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(Resolution adopted October 25, 1926 and revised February 6, 1933 and February 24, 1941)

SEASONAL ADJUSTMENTS BY ELECTRONIC COMPUTER METHODS*

JULIUS SHISKIN AND HARRY EISENPRESS
Bureau of the Census

I. INTRODUCTION AND SUMMARY

DURING the past few years, electronic computer programs for seasonally adjusting time series have been developed at the Bureau of the Census and improved and extended at the National Bureau of Economic Research. The electronic computer programs have been made available to other organizations and seasonal adjustments are now being made in several parts of the country on several different machines. More than 3,000 series had been adjusted for seasonal variations on electronic computers by mid-1957 and these series are being released in seasonally adjusted form by the responsible statistical agencies.

The electronic computer programs described in this paper have a limited objective—to eliminate the heavy burdens and high costs previously required for seasonal adjustments of time series and, consequently, to make seasonally adjusted data available for all important series. This paper does not try to resolve the many complex conceptual problems implicit in the decomposition

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The revised paper has been approved for publication, as a report of the National Bureau of Economic Research, by the Director of Research and the Board of Directors of the National Bureau in accordance with the resolution of the Board governing National Bureau reports (see Annual Report of the National Bureau of Economic Research). It is to be reprinted as No. 12 in the National Bureau's series of Technical Papers.

Many persons and organizations have made important contributions to our work on the use of electronic computers for seasonal adjustments of time series. Almost all the different groups utilizing the Census Univac service offered suggestions, and some of the strong points of the present method are their contribution. The staffs of the Bureau of the Census, the National Bureau of Economic Research, the Board of Governors of the Federal Reserve System, the Department of Agriculture, and the Department of Trade and Commerce in Canada should be specifically mentioned.

Thanks are also due to Howard C. Grieves and Morris H. Hansen of the Bureau of the Census for encouragement and practical assistance in the first stages of the project; to Arthur L. Broida of the Federal Reserve System and Maxwell R. Conklin of the Bureau of the Census for valuable suggestions and criticisms of the early work; to Geoffrey H. Moore of the National Bureau of Economic Research for similar contributions more recently; to Max A. Bershad of the Bureau of the Census for painstakingly reviewing and improving several early drafts of this paper; to a National Bureau of Economic Research staff committee consisting of Millard Hastay, Ruth P. Mack, and Victor Zarnowitz, and to W. Allen Wallis of the University of Chicago for helpful criticisms of a later draft; to Gladys F. Webbink for editorial suggestions; and to H. Irving Forman for drawing the charts. For assisting with the Univac programming, the writers are indebted to Lancelot W. Armstrong, George M. Heller, James L. McPherson, and the late Edward I. Lober, all of the Bureau of the Census.

During the 1956–57 academic year, while the writers were on leave of absence from the Bureau of the Census, working with the staff and records of the National Bureau of Economic Research, both Univac time and programming resources were provided by the Remington Rand Division of the Sperry-Rand Corporation. This project was supported by a grant from the National Science Foundation.

of economic time series and more specifically in the adjustment of series for seasonal variations, but only to show that the present electronic computer methods generally yield results of at least the same order of quality as the best clerical methods. There is little doubt, however, that the use of electronic computers, by forcing us to make explicit our assumptions at each stage of the work and enabling us to make comprehensive tests of the results, already has thrown considerable light on these problems and led to some improvements over the techniques previously used.

This paper describes the two methods developed at the Bureau of the Census and compares the results. The first method is a mechanical version of the familiar and widely used ratio-to-moving-average method and the second a refinement of the first. In the newer method the trend-cycle curve is traced out by a weighted fifteen-month moving average which provides a flexible yet smooth graduation. Smooth curves are also fitted to the seasonal-irregular ratios to provide seasonal adjustment factors, and follow the ratios for the full period of the data. Extreme values among the ratios are isolated automatically by a built-in system of control charts and are replaced by averages of the extreme ratio and surrounding ratios. Series as short as six years and as long as thirty years can be seasonally adjusted, and quarterly as well as monthly data can be handled.

Comparisons for a large number of different types of series show the second method to be superior. Comparisons with adjustments carefully made clerically by three different statistical organizations indicate that the results are at least as good as manual adjustments of the same series. These comparisons indicate that this electronic computer program has brought us fairly close to providing on a mass basis a fully mechanical method of making seasonal adjustments as good as those previously prepared for only a small number of series by a combination of laborious hand computations and professional judgments. For the few series where this is not the case, the electronic computer program provides data which can be converted to satisfactory seasonal adjustments with only a small amount of additional hand manipulations. Some of the kinds of series for which Method II is likely to yield inadequate adjustments are described, also.

Continuing studies are being made to find ways of reducing the number of unsatisfactory adjustments, and the resulting refinements of the method will improve it still further. Nevertheless, professional review of the results, particularly for the initial and terminal years of series, still is, and probably always will be, necessary.

II. SEASONAL ADJUSTMENTS BY METHODS I AND II

The first seasonal method programmed for the Census Bureau work, Method I, is an adaptation and elaboration of the familiar ratio-to-moving-average method at its most advanced stage of development.[1] A series reflecting the

[1] See, for example, F. C. Mills, *Statistical Methods* (New York, 1955), pp. 360–375; F. E. Croxton and D. J. Cowden, *Applied General Statistics* (New York, 1955), pp. 320–363; W. A. Wallis and H. V. Roberts, *Statistics: A New Approach* (Glencoe, Illinois, 1956), pp. 580–586; A. F. Burns and W. C. Mitchell, *Measuring Business Cycles* (New York, 1946), pp. 43–55; H. C. Barton, Jr., "Adjustment for Seasonal Variation," *Federal Reserve Bulletin*, v. 27 (1941), pp. 518–528.

trend-cycle components is estimated by a twelve-month moving average of the original observations. This estimate is then divided into the original observations to obtain a series reflecting the seasonal and irregular components. For each month, a moving average curve is next fitted to the time series representing the seasonal-irregular component for that month in successive years in order to obtain estimates of the seasonal factors alone. This last step yields twelve sets of moving seasonal factors, one for each month. The seasonal factors for each year are then "centered" so that their sum equals 1,200.

An iterative procedure is used: first, the seasonal factors obtained as above are divided into the original observations to obtain a preliminary seasonally adjusted series, representing the trend-cycle-irregular components. This series is, in turn, smoothed by a five-month moving average to provide a trend-cycle curve that is more flexible than the twelve-month moving average; that is, a five-month moving average can change direction over a short interval, so that it follows fairly sharp peaks smoothly, as well as shallow ones. The sequence of computations first made on the twelve-month moving average is then repeated on the five-month average to yield the final seasonally-adjusted series.

Altogether, the method yields nineteen tables which show the successive stages of the computations from the original observations to the final seasonally adjusted series.[2] Included are five different moving averages, two sets of ratios to moving averages, two centered and two uncentered sets of moving seasonal factors, two seasonally adjusted series, and five tests of the work. Method I is described more fully below (Section III) in the course of the explanation of the changes made for Method II.

The present writers studied the results of this method as applied to many series and also discussed it with other time series analysts who made similar studies. There is general agreement that this method is very good; that while it is sometimes possible to make a better adjustment for a single series or a few series, up to now it has not been possible to make adjustments of such high quality for large numbers of series. Nevertheless, a number of weaknesses have become evident. The possibilities of correcting these weaknesses depend partly upon the ingenuity of statisticians, but also upon the availability of a facility for carrying out masses of computations rapidly at low cost. The electronic computer comprises such a facility. The writers, therefore, carefully examined each one of these faults and proceeded to develop methods of overcoming them. These improvements have been incorporated in a revised seasonal method—Method II.

Method II follows the general procedure of Method I but takes advantage of the great capacities of electronic computers for statistical computations, by utilizing more powerful and refined techniques and producing more information about each series. Thus, it substitutes weighted for simple moving averages and isolates and reduces the weight of extreme items more selectively. It computes measures of the relative significance of the trend-cycle, seasonal, and irregular components of each series and uses these relations automatically to guide the course of subsequent computations. It adds a new basis for judging the validity of the seasonal adjustment to those provided by Method I. It

[2] See Julius Shiskin, "Seasonal Computations on Univac," *American Statistician*, February 1955, pp. 19–23.

provides optionally a constant seasonal index for special uses. It computes month-to-month percentage changes in the series and its components. It also produces point charts for the convenience of its users.[3] The full array of data now provided by this electronic computer program is shown for an illustrative series in Table 1.

The principal features of Method II are:

1. It computes a preliminary seasonally adjusted series which follows primarily the conventional ratio-to-moving-average technique. It starts with ratios computed by dividing the original observations by a twelve-month moving average; it computes moving seasonal adjustment factors from these ratios; and it obtains a seasonally adjusted series by dividing these preliminary seasonal adjustment factors into the original observations.

2. It utilizes a complex graduation formula—a weighted fifteen-month moving average—as the estimate of the trend-cycle curve used to obtain the final seasonally adjusted series. For most series this formula yields a curve which is flexible, follows the data closely, and gives a smooth representation of the trend-cycle components.

3. It utilizes a control chart procedure to identify extreme items among the seasonal-irregular ratios and systematically reduces the weight of these extremes for the subsequent computations. For each month control limits of two standard errors are determined above and below a five-term moving average fitted to the seasonal-irregular ratios. Any ratio falling outside the limits is designated as "extreme" and is replaced by the average of the "extreme" ratio and ratios immediately preceding and following.

4. It utilizes weighted moving averages of the seasonal-irregular ratios for each month to obtain the seasonal adjustment factors; for example, a three-term moving average of a three-term moving average, which is equivalent to a five-term moving average with the weights, 1, 2, 3, 2, 1.

5. It utilizes a measure of the irregular component of each series to determine the type of moving average to fit to the seasonal-irregular ratios. The larger the irregular component, the larger the amount of smoothing that is carried out. Alternative graduation formulas, each appropriate for series with irregular components of different magnitude, are placed in the computer memory and automatically selected according to the average month-to-month amplitude of the irregular fluctuations.

6. It takes into account changing trends in calculating seasonal adjustment factors for the first and last few years of each series. Instead of following the usual procedure of extrapolating the seasonal adjustment factor curve to the end of the series, this new method takes an average of the last two seasonal-irregular ratios for a given month as the estimated value of each of the following two or three ratios. These estimates are then used in computing the two seasonal factors that would otherwise be missing at the end of the series. A similar procedure is used to obtain missing values for computing the ends of the trend-cycle curve.

The electronic computer programs for Methods I and II provide for working or trading day corrections where they are needed. The working or trading day

[3] For a description of how these charts are prepared, see Harry Eisenpress, James L. McPherson, and Julius Shiskin, "Charting on Automatic Data Processing Systems," *Computers and Automation*, August 1955.

correction factors must, however, be available, for punching or taping, along with the original observations; there is no technique built into the electronic computer program for estimating such factors. The working day correction is accomplished by the modification of the original observations, in the electronic computer routine, before they are started through the seasonal adjustment process.

The faults in Method I and the methods for overcoming them which have been adopted in Method II are described below and comparisons of the seasonal adjustments made by Methods I and II are shown and analyzed for several economic series. A detailed description of each of the steps in these seasonal methods can be obtained by writing to the authors.

III. FAULTS OF METHOD I AND THEIR IMPROVEMENT IN METHOD II

1. *Improvements in the Trend-Cycle Curves*

(a) *Smoothing the trend-cycle curves:* The five-month moving average of the preliminary seasonally-adjusted series, which has been used in Method I as the underlying trend-cycle curve, occasionally yields a somewhat irregular curve, although for most series it produces better results than earlier methods based on a 12-month moving average of the original series. Nevertheless, for series with large irregular components, the 5-month moving average does not result in a smooth delineation of the trend-cycle components of the series. (See, for example, Chart 1.)

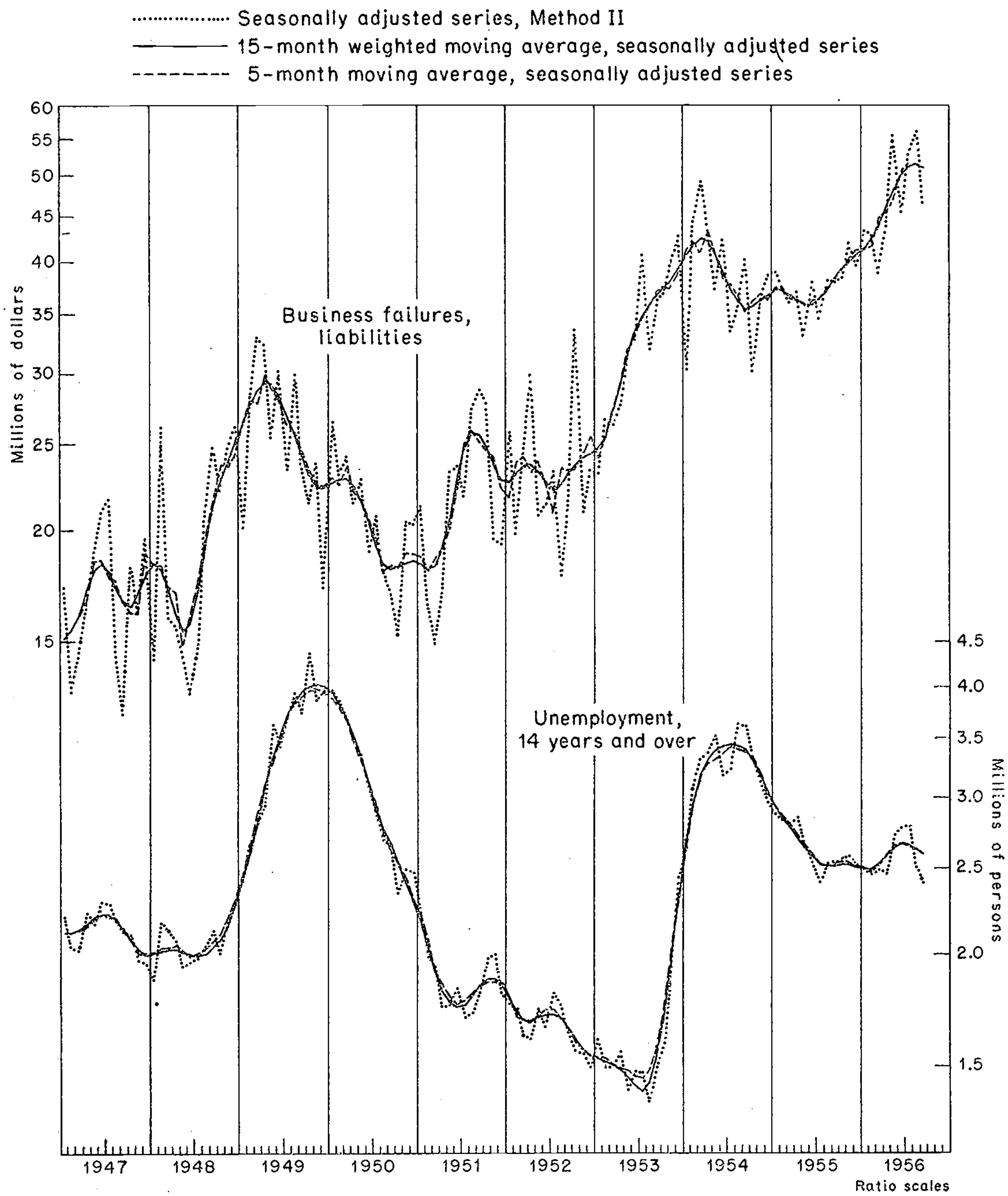
With the burden of computations no longer a factor, the writers were able to turn to the large array of complex graduation formulas previously developed by others to select a curve which is as flexible as, yet smoother than the five-month moving average.

It seems fairly clear to students of this problem that there is no single graduation formula which best delineates the underlying cyclical movements of all economic series.[4] Perhaps it may be possible eventually to develop criteria for selecting a particular graduation formula for each series according to the types of cyclical and irregular fluctuations characteristic of that series. Then with electronic computer programs for a large number of different graduation formulas available, the computer would calculate measures of the cyclical and irregular components in each series, and on the basis of these select the smoothing formula most suited to each particular series. The writers have tried to make such a start; however, its development is for the future. For the present, because of the time that will be required to develop a conceptual basis for this idea and to prepare the electronic computer programs, the writers have selected a single graduation formula to measure the trend-cycle factors.

Graduation formulas are available which provide smooth and flexible curves and also eliminate seasonal fluctuations; for example, Macaulay's 43-term formula. But such formulas involve the loss of a relatively large number of points at the beginnings and ends of series. Graduation formulas which provide similarly smooth and flexible curves and involve the loss of relatively few points do not also eliminate seasonal variations. The computation for a preliminary seasonally adjusted series is now easy mechanically; on the other hand, the

[4] See, for example, Arthur F. Burns and Wesley C. Mitchell, *op. cit.* Chapter 8, esp. p. 320.

CHART 1. Comparison of Spencer 15-month weighted moving average and simple 5-month moving average.



replacement of missing points is difficult conceptually. We, therefore, chose one of the formulas which requires a preliminary seasonally adjusted series, but also minimizes the loss of points—the Spencer fifteen-month weighted moving average.

The Spencer formula appears well suited for the purpose at hand: For most series it gives a smooth representation of the trend-cycle components, and fits the data as closely as a simple five-month moving average. The weights of the Spencer graduation are as follows: −3, −6, −5, 3, 21, 46, 67, 74, 67, 46, 21, 3, −5, −6, −3. This weighting scheme is equivalent to taking a five-month moving average of a five-month moving average of a four-month average of a four-month moving average of the data, with weights of −3, 3, 4, 3, −3 applied to either of the two five-month moving averages.[5] This graduation formula also has the property of fitting a third degree polynomial exactly. The marked improvement in smoothing that can result from the use of the Spencer formula in place of the simple five-month moving average is illustrated in Chart 1. The greater the amplitude of the irregular movements in a series in proportion to its cyclical movements the more advantageous will be the use of the Spencer formula in place of the simpler moving average. This improvement in smoothing is reflected in the resulting seasonal-irregular ratios and in all the subsequent computations.

Although the Spencer weighted fifteen-month moving average appears to yield a better estimate of the trend-cycle component (as we imagine it) than the five-month moving average, there is still the fundamental question of the suitability of either for this purpose. As we have said, different types of smooth curves will almost certainly be more appropriate for some series. We expect to investigate the subject of smoothing the preliminary seasonally adjusted series more intensively at a later stage (see Appendix A).

(b) *Extending the trend-cycle curves:* The five month moving average of the preliminary seasonally adjusted series used in Method I also is defective in that it entails the loss of two observations at the beginning and at the end of each series. Since the last two months of the series are usually of considerable importance, Method I fills in these months by extrapolating the seasonal adjustment factors to cover the missing data. (The beginning of the series is similarly completed by symmetry.) This method works well in most series, but, as with the extrapolation in Method I of the five-term moving average (described in subsection 2, below), it is not optimum when there is a trend in the seasonal factors (i.e., a moving seasonal) at the end or beginning of the data.

Method II attempts to improve upon this extrapolation procedure. Instead of extending the seasonal factors, we use an average of the last four months of the preliminary seasonally adjusted series as an estimate of the value of each of the seven months following the last month of this series. These estimates are then used in computing the seven missing values at the end of the Spencer graduation. The beginning of the Spencer graduation is supplied in similar manner. The Spencer graduations in Chart 1 have been extended to the ends of the series. The fit in these series, as in most of the series we have tested, appears quite good.

2. *Improvements in Seasonal Adjustment Factor Curves*

Moving positional means of five terms are fitted to the seasonal-irregular ratios for each month in Method I: The largest and the smallest ratios in each set of five terms are dropped from each computation before the remaining three are averaged. These positional means have not always provided smooth curves, and occasionally are not even good fits, particularly at the beginnings and ends of series. These defects arise partly from the method used for eliminating ex-

[5] For more information on the Spencer graduation, and on smoothing formulas, generally, see Frederick R. Macaulay's *The Smoothing of Time Series* (National Bureau of Economic Research, New York, 1931), esp. pp. 55, 121–140, and M. G. Kendall, *Advanced Theory of Statistics* (London, 1946), Vol. II, Chapter 29. The fifteen-month graduation formula used above was first described by J. Spencer in his article "On the Graduation of the Rates of Sickness and Mortality," *Journal of the Institute of Actuaries*, Vol. 38 (1904), p. 334.

CHART 2. Comparison of seasonal adjustment factors computed by methods I and II, sample months of sample series.

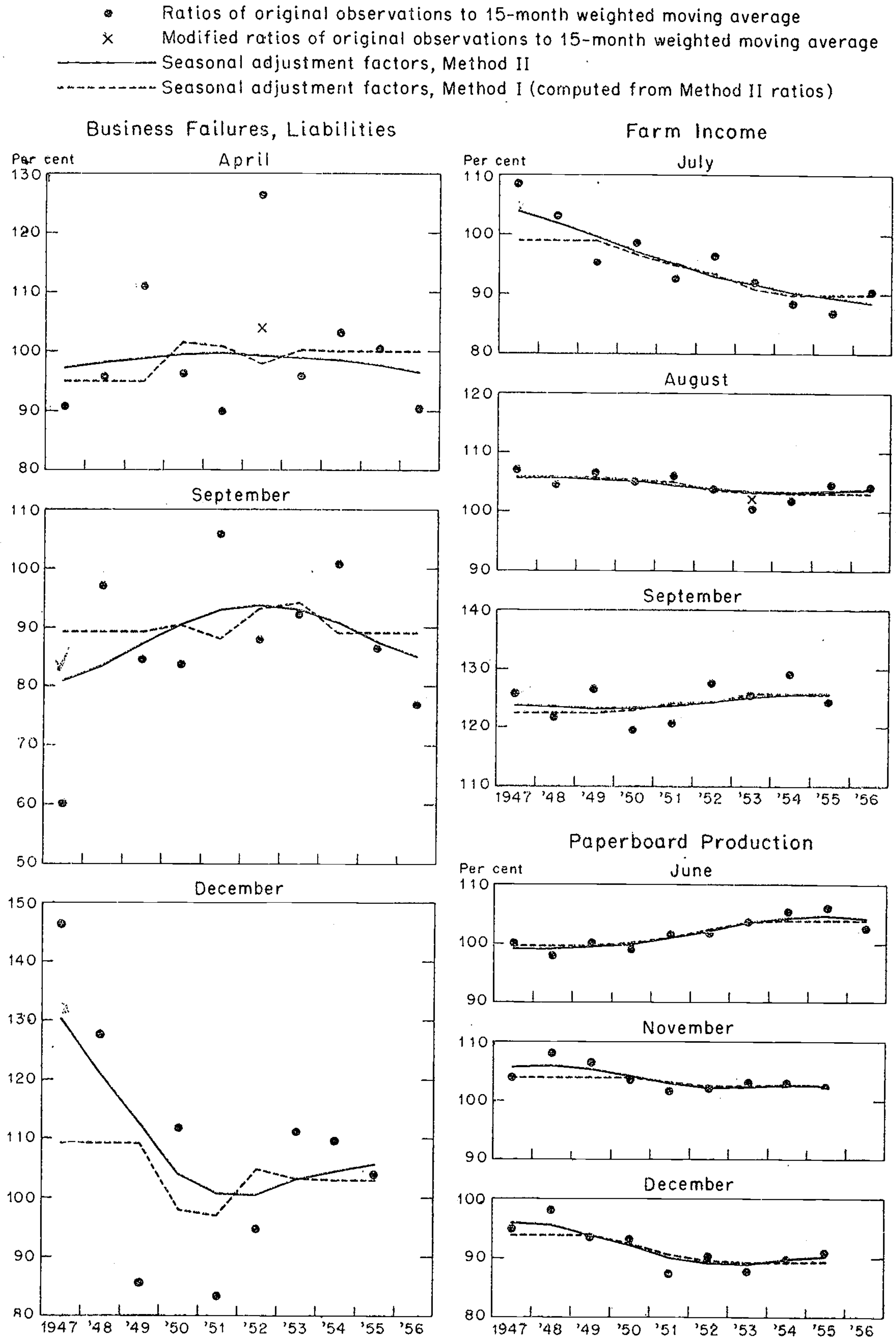
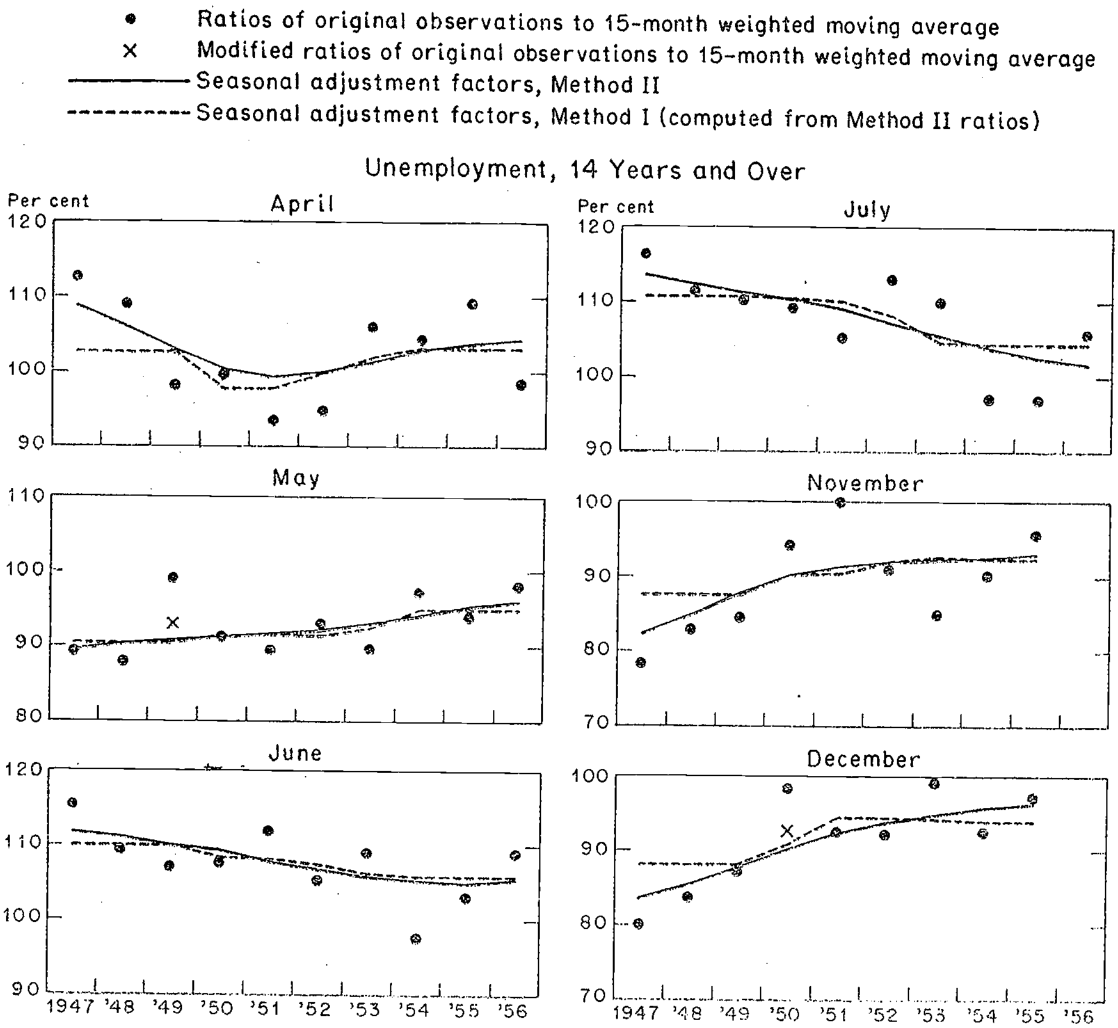


CHART 2. (*concl.*) Comparison of seasonal adjustment factors computed by methods I and II, sample months of sample series.



treme ratios—a method which sometimes eliminates ratios which are probably not extreme, or retains ratios which had best be omitted, and thus distorts the estimate of the seasonal factor—and partly from the limitations of a simple five-term moving average of the seasonal-irregular ratios.

(a) *Isolating extreme ratios:* To improve the identification of extreme ratios, a control chart procedure has been adopted in Method II. For each month, control limits of two "standard errors" are determined above and below the five-term moving average of the ratios. (The square of the standard error is here defined as the average of the squared deviations of the ratios from their corresponding five-term moving average values.) Any ratio falling outside the limits is designated as "extreme" and is replaced by the average of the "extreme" ratio and the ratios immediately preceding and following. If the extreme ratio is the first ratio for the month, it is replaced by the average of the first three ratios for the month; if it is the last ratio, it is replaced by the average of the last three ratios for the month. In effect, the weight accorded the extreme ratio in subsequent smoothing operations is reduced by two-thirds, while the weights of the adjacent ratios are each increased by one-third. This procedure is applied separately to the ratios of each month, from January to December.

The results of the new procedure as compared with the method of positional means are illustrated in Chart 2. The effects of centering (in both methods) and smoothing (in Method II), which are discussed below, mask the differences due to the different treatment of extremes. Nevertheless, it is clear that small dips or crests in the lines of smoothed ratios due to the treatment of extremes in Method I have now been eliminated (see especially Chart 2, Business Failures, April 1952 and September 1951).

It should be borne in mind that the determination of "extremeness" for any ratio depends on the deviations of all the ratios in the series for that particular month from their moving average values. The standard error varies from month to month within series and between series. At present the data for all the years in the series for each month are used as one period for the purpose of calculating the standard error. Future experience may prove that two or more periods are preferable. Furthermore, our selection of *two* standard errors as the control limits is arbitrary. Tests of these limits now planned may lead to a change, probably to a smaller figure, say $1\frac{1}{2}$ standard errors, so that more items are identified as extremes (see Appendix A). This procedure would involve more smoothing of the seasonal-irregular ratios, which would in turn yield smoother seasonal-adjustment factor curves.

A limitation of the new procedure may be mentioned here; since the five-term moving average, which serves as the base for the computation of the standard error, does not reach to the ends of the series, it must be extrapolated if any extremes in the first or last two years are to be identified and properly modified. Now, what weight shall be given to the ending (or beginning) years in this extrapolation? If the ratios for these years receive large weights, they will hardly ever be identified as extreme ratios; if the weights are small, a trend in the ratios may be confused with extreme items and the ratio curves may not be given their proper slope in the beginning and ending years. This problem is difficult to solve. In Method II the following procedure has been adopted: The average of the last two ratios for a given month is used as the estimated value of the ratio for each of the two years following the last year available; these estimated values are then used in calculating the moving average values for the last two years. The beginning years are treated similarly.

(b) *Smoothing the fitted curves:* Even after adjusting extreme ratios properly, the five-term moving average of the ratios for each month sometimes is too erratic in its changes from year to year to fit our model of time series analysis, which assumes gradual seasonal change from year to year. The five-term moving average in Method I is therefore replaced in Method II by a three-term moving average of a three-term moving average. This is equivalent to a five-term moving average with the weights 1, 2, 3, 2, 1. This smoothing formula appears to be superior to the simple five-term moving average in eliminating erratic year-to-year changes in direction, while at the same time retaining the smooth short-term movements of the ratios. Furthermore, the ratios are smoothed *after* they are centered (i.e., adjusted so that their sum will be 1200.0 for each calendar year), rather than *before* centering, as in Method I, to avoid any distortions in the smoothed series due to centering. (It can easily be shown that distortions of the centered values will not occur in this case; that is, that smoothing based on linear formulas—of which the unweighted moving average is the simplest example—will not change annual totals.) Thus, Method II now produces seasonal adjustment factors that are centered and change only gradually from year to year. Moreover, an important innovation has now been introduced: The three-term of the three-term moving average is replaced by the three-term of the five-term moving average, whenever irregular movements are pronounced.[6] Thus, a more powerful smoothing process is used for series having large irregular movements (see Appendix A).

The effects of the revised smoothing formulas for seasonal-irregular ratios used in Method II compared with those used in Method I are shown in Chart 2. The fit of the smoothed lines to the ratios, with smoothing and centering accomplished in a mechanical manner, will, of course, differ from any smoothing done manually by the usual trial and error process. However, the differences in terms of the seasonally adjusted data will probably not be large or significant. In general, the fit of Method II is closer to the ratios and is smoother than that of Method I.

(c) *Extending the fitted curves:* Method I does not take into account obvious changing trends and new seasonal factors in obtaining seasonal factors for the first and the last few years of each series. In Method I the first seasonal factor that can be computed for each month relates to the *third* year, but is also used for the first two years; and the last seasonal factor computed, which relates to the third year from the end of the series, is extrapolated to the last two years.

This procedure—of bringing seasonal adjustment factors up to date by leveling off the curves so that their slopes are zero for the recent years—has been followed quite generally. It is, however, at variance with a basic assumption of our method, that the seasonal factors may vary gradually from year to year. Where the seasonal is truly constant—that is, where the slope of a seasonal adjustment factor curve is zero for several years—all the methods that we have considered for bringing the factors up to date give about the same results. For cases where the slopes may be significantly different from zero, level curves at the beginnings and ends will not measure the full seasonal factors; and consequently, the seasonally adjusted series will contain not only the trend, cycle, and irregular, but also some seasonal components.

For this reason, a more sensitive extrapolation procedure has been introduced in Method II. The seasonal adjustment factor curve is not extrapolated directly to the end of the series; instead, the average of the last two seasonal-irregular ratios for a given month is taken as the estimated value of each of the following two ratios; and these estimates are used in computing the two seasonal factors that would otherwise be missing at the end of the series. (A similar procedure is used for the initial years.) The average of the last two available ratios, rather than the value of the last ratio alone, is used as the estimate in order to avoid any distortion that might result from a highly irregular terminal ratio.

[6] To make this decision, measures of the average amplitude of the month-to-month movements in the trend-cycle, seasonal, and irregular components of series have been developed and are used automatically in the computer program. For a description of these measures, see Julius Shiskin, "New Measures of Economic Fluctuations," *Improving the Quality of Statistical Surveys, Papers Contributed as a Memorial to Samuel Weiss*, American Statistical Association, Washington, D.C., 1956.

This procedure has the advantage of flexibility in the types of curves used at the ends of series. On the one hand, where there are strong forces making for a constant seasonal pattern, the method will yield level curves at the ends of series. On the other hand, where there are strong forces making for a changing seasonal pattern, it will permit changes at the ends of series. The leveling off of the ratios for years following the last year of actual data will, however, exercise a constraint on the extent to which the slopes can change. While this procedure makes full use of the available data, it is neutral with respect to the question of future turns in seasonal behavior. It does not assume that trends will continue up or down or that they will reverse themselves but, instead, assumes only that the seasonal-irregular ratios continue at current levels. In the cases where this assumption proves to be wrong, it will not give as bad results as would follow from one of the alternative assumptions.

The difference in our methods of fitting curves to the first and last years of the seasonal-irregular ratios may be clarified in the following algebraic terms.

If X_n is the last ratio available, then it is implicit in Method I that $X_{n+1}=X_{n-4}$ and $X_{n+2}=X_{n-3}$, while in Method II we explicitly make $X_{n+1}=X_{n+2}=\frac{1}{2}(X_n+X_{n-1})$.

It seems reasonable to assume that better estimates of the missing ratios will usually be provided by ratios for more current than for less current years.

Inspection of this approach for our test series indicates that it generally gives reasonable results. The results of employing these different methods routinely to obtain seasonal adjustment factors for the beginnings and ends of series are illustrated in Chart 2. It is clear from the chart that a trend in the ratios will now be reflected at the ends of the series and that the resultant curves for the terminals of series will be similar to those for the middles.

It is important to note, however, that this method of adjusting the ends is not always satisfactory. Unsatisfactory adjustments will appear more frequently in series with large irregular components, when the last two ratios are both relatively extreme, and particularly when they fall on the same side of the seasonal adjustment factor curve.

The changes in the treatment of the initial and terminal years in Method II, as compared to Method I, appear to account for most of the differences that have been observed in series adjusted by both methods. Future experience with Method II is expected to lead to modifications of this procedure by introducing more complex extrapolation methods.

The technique of using extrapolated average values at the ends of series to extend moving averages to cover the full period of the data is employed three times in Method II: (1) to extend the weighted Spencer 15-month moving average fitted to the preliminary seasonally-adjusted series (Section III, 1, b); (2) to extend the five-term moving average used as a basis for calculating control limits needed to isolate extreme ratios (Section III, 2, a); and (3) to extend the seasonal adjustment factor curve fitted to the seasonal-irregular ratios. A good deal obviously depends upon this technique. It seems reasonably safe and is certainly preferable to the alternative assumption that the cyclical or seasonal curves level off at the beginnings and ends of series. We recognize, however, that we are dealing here with the basic problem of economic forecasting, and that this technique may sometimes lead us astray.

3. *Extending the Electronic Computer Program to Cover 30-Year Monthly Series*

Method I is limited to monthly series of a maximum duration of fifteen years. For most of our users, concerned primarily with postwar data, this has been satisfactory; but for groups concerned with longer series, we were only able to make this service available in a rather clumsy way by splitting the data into segments with very long overlaps.

The memory capacity of the electronic computing machines for which the Method II program has been prepared does not permit an indefinite expansion of the period that can be used. A substantial increase in the number of years to be covered would require the use of relatively inefficient techniques and would slow down operations. Fortunately, a simple expedient permitted the doubling of the maximum number of years included. (Instead of using one computer memory position for each monthly figure as in the earlier method, Method II puts *two* months' data into each position. While this limits the maximum number of digits for each month to six, it is, for most economic series, a satisfactory upper limit.) Thus, the new method can now be routinely applied to any time series from six to thirty years long. For longer series division into several overlapping segments is necessary for the present.

4. *Additional Tests*

In the analysis of current economic conditions, a great deal of interest attaches to monthly changes. For this reason a reasonable argument can be made that month-to-month *changes* rather than monthly *levels* should be adjusted for seasonality. Indeed, the well-known link relative method developed by Warren M. Persons follows this idea.[7] The link relative method, however, lacks the flexibility or the simplicity of the ratio-to-moving-average method for computing moving seasonal adjustment factors.

To determine whether Method II makes a good seasonal adjustment of month-to-month changes as well as monthly levels, link relatives of seasonal-irregular ratios were compared with the link relatives of the seasonal adjustment factors implicitly fitted to these link relatives by Method II. The results indicate that the implicit curves fitted to the link relatives of the seasonal-irregular ratios are similar in smoothness, closeness of fit and general sweep to the curves fitted to the ratios to moving average. Consequently, Method II seems to yield a seasonal adjustment of the month-to-month changes of about the same quality as the seasonal adjustment of the absolute observations. Chart 3 illustrates this point.

What is the effect of our method of seasonal adjustment upon series that have no seasonal component—does our method introduce spurious fluctuations in series? To answer this question partially Method II was applied to stock prices, which are not considered to have any seasonal fluctuations, and to unemployment after adjustment for seasonal variations by Method II. As can be seen from Chart 4, the effect of a Method II adjustment upon such series is trivial.

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[7] See Warren M. Persons, "Indices of Business Conditions," *Review of Economic Statistics*, January 1919.

Chart 3. Comparison of link relatives of seasonal-irregular ratios and seasonal adjustment link relative factors implicitly fitted to these link relatives by method II, sample months of two sample series.

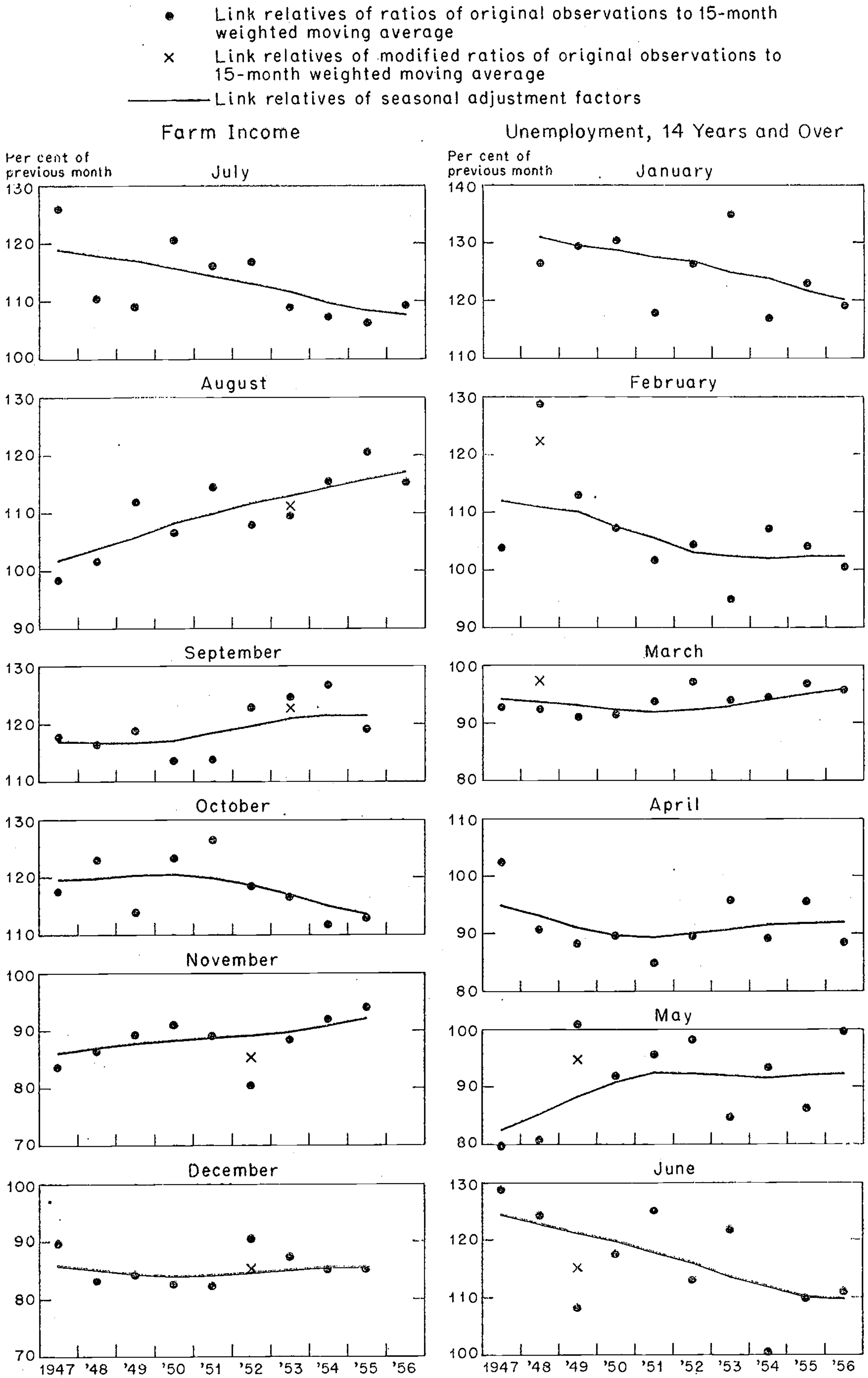
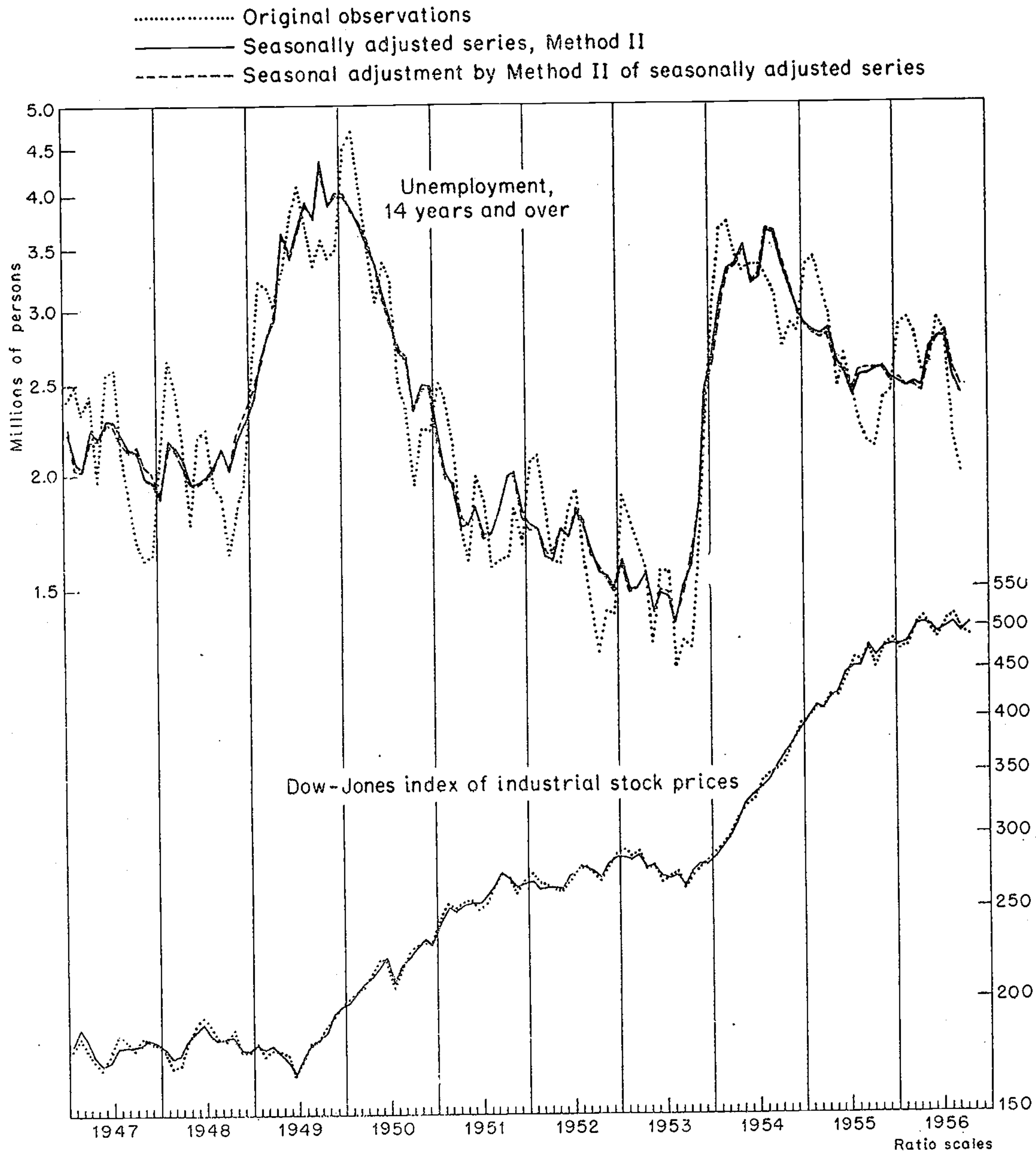


CHART 4. Effect of seasonal adjustment by method II on series without seasonal components.



5. *Conclusions Regarding Method II*

It is difficult to measure objectively the quality of a seasonal adjustment. There is widespread agreement, however, that a good adjustment is one that minimizes repetitive intra-year movements. While moving average curves satisfy this criterion such curves have in the past had limited use for business-cycle analysis because they distort or bias the dates of turning points, the amplitudes, and the patterns of business cycles, and because there is no satisfactory way of bringing them up to date. While it is conceivable that a moving average curve that overcomes these limitations can eventually be developed, for the present, conventional seasonally adjusted series appear preferable.

Inspection of the results yielded by Methods I and II for a sample of series indicates that in terms of this criterion, i.e., the minimization of repetitive intra-year movements, Method II is the better. The techniques for estimating the trend-cycle component, for isolating extreme items, and for smoothing the seasonal-irregular ratios for each month are certainly better than the corresponding techniques used in Method I. The technique for extending the different moving average curves to the beginnings and ends of series also seems better. Comparisons of the net results of all these factors are made in Chart 5, which shows the original observations and the data seasonally adjusted by Methods I and II for some of our test series. The theoretical advantages of Method II have little impact on these series, except at the beginnings and ends. However, where the differences do occur, the advantages appear to be in favor of the newer method.

CHART 5. Comparison of seasonal adjustments by methods I and II.

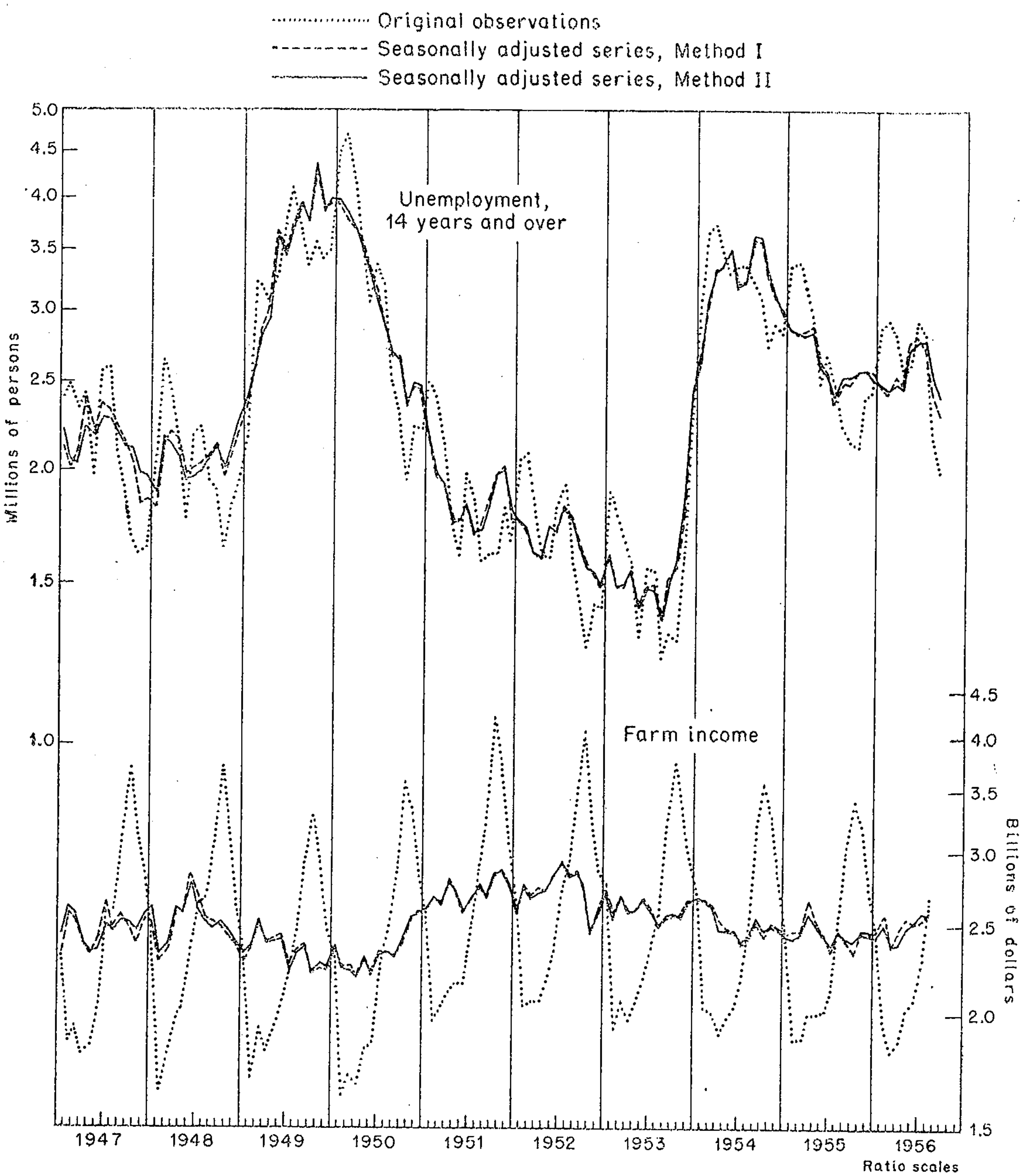
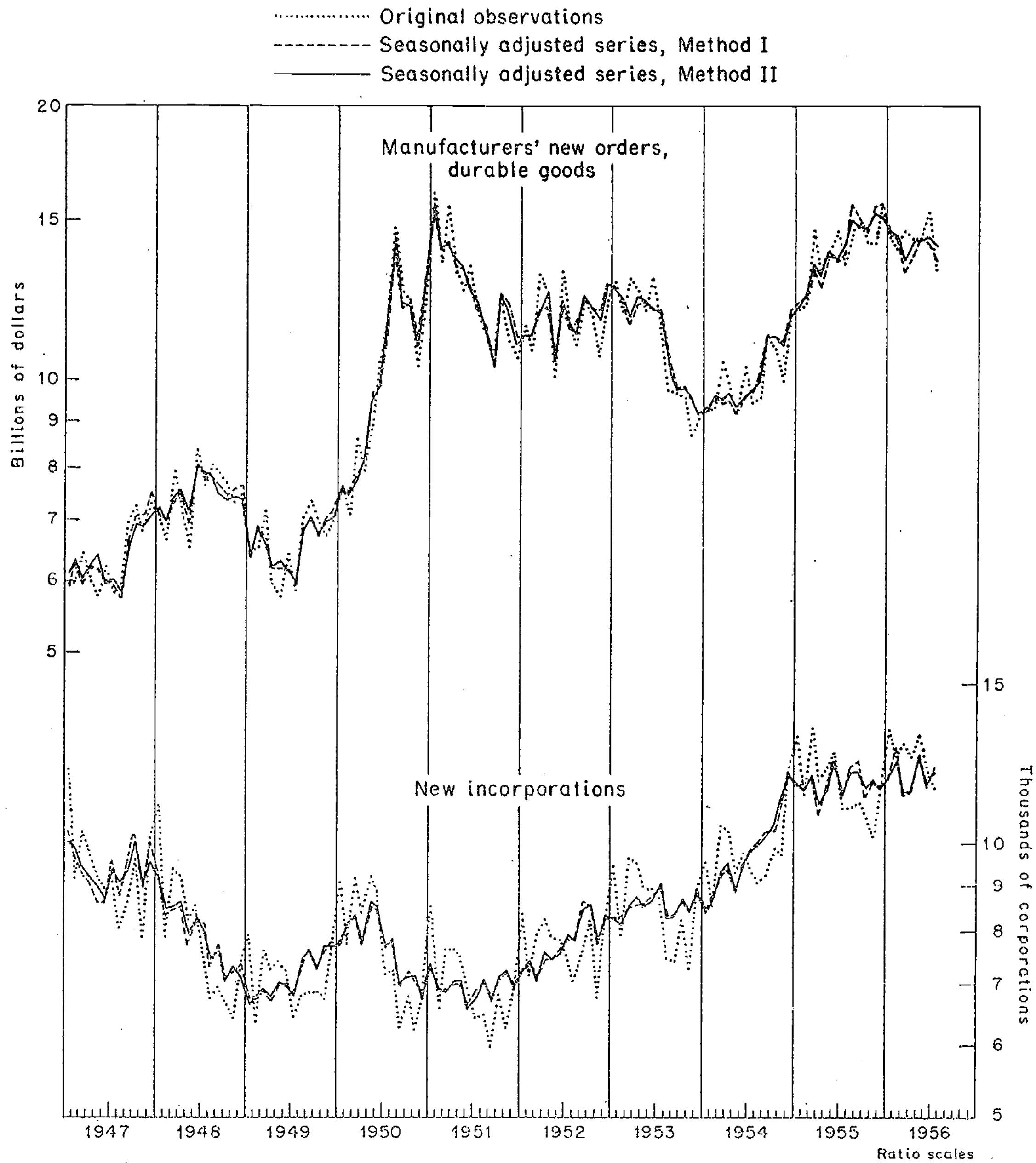


Chart 5. (*concl.*) Comparison of seasonal adjustments by methods I and II.



A comparison has also been made of seasonal adjustments prepared manually at the National Bureau of Economic Research, the Office of Business Economics of the Department of Commerce, and the Department of Agriculture, and the Method II adjustments for the same series. The NBER adjustments, shown in Chart 6, employ stable seasonal factors, with two short periods selected for each series; the OBE and Department of Agriculture employ moving adjustments for the series selected. The differences in the results are small. Where differences do appear, Method II usually yields the smoother seasonally adjusted series. It seems plain from these comparisons that Method II can be counted upon to yield an adjustment of the same order of quality as the best manual methods. Furthermore, this method appears to be of such generality that it can make stable and moving adjustments about equally well.

CHART 6. Comparison of manual and electronic computer seasonal adjustments.

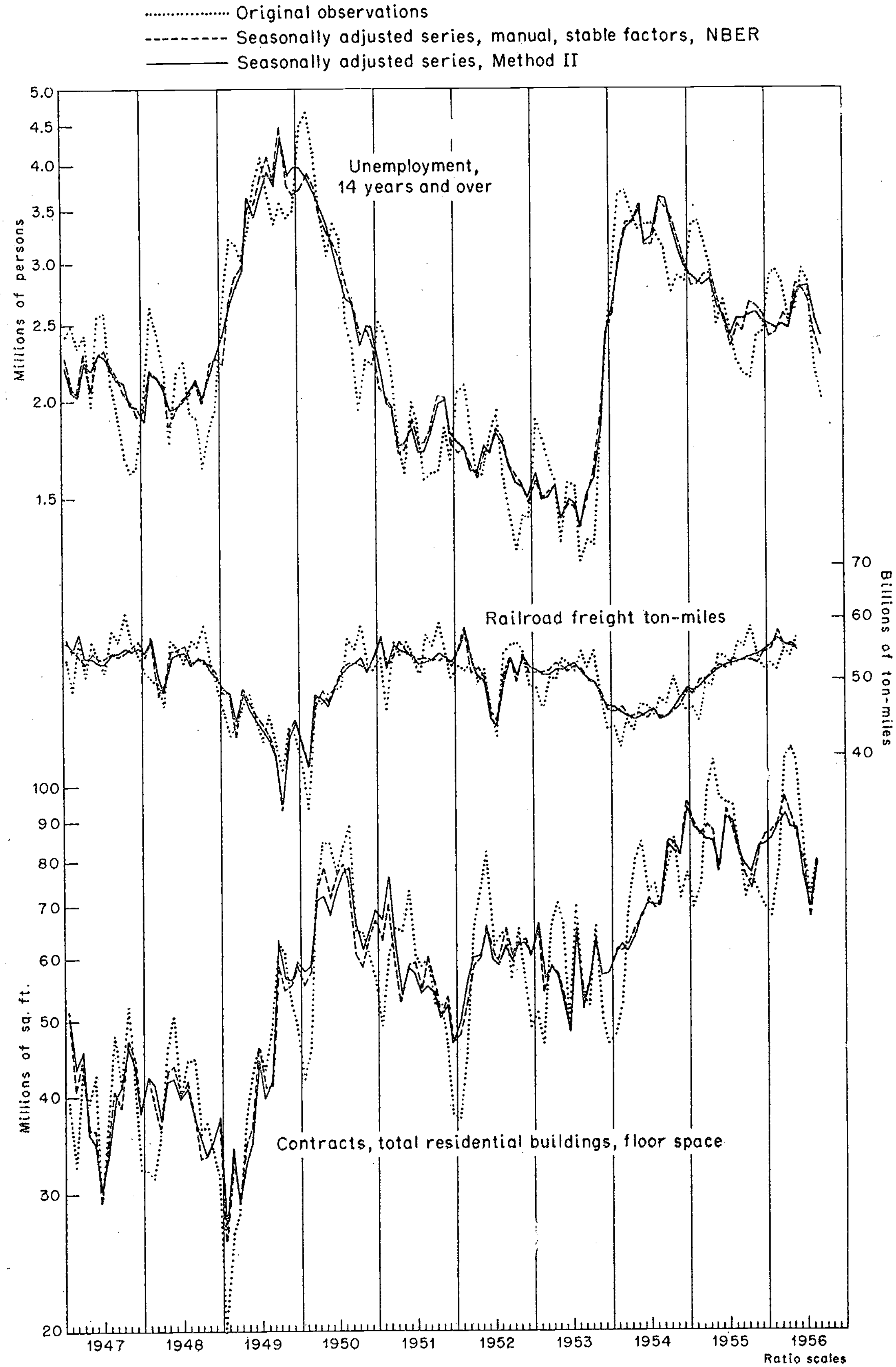
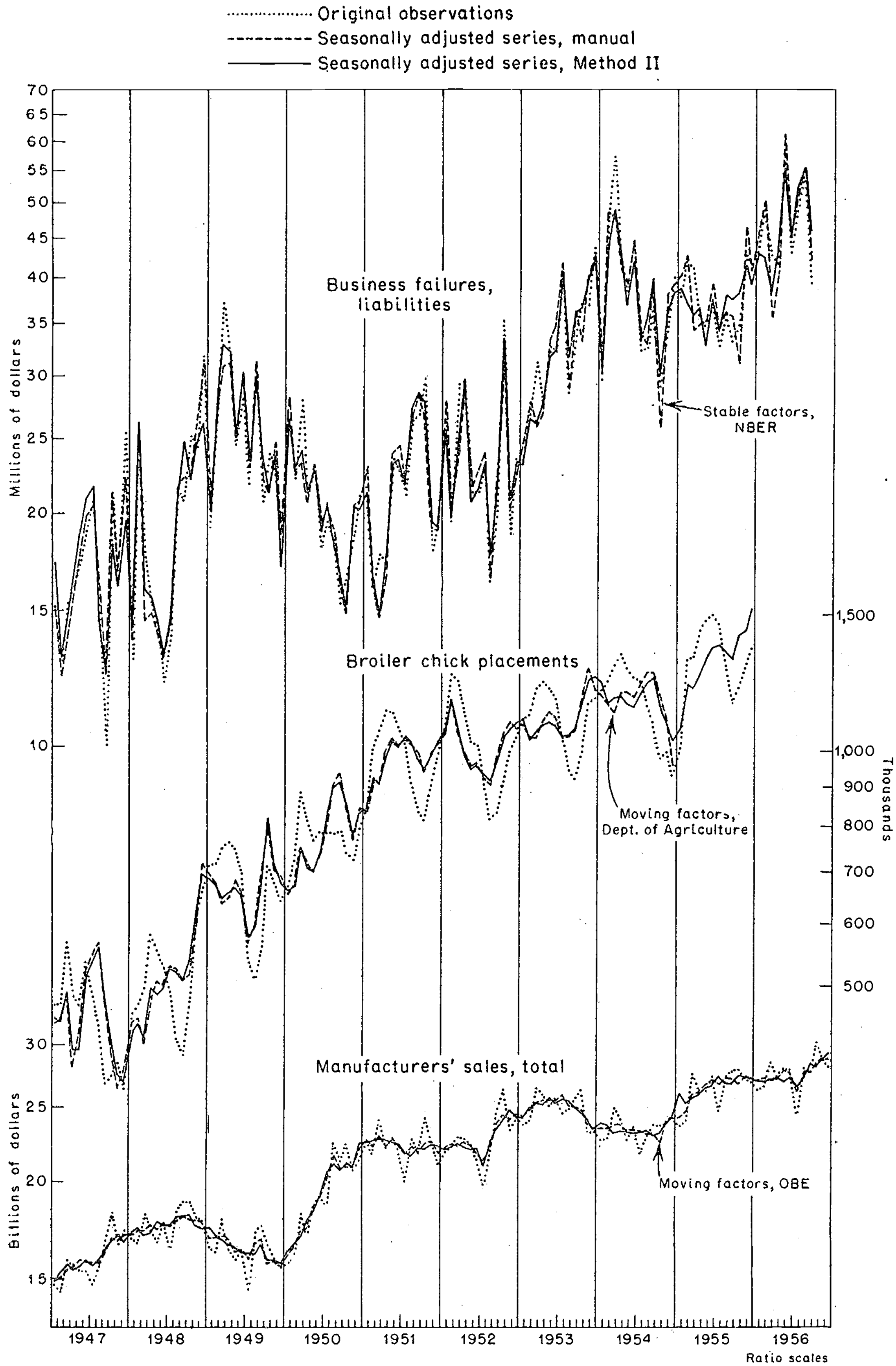


Chart 6. (*concl.*) Comparison of manual and electronic computer seasonal adjustments.



A professional review of each Method II adjustment is, however, still necessary. As in the case of all methods of seasonal adjustment, this method implicitly makes certain assumptions regarding the nature of the forces affecting each series. These assumptions are probably applicable to most series, but not to all. For example, it assumes that the relations between seasonal and cyclical forces are multiplicative rather than additive. For the comparatively few series for which these relations are not primarily multiplicative, poor seasonal adjustments may result. In the light of current figures that became available after some of the adjustments were made, it is also clear that the adjustments at the ends of series are sometimes unsatisfactory. There may be other deficiencies of which we are not yet aware. Constant vigilance is therefore required.

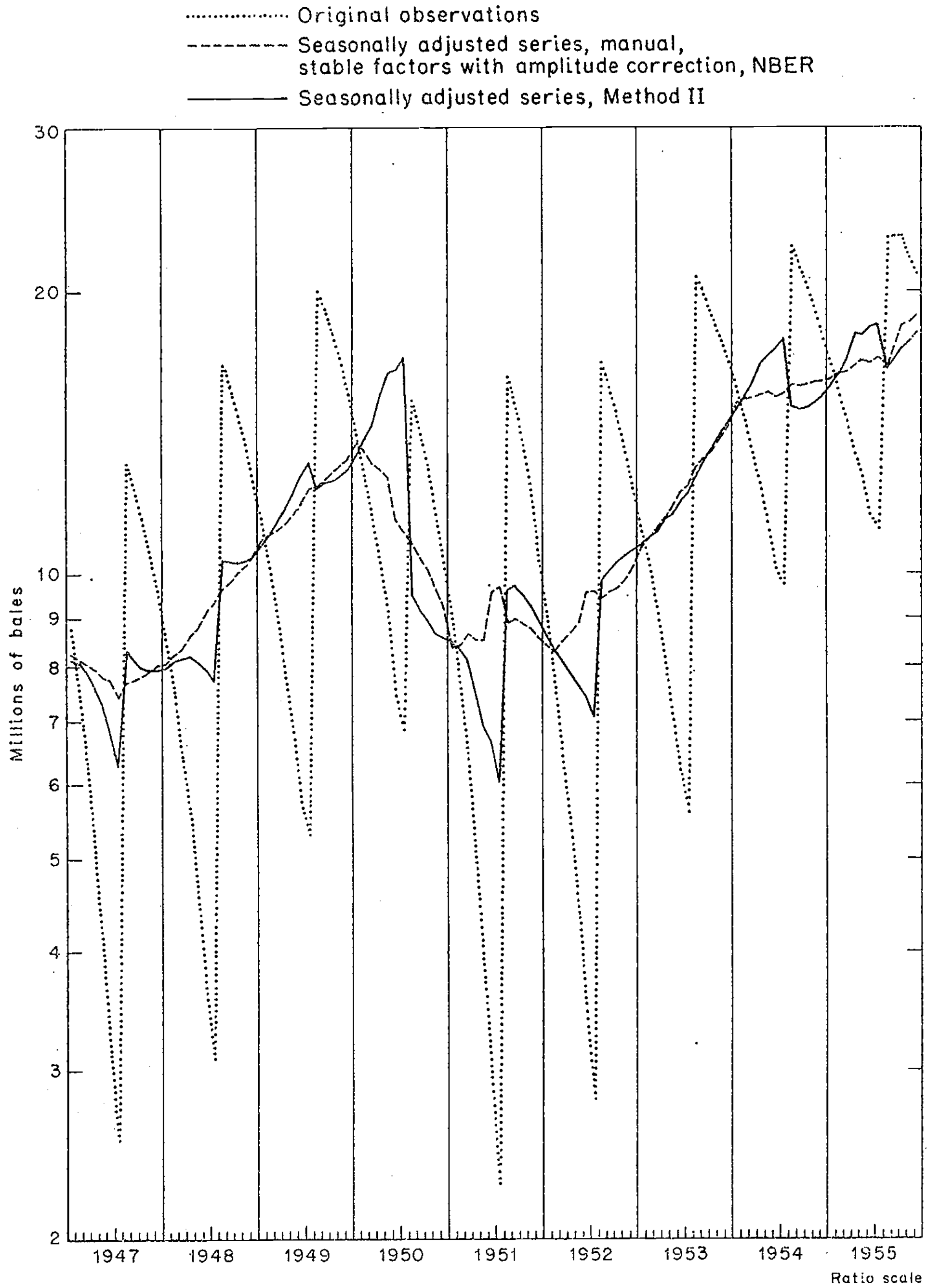
That Method II does not always yield good adjustments can be seen from the series shown in Chart 7. The Method II adjustment for cotton stocks does not smooth out the annual patterns fully, leaving positive or inverted patterns of the same shape but smaller amplitude than that of the seasonal factors. As can be seen from the chart, a much more satisfactory adjustment was obtained by using a stable seasonal index with an amplitude correction. This illustration suggests difficulties where the monthly figures for the year (calendar or fiscal) are tied together by a single common event (e.g., in agricultural crop series).

Another type of series for which Method II will not produce a uniformly good adjustment is one in which there is an abrupt change in the seasonal pattern. The technique adopted for fitting moving averages to seasonal-irregular ratios will always yield smooth seasonal factor curves, in accordance with our assumption of slow, gradual changes in the seasonal factors from year to year. Sudden year-to-year shifts can, however, occur for various reasons, for example, as a result of administrative decisions by business associations or government agencies. Thus abrupt seasonal changes no doubt occurred in some parts of the economy when the automobile industry changed the dates for introducing new models from the spring to the fall, and when the government deferred the date for submitting income tax returns from March 15 to April 15.

It is also clear from our studies that the isolation of the seasonal factor is suspect in the case of series with very large irregular factors. For this reason the Univac program routinely adds constant seasonal adjustment factors and corresponding seasonally adjusted series when the average month-to-month amplitude of the irregular factor is four per cent or more.

Experience gained with the results of Method II has led to a program of testing some alternative procedures with a view to introducing further improvements. Thus the present method of obtaining seasonal-irregular ratios at the ends of series does not give good results when the last two ratios, whose average is used as the estimate for the years following the last one for which a figure is available, are both relatively extreme, and particularly when they fall on the same side of the seasonal adjustment factor curve. Experiments are being made with various alternatives, including averaging more ratios when the irregular component is large. A moving average curve, of a period that varies with the magnitude of the irregular fluctuations of the series, is planned instead of the fifteen-month weighted moving average alone. At present the program provides

CHART 7. Sample of unsatisfactory method II seasonal adjustment: Total cotton stocks.



no precise test of the existence of seasonality in a series though some computations are made to guide the user in making such a judgment. A test which involves correlating the irregular and seasonal components, year by year, may be feasible, and statements could be printed with the computations explaining whether a seasonal adjustment is necessary and whether the results are satisfactory according to this test.[8]

[8] These possible revisions are described more fully in Appendix A.

This brief description of changes contemplated is intended to underline the fact that while we consider the results of Method II satisfactory for most purposes, we do not by any means consider them the best attainable within this framework. Improvements will continue to be introduced as the need for them becomes clear and techniques for making them are developed.

The direction of these changes will be toward including within the general approach a large variety of alternative techniques. Measures of the relations among the systematic economic forces characteristic of each series and of the relations between these forces and chance forces are now computed. In addition the electronic computer program will provide for a larger array of smoothing and curve fitting formulas. The appropriate technique for each series will then be selected automatically among the alternatives on the basis of the measures of the characteristics of each series. There are prospects that different techniques can even be used automatically for different time periods of the same series. As we stated earlier, the present program contains a start toward this goal, in that there is no fixed formula for computing the seasonal adjustment factors for all series, and that one of three formulas is now selected according to the magnitude of the average absolute amplitude of the irregular component of the series.

The Census seasonal electronic computer program appears, however, already to have brought us fairly close to a mechanical method of providing on a mass basis seasonal adjustments of the quality previously obtained for a small number of series by a combination of laborious hand methods and professional judgments.[9]

The computations of Method II take about two and one-half times as long on Univac as those of Method I—2.3 minutes for a ten-year monthly series as compared to one minute. While the relative increase in cost for Method II as compared to Method I may appear large, the cost of doing the calculations involved in either Method I or II on an electronic computer is small compared to the cost of simpler methods by conventional means, and a great many series can be adjusted rapidly. The necessary computing and printing for 3,000 ten-year series could be completed on a Univac system in one week. A large volume of data can thus be made ready for further analysis on short notice and large-scale seasonal computations that become necessary because of revisions in original data can be completed quickly.

IV. FINAL REMARKS

(1) The present electronic computer program has been prepared for monthly series only. However, experiments conducted at the National Bureau of Economic Research and the Dominion Bureau of Statistics of Canada indicate that it can also be applied to quarterly data. Good results can be obtained by the following procedure: convert the quarterly series to a monthly one by interpolating monthly values in the series, apply the computer program to the converted series, then convert the monthly adjusted series back to quarterly form. The interpolation can be accomplished very easily by repeating the quar-

[9] Several other methods of seasonal adjustment already have been or are being programmed for electronic computers. So far, however, they have been applied only on a small scale and, therefore, cannot be appraised. Appendix B gives a summary description of them.

terly figure for each of the months of the quarter. This method, the so-called "step method" of interpolation, gives almost the same results as a direct quarterly adjustment of the data.

(2) There are certain desirable adjustments that appear to be extremely difficult to make mechanically through the electronic computer program. An example is the problem of taking care of gaps in series, unrepresentative periods, and highly extreme individual items, such as arise from strikes. These extreme items may significantly affect both the trend-cycle curves fitted to the original and to the preliminary seasonally adjusted data and also the curves fitted to the seasonal-irregular ratios. Even our method of mitigating the influence of irregular items in computing the seasonal adjustment factors is sometimes not adequate to take care of such items. One method of handling these problems would be to adjust the original observations before putting them into the computer. Another example is provided by a series in which an abrupt change in the seasonal pattern takes place. Such a series might best be handled by separating it into two parts, at the point of the change in seasonality, and processing each part separately through the electronic computer. Such manual adjustments of the original observations would probably give better results than any mechanical method that we could devise.

(3) The writers have encountered, in their discussions with economists, some suspicion of the use of computers for economic analysis. There is a lurking fear that this highly fascinating new tool may divert us from analysis of real economic problems into the development of more elaborate, more refined, more intricate computations. This fear is probably well warranted. The temptation to put aside the substantive analysis in favor of the development of new methodology must be resisted.

(4) Others have felt that the application of such complex techniques as are involved in Method II to data of the crudeness that is characteristic of some economic series results in specious refinements. There is, however, another and, we think, better way of looking at this problem. Economic analysis is a search for uniformities in economic behavior. The analysis of large amounts of data by powerful techniques is more likely to uncover uniformities than the analysis of a few series with crude tools.

(5) As a result of the seasonal work done during the past few years, there is now available at the Census Bureau and the National Bureau a depository of punched cards containing several thousand economic series. Measures of trend-cycle, seasonal, and irregular components of these series, and other new measures that have recently been added to our electronic computer program,[10] could be calculated in a few days. The titles of these series have been punched on cards along with several identification codes, such as economic process and industry. Various statistical measures and additional codes could easily be added—for example, measures of business-cycle conformity and timing and the average long-run rate of growth. Through the punched cards, or electronic computer tapes based upon them, these data could be organized in many different ways. Such punched cards would provide the raw material for the de-

[10] See Julius Shiskin, "Electronic Computers and Business Indicators," *Journal of Business*, October, 1957; reprinted as Occasional Paper 57, National Bureau of Economic Research.

velopment and testing of new theories of economic fluctuations. They constitute an unparalleled challenge to the ingenuity and imagination of economic statisticians.

(6) Modern data-processing systems record, store, calculate, compare, choose, and print numbers, letters, and other symbols. They perform these operations automatically, accurately, and at lightning speeds, but with abject devotion to very detailed instructions provided by human beings. While there is no doubt that this equipment will eventually be used to proliferate other more elaborate measures of economic activities, the mechanical production of such new measures is not enough to assure an improvement in our understanding of economic events. The fruitfulness of this work will ultimately depend, as do all other empirical studies, upon the quality of the theoretical concepts formulated by economic scientists to organize and analyze the data.

APPENDIX A

REVISIONS OF SEASONAL METHOD II NOW UNDER CONSIDERATION

Since the completion of the Univac program considerable experience has been gained with the results of Method II. On the basis of this experience, we are making tests with a view to revising the electronic computer program. A brief description of each of the contemplated tests is given below. The series to be used in testing has been selected with the following criteria in mind: (1) differing irregular, cyclical, and seasonal components so that the results for series with different types of economic fluctuations will be known; and (2) widely used series, so that the substantive meaning of the results can better be understood. The five series selected are: total unemployment; railroad freight ton miles; residential construction contracts; business failures, liabilities; and Federal Reserve index of mining production.

(a) *Variable method of adjusting ends of series:* The present method of obtaining seasonal-irregular ratios at the ends of series will not give good results when the last two ratios, whose average is used as the estimate for the years following the last one for which a figure is available, are both relatively extreme, and particularly when they fall on the same side of the seasonal adjustment factor curve (see, for example, Chart 2, Business Failures, December). Experiments are under way to determine an effective way of handling such situations.

These experiments will involve adjusting the test series for periods which both include and exclude data for terminal years; for example, a series for which data for the period 1940–1956 are available will be adjusted for the period 1940–1950 and 1946–1956. The effect of the method of adjusting ends can thus be determined by comparing the adjustments for the years 1946–1950 when data for 1940–1945 and 1951–1956 are and are not used.

Several different methods of estimating seasonal-irregular ratios for the years for which they are needed to bring the seasonal adjustment factor curves to the end years will be tested. For illustrative purposes these alternative methods along with the implicit weights given in each case to the seasonal-irregular ratios, when a three-term of a three-term moving average is fitted to them, are shown in Table A-1. Our present thought is that a variable method will prove the best; for example, to average no more than two ratios, as at present, when the irregular component is small, and four ratios when it is large.

(b) *Control limits:* The selection of two standard errors as the limits for separating normal from extreme ratios was arbitrary, in the sense that it was not based on any study of the distribution of seasonal-irregular ratios. Now evidence is mounting that these limits are too broad—too many extreme ratios appear to be included without modification in the averaging for the seasonal adjustment factors. We are planning studies of the distribution of seasonal-irregular ratios and tests to determine the comparative results with limits of 1 and $1\frac{1}{2}$ standard errors.

TABLE A-1

METHODS OF ESTIMATING SEASONAL-IRREGULAR RATIOS AND IMPLICIT WEIGHTS GIVEN TO AVAILABLE RATIOS IN COMPUTING SEASONAL ADJUSTMENT FACTORS

(N is the last year for which a seasonal-irregular ratio, X_N, is available; the weights are adjusted so their sum equals 10)

Extrapolation Method	Factor for Year N-1							Factor for Year N						
	Implicit Weights Given to Ratio for Year							Implicit Weights Given to Ratio for Year						
	N-6	N-5	N-4	N-3	N-2	N-1	N	N-6	N-5	N-4	N-3	N-2	N-1	N
Three-Term Moving Average of Three-Term Moving Average														
I. $\frac{1}{2}(X_N+X_{N-1})=X_{N+1}=X_{N+2}$ (Method II)				1.1	2.2	3.9	2.8					1.1	3.9	5.0
II. $\frac{1}{3}(X_N+X_{N-1}+X_{N-2})=X_{N+1}=X_{N+2}$				1.1	2.6	3.7	2.6					2.2	3.3	4.4
III. $\frac{1}{4}(X_N+X_{N-1}+X_{N-2}+X_{N-3})=X_{N+1}=X_{N+2}$				1.4	2.5	3.6	2.5				0.8	1.9	3.1	4.2
IV. Straight line fitted to moving average values of X_{N-4}, X_{N-3}, X_{N-2}; fitted value for $X_N=X_{N+1}=X_{N+2}$	−0.1	−0.2	−0.1	1.4	2.8	3.8	2.4	−0.4	−0.7	−0.4	0.9	3.0	3.7	4.0
Simple Five-Term Moving Average														
V. $X_{N+1}=X_{N-4}$; $X_{N+2}=X_{N-3}$ (Method I)			2.0	2.0	2.0	2.0	2.0			2.0	2.0	2.0	2.0	2.0

(c) *Moving averages of seasonal-irregular ratios:* Where the average monthly irregular amplitude is less than 2, Method II now uses a three-term moving average of a three-term moving average, which is equivalent to a five-term moving average with weights 1, 2, 3, 2, 1; for series where the average irregular amplitude is 2 or more, it uses a three-term moving average of a five-term moving average, which is equivalent to a seven-term moving average with weights 1, 2, 3, 3, 3, 2, 1. This weighted seven-term moving average sometimes does not turn with the ratios, and, of course, requires more extrapolation for missing ratios than the weighted five-term moving average. We are now considering two changes: (i) the substitution for the three of a five-term moving average, of a five-term moving average with different weight patterns, for example 1, 3, 4, 3, 1—this curve, a member of a family of weighted moving averages suggested by Victor Zarnowitz, has the advantage of a shorter period involving less extrapolation at the ends and may also be expected to follow the seasonal-irregular ratios more closely, since the central points have relatively more weight; (ii) the use of less flexible curves, possibly straight lines, for measuring the seasonal adjustment factor for series in which the irregular factor is very pronounced.

(d) *Variable cycle-trend curves:* We are searching for a family of curves to use for series with different irregular components. We are considering (i) Robert Henderson's general formula which makes the sum of the squares of the third differences in the weights of the weight diagram a minimum for any number of terms desired; (ii) variants of the five-term moving average with weights 1, 3, 4, 3, 1: for example, a nine-term moving average with weights 1, 3, 6, 8, 9, 8, 6, 3, 1. For relatively smooth series, as indicated by the magnitude of the irregular component, these curves would be used in place of the weighted fifteen-term moving average (Spencer curve), now used to delineate the cycle-trend component. Such curves, being for a shorter period, would involve less extrapolation at the end and would perhaps also result in better estimates of the irregular component.

(e) *Correlation of I and S:* A common method of judging the validity of a seasonal adjustment is to compare the month-to-month movements in the seasonally adjusted series with the month-to-month movements in the seasonal adjustment factors. Following our usual thinking, the seasonally adjusted series is considered to be made up of trend-cycle and irregular factors. Since a smooth curve, usually the Spencer graduation, is used as the estimate of the trend-cycle factor, it may be disregarded for this purpose and the correlation coefficient between the month-to-month movements of the irregular and seasonal factors may provide a test of the validity of the seasonal adjustment. Since a residual seasonal will often appear in a positive pattern in some years and in an inverted pattern in others, separate correlation coefficients have to be computed for each year. The presence of significant correlation coefficients would be interpreted to mean that there is a seasonal component in the adjusted series; in this case a statement would automatically be printed after the computations indicating that a residual seasonal pattern remains and that further work is required.[1]

This test would also be applied to determine whether there is a seasonal pattern in the original observations. Here the cycle-trend curve would be divided into the original observations and the quotient correlated with the seasonal adjustment factors. The absence of significant correlation coefficients would be interpreted to mean that there is no seasonal pattern in the original observations. In such cases, the statement that the original observations have no seasonal pattern would be printed instead of the tables.

While these changes may appear to be large, we do not believe they would affect many series. The Univac programming and the experimental work involved is substantial, however, and changes cannot, therefore, be introduced in the method for some time. The user of Method II should expect further refinements with the accumulation of additional experience. Many of these improvements have been suggested by the experience of users and further suggestions would be most welcome.

[1] See Arthur F. Burns and Wesley C. Mitchell, *op. cit.*, pp. 54–55.

APPENDIX B

OTHER ELECTRONIC COMPUTER METHODS FOR SEASONAL ADJUSTMENT

Two additional computer methods for seasonal analysis have been programmed recently and applied on a limited scale. A brief description of them follows:

1. *Regression Seasonal Adjustments*

The present writers have prepared and "proved-in" a program for the calculation of regression seasonal adjustments. In this method, the original observations and a Spencer fifteen-month weighted moving average of the standard seasonally adjusted data in Method II are used as the basis for the computations. Differences between the original observations and the Spencer graduation are computed to provide a measure of the seasonal-irregular component. Seasonal adjustment factors are then fitted to (a) the differences as the dependent variable, and (b) the corresponding values of the smooth curve of the seasonally adjusted series as the independent variable.

The logic of this approach is as follows: Consider a monthly time series for which a scatter diagram is drawn so that values for a given month are plotted as the ordinate and the corresponding values representing the trend and cyclical components as the abscissa. If the original values for the month include neither a random nor a seasonal component, all the points fall on a straight line that passes through the origin and has a slope of one because the trend-cycle component has merely been plotted against itself. If the assumptions are changed to allow a multiplicative seasonal component in the original values, all the points fall on a straight line that passes through the origin, but the slope deviates from one. If the original values include an additive seasonal component, the slope of the line remains one, but the line no longer passes through the origin. If the seasonal component is partly additive and partly multiplicative, the line does not pass through the origin and its slope differs from one. These relations tend to prevail if the series also includes a random component. However, the observations no longer fall on a straight line, but tend to be distributed at random around such a line. It can be concluded, therefore, that the seasonal component for a given month can be measured by the difference between the parameters of a fitted straight line and the parameters of a line passing through the origin and having a slope of one.

In order to allow for the possibility of a changing seasonal pattern, time is introduced as a third variable. The equation used to derive the seasonal adjustment factors for each month is $y - x = a + bx + ct + dxt$, where y represents the original observations, x represents the corresponding values of the trend-cycle curve, and t represents time. Other variables could, of course, be added to this program, for example, variations in the average temperature, the number of Saturdays and Sundays in each month, and so on.

The regression technique for measuring and adjusting seasonal fluctuations comprises an entirely different conceptual approach from that followed in Methods I and II. In making the adjustments it attempts to take into account certain causes of seasonal variations. This is intellectually preferable to the more mechanical approach of the earlier methods. On the other hand, the regression technique is very sensitive: The regression curves are fitted to approximate measures of the seasonal-irregular factors; minor defects of measurement can result in poor regression curves, as was demonstrated by earlier experiments with the use of deviations from the twelve-month moving average of original observations. Furthermore, a method of handling extremes must also be developed for this program. While this approach is promising, the writers do not feel that there is as yet enough experience with it to form a judgment of its usefulness.

2. *Moving Polynomial Graduations*

A seasonal program has been prepared for the IBM 701 electronic computer following a plan developed at the National Bureau by Millard Hastay. While this program, like Method II described above, is based on the standard ratio-to-moving-average method, it differs in a number of important respects. First, the smoothing of the seasonal-irregular ratios for each month is accomplished in the IBM program by moving polynomial graduations. More specifically, for each month a third-degree polynomial is fitted by least squares to overlapping eleven-term periods of seasonal-irregular ratios. The smoothed value for each point is the central fitted value of its associated third-degree polynomial. For the last five ratios for each month, the smoothing is accomplished by taking the last five fitted values of the same polynomial, that which is fitted to the last eleven ratios of the month. Similar smoothing is made in the first five ratios of the month. Certain constraints are also put on the smoothed curves used for the beginning and ending years; for example, the first derivative is required to equal zero at the terminal year. (The moving polynomial approach is like the use of short-term weighted moving averages in the Univac program. The ratios required to bring these short-term averages up to date are obtained in the Univac program by taking averages of the last two ratios available as the estimated values of each of the following two ratios.)

To minimize the effects of "extreme" ratios, the period used for the IBM program was taken as eleven years. For the test series studied, this sometimes did not give satisfactory results, with poor adjustments almost always traceable to extreme ratios. Moreover, the method cannot be applied without modification to periods shorter than eleven years. (The Univac program uses control limits to identify extreme ratios and then reduces the weights assigned to the extreme items.)

Other differences between the two electronic computer programs are the use in the Univac method of (1) an iterative procedure to obtain improved seasonal-irregular ratios—that is, a fifteen-term weighted moving average (approximately equivalent to a moving third-degree polynomial) of a preliminary seasonally adjusted series is used as the basis for obtaining the final seasonal-irregular ratios; and (2) different weighted moving average curves, which vary according to the magnitude of the irregular component of each series, to obtain the final seasonal adjustment factors from the seasonal-irregular ratios.

Thus far experience with the IBM 701 program has been quite limited. However, drawing on experience with the Univac program, Hastay has recommended the direct identification and replacement of extreme ratios, as in the Univac method, instead of the present indirect attack on this problem by long-period smoothing. With extreme ratios handled directly, polynomial smoothing over shorter periods would become feasible. This improvement, and the addition to the IBM program of the iterative technique, with a weighted moving average to measure the trend-cycle component, would bring the IBM and Univac programs closer together.

TABLE 1

SEASONAL COMPUTATIONS, METHOD II

TOTAL UNEMPLOYMENT, UNITED STATES, 1940–1957

Reproduction of Actual High-Speed Print-Out, Reduced 60 Per Cent
Original Observations derived from Census Bureau's Monthly Report on the Labor Force, Series P-57 (Thousand Persons)

ORIGINAL SERIES SERIES #4406

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1940			836	823	799	831	915	874	685	724	726	691
1941	741	693	650	638	566	619	600	562	468	384	380	362
1942	432	404	358	305	259	289	283	219	168	161	163	152
1943	148	142	112	101	95	130	139	105	87	78	71	69
1944	61	69	69	63	73	88	89	68	60	44	50	50
1945	63	64	59	53	53	89	95	83	165	156	174	197
1946	230	265	270	233	231	257	227	206	207	196	193	212
1947	240	249	233	242	196	256	258	210	191	169	162	164
1948	206	264	244	219	176	218	223	194	190	164	183	194
1949	266	322	317	302	329	378	410	369	335	358	341	349
1950	448	468	412	352	306	338	321	250	234	194	224	223
1951	250	241	215	174	161	198	186	158	161	162	183	167
1952	205	209	180	161	160	182	194	160	144	128	142	141
1953	189	179	167	158	131	156	155	124	132	130	170	231
1954	309	367	372	346	330	335	335	324	310	274	289	284
1955	335	338	318	296	249	268	247	224	215	213	240	243
1956	288	291	283	256	261	293	283	220	200	191	246	248
1957	294	288	270	248								

2 RATIOS OF ORIGINAL TO PRECEDING AND FOLLOWING SERIES #4406

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1940			-	100.7	96.6	97.0	107.3	109.3	85.7	102.6	102.6	94.2
1941	107.1	99.6	97.7	104.9	90.1	106.2	101.6	105.2	98.9	90.6	101.9	89.2
1942	112.8	102.3	101.0	98.9	87.2	106.6	111.4	97.1	88.4	97.3	104.2	97.7
1943	100.7	109.2	92.2	97.6	82.3	111.1	118.3	92.9	95.1	98.7	96.6	90.8
1944	117.4	92.0	104.5	88.7	96.7	108.6	114.1	91.3	107.1	80.0	106.4	88.5
1945	110.5	104.9	100.9	94.6	74.6	120.3	110.5	63.8	138.1	92.0	98.6	97.5
1946	99.6	106.0	108.4	93.0	94.3	112.2	98.1	94.9	103.0	98.0	94.6	97.9
1947	104.1	105.3	94.9	112.8	78.7	112.8	110.7	93.5	100.8	95.8	97.3	89.1
1948	96.3	117.3	101.0	104.3	80.5	109.3	108.3	93.9	106.1	87.9	102.2	86.4
1949	103.1	110.5	101.6	93.5	96.8	102.3	109.8	99.1	92.2	105.9	96.5	88.5
1950	109.7	108.8	100.5	98.1	88.7	107.8	109.2	90.1	105.4	84.7	107.4	94.1
1951	107.8	103.7	103.6	92.6	86.6	114.1	104.5	91.1	100.6	94.2	111.2	86.1
1952	109.0	108.6	97.3	94.7	93.3	102.8	113.5	94.7	100.0	89.5	105.6	85.2
1953	118.1	100.6	99.1	106.0	83.4	109.1	110.7	86.4	103.9	86.1	94.2	96.5
1954	103.3	107.8	104.3	98.6	96.9	100.8	101.7	100.5	103.7	91.5	103.6	91.0
1955	107.7	103.5	100.3	104.4	88.3	108.1	100.4	97.0	98.4	93.6	105.3	92.0
1956	107.9	101.9	103.5	94.1	95.1	107.7	110.3	91.1	97.3	85.7	112.1	91.9
1957	109.7	102.1	100.7									

AVERAGES OF RATIOS SERIES #4406

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
107.3	104.9	100.7	98.7	88.8	108.0	108.3	93.6	101.5	92.6	102.4	91.6

3 UNCENTERED 12-MONTH MOVING AVERAGE OF ORIGINAL SERIES #4406

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1940			-	-	-	-	-	778	763	747	728	710
1941	684	658	640	611	583	555	529	505	481	453	428	400
1942	374	345	320	302	284	266	242	221	200	183	169	156
1943	144	135	128	121	113	106	101	95	91	88	86	83
1944	78	75	73	70	69	67	65	65	64	63	62	62
1945	62	64	72	82	92	104	118	135	152	167	182	196
1946	207	218	221	224	226	227	228	227	224	224	221	221
1947	224	224	223	221	218	214	211	213	213	212	210	207
1948	204	202	202	202	204	206	211	216	222	229	242	255
1949	271	285	297	314	327	340	355	367	375	379	377	374
1950	366	356	348	334	325	314	298	279	262	247	235	224
1951	212	205	199	196	193	188	184	182	179	178	177	176
1952	177	177	176	173	169	167	166	163	162	162	160	157
1953	154	151	150	150	153	160	170	186	203	219	235	250
1954	265	282	297	309	318	323	325	323	318	314	307	302
1955	294	286	278	273	269	265	262	258	255	251	252	254
1956	257	257	256	254	255	255	255	255	254	253	-	-
1957	-	-	-	-								

4 CENTERED 12-MONTH MOVING AVERAGE OF ORIGINAL SERIES #4406

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1940			-	-	-	-	-	-	770	755	738	719
1941	697	671	649	626	597	569	542	517	493	467	441	414
1942	387	360	333	311	293	275	254	232	210	192	176	163
1943	150	139	131	124	117	110	104	98	93	90	87	84
1944	81	77	74	72	69	68	66	65	65	64	63	62
1945	62	63	68	77	87	98	111	127	144	160	175	189
1946	202	212	219	223	225	227	228	227	225	224	223	221
1947	223	224	224	222	219	216	213	212	213	213	211	208
1948	205	203	202	202	203	205	209	214	219	226	235	249
1949	263	278	291	306	320	333	347	361	371	377	378	376
1950	370	361	352	341	330	319	306	288	271	255	241	230
1951	218	209	202	197	194	190	186	183	180	178	178	177
1952	177	177	176	174	171	168	167	165	163	162	161	159
1953	156	153	151	150	152	156	165	178	194	211	227	243
1954	258	273	289	303	314	321	324	324	320	316	311	304
1955	298	290	282	276	271	267	264	260	256	253	252	253
1956	256	257	257	255	254	255	255	255	255	254		

5 RATIOS OF ORIGINAL TO 12-MONTH MOVING AVERAGE SERIES #4406

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1940			-	-	-	-	-	-	89.0	95.9	98.4	96.1
1941	106.3	103.3	100.2	101.9	94.8	108.8	110.7	108.7	94.9	82.2	86.2	87.4
1942	111.6	112.2	107.5	98.1	88.4	105.1	111.4	94.4	80.0	83.9	92.6	93.3
1943	98.7	102.2	85.5	81.5	81.2	118.2	133.7	107.1	93.5	86.7	81.6	82.1
1944	100.0	89.6	93.2	87.5	105.8	129.4	134.8	104.6	92.3	68.8	79.4	80.6
1945	101.6	101.6	86.8	68.8	60.9	90.8	85.6	65.4	114.6	97.5	99.4	104.2
1946	113.9	125.0	123.3	104.5	102.7	113.2	99.6	90.7	92.0	87.5	86.5	95.9
1947	107.6	111.2	104.0	109.0	89.5	118.5	121.1	99.1	89.7	79.3	76.8	78.8
1948	100.5	130.0	120.8	108.4	86.7	106.3	106.7	90.7	86.8	72.6	77.9	77.9
1949	101.1	115.8	108.9	98.7	102.8	113.5	118.2	102.2	90.3	95.0	90.2	92.8
1950	121.1	129.6	117.0	103.2	92.7	106.0	104.9	86.8	86.3	76.1	92.9	97.0
1951	114.7	115.3	106.4	88.3	83.0	104.2	100.0	86.3	89.4	91.0	102.8	94.4
1952	115.8	118.1	102.3	92.5	93.6	108.3	116.2	97.0	88.3	79.0	88.2	88.7
1953	121.2	117.0	110.6	105.3	86.2	100.0	93.9	69.7	68.0	61.6	74.9	95.1
1954	119.8	134.4	128.7	114.2	105.1	104.4	103.4	100.0	96.9	86.7	92.9	93.4
1955	112.4	116.6	112.8	107.2	91.9	100.4	93.6	86.2	84.0	84.2	95.2	96.0
1956	112.5	113.2	110.1	100.4	102.8	114.9	111.0	86.3	78.4	75.2		

6 PRELIMINARY ADJUSTMENT FACTORS SERIES #4406

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1940			101.1	101.6	94.2	108.5	110.9	107.2	90.4	89.2	93.1	92.5
1941	107.7	106.3	101.2	99.7	92.8	110.1	114.7	106.4	90.7	87.7	91.4	91.4
1942	107.8	107.6	100.6	96.4	92.7	112.4	121.3	105.3	90.6	85.5	89.7	90.2
1943	106.2	106.8	96.8	92.1	93.6	115.2	127.4	104.9	94.0	85.4	88.7	88.8
1944	106.0	107.3	95.7	91.7	97.3	115.0	125.7	101.6	95.7	85.4	89.2	89.5
1945	106.7	109.4	96.1	94.8	97.4	114.3	118.9	97.6	96.8	87.7	89.7	90.4
1946	108.2	115.7	102.4	101.4	96.7	113.4	112.4	94.6	94.0	85.3	86.7	89.1
1947	107.0	119.0	107.6	105.2	94.1	113.6	112.3	95.2	91.6	84.1	84.0	86.3
1948	106.4	122.7	112.8	105.9	93.7	111.8	112.0	95.1	89.1	81.3	83.3	85.8
1949	107.6	121.5	112.6	101.8	93.1	109.7	110.9	94.0	88.4	83.5	87.9	88.9
1950	112.4	122.1	111.6	98.2	92.1	107.5	108.2	91.6	88.1	83.5	92.3	92.4
1951	117.0	120.7	109.8	96.7	91.0	107.3	107.2	89.6	89.0	83.0	93.9	94.7
1952	119.7	122.0	111.2	99.5	92.0	106.4	106.5	88.8	89.7	79.3	90.7	94.3
1953	120.0	122.6	114.1	104.3	93.5	105.0	103.1	87.0	89.8	77.6	88.3	94.9
1954	117.2	122.1	115.8	106.6	96.1	104.1	101.2	87.8	88.0	78.0	88.9	94.2
1955	115.1	119.3	115.1	106.2	97.7	106.1	101.5	87.2	84.9	79.1	92.4	95.4
1956	113.1	116.1	112.6	103.3	100.4	110.4	106.2	87.6	81.5	78.4	94.9	95.6
1957	113.1	114.1	111.0	101.6								

7 PRELIMINARY ADJUSTED SERIES SERIES #4406

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1940			827	810	848	766	825	815	758	812	780	747
1941	688	652	642	640	610	562	523	528	516	458	416	396
1942	401	375	356	316	279	257	233	208	185	188	182	169
1943	139	133	116	110	101	113	109	100	93	91	80	78
1944	76	64	72	69	75	77	71	67	63	52	56	56
1945	59	59	61	56	54	78	80	85	170	178	194	218
1946	213	229	264	230	239	227	202	218	220	230	223	238
1947	224	209	217	230	208	225	230	221	209	201	193	190
1948	194	215	216	207	188	195	199	204	213	202	220	226
1949	247	265	282	297	353	345	370	393	379	429	388	393
1950	399	383	369	358	332	314	297	273	266	232	243	241
1951	214	200	196	180	177	185	174	176	181	195	195	176
1952	171	171	162	162	174	171	182	180	161	161	157	150
1953	158	146	146	151	140	149	150	143	147	168	193	243
954	264	301	321	325	343	322	331	369	352	351	325	301
955	291	283	276	279	255	253	243	257	253	269	260	255
956	255	251	251	248	260	265	266	251	245	244	259	259
957	260	252	243	244								

8 WEIGHTED 15-MO MOVING AVERAGE OF PREL ADJ — SERIES #4406

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1940			819	818	815	812	808	803	796	783	763	736
1941	706	675	647	621	597	572	544	515	485	457	431	409
1942	388	368	344	316	287	258	232	212	197	184	172	159
1943	146	132	121	113	108	106	103	100	95	89	83	77
1944	73	71	71	72	72	72	70	66	62	59	57	56
1945	56	56	56	57	62	72	90	115	142	170	194	212
1946	226	235	239	238	233	226	221	219	220	223	226	225
1947	224	221	220	220	221	222	220	216	210	203	199	198
1948	200	203	204	203	201	199	199	201	205	211	219	230
1949	245	264	286	309	332	353	371	385	396	401	402	399
1950	393	383	369	353	335	315	295	277	262	249	238	227
1951	216	204	194	185	180	178	179	181	184	185	184	180
1952	175	170	168	168	170	173	174	172	168	163	158	154
1953	151	149	147	146	144	143	143	147	158	176	202	233
1954	265	292	312	326	335	342	347	349	347	339	327	312
1955	297	285	275	267	260	255	253	254	256	258	258	257
1956	255	253	253	255	257	258	257	255	253	253	253	254
1957	254	252	250	248								

9 RATIOS OF ORIGINAL TO WEIGHTED 15-MO MOV AV — SERIES #4406

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1940			102.1	100.6	98.0	102.3	113.2	108.8	86.1	92.5	95.2	93.9
1941	105.0	102.7	100.5	102.7	94.8	108.2	110.3	109.1	96.5	84.0	88.2	88.5
1942	111.3	109.8	104.1	96.5	90.2	112.0	122.0	103.3	85.3	87.5	94.8	95.6
1943	101.4	107.6	92.6	89.4	88.0	122.6	135.0	105.0	91.6	87.6	85.5	89.6
1944	111.0	97.2	97.2	87.5	101.4	122.2	127.1	103.0	96.8	74.6	87.7	89.3
1945	112.5	114.3	105.4	93.0	85.5	123.6	105.6	72.2	116.2	91.8	89.7	92.9
1946	101.8	112.8	113.0	97.9	99.1	113.7	102.7	94.1	94.1	87.9	85.4	94.2
1947	107.1	112.7	105.9	110.0	88.7	115.3	117.3	97.2	91.0	83.3	81.4	82.8
1948	103.0	130.0	119.6	107.9	87.6	109.5	112.1	96.5	92.7	77.7	83.6	84.3
1949	108.6	122.0	110.8	97.7	99.1	107.1	110.5	95.8	84.6	89.3	84.8	87.5
1950	114.0	122.2	111.7	99.7	91.3	107.3	108.8	90.3	89.3	77.9	94.1	98.2
1951	115.7	118.1	110.8	94.1	89.4	111.2	103.9	87.3	87.5	87.6	99.5	92.8
1952	117.1	122.9	107.1	95.8	94.1	105.2	111.5	93.0	85.7	78.5	89.9	91.6
1953	125.2	120.1	113.6	108.2	91.0	109.1	108.4	84.4	83.5	73.9	84.2	99.1
1954	116.6	125.7	119.2	106.1	98.5	98.0	96.5	92.8	89.3	80.8	88.4	91.0
1955	112.8	118.6	115.6	110.9	95.8	105.1	97.6	88.2	84.0	82.6	93.0	94.6
1956	112.9	115.0	111.9	100.4	101.6	113.6	110.1	86.3	79.1	75.5	97.2	97.6
1957	115.7	114.3	108.0	100.0								

10 MODIFIED RATIOS, ORIGINAL/WTD 15-MO MOV AV — SERIES #4406

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1940			102.1	100.6	98.0	102.3	113.2	108.8	86.1	92.5	95.2	93.9
1941	105.0	102.7	100.5	102.7	94.8	108.2	110.3	109.1	96.5	84.0	88.2	88.5
1942	111.3	109.8	104.1	96.5	90.2	112.0	122.0	103.3	85.3	87.5	94.8	95.6
1943	101.4	107.6	92.6	89.4	88.0	122.6	128.0	105.0	91.6	87.6	85.5	89.6
1944	111.0	106.4	97.2	87.5	101.4	122.2	127.1	103.0	96.8	84.7	87.7	89.3
1945	112.5	114.3	105.4	93.0	85.5	123.6	105.6	89.8	102.4	91.8	89.7	92.9
1946	101.8	112.8	113.0	97.9	99.1	113.7	102.7	94.1	94.1	87.9	85.4	94.2
1947	107.1	112.7	105.9	105.3	88.7	115.3	117.3	97.2	91.0	83.3	81.4	82.8
1948	103.0	121.6	119.6	107.9	87.6	109.5	112.1	96.5	92.7	77.7	83.6	84.3
1949	108.6	122.0	110.8	97.7	99.1	107.1	110.5	95.8	84.6	89.3	84.8	87.5
1950	114.0	122.2	111.7	99.7	91.3	107.3	108.8	90.3	89.3	77.9	94.1	98.2
1951	115.7	118.1	110.8	94.1	89.4	111.2	103.9	87.3	87.5	87.6	94.5	92.8
1952	117.1	122.9	107.1	95.8	94.1	105.2	111.5	93.0	85.7	78.5	89.9	91.6
1953	119.6	120.1	113.6	108.2	91.0	109.1	108.4	84.4	83.5	73.9	84.2	99.1
1954	116.6	125.7	119.2	106.1	98.5	104.1	96.5	92.8	89.3	80.8	88.4	91.0
1955	112.8	118.6	115.6	110.9	95.8	105.1	97.6	88.2	84.0	82.6	93.0	94.6
1956	112.9	115.0	111.9	100.4	101.6	113.6	110.1	86.3	79.1	75.5	97.2	97.6
1957	115.7	114.3	108.0	100.0								

** STABLE-SEASONAL ADJUSTMENT FACTORS SERIES #4406

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1109	1156	1082	996	937	1113	1109	955	893	837	892	919

** STABLE-SEASONAL ADJUSTED SERIES SERIES #4406

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1940			773	826	853	747	825	915	767	865	814	752
1941	668	599	601	641	604	556	541	588	524	459	426	394
1942	390	349	331	306	276	260	255	229	188	192	183	165
1943	133	123	104	101	101	117	125	110	97	93	80	75
1944	73	60	64	63	78	79	80	71	67	53	56	54
1945	57	55	55	53	57	80	86	87	185	186	195	214
1946	207	229	250	234	247	231	205	216	232	234	216	231
1947	216	215	215	243	209	230	233	220	214	202	182	178
1948	166	228	226	220	188	196	201	203	213	196	205	211
1949	240	279	293	303	351	340	370	386	375	428	382	380
1950	404	405	381	353	327	304	289	262	262	232	251	243
1951	225	208	199	175	172	178	168	165	180	194	205	182
1952	185	181	166	162	171	164	175	168	161	153	159	153
1953	170	155	154	159	140	140	140	130	148	155	191	251
1954	279	317	344	347	352	301	302	339	347	327	324	309
1955	302	292	294	297	266	241	223	235	241	254	269	264
1956	260	252	262	257	279	263	255	230	224	228	276	270
1957	265	249	250	249								

11 CENTERED RATIOS, ORIGINAL/WTD 15-MO MOV AV SERIES #4406

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1940			1021	1006	980	1023	1132	1088	861	925	952	939
1941	1058	1035	1013	1035	956	1091	1112	1100	973	847	889	892
1942	1102	1087	1030	955	893	1109	1208	1022	844	866	938	946
1943	1023	1086	935	902	888	1237	1292	1060	925	884	863	904
1944	1097	1051	961	865	1002	1208	1256	1018	957	837	867	882
1945	1119	1137	1048	925	850	1229	1050	893	1018	913	892	924
1946	1021	1131	1133	982	994	1140	1030	944	944	881	856	945
1947	1082	1138	1070	1064	896	1165	1185	982	919	841	832	836
1948	1033	1220	1200	1083	879	1099	1125	968	930	780	839	846
1949	1088	1222	1110	979	993	1073	1107	960	848	895	850	877
1950	1135	1217	1113	993	909	1069	1084	899	889	776	937	978
1951	1164	1188	1115	947	899	1119	1045	878	880	881	951	934
1952	1178	1237	1078	964	947	1059	1122	936	862	790	905	922
1953	1201	1206	1141	1086	914	1095	1088	847	838	742	845	995
1954	1157	1248	1183	1053	978	1033	958	921	886	802	877	903
1955	1129	1187	1157	1110	959	1052	977	883	841	827	931	947
1956	1128	1149	1118	1003	1015	1135	1100	862	790	754	971	975
1957	1158	1144	1081	1001								

12 FINAL SEASONAL ADJ FACTORS: 3*5 MO MOV AVS SERIES #4406

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1940			101.3	100.4	95.3	107.6	114.5	108.2	90.8	88.3	91.9	91.9
1941	106.2	105.1	100.5	98.1	94.5	110.1	117.1	107.0	90.6	87.8	91.3	91.8
1942	106.8	106.3	99.8	95.8	93.3	113.7	118.6	105.0	92.0	87.4	90.1	91.4
1943	107.3	107.8	100.4	93.8	92.9	116.4	118.4	102.1	93.1	87.2	89.2	91.4
1944	107.4	109.5	101.6	93.7	92.3	118.5	117.1	99.5	94.5	87.2	87.8	90.9
1945	107.0	111.4	104.4	95.2	92.5	118.3	115.3	97.6	94.8	86.6	86.6	90.2
1946	106.9	113.8	107.5	97.9	92.4	116.8	113.0	96.3	94.6	86.1	85.6	89.0
1947	107.0	116.4	110.7	100.4	92.7	114.0	111.2	95.4	93.0	84.9	85.6	89.0
1948	108.0	118.4	112.0	101.3	92.4	111.8	110.5	94.6	91.0	84.4	86.4	89.2
1949	109.7	120.0	112.3	100.9	92.5	109.9	110.4	93.9	89.4	83.1	87.9	90.1
1950	112.4	120.9	111.9	100.0	92.4	109.1	109.8	92.3	87.9	82.5	89.1	91.6
1951	114.7	121.7	112.0	99.9	92.9	108.1	108.2	90.9	87.2	81.3	89.9	93.3
1952	116.2	121.5	112.4	101.1	93.4	107.7	106.2	89.8	86.5	80.8	90.1	94.3
1953	116.4	121.3	113.2	102.8	94.4	107.4	104.9	89.3	85.9	79.7	90.4	94.5
1954	116.0	120.2	113.5	104.2	96.0	107.9	104.4	88.6	84.5	78.9	90.9	94.9
1955	115.2	118.9	113.3	104.3	97.9	108.8	104.7	88.1	83.1	77.9	92.3	95.4
1956	114.6	117.2	112.5	103.6	99.3	110.3	105.6	87.4	81.7	77.5	94.3	96.2
1957	114.2	115.9	111.3	102.0								

13 FINAL SEASONALLY ADJUSTED SERIES SERIES #4406

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1940			825	820	838	772	799	808	754	820	790	752
1941	698	659	647	650	599	562	512	525	517	437	416	394
1942	404	380	359	318	278	254	239	209	183	184	181	166
1943	138	132	112	108	102	112	117	103	93	89	80	75
1944	75	63	68	67	79	74	76	68	63	50	57	55
1945	59	57	57	56	57	75	82	85	174	180	201	218
1946	215	233	251	238	250	220	201	214	219	228	225	238
1947	224	214	210	241	211	225	232	220	205	199	189	184
1948	191	223	218	216	190	195	202	205	209	194	212	217
1949	242	268	282	299	356	344	371	393	375	431	388	387
1950	399	387	368	352	331	310	292	271	266	235	251	243
1951	218	198	192	174	173	183	172	174	185	199	204	179
1952	176	172	160	159	171	169	183	178	166	158	158	150
1953	162	148	148	154	139	145	148	139	154	163	188	244
1954	266	305	328	332	344	310	321	366	367	347	318	299
1955	291	284	281	284	254	246	236	254	259	273	260	255
1956	251	248	252	247	263	266	268	252	245	246	261	258
1957	257	248	243	243								

14 RATIOS, FINAL ADJ TO PRECEDING AND FOLLOWING SERIES #4406

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1940			-	98.6	105.3	94.3	101.1	104.1	92.6	106.2	100.5	101.1
1941	98.9	98.0	98.9	104.3	98.8	101.2	94.2	102.0	107.5	93.7	100.1	96.1
1942	104.4	99.6	102.9	99.8	97.2	98.3	103.2	99.1	93.1	101.1	103.4	104.1
1943	92.6	105.6	93.3	100.9	92.7	102.3	108.8	98.1	96.9	102.9	97.6	96.8
1944	108.7	88.1	104.6	91.2	112.1	95.5	107.0	97.8	106.8	83.3	108.6	94.8
1945	105.4	98.3	100.9	98.2	87.0	107.9	102.5	66.4	131.3	96.0	101.0	104.8
1946	95.3	100.0	106.6	95.0	109.2	97.6	92.6	101.9	99.1	102.7	96.6	106.0
1947	99.1	98.6	92.3	114.5	90.6	101.6	104.3	100.7	97.9	101.0	98.7	96.8
1948	93.9	109.0	99.3	105.9	92.5	99.5	101.0	99.8	104.8	92.2	103.2	95.6
1949	99.8	102.3	99.5	93.7	110.7	94.6	100.7	105.4	91.0	113.0	94.9	99.3
1950	103.1	100.9	99.6	100.7	100.0	99.5	100.5	97.1	105.1	90.9	105.0	103.6
1951	98.9	96.6	103.2	95.3	96.9	106.1	96.4	97.5	99.2	102.3	107.9	94.2
1952	100.3	102.4	96.7	96.1	104.3	95.5	105.5	102.0	98.8	97.5	102.6	93.8
1953	108.7	95.5	98.0	107.3	93.0	101.0	104.2	92.1	102.0	95.3	92.4	107.5
1954	96.9	102.7	103.0	98.8	107.2	93.2	95.0	106.4	102.9	101.3	98.5	98.2
1955	99.8	99.3	98.9	106.2	95.8	100.4	94.4	102.6	98.3	105.2	98.5	99.8
1956	99.8	98.6	101.8	95.9	102.5	100.2	103.5	98.2	98.4	97.2	103.6	99.6
1957	101.6	99.2	99.0									

AVERAGES

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
100.4	99.7	99.9	100.1	99.8	99.3	100.9	98.3	101.5	98.9	100.8	99.5

15 UNCENTERED 12-MO MOVING AVERAGE FINAL ADJ SERIES #4406

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1940			-	-	-	-	-	778	763	749	729	711
1941	688	664	644	612	581	551	527	504	480	452	425	399
1942	377	350	323	301	282	263	241	220	199	182	167	155
1943	145	136	129	121	113	105	100	94	90	87	85	82
1944	78	76	73	70	68	66	65	64	63	63	61	61
1945	61	63	72	83	95	108	121	136	152	167	183	196
1946	205	216	220	224	226	228	228	227	223	224	220	221
1947	223	224	223	220	217	213	210	211	211	209	208	205
1948	203	201	202	201	203	206	210	214	219	226	240	252
1949	267	282	296	316	330	345	358	368	375	379	377	374
1950	368	358	348	332	321	309	294	278	263	248	235	225
1951	215	207	200	197	193	188	184	182	179	178	178	177
1952	178	178	176	173	169	167	165	163	162	162	159	157
1953	154	151	150	151	153	161	170	183	198	213	230	243
1954	258	277	294	310	321	325	327	326	322	318	310	305
1955	298	288	279	273	268	265	261	258	256	253	254	255
1956	258	258	257	254	254	255	255	255	254	254		

16 RATIOS, 12-MO MOV AVS, FINAL ADJ TO ORIGINAL SERIES #4406

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1940			-	-	-	-	-	100.0	100.0	100.3	100.1	100.1
1941	100.6	100.9	100.6	100.2	99.7	99.3	99.6	99.8	99.8	99.8	99.3	99.8
1942	100.8	101.4	100.9	99.7	99.3	98.9	99.6	99.5	99.5	99.5	98.8	99.4
1943	100.7	100.7	100.8	100.0	100.0	99.1	99.0	98.9	98.9	98.9	98.8	98.8
1944	100.0	101.3	100.0	100.0	98.6	98.5	100.0	98.5	98.4	100.0	98.4	98.4
1945	98.4	98.4	100.0	101.2	103.3	103.8	102.5	100.7	100.0	100.0	100.5	100.0
1946	99.0	99.1	99.5	100.0	100.0	100.4	100.0	100.0	99.6	100.0	99.5	100.0
1947	99.6	100.0	100.0	99.5	99.5	99.5	99.5	99.1	99.1	98.6	99.0	99.0
1948	99.5	99.5	100.0	99.5	99.5	100.0	99.5	99.1	98.6	98.7	99.2	98.8
1949	98.5	98.9	99.7	100.6	100.9	101.5	100.8	100.3	100.0	100.0	100.0	100.0
1950	100.5	100.6	100.0	99.4	98.8	98.4	98.7	99.6	100.4	100.4	100.0	100.4
1951	101.4	101.0	100.5	100.5	100.0	100.0	100.0	100.0	100.0	100.0	100.6	100.6
1952	100.6	100.6	100.0	100.0	100.0	100.0	99.4	100.0	100.0	100.0	99.4	100.0
1953	100.0	100.0	100.0	100.7	100.0	100.6	100.0	98.4	97.5	97.3	97.9	97.2
1954	97.4	98.2	99.0	100.3	100.9	100.6	100.6	100.9	101.3	101.3	101.0	101.0
1955	101.4	100.7	100.4	100.0	99.6	100.0	99.6	100.0	100.4	100.8	100.8	100.4
1956	100.4	100.4	100.4	100.0	99.6	100.0	100.0	100.0	100.0	100.4	-	-
1957	-	-	-	-								

17 RATIOS, EACH MO TO PRECEDING JAN, FINAL ADJ SERIES #4406

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1940			-	-	-	-	-	-	-	-	-	-
1941	-	944	927	931	858	805	734	752	741	626	596	564
1942	579	941	889	787	688	629	592	517	453	455	448	411
1943	342	957	812	783	739	812	848	746	674	645	580	543
1944	543	840	907	893	1053	987	1013	907	840	667	760	733
1945	787	966	966	949	966	1271	1390	1441	2949	3051	3407	3695
1946	3644	1084	1167	1107	1163	1023	935	995	1019	1060	1047	1107
1947	1042	955	938	1076	942	1004	1036	982	915	888	844	821
1948	853	1168	1141	1131	995	1021	1058	1073	1094	1016	1110	1136
1949	1267	1107	1165	1236	1471	1421	1533	1624	1550	1781	1603	1599
1950	1649	970	922	882	830	777	732	679	667	589	629	609
1951	546	908	881	798	794	839	789	798	849	913	936	821
1952	807	977	909	903	972	960	1040	1011	943	898	898	852
1953	920	914	914	951	858	895	914	858	951	1006	1160	1506
1954	1642	1147	1233	1248	1293	1165	1207	1376	1380	1305	1195	1124
1955	1094	976	966	976	873	845	811	873	890	938	893	876
1956	863	988	1004	984	1048	1060	1068	1004	976	980	1040	1028
1957	1024	965	946	946								