New York: Oxford University Press, 317–385.

Kernighan, B.W. (1975). A Preprocessor for a Rational Fortran. Software Practice and Experience, 5, 395–406.

Komhyr, W.D. and Harris, T.B. (1977). Measurements of Atmospheric CO_2 at the U.S. GMCC Baseline Stations. Air Pollution Measurement Techniques: Special Environmental Report 10, WMO 460, Geneva. World Meteorological Organization, 9–19.

Mallows, C. (1979). Robust Methods – Some Examples of Their Use. The American Statistician, 33, 179–184.

Pierce, D.A. (1979). Signal Extraction Error in Nonstationary Time Series. Annals of Statistics, 7, 1303–1320.

Shiskin, J., Young, A.H., and Musgrave, J.C. (1967). The $X - 11$ Variant of the Census Method II Seasonal Adjustment Program. Bureau of the Census Technical Paper 15, U.S. Department of Commerce, Washington, D.C.

Young, A. (1965). Estimating Trading-Day Variation in Monthly Economic Time Series. Technical Paper No. 12, U.S. Bureau, of the Census, Washington, D.C.

Received April 1989

Comment

Dennis Trewin[1]

First, I would like to congratulate the authors on the paper. Not only does the paper address the common practical statistical problem of seasonal adjustment with an innovative approach, but the presentation of the material is excellent. I enjoyed the paper thoroughly although I wish I could have experimented with the system more before preparing this comment.

In Section 1.1, the authors outline criteria they wanted STL to satisfy. The paper provides the readers with some confidence that the system does indeed satisfy these six criteria. I particularly like the flexibility in specifying the amounts of variation in the trend and seasonal components – this gives the experienced seasonal adjuster who has a good feeling for the data series a very powerful tool to refine his/her adjustments – more so than for the X-11 method.

The method also allows some flexibility in the specification of the number of cycles in the seasonal component. While this will be of limited value to government statistical agencies where most series are monthly or quarterly, it provides a distinct advantage over X-11 to those who wish to adjust a series that is not monthly or quarterly.

By its nature the method is robust to outliers. This, together with the strong graphics capabilities, must also make it a

[1] Australian Bureau of Statistics, P.O. Box 10, Belconnen, A.C.T. 2616, Australia.

Acknowledgement: I would like to thank Andrew Sutcliffe for the assistance he provided in preparing these comments and for the X-11 analysis of the U.S. unemployed male data.

very useful tool for the expert seasonal adjuster.

A non-expert seasonal adjuster, however, may like default options that may cost computing time but still give a reliable adjustment. I would appreciate the authors comments on this aspect but my impression is that default options could be easily developed. $n_{(p)}$ provides no difficulties. The default values of $n_{(i)}$ and $n_{(o)}$ could be 1 and 20 respectively; $n_{(l)}$ is derived from $n_{(p)}$; $n_{(s)}$ could be set artificially high and $n_{(t)}$ can be derived. Would the use of such default values result in adjustments that are not effective? A key factor is the robustness of the method to the choice of $n_{(s)}$.

I do have some other questions for the authors.

1. Can STL handle trend and seasonal breaks in series if the breaks can be determined exogenously? What about the situation when there are sufficient data to estimate the size of the break from the data series itself? In these circumstances, is it best to treat the series as two different series (i.e., one series prior to the break and the other series following the break) or is it possible to use loess to try and fit an approximation to a step function? Can significance tests be developed to test the existence of possible break points? (The Australian Bureau of Statistics has developed tests within its X-11 expert system (Trewin 1989)).
2. Section 2.3 states that $T_{\mu}^{(o)} \equiv 0$ works quite well as a starting point for the trend series in the inner loop. It will usually be possible to estimate $T_{\mu}^{(o)}$ more accurately. For example, when readjusting a series it would be possible to use the T_{μ} values from the previous adjustment cycle as a starting point. Does this provide any significant improvement in the performance of STL?
3. The X-11 method is non-linear so the sum of the seasonally adjusted

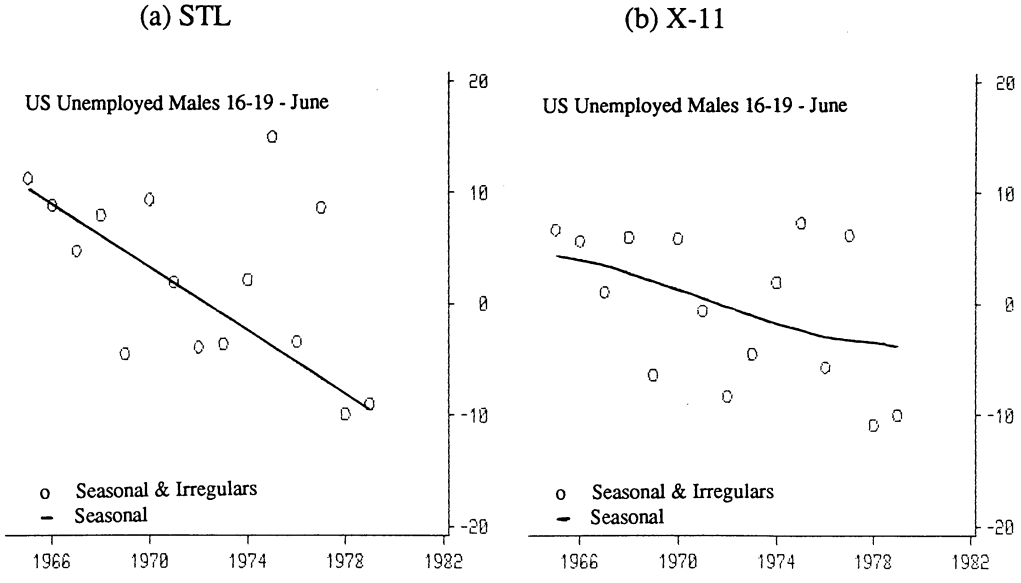

Fig. 1. Comparison of Seasonal Diagnostic Plots for STL and X-11 – Unemployed Males to August 1979.

component series does not equal the seasonally adjusted aggregate series, e.g., seasonally adjusted unemployed persons does not equal the sum of seasonally adjusted employed males and seasonally adjusted unemployed females. This can cause some confusion to users and a desirable property of seasonal adjustment methods is to minimize these differences. STL has similar non-linear properties but it is difficult to gauge from the paper as to whether this would be more or less of an issue compared with *X*-11. Perhaps the authors may have some useful experience.

4. The authors indicate that a trading day option will be added. The authors have expressed concern about the trend and seasonal components competing for the same variation, but our experience indicates that there is far greater competition between the seasonal and trading day components for the same variation. Can the trading day option provide the seasonal adjuster with flexibility in specifying the amount of variation in the trading day and seasonal components?

There is one aspect of STL that does cause concern. One very desirable property of a seasonal adjustment method is that the size of revisions is minimized as more data becomes available. Applying loess to smooth the seasonal component for many series will normally result in larger revisions to the seasonal factors than is the case for *X*-11. This is demonstrated by comparing the seasonal-irregular plots for the unemployed males data for STL and *X*-11 for the month of June. The plots for STL are shown in Figure 9 by Cleveland et al. but the June plots are reproduced in Fig. 1 for convenience.

Data on unemployed males is now available until May 1989 and it has been reanalyzed using *X*-11 see Fig. 2.

The *X*-11 seasonal factor path shows very little revision because of the conservative path taken in 1979 (to what proved, with the addition of subsequent data, to be outlier observations in 1978 and 1979) whereas STL seasonal factors will be subject to significant revisions.

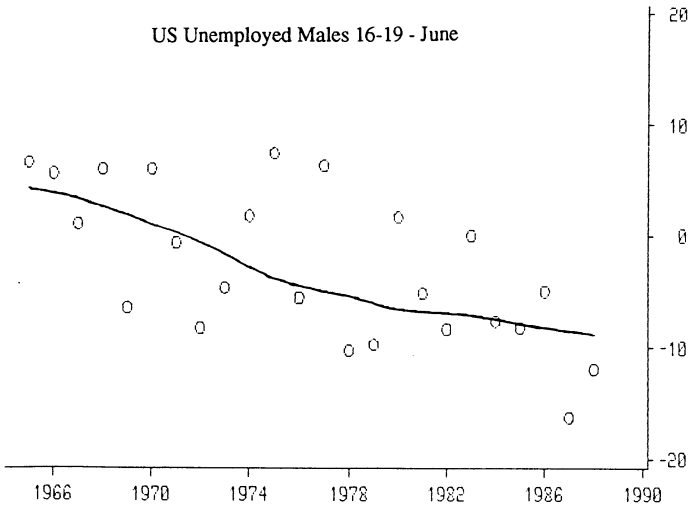

Fig. 2. Seasonal Diagnostic Plots for X-11 – Unemployed Males to May 1989.

There is considerable interest in being able to derive confidence intervals for the components of time series such as the trend series. I was particularly interested in the section on "models and confidence intervals" hoping that it might provide a neat method of deriving confidence intervals. However, it does not do so, and empirically based methods using past data will need to be developed to provide some indication of confidence intervals. Measures of the reliability of seasonal adjustment are generally not provided, but users are increasingly interested in having measures of data quality and it is important that seasonal adjustment packages include methods for approximating confidence intervals. This would be an important extension of the STL package.

There are no doubt many other highly desirable "bells and whistles" that should be added to STL as people have more experience with the system. This is natural for all software packages but the authors seem to have made an excellent start with their first version available to the public. Some of the "bells and whistles" would be regarded as essential by many seasonal adjusters and would need to be part of the early version of STL. The vast array of problems that can occur in seasonal adjustment has usually been tackled by having diagnostics to detect when problems (e.g., trend breaks) occur. Such diagnostics should also become part of the STL package, particularly diagnostics that indicate the reliability of the seasonal decomposition.

The authors have indicated that the multiplicative model option can be added to the STL method. This is essential for analysis of official time series as experience has indicated the multiplicative model is usually appropriate for economic series. Similarly, it will be necessary to add the trading day option and a correction for moving holidays such as Easter.

The Australian Bureau of Statistics and many other statistical offices have used and modified the *X*-11 package over a 20–25 year period. The package has proved extremely successful and statistical offices will need some convincing before abandoning the existing methods. The real test will be to apply both STL and *X*-11 to the same data series and to compare the differences. This will provide a real test of STL and how well it handles series with trading day patterns and other special characteristics that *X*-11 can cope with. I think proof of this nature will be required before statistical offices can be convinced to move from *X*-11. I am pleased to see the authors have placed the software in the public domain at a nominal charge. I hope that statistical offices do take up the challenge and experiment with STL and compare the results with *X*-11. However, I suspect that in the short term, STL will be mainly used for industry applications particularly those with data that is not monthly or quarterly or has missing values. Nevertheless, STL shall provide a valuable addition to the software packages available for seasonal adjustment.

Reference

Trewin, D.J. (1989). Development of an Expert System for Seasonal Adjustment. Bulletin of 47th Session of the International Statistical Institute.