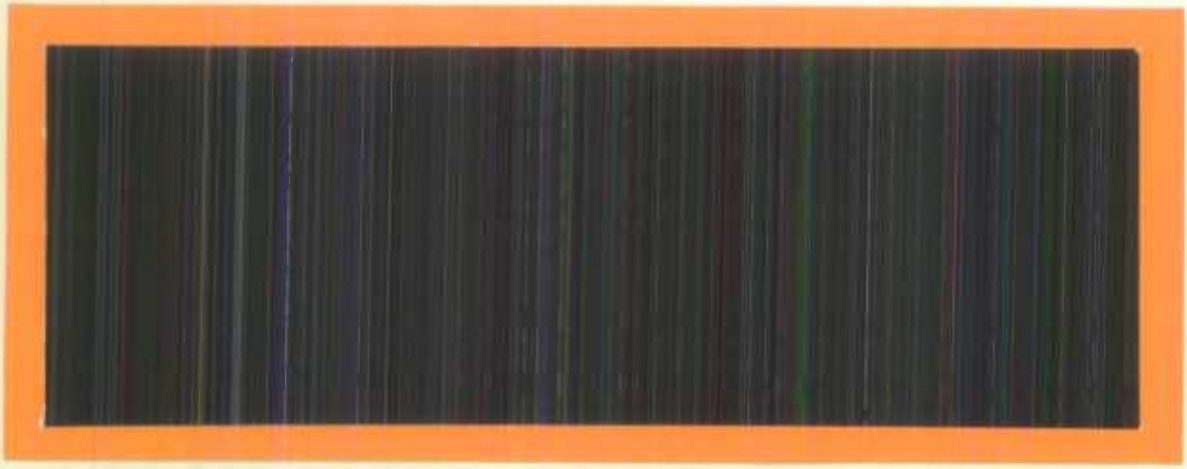

Methodology Branch

Time Series Research and Analysis Division

Direction de la méthodologie

Division de la recherche et de l'analyse des chroniques

Canada

WORKING PAPER TSRA-87-003E

TIME SERIES RESEARCH & ANALYSIS DIVISION

METHODOLOGY BRANCH

CAHIER DE TRAVAIL TSRA-87-003E

DIVISION DE RECHERCHE ET ANALYSE DES SERIES CHRONOLOGIQUES

DIRECTION DE LA METHODOLOGIE

SEASONAL ADJUSTMENT OPERATIONS OF CANADIAN SOCIO-ECONOMIC TIME SERIES

by

Estela Bee Dagum, Statistics Canada
Misako ozono Gratton, Statistics Canada

This is a preliminary version. Do not quote without authors' permission.
Comments are welcome.

SEASONAL ADJUSTMENT OPERATIONS OF CANADIAN SOCIO-ECONOMIC TIME SERIES

Estela Bee Dagum, Statistics Canada
Misako Kozono Gratton, Statistics Canada

ABSTRACT

This paper purports to discuss the operations involved in the production and dissemination of seasonally adjusted data, with special reference to the key functions available in the X-11-ARIMA seasonal adjustment method. This method has recently been developed as a SAS procedure PROC X11ARIMA.

The topics discussed are:
(A) Key functions involved in each of the following three steps: (1) an ex-ante seasonal analysis of the original series; (2) the seasonal adjustment per se; (3) an ex-post seasonal analysis of the seasonally adjusted series. (B) How the seasonally adjusted series are disseminated by means of publications, CANSIM and TELICHART. (C) A brief review of computerized tools including PROC X11ARIMA.

1. INTRODUCTION

The objective of seasonal adjustment is the elimination of variations in a time series which are attributable to predictable seasonal events. This clearly reveals the more important underlying variations, trend and cycle. Figure 1 shows an original series, its seasonal factors and the corresponding seasonally adjusted series. The resulting adjusted series can then serve as a useful tool in analysis such as: in determining at which stage of the business cycle the economy stands; in relating the time series to other series or external events, and comparing month-to-month changes of various series.

The seasonal adjustment of a series is not always a straightforward procedure. For instance, the 1981-82 recession had a very great impact not only on the structure of the series but also on the estimation of the trend-cycle and seasonal components at the end of the series. Consequently serious problems may occur, such as the over- or underestimation of the seasonally adjusted figures, leading to a false indication of a turning point.

There are practical problems when a large number of time series must be seasonally adjusted on a regular basis. Such an environment requires computerized tools with appropriate infrastructure which enables automated procedures to function properly. For example, a series of check points is needed to ensure the accuracy of data production and dissemination. From time to time, a problem may be discovered requiring further investigation and analysis. This may result in an additional explanation, suggestion for an alternative method of computation, or a piece of a new problem leading to a new methodological development.

In response to the increasing interest in and need for the seasonal adjustment of a large number of time series, this paper tries to synthesize the seasonal adjustment operations practised over Canadian socio-economic time series. Section 2 identifies major steps and key functions within each step. Section 3 describes various aspects of data dissemination related to the seasonally adjusted data. Section 4 contains a brief review of some of the computerized tools related to Sections 2 and 3.

2. STEPS IN SEASONAL ADJUSTMENT

2.0 An Overview

There are three major steps involved in the seasonal adjustment of time series, namely: (Dagum, 1979): (1) an ex-ante seasonal analysis of the original series; (2) the seasonal adjustment per se; (3) an ex-post seasonal analysis of the seasonally adjusted series.

The results from the first step determine all the necessary parameters on the seasonality of the original series in question. A successful analysis requires close consultations between subject-matter specialists (who are familiar with the subject on which the series is observed) and methodological experts on seasonal adjustment.

The second step produces seasonally adjusted data on a regular basis. Operations in this step are very much dependent on a particular software to carry out the adjustment. As reviewed in Section 4, a majority of Canadian socio-economic time series are seasonally adjusted using the X-11-ARIMA Seasonal Adjustment Program (Dagum, 1980). Subsequently, PROC X11ARIMA, an equivalent SAS procedure was developed at Statistics Canada, (Gratton and Dagum, 1986a and 1986b).

In the case of the X-11-ARIMA program, the information for the third step can be obtained from the regular operations of the second step. With a large-scale mainframe computer, the cost of seasonal adjustment, including extensive output materials, has become negligible (less than one second to seasonally adjust a monthly series).

In the remainder of this section, key functions in each step are explained.

2.1 Ex-Ante Seasonal Analysis of the Original Series

2.1.1. Test for the Presence of Seasonality

A test is available to assess the presence of seasonality in the original series. A series should only be seasonally adjusted if it has significant seasonal variations. Failure to adjust a candidate series will seriously limit the use of data. On the other hand, an inappropriate seasonal adjustment will produce misleading information.

2.1.2. Selection of a Decomposition Model

Once it is established that seasonality is present, the correct decomposition model must be selected. A test is available to determine the correct model. Selection of the wrong decomposition model will yield an erroneous indication of a turning point.

2.1.3. Prior Modifications before Attempting to Seasonally Adjust the Original Series

The X-11-ARIMA Program provides an option that enables users to make prior changes to the original series before its seasonal adjustment. Generally, these prior modifications are temporary (used to produce a better seasonal adjustment) and they are re-introduced with the final seasonally adjusted values. For example, the replace-

ment of some extreme values can be done by the users instead of letting the program do it automatically.

2.1.4. Trading Day Variations

If significant trading day variations are present in monthly series, these variations should be removed. Failure to remove them will produce larger irregular fluctuations in the seasonally adjusted figures. There are several options available for estimating trading day variations. A new option allows the user to automatically estimate, in both the additive and the multiplicative decomposition models the trading day variations before fitting an ARIMA model for data extrapolation.

2.1.5. Graphical Displays for Exploratory Analysis

Graphical displays of data are extremely useful in time series analysis. They are particularly effective in the ex-ante seasonal analysis of the original data.

2.2 Seasonal Adjustment - A Regular Operation

2.2.1. Extrapolations from an ARIMA Model

If a series can be fitted and extrapolated well by an ARIMA model of the Box and Jenkins (1976) type, this should be done in order to estimate correctly changing seasonal patterns and turning points in the trend-cycle at the end of the data. The use of ARIMA extrapolated values reduces the magnitude of revisions of the current seasonally adjusted values (Dagum, 1982.a). The model may be specified by the user or selected automatically from a set of three program-supplied ARIMA models according to a set of criteria for fitting and extrapolation (Dagum, 1981). The length of the forecast horizon is variable and the user can choose from 6 to 24 months. (12 months being the default option.)

2.2.2. Selection of the Length of Seasonal and Trend-Cycle Moving Averages

The X-11-ARIMA program allows the user to choose moving averages of different lengths to estimate the trend-cycle and seasonal factors. (The longer the moving average applied, the smoother the final output.) This program also enables the application of different seasonal moving averages for different months. For instance, in some series, seasonality for a given month may be much less regular than for any other month, and the user may apply a longer moving average for that month while the default option operates for the remaining months.

2.2.3. Automatic Identification and Replacement of Extreme Values

The automatic treatment of extreme values is of great importance. The user should exercise great care in choosing the designated number of standard deviations (sigma limits) of the irregulars to replace extreme values. Too much adjustment will produce an artificially smooth series, too little, will produce large fluctuations and thus, a poor estimate of the seasonal factors.

2.2.4. Strike Option

The occurrence of a strike may affect different series in different ways. A strike-treatment option is available in the X-11-ARIMA which should be used with care similarly to the automatic treatment of extreme values.

2.2.5. Revised Annual Totals

The X-11-ARIMA method is a non-linear estimation procedure thus, the annual totals of the seasonally adjusted data will generally not equal the totals of the original data. Some series used for accounting purposes, for example, require the two annual totals to coincide. The X-11-ARIMA program has an option which forces the two totals to be equal without distorting the month-to-month changes of the seasonally adjusted series.

2.2.6. Composition of Series

A composite series is one that results from the addition, subtraction, multiplication and/or division of several component series. The component series can enter into the aggregation with equal or different weights. Because of the non-linearities already discussed, the direct and indirect seasonally adjusted composites are usually different. In order to decide whether the composite series should be seasonally adjusted using the direct or the indirect procedure, the criterion of smoothness is often used. The wrong choice of method will produce highly varying seasonal factors which are usually undesirable. The X-11-ARIMA program offers two statistics to measure the degree of smoothness.

In an indirect seasonal adjustment, some component series may have no significant seasonality and in such cases, it is best to use the unadjusted figures in the total.

2.2.7. Concurrent versus Forecast Seasonal Factors

The current seasonal adjustment of a given series can be made using either a "concurrent" or a "forecast" seasonal factor. A concurrent seasonal factor is obtained by running the X-11-ARIMA each time a new observation is added to the series whereas a forecast seasonal factor is generally obtained from a series that ended in the previous calendar year. A concurrent adjustment always produces a more accurate seasonally adjusted series, hence subject to smaller revisions. (Dagum, 1982 and 1982.a).

2.2.8. Frequency of Revision

Users may have their own practices on revisions. However, when concurrent adjustments are made, the best revision policy (best from the viewpoints of cost reduction and gain in accuracy) is to revise each monthly value when the next month appears, keep this estimate constant for the remainder of the year and then, revise annually when the first month of the next year is available (Dagum, 1986). By revising each month once, the reliability of the end point filter increases significantly. Thus changes in month-to-month comparisons can be ascribed to the new data only and not due to a change in the moving average. The annual revision usually provides a significant improvement in the seasonally adjusted figures. Furthermore, it is advisable to revise only the last three years of data given the properties of the moving averages used by the X-11-ARIMA program.

2.3 Ex-Post Analysis of the Seasonally Adjusted Series

An ex-post analysis of the seasonally adjusted series should be made to assess the reliability of the adjustment.

The most common criteria used and which are available as measures and statistics in the X-11-

ARIMA program are: (1) testing the presence of residual seasonality; (2) testing the randomness of the residuals; (3) measuring the average revision of the seasonal factors for each month; (4) measuring the relative contribution of the components to the total variance of the series; (5) measuring the number of months (quarters) it takes the change in the trend-cycle to surpass the amount of change in the seasonals as compared to those of the irregulars; (7) measuring the amount of stable seasonality relative to the amount of moving seasonality. These measures are produced by the X-11-ARIMA in two major tables on Summary Measures and Quality Control Statistics. Their interpretation requires some level of expertise from the users and knowledge of the series in question.

3. DISSEMINATION OF SEASONALLY ADJUSTED DATA

3.0. Background

The demand for seasonally adjusted time series data changed dramatically when a new method of data dissemination became available. This new method was based on computer technology and created a large new market in addition to the existing one for usual printed publications. In Canada, Statistics Canada began distributing CANSIM Data Bank on magnetic tapes in mid 1960's. Then, the Data Bank was considered as a repository of officially published time series which covered a wide spectrum of Canadian socio-economic statistics. Since then, CANSIM has evolved into one of the most, if not the most significant data dissemination machinery for Canadian statistical data.

3.1. Printed Publications

Roughly speaking, several thousands time series are seasonally adjusted at Statistics Canada on a regular basis. A majority of these becomes a part of official publications. For example, the Labour Force [15] and New Motor Vehicle Sales [16] are monthly publications. In each case, there is a clear explanation about the method of seasonal adjustment used to produce seasonally adjusted series. This kind of explanation is helpful not only for the data users but also for the purpose of data quality assurance.

As described in 3.2, in a modern computing environment, data users can access a large volume of time series on publicly available data bases. However, it is not always easy for the user to ascertain: (a) that the series are the ones they are looking for; (b) that they are the appropriate ones for their purposes.

For these and other reasons, printed publications are a necessary part of public data use.

3.2. Electronic Dissemination Via CANSIM

After seasonally adjusted series are officially published, some of them (approximately 1,400) enter into the CANSIM MAIN BASE. This data base is a repository of Canadian socio-economic time series consisting of approximately 400,000 time series.

Since data on CANSIM MAIN BASE are not confidential, anyone can request a selection of series from Statistics Canada, or can obtain data via one of the ten secondary distributors. The secondary distributors are private computer services firms under a contract with Statistics Canada to distribute data to their clients. For example, one of them, I.P. Sharp Associates [10] offers 47 economic data bases including CANSIM MAIN BASE.

A subset of the MAIN BASE consists of about 25,000 popular time series stored in a CANSIM MINI BASE. These series are also accessible via secondary distributors.

Both MAIN BASE and MINI BASE are updated any time a new observation of the time series becomes available. For those who have less time critical needs, UNIVERSITY BASE is offered (25,000 series) with quarterly updates.

Another mode of data dissemination services offered by CANSIM is TELICHART Information Services. This system consists of a data base similar to the MINI BASE, TELIDON based graphics displays and user-friendly data retrieval facility. TELICHART Service is extremely effective for a rapid exploratory analysis of time series, which may occur at the beginning of the ex-ante seasonal analysis.

4. COMPUTERIZED TOOLS

For the purpose of briefly reviewing computerized tools, the following basic requirements emerge from sections 2 and 3: (1) flexible data retrieved facility for time series; (2) a comprehensive set of facilities for statistical and econometric data analysis; (3) a facility for graphical data displays; (4) a seasonal adjustment program.

If one is to look for an integrated environment, the SAS system from SAS Institute and SHARP APL for I.P. Sharpe Associates are the only ones which come close to satisfying most of the requirements.

SAS/ETS [11] has PROCX11, which is basically the same as the X-11 Variant of the Census Method II (Shiskin, Young and Musgrave, 1967). A similar facility is also available in SHARP APL. However, most of the statistical agencies of the world are using the X-11-ARIMA Seasonal Adjustment Program for the production of their seasonally adjusted data and a large number of these organizations uses the SAS System extensively, including Statistics Canada. Thus, PROC X11ARIMA was developed (Gratton and Dagum, 1986a, 1986b), for the required functions to be performed within the SAS System. Figure 2 shows functional relationships of PROC X11ARIMA.

5. REFERENCES

[1] Box, G.E.P. and Jenkins, G.M. (1976), Time Series Analysis Forecasting and Control, Holden-Day, San Francisco.

[2] Dagum, E.B. (1979), The Seasonal Adjustment of Economic Time Series Aggregates: A Case Study: The Unemployment Rate. Background Paper No. 31, the U.S. National Commission of Employment and Unemployment Statistics. Superintendent of Documents, U.S. Government Printing Office, Washington, DC.

[3] Dagum, E.B. (1980), The X-11-ARIMA Seasonal Adjustment Method, Statistics Canada Cat. No. 12-564E (in English, Cat. No. 12-564F (in French), Ottawa, Canada.

[4] Dagum, E.B. (1981), "Diagnostic Checks in the ARIMA Models of the X-11-ARIMA Seasonal Adjustment Method," in Time Series Analysis (O. Anderson and M.R. Perryman, eds.) North-Holland, pp. 133-145.

[5] Dagum, E.B. (1982): "Revisions of Time Varying Seasonal Filters" Journal of Forecasting, Vol. 1, No. 2, 173-187.
[6] Dagum, E.B. (1982.a), "The Effects of Assymmetric Filters on Seasonal Factor Revisions" Journal of the American Statistical Association, 77, 732-738.
[7] Dagum, E.B. (1986): "Monthly versus Annual Revisions of Concurrent Seasonall Adjusted Data" in Econometric and Time Series Modelling (I.B. MacNeill and G.F. Umphrey, editors) D. Reidel Pub. Co.
[8] Gratton, M.K. and Dagum, E.B. (1986.a), PROC X11ARIMA for Seasonal Adjustment of Time Series Proc. SUGI-J, 1986.
[9] Gratton, M.K. and Dagum, E.B. (1986.b), PROC X11ARIMA User's Manual, Statistics Canada, 1986.
[10] I.P. Sharp Associates, Economic Data Bases Reference Guides 1985.
[11] SAS Institute (1982), SAS/ETS User's Guide: Econometric and Time Series Library, SAS Institute, Cary, NC.
[12] SAS Institute (1981), SAS/GRAPH User's Guide 1981 Edition, SAS Institute, Cary, NC.
[13] Shiskin, J., Young, A.H. and Musgrave, J.C. (1967), The X-11 Variant of the Census Method II Seasonal Adjustment Program, Technical Paper No. 15, Bureau of the Census, U.S. Department of Commerce, Washington, DC.
[14] Statistics Canada, CANSIM Information kit.
[15] Statistics Canada, The Labour Force Catalogue No. 71-001.
[16] Statistics Canada, New Motor Vehicle Sales, Catalogue No. 63-007.

Dr. Estela Bee Dagum, Director, Time Series Research and Analysis Division, 13-K, R.H. Coats Building, STATISTICS CANADA, Ottawa - CANADA K1A OT6.

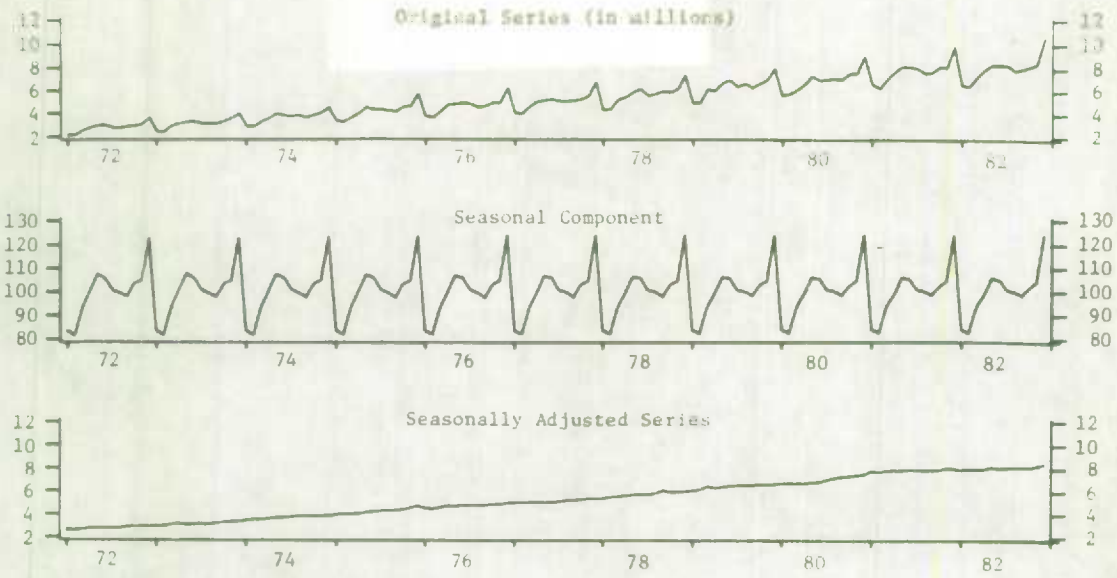

Figure 1. Original series, its seasonal component and the corresponding seasonally adjusted series.

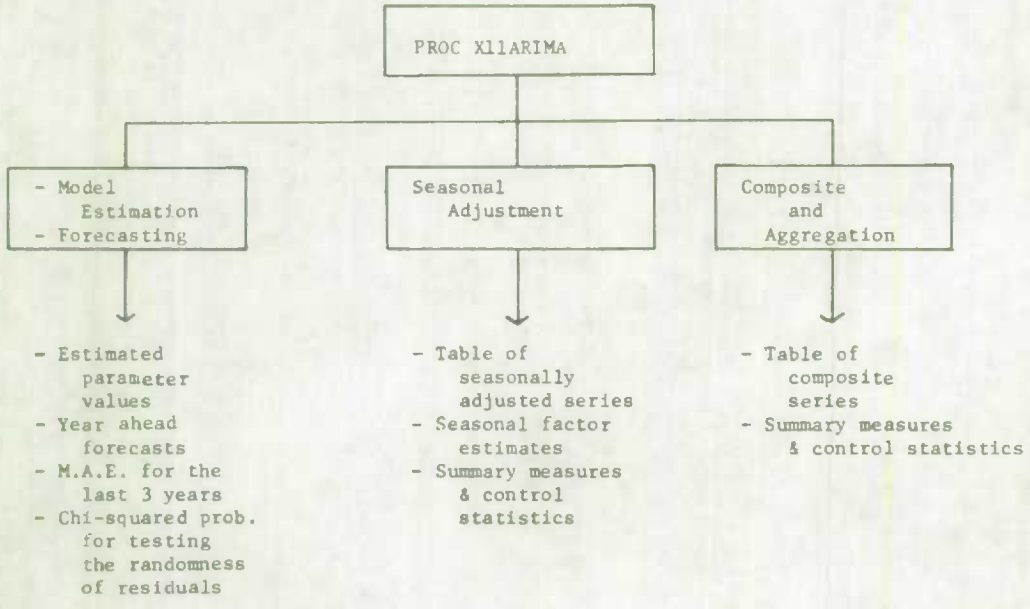

Figure 2. Basic Functions of PROC X11ARIMA