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Concurrent Seasonal Adjustment With Census X-11

Sandra K. McKenzie
Statistical Research Division, U.S. Bureau of the Census, Washington, DC 20233

Much investigative effort is being expended worldwide toward improving seasonally adjusted estimates from the Census X-11 program. Several recent investigations have resulted in a recommendation to obtain the most recent month's adjustment by applying X-11 to data through that month (concurrent adjustment), rather than relying on projected factors obtained from an earlier run. Although there are theoretical arguments supporting the applicaton of X-11 concurrently, a comprehensive study documenting the results of concurrent adjustment with X-11 on U.S. economic series has not previously been undertaken. This study evaluates the effect of applying X-11 concurrently to a set of selected Census Bureau economic time series. The accuracy of concurrent estimates, in terms of mean absolute deviations from historical estimates, is examined. The results obtained are generally favorable to concurrent adjustment.

KEY WORDS: Seasonal adjustment; Concurrent adjustment; X-11; Current updating.

1. INTRODUCTION

The development of the Census Method II seasonal adjustment procedure in the 1950's and 1960's, culminating in the X-11 variant in 1967, represented a major breakthrough in the practice of seasonal adjustment. The use of computers for seasonal adjustment made the adjustment of large numbers of series practical. Census X-11 gained widespread acceptance as a seasonal adjustment method, and it is now in use throughout the world in both government and private industry.

In the years since the introduction of Census X-11, a variety of improvements in seasonal adjustment procedures and possible alternatives to Census X-11 have been developed. Some of these alternatives are modifications of the usual Census X-11 procedure, and some use an entirely different approach. This article addresses a modification to the Census Bureau's use of X-11 that has been suggested over the years and has become increasingly feasible in recent years as computing resources have increased.

The traditional practice for producing seasonally adjusted data from a Census X-11 adjustment is to run the X-11 program at the end of each calendar year, thereby obtaining seasonal factors for the input data and 12 projected factors for the following year. The projected factors are then used in turn to seasonally adjust each new monthly datum as it becomes available. The term "seasonal factors" will be used in its broadest sense throughout the article to include not only the seasonal factor alone but the combined factor that includes the seasonal, trading-day, and holiday effects. The use of projected factors was initially necessary because of the operational constraints involved in seasonally adjusting many series each month, but as greater computing resources have become available, the significance of these constraints has diminished. The use of 12 projected factors has the further advantage of promoting public confidence in the objectivity of sensitive seasonally adjusted economic indicators, since the projected factors are determined before they are actually applied. The production and use of projected seasonal factors does not take into account, however, the most recent history of the series, as would be the case if X-11 were rerun every month as the latest datum becomes available. In the latter case, no projection of the seasonal factor by X-11 would be involved; the seasonally adjusted estimate would be the result of applying the Census X-11 filters to the entire data set, including the current month. This procedure—using the most recent month's datum to produce the seasonal factor from which the seasonally adjusted estimate for that month is derived—is commonly referred to as *concurrent adjustment.* (Concurrent adjustment is the term used in the United States and Canada; *current updating* is the equivalent term used in the United Kingdom.)

This article examines some of the possible advantages offered by concurrent adjustment with Census X-11 on a selected set of Census Bureau time series. The final seasonal adjustment, when all the data are available, is the same with both concurrent adjustment and adjustment with projected factors. However, the first-published estimates under both methods are different. The first-published seasonally adjusted numbers (whether from projected factors or concurrent factors) are subject to revision, because different seasonal factors are produced for any point in time t as more data are accumulated past time t, until a final adjustment is reached some years later. (The exact length of time to final adjustment depends on the choice of seasonal filter lengths.) The chief advantage being sought is first-published seasonal adjustments that are closer to this final seasonal adjustment. Estimation of both the level and the month-to-month rates of change are investigated. Statistics measuring the relative improvements offered by concurrent adjustment over the usual procedure of seasonally adjusting once a year with projected factors are computed and analyzed. The same statistics are also computed for two other modes of adjustment.

The next section presents a review of the research history that laid the foundations for this study. Following the review, the 21 Census Bureau time series used in the study are described in Section 3. Two measures were selected to evaluate the alternative modes of using X-11, the mean absolute error and a month-to-month percentage change statistic. These measures are described in Section 4. The results discussed in Section 5 for 17 of the series indicate that significant improvements in initial seasonally adjusted estimates are obtainable from concurrent adjustment for most series. Each of the five construction series are discussed in Section 6, as unexpected results for some of these series provoked further investigations. Some issues remain to be addressed in contemplating the operational implementation of concurrent adjustment with X-11. A few of these, including the public confidence issue mentioned before, are discussed in the remarks in Section 7. The concluding section cites the improvements found with concurrent adjustment in this study and presents the primary advantages to seasonally adjusting concurrently.

2. REVIEW OF RECENT RESEARCH ON CONCURRENT ADJUSTMENT

A number of researchers and government statisticians have proposed concurrent adjustment as a possible improvement over the present practice of seasonally adjusting with projected seasonal factors. Wayne Fuller, in consultations with Census Bureau staff members, expressed his belief, in the mid-1960's and again in an informal report (Fuller 1978), that "the biggest potential gain in seasonal adjustment lies in the inclusion of the current observation in the construction of the seasonal factor for that observation." In the 1978 report Fuller elaborated on the statistical reasoning behind this conclusion. He considered two models based on the use of five observations: a fixed-weights seasonal model based on Young's linear approximation to X-11 (Young 1968) and an autoregressive prediction method of seasonal adjustment. Using the theoretical models, Fuller found a reduction in root mean square error between the estimated and the historical factors of at least 15% by using the most recent observation. This was substantiated empirically by Fuller's evaluation of two Census Bureau economic series. Evaluating the theoretical variance of the adjusted series, Fuller found that inclusion of the most recent observation produced a smaller variance.

Three other empirical studies have also led to recommendations for concurrent adjustment. Empirical work at Statistics Canada in 1975 led to the decision to use concurrent adjustment for the majority of the series adjusted by Statistics Canada with the X-11-ARIMA program. Second, in his study of 16 Census Bureau series, Geweke (1978) also found evidence supporting the value of concurrent adjustment. Two forecasting methods, a spectral method and an autoregressive method, were used to forecast values, which were then appended to the series submitted to X-11 for seasonal adjustment (referred to subsequently as X-11-augmented procedures). With the current month's datum used in producing the current month's seasonal adjustment, there was substantial improvement over the year-ahead procedure of using either X-11 or X-11-augmented procedures. Geweke found substantial gains from concurrent X-11-augmented procedures in series having only minor problems with revisions as well as in more troublesome series, and he presented strong evidence that by far the greatest improvement in terms of month-to-month changes in the seasonally adjusted data came from using the most recent month's datum. The third study, which is the most extensive empirical investigation published so far, was conducted by Kenny and Durbin (1982), who studied 23 economic time series from the United Kingdom. Kenny and Durbin found an overall reduction in root mean square error (from the initial estimate of the seasonally adjusted series to the final, historical estimate) of around 15% when X-11 was used in a concurrent fashion. This contrasts with the 6% improvement they found using the best of several forecasting procedures in conjunction with X-11 (to obtain a year's seasonal factors from data through December of the preceding year). Thus as Fuller conjectured and the Geweke study concluded, the greatest gain came from using current data in producing the seasonally adjusted estimate for the current month.

Theoretical evidence supporting concurrent adjustment is found in Dagum (1981, 1982) and Wallis (1982). Dagum considered measures of the difference between the frequency response functions associated with the theoretical filter for the first adjustment with X-11 and the theoretical filter for the final, historical adjustment. By the standards of these measures, she found the concurrent adjustment filter closer to the central (final) filter than any of the 12 monthly forecasting filters, including those of X-11-ARIMA. This suggests again that more accurate (i.e., closer to final) estimates are achieved by X-11 with concurrent adjustment than with the standard year-ahead seasonal factor adjustment, regardless of whether these year-ahead seasonal factors are obtained by forecasting the factors (X-11) or the series' values (X-11-ARIMA). Dagum's theoretical results conform well with and help to explain the empirical results of Kenny and Durbin (1982). Additional theoretical support is offered by Wallis (1982). Wallis contrasted the transfer function properties of the 12-months-ahead filter with that of the concurrent filter and found more distortions in the 12-months-ahead filter. In the business cycle range where the transfer function should ideally be 1.0, it deteriorates more rapidly in the case of the 12-months-ahead filter. The fluctuations at higher frequencies are also greater and more erratic in the case of the 12-months-ahead filter. In addition, the phase shift exhibited by the 12-months-ahead filter is less desirable because greater shifts are observed at frequencies close to the annual cycle, when the phase shift ideally should be zero (as in the case of symmetric filters). By studying the sums of squares of moving average coefficients in the various filters, Wallis concluded that the 12-months-ahead filter actually enhances the variance of the irregular and requires larger first-year revisions in the data.

Other statistical agencies have also been evaluating concurrent adjustment. One of the Committee of Experts on Seasonal Adjustment Techniques' recommendations to the Federal Reserve Board (Moore et al. 1981) was to seriously consider performing seasonal adjustment on a concurrent basis. Following up on this recommendation, a recent study of two monetary series by Bayer and Wilcox (1981) provided a favorable assessment of concurrent adjustment with X-11 for those two series. The Bureau of Labor Statistics also has a concurrent adjustment study underway and already publishes (as one of the alternative, unofficial estimates of unemployment) the estimate based on concurrent adjustment each month, in accordance with the recommendation of the National Commission on Employment and Unemployment Statistics (1979).

Other countries that already follow a practice of concurrently adjusting many or, in some cases, all of their series include Canada, Portugal, and the Netherlands.

Given the evidence in favor of concurrent adjustment, we conducted this study to assess the potential value of concurrent adjustment on Census Bureau time series. This study differs from the empirical studies mentioned previously, particularly the Kenny and Durbin study, in several respects. For one, the Census Bureau's procedures for the seasonal adjustment of these series are duplicated as closely as possible. Thus the options in X-11 that are frequently used by the Census Bureau, particularly other-than-default seasonal moving average lengths, are used where applicable. In addition, whereas the Kenny and Durbin study started with the removal of extremes before any analysis was done, this study does not utilize any prior treatment of extremes, since Census Bureau procedures do not call for prior treatment of extremes. In contrast with the Kenny–Durbin study, improvements in seasonal adjustment obtainable with X-11 are the focus of this study; neither trend estimation nor forecasting methods used in conjunction with X-11 are considered here. The sample of time series is of course unique to this study, but it differs from other studies by being composed exclusively of economic series and by having more detailed (i.e., lower) levels of aggregation than some other authors have considered. The time span of the data in this study (1967, or earlier, to 1979) dictates, for reasons described later, a comparison period (usually) beginning in 1974. This is a relevant distinction from previous studies, since many of the series in the present study are affected by the 1974 economic recession. Finally, in addition to the comparisons based on the level of the series considered by Kenny and Durbin, this study includes comparisons based on month-to-month rates of change, such rates being of considerable interest to policymakers.

3. DESCRIPTION OF THE DATA AND DESIGN OF THE STUDY

The data used in this study come from four different divisions of the Bureau of the Census and are described in Table 1. Five series are from the retail and wholesale trade area (BUS); six series are from the manufacturers' shipments, orders, and inventories survey in the Industry Division (IND); five series are from the export statistics compiled by the Foreign Trade Division (FTD); and five series are from the Construction Statistics Division (CSD). Plots of these series are shown in Figures 1–4. The BUS, FTD, and IND series span January 1967–July 1980. The value-put-in-place series from construction spans January 1967–December 1979. The other four construction series were augmented by earlier data for reasons discussed in Section 5.

The series were selected for the study by the economic statistics divisions at the Bureau of the Census. The particular series were chosen because they were consistent in definition during the period of the study and because they provided a variety of types of series. All of the series show significant seasonality in the X-11 program's F test for seasonality (Shiskin, Young, and Musgrave 1967). Even if significant seasonality is present in this test, the strength of the seasonal relative to the irregular (the noise component) has an impact on

Table 1. Selected Series Used in the Evaluation of Concurrent Adjustment Study

Code Name	Title	MCD Minimum Span of Data	MCD Complete Data Set
Business			
RFURNDLRS	Retail sales of furniture and home	2	2
RGROC	Retail sales of grocery stores	2	2
RHARDWARE	Retail sales of hardware stores	3	3
RTAUTO	Total retail sales of automotive dealers	3	3
WFURN	Wholesale sales of furniture and home furnishings	2	3
Construction			
CON-BPNC1*	Building Permits, North-Central Region, Single Family Units	8	4
CON-BPNE1*	Building Permits, North-East Region, Single Family Units	5	5
CON-HSNC1*	Housing Starts, North-Central Region, Single Family Units	4	7
CON-HSNC5*	Housing Starts, North-Central Region, Units of Five or More Families	8	9
CON-PRAOTH	Value Put in Place, All Other Private Construction (not classified otherwise)	2	2
Foreign Trade			
FTDXUCAN*	Exports to Canada	3	3
FTDXUCARSC*	Exports of Cars to Canada	5	5
FTDXULAR*	Exports to Latin American Republics	6	4
FTDXUWH*	Exports to Western Hemisphere	4	3
FTDXU2*	Exports, SITC Section 2, Crude Materials, Inedible (except fuel)	3	3
Industry			
INS21VS	Value of Shipments: Steam Engines and Turbines	5	8
INS36VS	Value of Shipments: Radio and TV	3	3
INS46VS	Value of Shipments: Railroad Equipment	3	3
INS63TI	Total Inventories: Fats and Oils	4	3
INS80UO	Unfilled Orders: Newspapers, Books, and Periodicals	2	2
INS86VS	Value of Shipments: Fertilizer	3	3

* 3 × 9 seasonal moving averages are used for all months.

the quality of the seasonal adjustment achieved; a seasonal (signal) that is stronger than the irregular (noise) is desirable for a good seasonal adjustment with X-11. In 15 of these 21 series, the month-to-month percentage contribution of the seasonal to the original series (an X-11 diagnostic) is twice that of the irregular, which is satisfactory. In three series—INS46VS, FTDXU2, and CON-PRAOTH—the percentage of contribution to variance in the original series of the seasonal is 1–1.6 times that of the irregular. In the remaining three series, the percentage of contribution of the seasonal is low—approximately equal to that of the irregular in CON-HSNC5 and smaller than that of the irregular in FTDXULAR. Smoothness, another characteristic of the series, is measured by the months for cyclical dominance (MCD), which is the minimum span of months required for the average absolute change in the trend to exceed that of the irregular. The MCD was computed on the minimum span of data used in the study, as well as on the complete set of data as shown in Table 1. In 18 of the series the MCD was essentially the same for both sets of data: 12 series having an MCD of two or three; five series an MCD of four, five, or six; and one series, CON-HSNC5, an MCD of seven or more. The MCD changed from eight to four, four to seven, and five to eight for CON-BPNC1, CON-HSNC1, and INS21VS, respectively. These characteristics of the series have a bearing on the results discussed later.

Except as noted later, each series studied had a seven-year start-up period (1967–1973) preceding the test period in which concurrent adjustments were calculated. After the datum for each succeeding month past the start-up period was added, a seasonal adjustment with Census X-11 was calculated. This simulated the effect of adjusting in a concurrent mode. The important caveat to mention concerns the use of final values for the unadjusted data in the 21 series used in this study. When the actual monthly statistic for a given series is released, time delays in survey response and processing require the release of an advance or preliminary unadjusted number, which is then subject to revision in the following month's release, as more respondent data become available. This preliminary unadjusted figure is seasonally adjusted by the appropriate factor from the set of 12-months-ahead projected factors (the usual application of Census X-11). Recent research by one of the economic divisions at the Census Bureau (Shimberg 1984) confirms that the results of this study are transferable to the actual seasonal adjustment situation with preliminary data, although in the latter case the effect of revisions in the unadjusted numbers themselves is a confounding effect (see Section 7).

In addition to the concurrent mode of adjustment, two other alternatives to the usual 12-months-ahead adjustment were evaluated in this study—six-months-ahead adjustment and one-month-ahead adjustment. Six-months-ahead adjustment refers to running the X-11 program semiannually and using the first six projected factors from X-11 to adjust the next six months of data. A procedure very similar to the six-months-ahead mode of adjustment used in this study is now used by the Census Bureau for the seasonal adjustment of the four retail trade series included in this study. One-month-ahead adjustment refers to the monthly

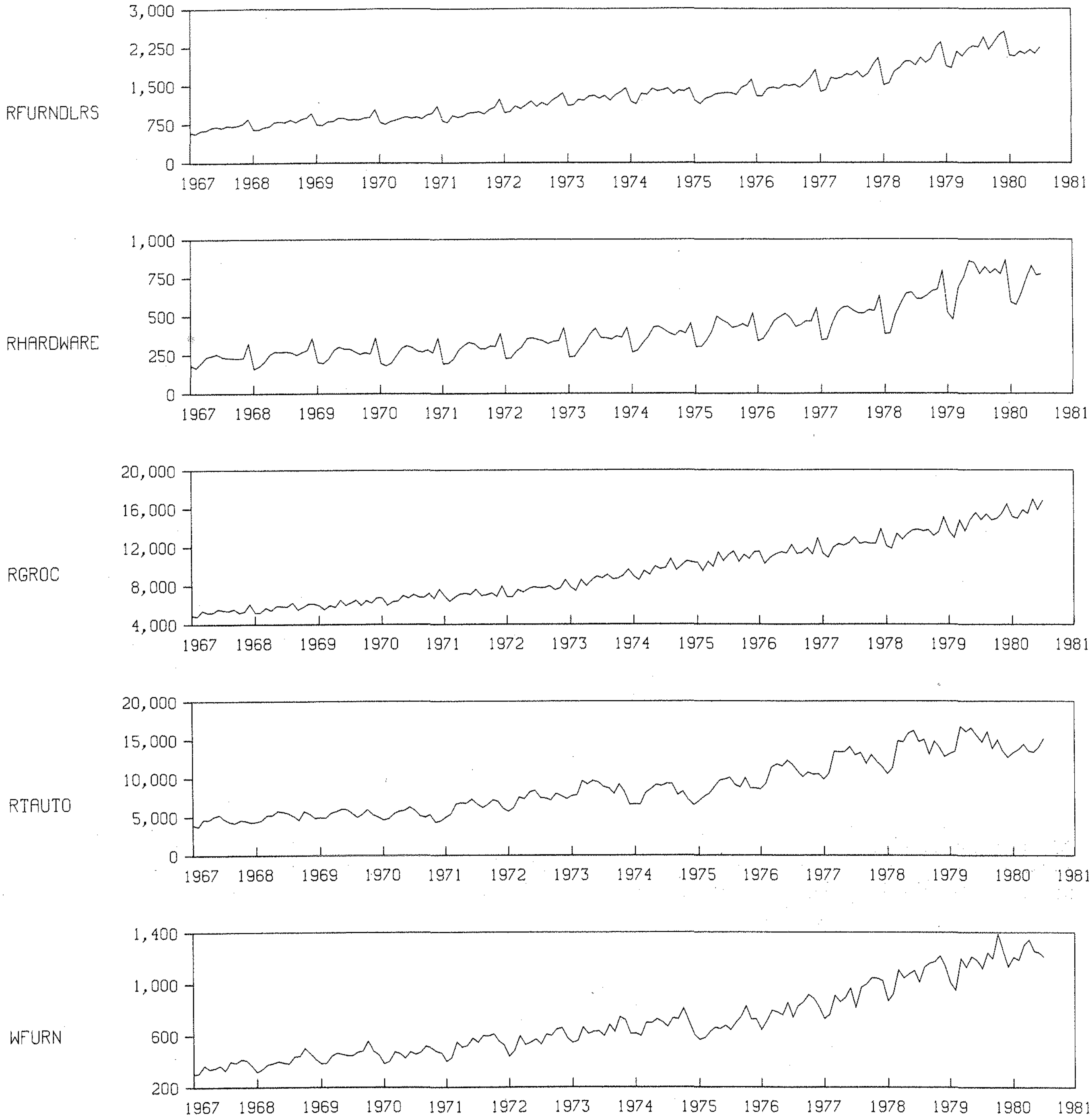

Figure 1. Business Series.

event of running X-11 with data up to time $t - 1$ and using the first projected factor from that run (for month t) to adjust month t.

For each series the X-11 seasonal adjustment options in use in 1981 at the Census Bureau were used through the entire period of the study. Although the use of a seven-term seasonal filter, called the "3 × 5 *seasonal moving average*, is the default in Census X-11, series can optionally be adjusted with different lengths of seasonal moving averages. (A $3 \times n$ moving average is a three-term simple average of n-term simple averages; the overall impact is that of an $(n + 2)$-term weighted average applied to the data. See Shiskin, Young, and Musgrave (1967) for details of the seasonal moving averages.) In BUS and IND series, these filter lengths are determined individually by Census Bureau analysts

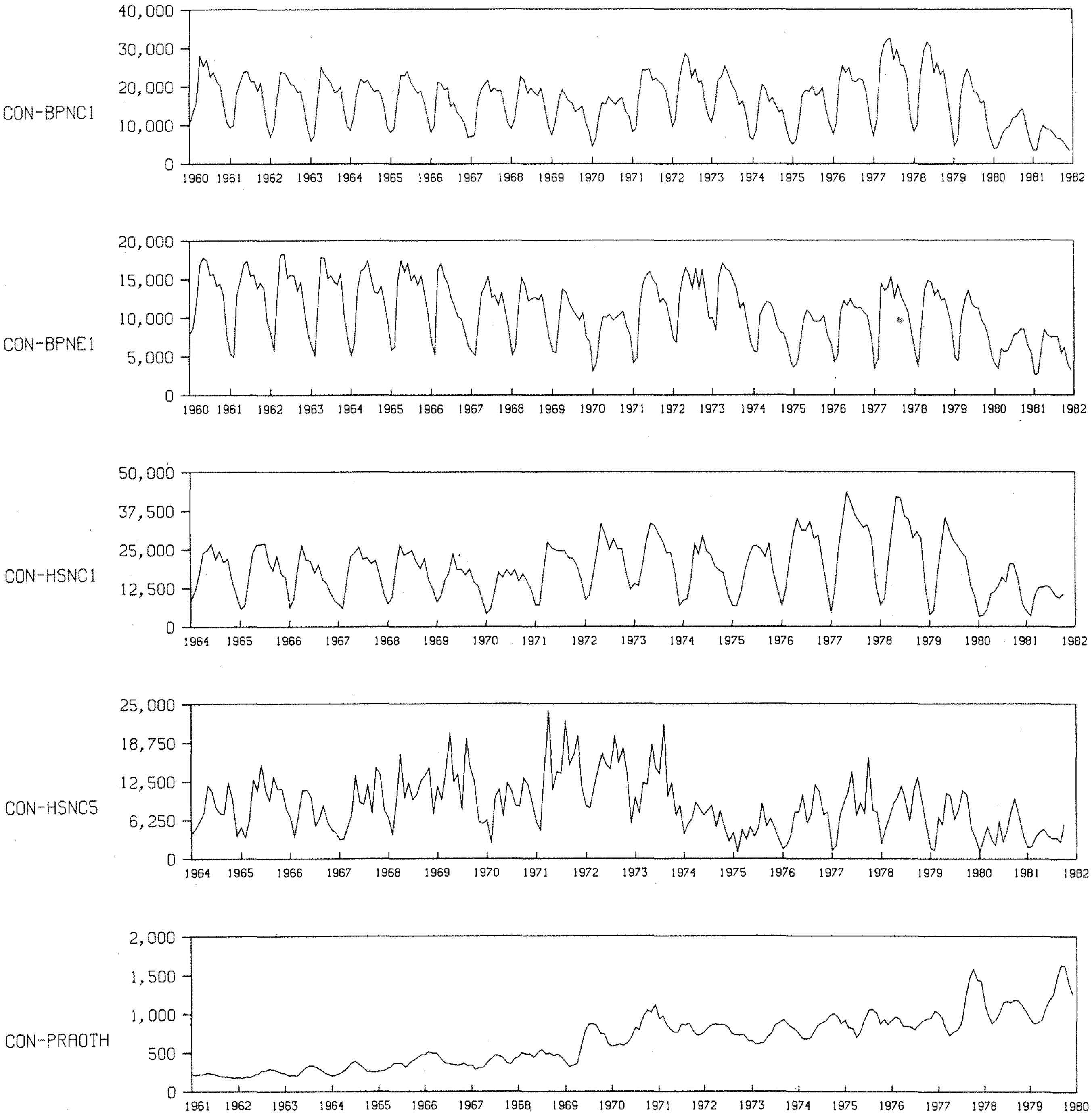

Figure 2. Construction Series.

for the different calendar months. In the FTD series and four of the CSD series, the 11-term, 3 × 9 seasonal filter is used for all calendar months.

4. COMPARISON STATISTICS FOR EVALUATING ALTERNATIVES

To evaluate the relative improvement of concurrent adjustment (or any alternative mode) over the operational, 12-months-ahead adjustment, comparisons between a first-published figure and a target, or *correct*, figure are needed. The definition of the target seasonal adjustment used in this study and in the study by Kenny and Durbin is the final seasonal adjustment produced by X-11 on all the data. For instance, the seasonal adjustment produced in July 1980 is taken to be the final adjustment for the relevant experimental periods, January 1974–July 1977, in the BUS series. A final adjustment is achieved with X-11 when sufficient data are available to use a symmetric filter for the adjustment

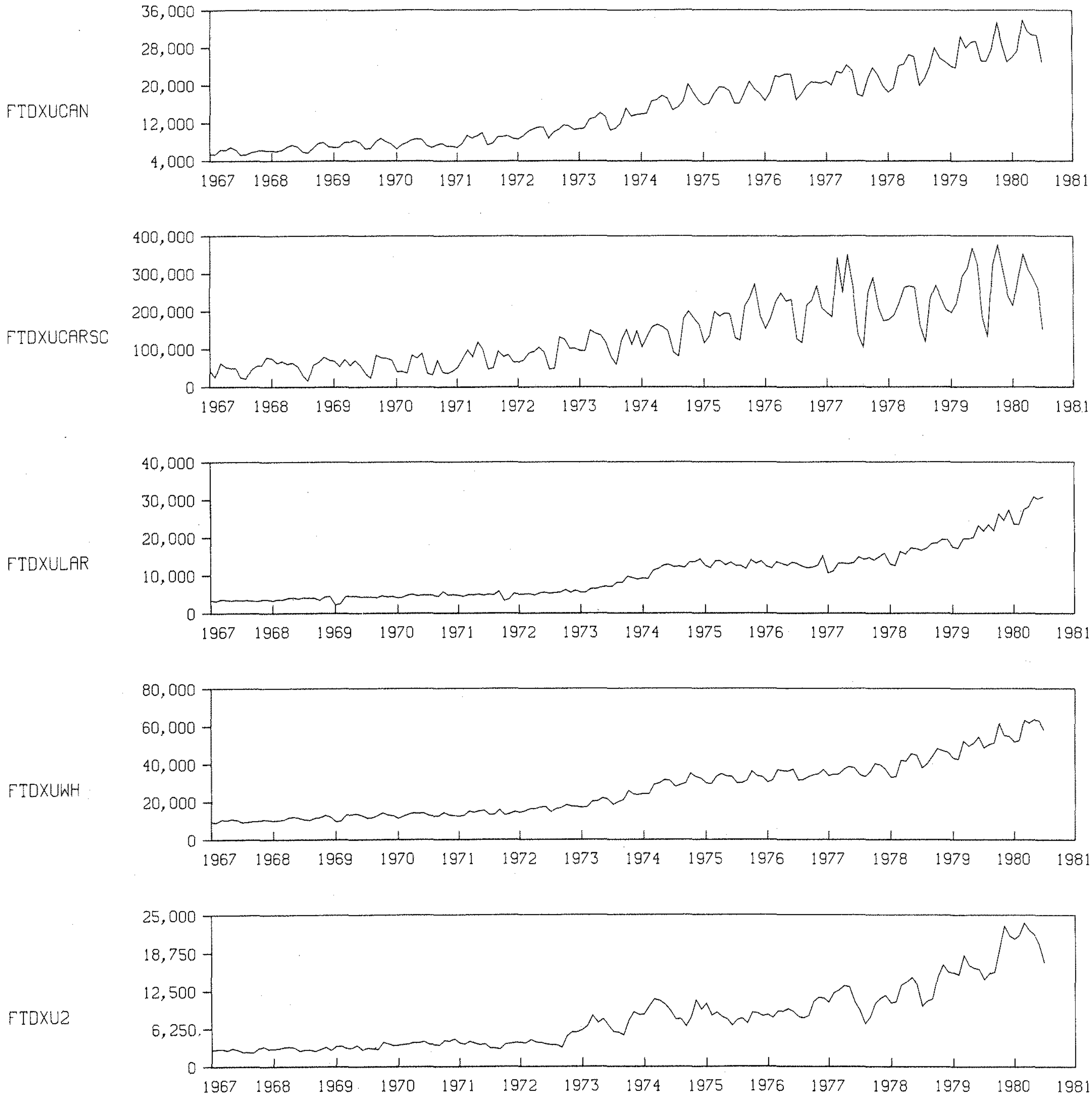

Figure 3. Foreign Trade Series.

of the center term. Young (1968) noted that whereas the true central-term adjustment (for default X-11 options) requires 145 terms (six years on each side of the point being adjusted), an approximately final adjustment is achievable with a nearly symmetric filter obtained with only 73 terms (three years of data before and after the point being adjusted). Thus for the purposes of this study, the final adjustment obtained with the nearly symmetric filter of at least 73 terms is taken to be the target seasonal adjustment. For series for which longer seasonal moving averages are specified (FTD, CSD), the nearly symmetric filter requires more than three years of data subsequent to the month being adjusted—five years in the case of 3 × 9 moving averages.

Having defined the target seasonal adjustment, we want to evaluate the accuracy of any method's seasonal adjustment against the target. It is important not only to measure the accuracy with respect to the level of the series but also to measure the accuracy with respect to month-to-month movements. For example, the release of important economic statistics to the public and news

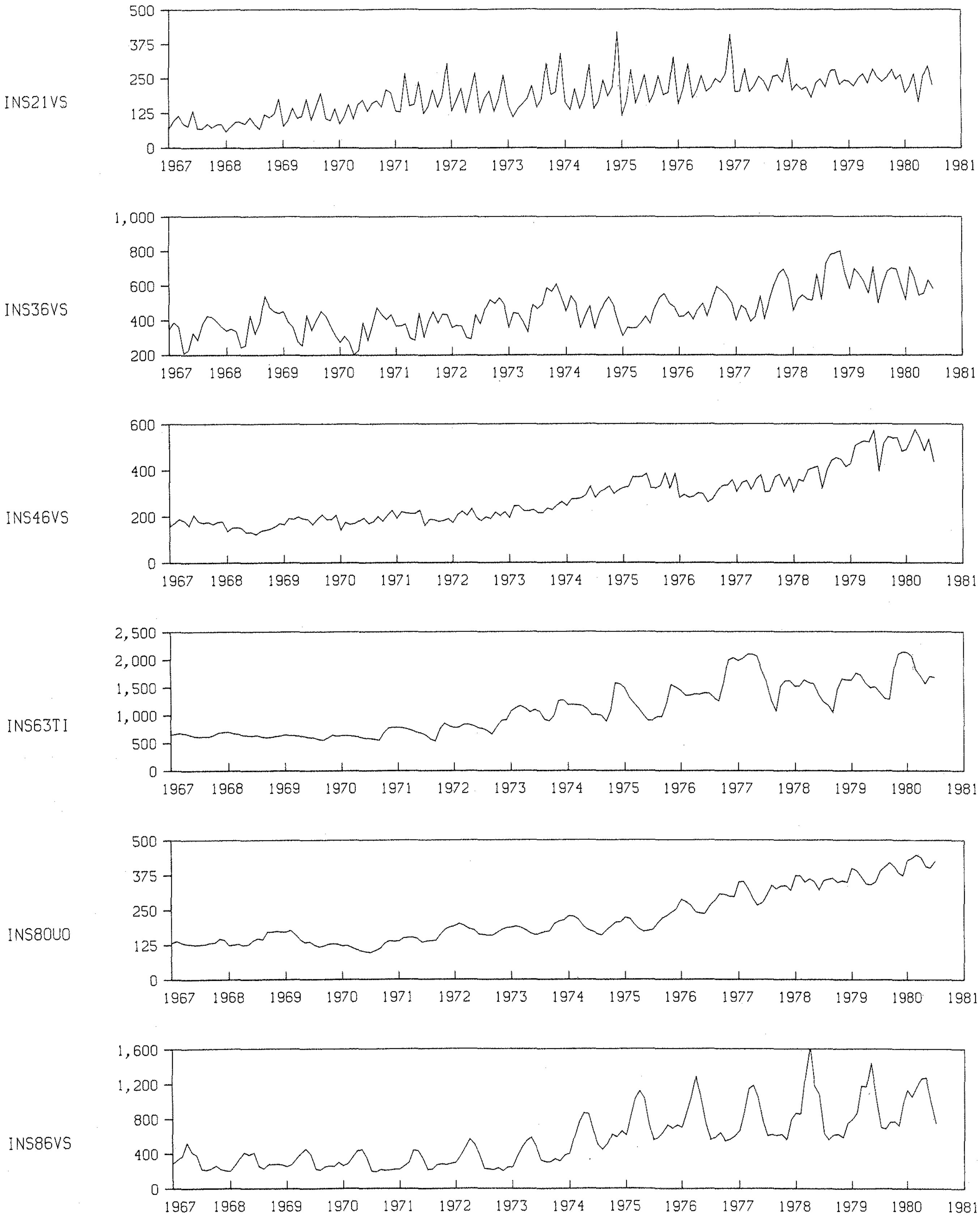

Figure 4. Industry Series.

media usually involves an estimate of the level, accompanied by a statement of month-to-month change. Thus we choose two measures, defined as follows, to evaluate the accuracy of the various methods' estimated seasonal adjustment.

Let x_t denote the first-published estimated seasonal adjustment from any one of the modes of adjustment, X_t the final (target) estimated seasonal adjustment, and n the number of observations. We then denote the difference in level by L_t,

$$L_t = (x_t - X_t) \qquad t = 1, \ldots, n,$$

and the difference in month-to-month percentage changes by M_t,

$$M_t = (x_{t+1}/x_t - X_{t+1}/X_t) \qquad t = 1, \ldots, n - 1.$$

The sets of values of the L_t and M_t statistics were examined for each series, and the overall averages were calculated as summary statistics for each series.

The results of this study were reported in terms of statistics that measure mean absolute deviations, for reasons of interpretability and outlier resistant properties. The tabled results are reported in terms of the mean absolute error (MAE),

$$\text{MAE} = (1/n) \sum |L_t|, \qquad (1)$$

and the average absolute difference in month-to-month percentage change,

$$\text{AADM} = (1/(n-1)) \sum |M_t|. \qquad (2)$$

For comparison with other studies, the root mean square error statistics were calculated and are available in a technical report (McKenzie 1982). The results are similar to those presented here.

5. RESULTS

The two measures—MAE and the average absolute difference of the month-to-month percentage change (AADM)—were computed for concurrent adjustment, one-month-ahead adjustment, six-months-ahead adjustment, and 12-months-ahead adjustment. The statistics calculated for the alternative modes of adjustment were then compared individually. The ratio was calculated of the value of the statistic for the alternative mode divided by that value for 12-months-ahead adjustment. A ratio less than 1.00 thus indicates that the alternative mode produces seasonally adjusted values that differ from the final to a lesser extent than do the seasonally adjusted values from 12-months-ahead adjustment. In this case, the alternative mode is an improvement over the usual practice of 12-months-ahead adjustment. In contrast, a ratio value greater than 1.00 indicates the alternative mode does not offer improvement over the 12-months-ahead adjustment.

The MAE results for the 16 BUS, FTD, and IND series are summarized in Table 2. (Some of the construction series presented particular problems. These series are discussed separately in Section 5.) The value of the ratio [MAE (alternative mode)/MAE (12-months-ahead)] is given in parentheses in Table 2 for each series for alternative modes. For each series, the relative MAE ratios were also ranked from the smallest (i.e., most reduction in MAE) to the largest.

Table 2. Mean Absolute Error of Alternative Modes, Relative to 12-Months-Ahead Adjustment

		Rank and Ratio for Alternative Modes			
Economic Area (period of observations)	*Series*	*Concurrent*	*1 Month Ahead*	*6 Months Ahead*	*12 Months Ahead*
Business—Retail and Wholesale Trade (January 1977–July 1977)	RFURNDLRS	1 (.8059)	2 (.9616)	3[1] (.9940)	4
	RGROC	1 (.9304)	3 (.9982)	2[1] (.9867)	4
	RHARDWARE	1 (.6979)	2 (.9563)	3[1] (.9673)	4
	RTAUTO	1 (.8908)	2 (.9751)	4[1] (1.0056)	3
	WFURN	1 (.8255)	4 (1.0654)	2 (.9938)	3[1]
Business Average[2]		.8261	.9905	.9894	
Foreign Trade (January 1974–July 1975)	FTDXUCAN	1 (.7904)	2 (.9474)	4 (1.0239)	3[1]
	FTDXUCARSC	1 (.5800)	2 (.9907)	3 (.9921)	4[1]
	FTDXULAR	1 (.9364)	3 (1.0815)	4 (1.0984)	2[1]
	FTDXUWH	1 (.8394)	4 (1.0453)	2 (.9933)	3[1]
	FTDXU2	3 (.9444)	1 (.8112)	2 (.8321)	4[1]
Foreign Trade Average[2]		.8061	.9705	.9839	
Industry—Shipments, Orders, Inventories (January 1974–July 1977)	INS21VS	1 (.8835)	2 (.9536)	3 (.9717)	4[1]
	INS36VS	1 (.8276)	2 (.9193)	3 (.9751)	4[1]
	INS46VS	1 (.8710)	2 (.9990)	4 (1.0005)	3[1]
	INS63TI	1 (.9519)	2 (.9622)	3 (.9685)	4[1]
	INS80UO	1 (.9338)	3 (.9665)	2 (.9591)	4[1]
	INS86VS	1 (.9093)	3 (1.0505)	2 (1.0196)	4[1]
Industry Average[2]		.8952	.9743	.9822	
Overall Average[3]		.8533	.9798	.9852	

[1] Rank of mode currently in use.
[2] Unweighted geometric mean.
[3] Weighted geometric mean, where w_i = (number of observations in specific series) ÷ (total number of observations in all series).
NOTE: Values are the ratios of the MAE statistic for the mode indicated divided by that for 12 months ahead. Ratios are given in parentheses.

The average reduction in MAE with concurrent adjustment over these 16 series is 15%. Because these numbers are positive ratios, a weighted geometric mean was used to compute the average, where the weights (exponents) are w_i = (number of observations in the specific series)/(total number of observations in all series). The one-month-ahead and six-months-ahead adjustments provide reductions of 2% and 1%, respectively. (By comparison, the overall reduction in root mean square error with concurrent adjustment observed by Kenny and Durbin was 15%; the equivalent statistic for these 16 series is 17%.)

Almost all series show a substantial reduction in MAE with concurrent adjustment. With the exception of FTDXU2, concurrent adjustment consistently offers the most reduction in MAE among the alternatives considered, from the usual 12-months-ahead procedure.

The averages over the series taken separately by division are also shown in Table 2. The average reduction in MAE with concurrent adjustment of BUS series is 17%, that of FTD series is 19%, and that of IND series is 10%. The results for FTDXULAR are different in magnitude from the other FTD series, which is not surprising. This series has seasonality that borders on being insignificant for the purposes of adjustment with Census X-11.

The reduction in MAE for one-month-ahead and six-months-ahead adjustment over all three groups is not nearly as large as for concurrent adjustment, with the exception of FTDXU2. On the basis of the MAE, which assesses the accuracy of the estimate of the level, the most promising of the three alternatives evaluated is clearly concurrent adjustment.

The comparison of month-to-month movements in the alternative modes with those of 12-months-ahead adjustment is summarized in Table 3. Again, the values shown in the table are the ratios [AADM (alternative mode)/AADM (12-months-ahead)], and they are ranked from the greatest reduction to the least. The overall average reduction in the AADM statistic for these 16 series is 20% for concurrent adjustment, contrasted with essentially no reduction for the one-month-ahead and six-months-ahead alternatives. Note that the RGROC series shows very little difference among all four modes, making the rankings uninformative. It is a series with little irregularity and a very stable and hence predictable seasonal pattern (mostly due to trading-day variation). Considering the results for the alternative modes for RGROC to be essentially the same, we conclude that concurrent adjustment always offers the most reduction from the usual X-11 procedure, with regard to the average absolute difference of month-to-month percentage change. Thus the evidence again favors concurrent adjustment as the best alternative.

Further insights into the relative merits of concurrent adjustment versus 12-months-ahead adjustment are provided by examining the sets of values of each measure for each series. Histograms of the difference in level, L_t, and the difference in month-to-month ratios,

Table 3. Average Absolute Difference of Month-to-Month Percentage Change of Alternative Modes, Relative to 12-Months-Ahead Adjustment

		Rank and Ratio for Alternative Modes			
Economic Area (period of observations)	Series	Concurrent	1 Month Ahead	6 Months Ahead	12 Months Ahead
Business—Retail and Wholesale Trade (January 1974–July 1977)	RFURNDLRS	1 (.6824)	2 (.9663)	4[1] (1.0098)	3
	RGROC	3 (.9857)	1 (.9589)	2[1] (.9821)	4
	RHARDWARE	1 (.7634)	3 (.9492)	2[1] (.9477)	4
	RTAUTO	1 (.9052)	4 (1.0947)	3[1] (1.0394)	2
	WFURN	1 (.7683)	3 (1.0229)	4 (1.0346)	2[1]
Business Average[2]		.8139	.9970	1.0021	
Foreign Trade (January 1974–July 1975)	FTDXUCAN	1 (.4505)	2 (.8802)	3 (.9818)	4[1]
	FTDXUCARSC	1 (.6200)	2 (.9904)	3 (.9938)	4[1]
	FTDXULAR	1 (.8553)	4 (1.0468)	3 (1.0283)	4[1]
	FTDXUWH	1 (.6003)	3 (.9765)	2 (.9720)	4[1]
	FTDXU2	1 (.7631)	3 (.8394)	2 (.7697)	4[1]
Foreign Trade Average[2]		.6424	.9436	.9442	
Manufacturer's Shipments, Orders, and Inventories (January 1974–July 1977)	INS21VS	1 (.9384)	2 (.9916)	4 (1.0038)	3[1]
	INS36VS	1 (.8143)	2 (.9852)	4 (1.0183)	3[1]
	INS46VS	1 (.8755)	3 (1.0084)	4 (1.0232)	2[1]
	INS63TI	1 (.8818)	2 (.9312)	3 (.9313)	4[1]
	INS80UO	1 (.8502)	3 (.9534)	2 (.9393)	4[1]
	INS86VS	1 (.7247)	4 (1.1439)	3 (1.0901)	2[1]
Industry Average[2]		.8448	1.0001	.9996	
Overall Average[3]		.7957	.9892	.9910	

[1] Rank of mode currently in use.
[2] Unweighted geometric mean.
[3] Weighted geometric mean, w_i = (number of observations in specific series) ÷ (total number of observations in all series).
NOTE: Values are the ratios of the AADM statistic of the mode indicated divided by that for 12 months ahead. Ratios are given in parentheses.

M_t, were basically symmetric for all series. More was revealed by summarizing each of the sets of values with boxplots. This was done for the measure M_t and for the modified measure L_t/X_t (the modification producing scale independent quantities for the purposes of graphing all series together). These boxplots are shown in Figures 5 and 6, where the boxplot summary of the monthly values of the measures for each series for the projected 12-months-ahead adjustment (P) is plotted next to that for the concurrent adjustment (C). (The boxplots were generated by the DATAPLOT package (Filliben 1982) and show extremes, upper and lower quartiles, and the median.) The most noticeable difference in the sets of values is the decreased dispersion of the error statistics when concurrent adjustment is used. The most dramatic difference appears in the Foreign Trade series (FTDXU) CARSC, where the midspread (the interval between the upper and lower quartiles) is dramatically reduced with concurrent adjustment—for both measures. This coincides with the improvement shown in the summary statistics based on these measures (a reduction of over 40% with concurrent adjustment)—the largest improvement among all series.

This characteristic of the improvements available with concurrent adjustment is highlighted best by plotting the L_t and M_t measures with both the concurrent and the 12-months-ahead methods on the same time axis. Examples are shown in Figures 7 and 8 for the Industry Series INS86VS, which are typical of the plots for all series. The most significant feature shown by

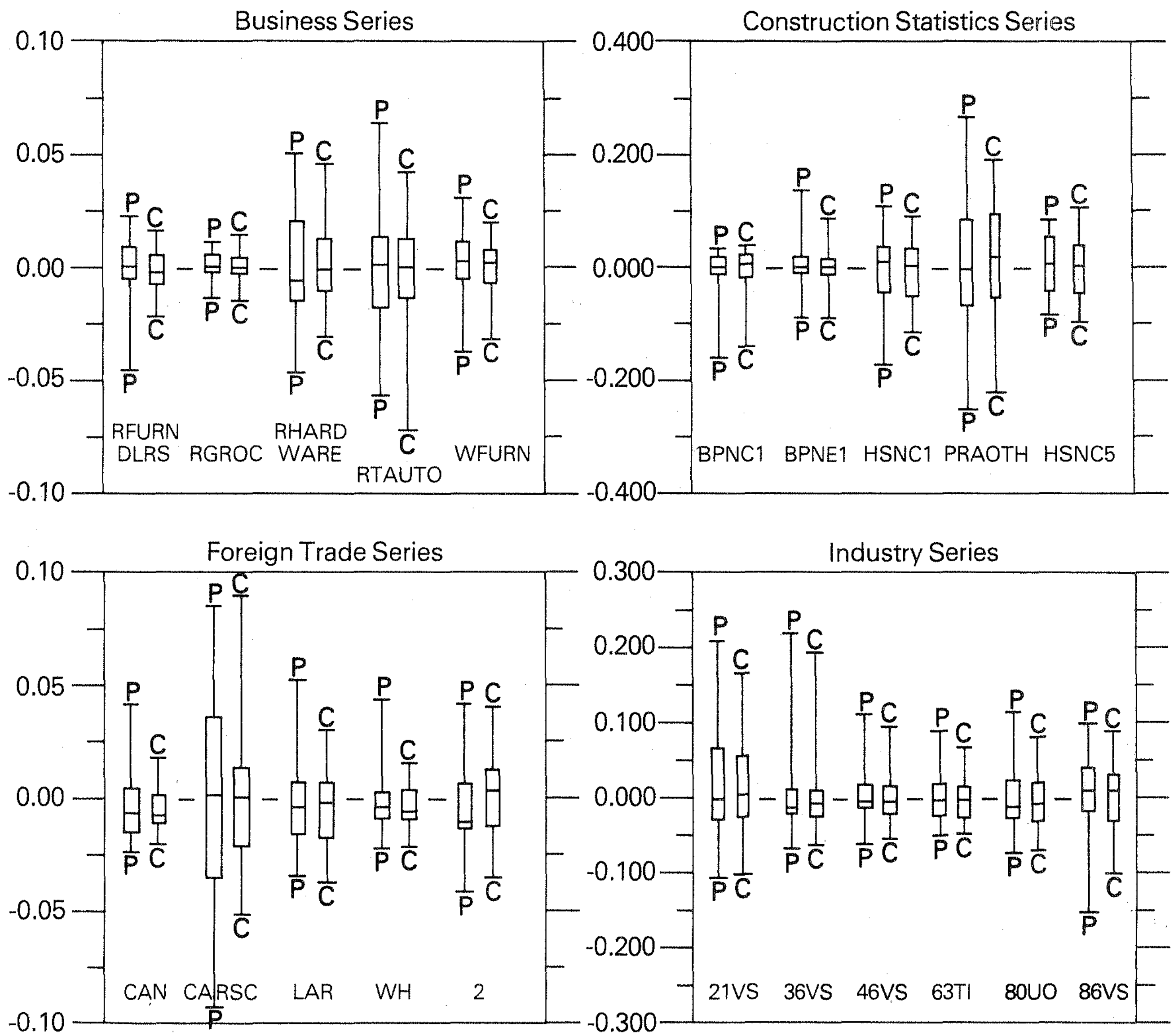

Figure 5. Boxplots of Percentage Error in Estimating Level (L_t/X_t) for Two Methods: P = Projected 12 Months Ahead, C = Concurrent.

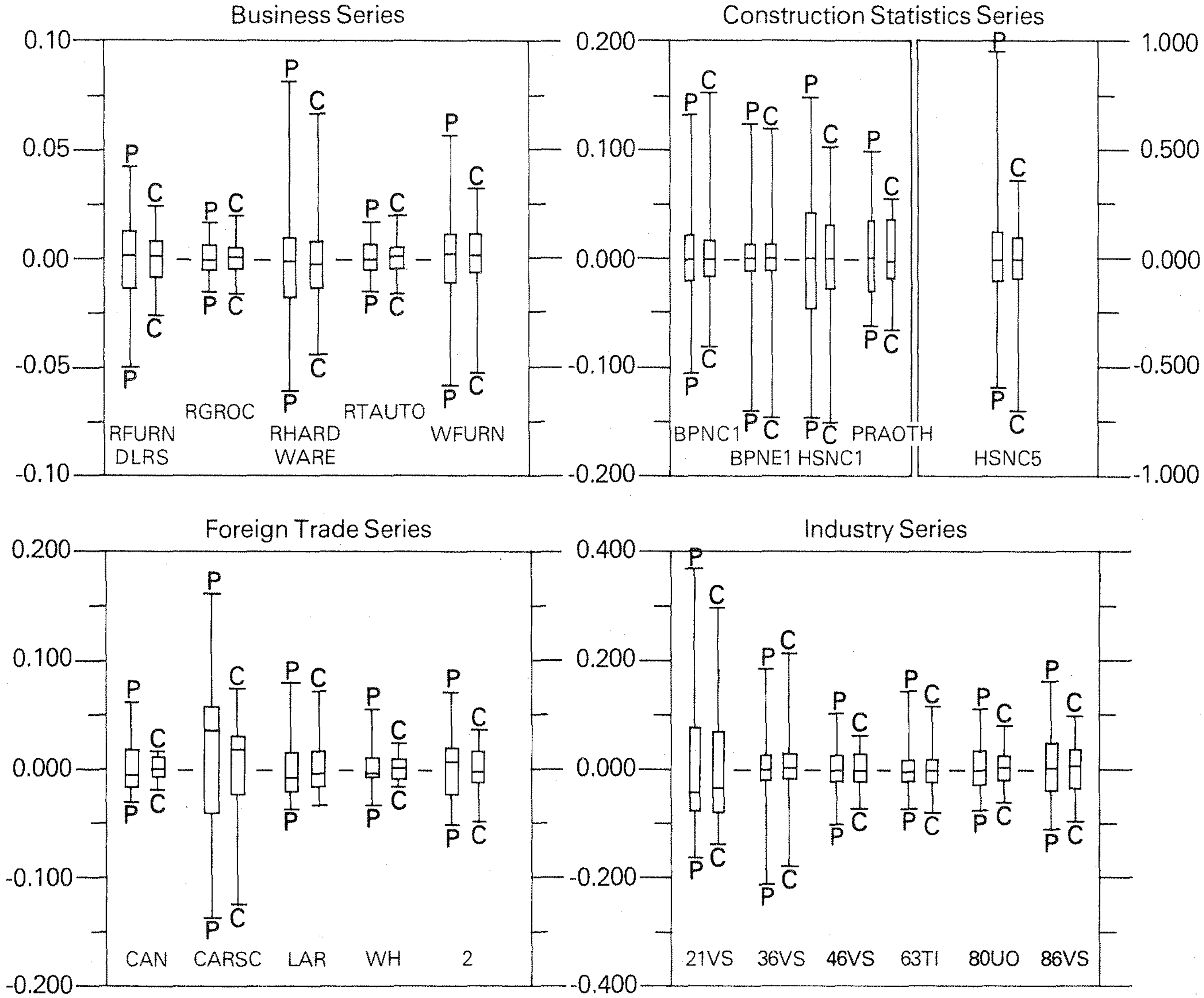

Figure 6. Boxplots of Differences Between Initial and Targeted Month-to-Month Ratios (M_t) for Two Methods: P = *Projected 12 Months Ahead,* C = *Concurrent.*

these plots arises in the cases where both the projected-12-months-ahead and concurrent estimates substantially deviate from the targeted final value. These appear on the plots as large deviations from zero. In almost all such cases, the deviation is larger with the projected-12-months-ahead mode than with concurrent adjustment. Not only were there usually fewer extreme misses with concurrent adjustment than with the present seasonal adjustment procedure, but most such extreme misses are less extreme with concurrent adjustment (i.e., in the months for which either method produces an extreme deviation, concurrent adjustment is off by somewhat less). Since policymakers could be misled by large adjustment errors, it is important for practitioners that *both* the number of extreme misses is less *and* the magnitude of such extremes is generally reduced with concurrent adjustment. This same pattern recurred throughout the rest of the series in the study.

6. CONSTRUCTION SERIES

This section discusses the analysis of the five construction series. Three series—CON-PRAOTH, CON-BPNE1, and CON-HSNC5—demonstrate improvement with concurrent adjustment. The results for the housing starts and building permits series were not what was expected, based on the experience with the 16 previous series.

One of the construction series, the value-put-in-place series (CON-PRAOTH), is regular and is adjusted with the default 3 × 5 seasonal moving averages. The evaluation statistics for CON-PRAOTH are presented in Tables 4 and 5 and show improvement with concurrent adjustment over the 12-months-ahead adjustment, similar to the overall improvement with concurrent adjustment exhibited in the previous 16 series.

The remaining four construction series are presently

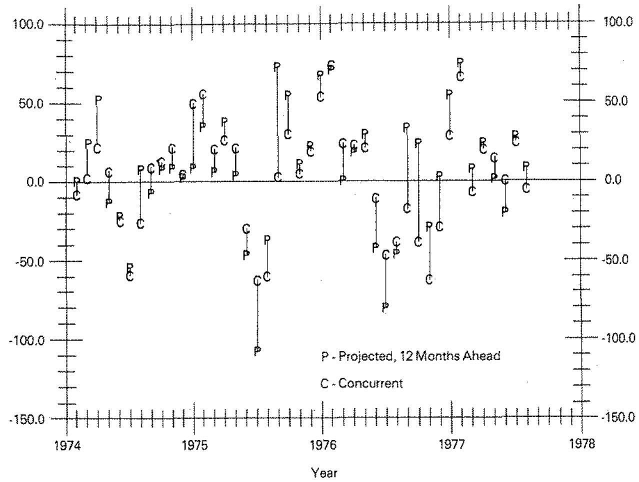

Figure 7. $L_t = x_t - X_t$ for Series INS86VS.

adjusted with the 3 × 9 seasonal moving averages, which require five years of data subsequent to the experimental period of observation to compute the X-11 final adjustment (used as the target adjustment). Data from 1960 on were used for these four series, which meant that 1967–1974 became the experimental period. These four series are characterized by a large irregular component, a rapidly changing trend, and changing amplitude of the seasonal (the latter of which is evident even after stabilizing transformations correct for the increase in amplitude of the seasonal due merely to the increase in the level of the series). The large irregular component reflects in part the fact that these series are not highly aggregated (their data being cross-classified by region and type of structure), and the CON-HSNC5 series has high sampling variability. The evaluation results for these four series are included in Tables 4 and 5. Both statistics show improvement with concurrent adjustment only for the CON-HSNC5 series—a 17% reduction in MAE and a 25% reduction in AADM. For the CON-BPNE1 series, although there was a 15% overall improvement in AADM, the MAE

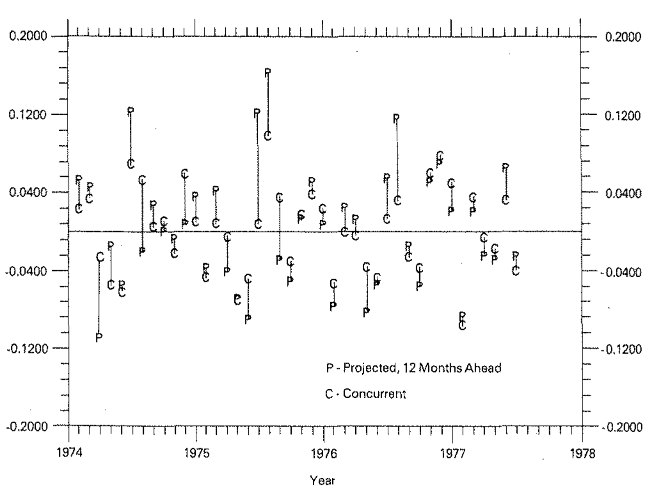

Figure 8. $M_t = x_{t+1}/x_t - X_{t+1}/X_t$ for Series INS86VS.

Table 4. Mean Absolute Error of Alternative Modes, Relative to 12-Months-Ahead Adjustment

Series (period of observations)	Rank and Ratio for Alternative Modes: Concurrent	1 Month Ahead	6 Months Ahead	12 Months Ahead
CON-BPNC1 (Jan. 1967–Dec. 1974)	4 (1.1652)	2 (1.0171)	3 (1.0350)	1[1]
CON-BPNE1 (Jan. 1967–Dec. 1974)	4 (1.0112)	2 (.9920)	1 (.9883)	3[1]
CON-HSNC1 (Jan. 1971–Dec. 1974)	4 (1.0068) (.8942)[2]	1 (.9710) (1.0016)[2]	2 (.9997) (.9935)[2]	3[1]
CON-HSNC5 (Jan. 1971–Dec. 1974)	1 (.8330)	2 (.9946)	3 (.9979)	4[1]
CON-PRAOTH (Jan. 1974–Dec. 1976)	1 (.9351)	2 (.9668)	3 (.9678)	4[1]
Construction Average[3]	1.0148	.9938	1.0027	

[1] Rank of mode currently in use.
[2] Results of using the shorter 3 × 5 seasonal moving average for CON-HSNC1.
[3] Weighted geometric mean, where w_i = (number of observations in specific series) ÷ (total number of observations in all Construction Series).
NOTE: Values are the ratios of the MAE statistic for the mode indicated divided by that for 12 months ahead. Ratios are given in parentheses.

statistic showed essentially no difference between concurrent and 12-months-ahead adjustment. A year-by-year analysis of the comparison statistics revealed that this is attributable to the large discrepancy in a single year (1971), and in fact, there were four years of substantial reduction in MAE for this series. In all four series, 1971 seems to be a particularly difficult year in

Table 5. Average Absolute Difference of Month-to-Month Percentage Change of Alternative Modes, Relative to 12-Months-Ahead Adjustment

Series (periods of observations)	Rank and Ratio for Alternative Modes: Concurrent	1 Month Ahead	6 Months Ahead	12 Months Ahead
CON-BPNC1 (Jan. 1967–Dec. 1974)	4 (1.0792)	2 (.9701)	1 (.9542)	3[1]
CON-BPNE1 (Jan. 1967–Dec. 1974)	1 (.8497)	2 (.9428)	3 (.9823)	4[1]
CON-HSNC1 (Jan. 1971–Dec. 1974)	2 (1.0148) (.7841)[2]	3 (1.0613) (1.0378)[2]	4 (1.0675) (1.0487)[2]	1[1]
CON-HSNC5 (Jan. 1971–Dec. 1974)	1 (.7500)	2 (.9792)	3 (.9806)	4[1]
CON-PRAOTH (Jan. 1974–Dec. 1976)	1 (.8598)	2 (.9316)	3 (.9493)	4[1]
Construction Average[3]	.9204	.9718	.9820	

[1] Rank of mode currently in use.
[2] Results of using the shorter 3 × 5 seasonal moving average for CON-HSNC1.
[3] Weighted geometric mean, where w_i = (number of observations in specific series) ÷ (total number of observations in all Construction Series).
NOTE: Values are the ratios of the AADM statistic for the mode indicated divided by that for 12 months ahead. Results reflect presently used options. Ratios are given in parentheses.

which to produce a concurrent adjustment close to the target adjustment.

The general results for two of the construction series—CON-BPNC1 and CON-HSNC1—were thus not what was expected for concurrent adjustment based on the experience with the previous 16 series. Further investigation showed some improvement with shorter 3 × 5 seasonal moving averages for the CON-HSNC1 series (see Tables 4 and 5). In general, however, the investigations to date have not explained the anomalous results for these construction series.

On the basis of the results shown and investigations pursued for the Construction Series, concurrent adjustment with the presently-used options can be recommended for three series: CON-PRAOTH, CON-BPNE1, and CON-HSNC5. CON-HSNC1 also benefits from concurrent adjustment provided that shorter moving averages are employed. The CON-BPNC1 series does not benefit from concurrent adjustment in the experimental period under either of the seasonal moving average options considered.

7. REMARKS

The research completed (subsequent to this study) by the economic divisions of the Census Bureau further demonstrated the value of concurrently adjusting many of the Bureau's series. Accordingly, the introduction of concurrent adjustment will begin in 1984, proceeding by type of survey or trade area within each economic division.

Several issues arise when the operational implementation of concurrent adjustment is considered. The use in this study of the final, unadjusted data for the series was important in order to isolate the possible improvement with concurrent adjustment that was solely due to improved estimation of the seasonal component. As mentioned in Section 2, however, the first-released, unadjusted data are often the advance or preliminary unadjusted figures, subject to revision in succeeding months. Research by Shimberg (1984) showed that the results of this study are applicable to the case of preliminary unadjusted values, and more research is in progress concerning the case of advance unadjusted values. Moreover, since new adjustments of previous months are obtained each time a new concurrent adjustment run is made, the question arises about whether to publish these revised estimates of prior months. The Bureau's economic divisions are seeking to determine which revised seasonally adjusted estimates should be published to maintain or improve the accuracy of important month-to-month change and year-to-year change estimates. Finally, in implementing concurrent adjustment, the Census Bureau is cognizant of the need to provide a seasonal adjustment that would provide the best numbers to the public and maintain public confidence in the objectivity of the seasonal adjustment procedure. The planned publication, several months in advance of the adjustment, of the precise X-11 options to be used for the seasonal adjustment of each series is designed to meet this responsibility.

8. CONCLUSIONS

This study has shown that concurrent seasonal adjustment with Census X-11 offers improvements over the present practice of using 12 projected seasonal factors for seasonal adjustment. In quantitative terms, obtained by averaging the results for all of the series in the study except CON-BPNC1, there is a 12% reduction in the mean absolute error and a 20% reduction in the average absolute difference of month-to-month percentage changes, using X-11's final adjusted values as the target. These results conform with those of other researchers described in Section 2. In addition, evidence was presented that extreme deviations from the final value are fewer and smaller with concurrent adjustment.

A further advantage to concurrent adjustment relates to the size of the sampling variance when concurrent adjustment is employed, as shown in research by Monsour (1975) and Wolter and Monsour (1981). The work showed that variances of the data are ordered roughly as follows:

$$\text{final adjusted} \leq \text{concurrent adjusted}$$
$$\doteq \text{unadjusted} \leq \text{projected-12-months-ahead adjusted}.$$

If the sampling variance under concurrent adjustment is thus roughly on the order of the original series, it is therefore possible (in the absence of published standard errors for the seasonally adjusted series) to view the published standard errors for the unadjusted series as some measure of the variability of the concurrent seasonally adjusted series. Users of the data often use the standard error of the published series in this way as a guide to the variability of the seasonally adjusted series, but under the present method of 12-months-ahead adjustment, this will result in underestimating the variability of the seasonally adjusted series. Based on the research so far, however, it is apparently not misleading to use the standard error of the unadjusted series, at least until more research is produced on estimating the variances of seasonally adjusted estimates.

In summary, therefore, the main advantages of seasonally adjusting concurrently are (a) greater overall accuracy in estimating the final level and the final month-to-month movements of the series with concurrent adjustment and (b) fewer individual extreme deviations from the final value. There is also the further advantage of using published standard errors for the unadjusted series as a guide to the variability of the seasonally adjusted series.

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