (a)−(c) ratio average for all years | (e)* = (d)·CF seasonal index (%) | (f) seasonal strength | (g)** original 1984 sales | (h) = (g)/(e) 1984 deseasonalized sales |
|---|---|---|---|---|---|---|---|---|
| 1 | | 85.5 | 87.2 | 86.35 | 86.1 | − | 189 863 | 220 514.5 |
| 2 | | 97.8 | 93.9 | 95.90 | 95.7 | ↓ − | 205 745 | 214 989.6 |
| 3 | | 99.1 | 97.0 | 98.1 | 97.9 | − | 213 248 | 217 822.3 |
| 4 | | 103.7 | 103.5 | 103.6 | 103.3 | + | 228 480 | 221 181.0 |
| 5 | | 106.5 | 104.4 | 105.5 | 105.2 | + | 231 781 | 220 324.1 |
| 6 | | 103.9 | 106.1 | 105.0 | 104.7 | + | 237 120 | 226 475.6 |
| 7 | | 111.4 | 113.1 | 112.25 | 112.0 | ↑ + | 254 384 | 227 128.6 |
| 8 | | 112.6 | | 112.6 | 112.3 | + | 253 862 | 226 057.0 |
| 9 | | 104.7 | | 104.7 | 104.5 | + | 232 810 | 222 784.7 |
| 10 | | 102.3 | | 102.3 | 102.0 | + | 226 728 | 222 282.4 |
| 11 | | 97.0 | | 97.0 | 96.8 | − | 223 668 | 231 062.0 |
| 12 | | 92.4 | | 92.4 | 92.2 | ↓ − | 218 328 | 236 798.3 |
| 13 | 87.3 | 87.7 | | 87.5 | 87.3 | − | 209 008 | 239 413.5 |
| total | | | | 1303.2 | 1300.0 | | | |

* CF = correction factor for roundoff error = n(100%)/(total of (d)) (= 1300/1303.2 for WOMETCO case).
** from Table 1.

for period 3 in 1983 = 186731.2 + 1450.74 (10) = 201238.6. The case trend line is shown in Figure 1.

## MEASURING THE CYCLIC EFFECTS

To measure how the general business cycle affects sales levels, we calculate a series of cyclic indexes. Theoretically, the deseasonalized data still contains trend, cyclic, and irregular components. Also, we believe predicted sales levels using the trend line equation do represent pure trend effects. Thus, it stands to reason that the ratio of these respective sales values should provide an index which reflects cyclic and irregular components only. Sample calculations are given in Table 4 below. As we did with the seasonal analysis, we assign each period a plus(+) or minus(−) to signify whether the period is thought to be above or below the cyclic average (cyclic index = 100%) for sales. Such assignments for all periods in all given years are shown in Table 5 using full cyclic index calculations. On examination of the plus/minus assignments, beginning and ending time intervals for the whole data set are difficult to discern. From the second period of 1983 to the first period of 1984 however, there is clearly an economic upturn shown by the long string of pluses during this time interval. To gain further insight, we plot the cyclic indexes for all periods in Figure 2. As the business cycle is usually longer than the

**TABLE 4: CYCLIC INDEX AND SMOOTHED CYCLIC INDEX FOR SELECTED PERIODS (WOMETCO CASE)**

| | (a) deseasonalized sales* | (b) predicted (trend) sales** | (c) = (a)/(b) cyclic index (%) | (d) 3-period index smoothing |
|---|---|---|---|---|
| ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| 1983: | | | | |
| 1 | 197 451.8 | 198 337.1 | 99.6 | |
| 2 | 204 923.7 | 199 787.9 | 102.6 | 101.3 |
| 3 | 204 475.0 | 201 238.6 | 101.6 | 101.8 |
| 4 | 205 105.5 | 202 689.3 | 101.2 | |
| ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |

* Calculated similar to Table 3 sales values.
** Calculated by using the trend line equation.

seasonal cycle, it should be understood that cyclic analysis is not expected to be as accurate as a seasonal analysis. Due to the tremendous complexity of general economic factors on long run sales behavior, a general approximation of the cyclic sales factor is the more realistic aim. Thus, in reference to the Figure 2 plot of cyclic indexes, the specific sharp upturns and downturns are not so much the primary interest as the general tendency of the cyclic effect to gradually move in either direction.

**TABLE 5: PLUS/MINUS INDICATORS OF CYCLIC INDEX SET***

| period | 1982 | 1983 | 1984 |
|---|---|---|---|
| 1 | | − | + |
| 2 | | + | − |
| 3 | | + | − |
| 4 | | + | − |
| 5 | | + | − |
| 6 | | + | + |
| 7 | − | + | + |
| 8 | + | + | − |
| 9 | + | + | − |
| 10 | − | + | − |
| 11 | − | + | − |
| 12 | + | + | + |
| 13 | | + | + |

*Using a full cyclic index set [calculated as shown by the sample in column (c) of Table 4], indicator equals + or − if cyclic index is greater than or less than 100% respectively. A string of pluses is a cyclic upturn; a string of minuses is a downturn.

To study the general cyclic movement rather than precise cyclic changes (which may falsely indicate more accuracy than is present under this situation), we 'smooth' out the cyclic plot by replacing each index calculation with a centered 3-period moving average. The reader should

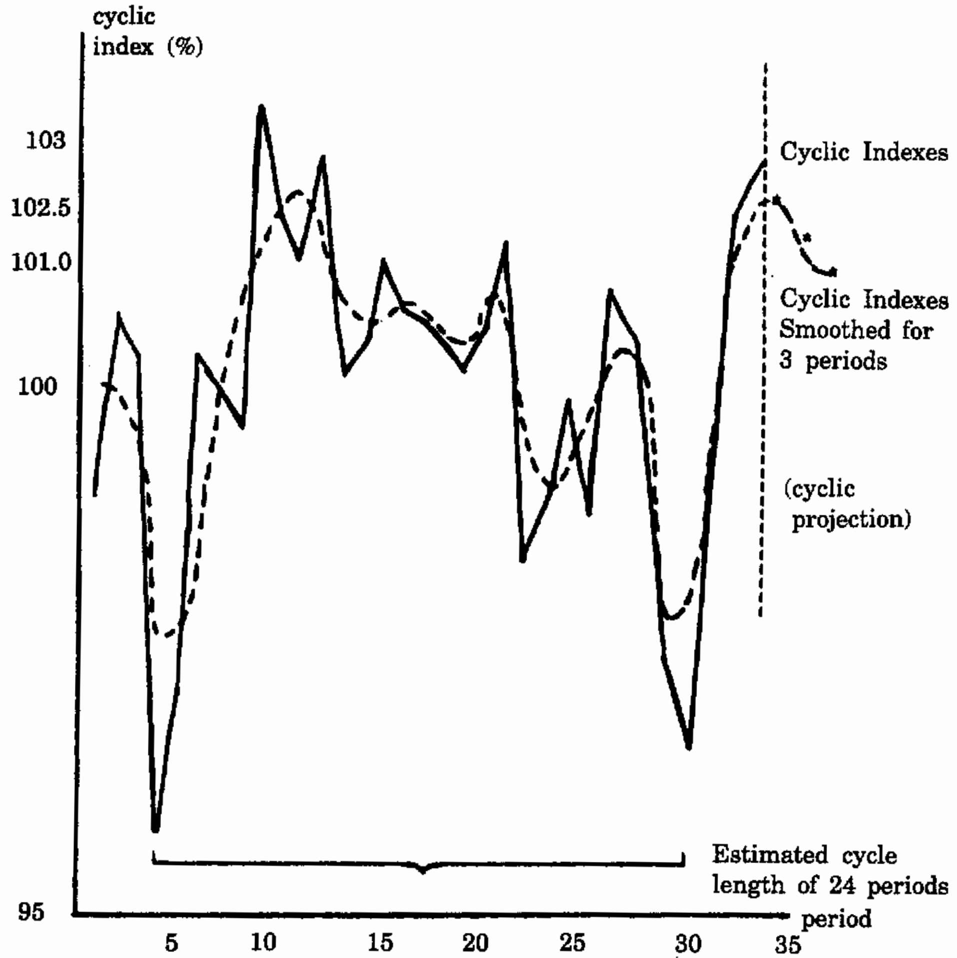


**FIGURE 2: CYCLIC INDEX AND SMOOTHED CYCLIC INDEX PLOT (WOMETCO CASE)**

note that as the number of periods in the moving average increases, the smoother or flatter the data become. The choice of 3 periods perhaps viewed as slightly subjective may be justified as an attempt to dampen out the many up-and-down minor actions of the cycle index plot so that only the major changes remain. Calculations for selected periods are given in Table 4. Plots of the cyclic index set and smoothed index set are shown in Figure 2. We note the following characteristics of the index plots in Figure 2.

- Cyclic peaks occurring in periods 12 & 33, and 4 & 27 are approximately of the same magnitude and may thus be parts of different business cycles.
- Much of the index plot lies between 100-103%.

Based on the above observations, we infer that the cyclic length (i.e., the amount of elapsed time before the cycle repeats itself) is about 24 periods. The general behavior of the cycle is a sharp rise at the beginning followed by a reasonably stable period between 100-103%, then a cyclic decline starting in about the 16th period of the cycle. In order to make sales forecasts, we project the approximate continuation of this cycle curve into the next few periods of 1985 as indicated in the figure.

## MAKING THE SALES FORECAST

At this point of the sales analysis, we have completed the study of the sales components. We now attempt to make sales forecasts for the next few periods. The procedure is summarized below.

Step 1: Compute the future sales trend level using the trend line equation.
Step 2: Multiply the sales trend level from Step 1 by the period seasonal index to include seasonal effects.
Step 3: Multiply the result of Step 2 by the projected cyclic index to include cyclic effects and get the final forecast result.[4]

Table 6 gives sample calculations for a 3-period-ahead forecast.

## SUMMARY AND FINAL REMARKS

It was stated at the outset that smaller business operations often do not have the resources enjoyed by larger firms. Under such conditions, sales forecasting may be done more by instinct and guesswork than by the proper data analysis and forecast methodology. An alternative to this haphazard approach does exist, however. Businesses which have some degree of regularity to sales may utilize the procedure described herein to study and decompose the relevant components of sales variation. Once these components are understood, sales forecasts can be made for future periods by recombining these component effects into a projected sales estimate (see Table 6).

By illustrating the procedure in a real business case situation, we have shown that combining mathematical calculations with management's

**TABLE 6: SALES FORECAST CALCULATIONS FOR 3 PERIODS AHEAD (WOMETCO CASE)**

| period | (a) X | (b) predicted (trend) sales | (c)** seasonal index (%) | (d) =(b)·(c) estimated sales with trend & seasonal effects | (e)*** projected cyclic index (%) | (f)**** =(d)·(e) sales forecast |
|---|---|---|---|---|---|---|
| 1985: | | | | | | |
| 1 | 34 | 236 056.36* | 86.1 | 203 244.52 | 102.5 | 208 326 |
| 2 | 35 | 237 507.10 | 95.7 | 227 294.29 | 101.5 | 230 704 |
| 3 | 36 | 238 957.84 | 97.9 | 233 939.72 | 101.0 | 236 279 |

* for example, $Y = 186731.2 + 1450.74(34) = 236056.36$

** from column (e) of Table 3

*** estimation by inspection of the cyclic projection in Figure 3

**** actual sales levels for periods 1 and 2 in 1985 were 194467 and 230547, respectively.

firsthand knowledge of the situation can lead to logical and justified new sales estimates. Finally, in light of the relative complexity of more inclusive but very sophisticated forecasting techniques, we recommend that management go through an evolutionary progression in adopting new forecast techniques. That is to say, a simple forecast method well understood is better implemented than one with all inclusive features but unclear in certain facets. For further study, see the excellent survey paper in Chamber et al. [1] as well as such advanced forecasting texts by Levenbach el al. [3] and Thomopoulos [8].

## FOOTNOTES

[1] Vending machine sundries include candy bars, softdrinks, snacks, cigarettes, etc. When more than one product type is grouped into the general forecast, the sales data is said to be aggregated. Aggregated data is easier to forecast than individual items as irregular sales variation for the related products tend to cancel each other out.

[2] A centered moving average for n periods (when n is odd) for a given period i is calculated by summing up the sales in n consecutive periods such that period i is exactly in the middle of the sales group. This sales total is then divided by n to get the n-period moving average. Then, to calculate the moving average for period i + 1, the next total will drop the oldest period and pick up the newest period from the 'moving' total for period i. See, for example Monks [4] or Shao [7].

[3] $B = (\sum_i X_i Y_i - n\overline{X}\overline{Y}) / (\sum_i X_i^2 - n\overline{X}^2)$, $A = \overline{Y} - B\overline{X}$ where $\overline{X}$ and $\overline{Y}$ are averages for the number of periods and actual sales respectively, and n is the number of sales periods contained in the data. For further discussion of least square line fits, see for example, Chao [2] or Shao [7]. Also, an easy approximation method for least square fits is discussed in Ott [5].

[4] Except for initial outlier considerations, we make no attempt to explicitly address the difficult task of measuring irregular effects but assume such effects are random throughout and are thus recomposed implicitly.

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