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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 1½ standard errors.