Experiences With Indirect Seasonal Adjustment

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Abstract

Many published seasonally adjusted series are composites of individual seasonally adjusted series: for instance, subcategories sum to main categories and regions sum to the U.S. total. Many seasonal adjusters who publish these indirect totals use seasonal adjustment programs to adjust the individual series and then combine them using separate software. The U.S. Census Bureau uses X-12-ARIMA to perform seasonal adjustment. X-12-ARIMA, like X-11-ARIMA before it, has the capability to combine adjusted series and provide indirect adjustment diagnostics that are not available when the individual adjustments are combined using outside programs. Further expansions to the program will allow users to perform model-based seasonal decomposition as well as the traditional moving-average method of X-11. We investigated the issues involved when performing indirect seasonal adjustments under different circumstances including subjective prior adjustments for individual series and totals with mixed decomposition types (multiplicative vs. additive and semiparametric vs. model-based adjustments). From our experiences we describe what users should know before performing indirect seasonal adjustment.

Keywords: RegARIMA model, Time series

1. Background and Motivation

X-12-ARIMA is the latest U.S. Census Bureau seasonal adjustment program (Findley, Monsell, Bell, Otto, and Chen 1998, U.S. Census Bureau 2002). It follows X-11 (Shiskin, Young, and Musgrave 1967) and X-11-ARIMA and its later developments from Statistics Canada (Dagum 1980, 1988). The Census Bureau is preparing to release new features in a program that in this paper we will call X-13 (U.S. Census Bureau 2005).

Features such as the sliding spans (Findley, Monsell, Shulman, and Pugh 1990) and revision history diagnostics that we used and that we describe as being available in X-13 are also now available in X-12-ARIMA. However, X-13 includes many new features that are not available in the current-release version of X-12-ARIMA. Along with the automatic modeling procedure introduced in X-11-ARIMA (a procedure that chooses the best ARIMA model from a list), X-13 includes an additional automatic modeling procedure based on the method found in TRAMO (Gómez and Maravall 1997). X-13 also contains the SEATS algorithm (Gómez and Maravall 1997) allowing users to perform regARIMA model-based seasonal adjustment. Whereas the X-11 seasonal adjustment method computes the decomposition using a family of seasonal and trend moving-average filters, the SEATS method computes the decomposition using filters determined by the estimated regARIMA model.

Since converting from projected adjustment factors to concurrent adjustment in the 1980s and incorporating regARIMA models for extending the series with forecasts and identifying outliers in the 1990s, the U.S. Census Bureau has made few changes in its seasonal adjustment methods. Recent focus has been on diagnostics for regARIMA modeling and seasonal adjustment. See Findley (2005) for a discussion of recent developments in seasonal adjustment. All subject areas perform adjustments with the traditional X-11 moving-average method.

Research from Hood, Ashley, and Findley (2000) recommended using SEATS adjustments for some series once more diagnostics became available. Now with X-13, there are spectral diagnostics, revision history diagnostics, and sliding spans diagnostics that have long been available for X-11 types of adjustments. Spectral diagnostics are essential for checking the adjusted series for residual seasonal and calendar effects, and the diagnostics from history and sliding spans analyses are useful for deciding whether a particular seasonal adjustment is acceptably stable. See the beta version of the X-13 Reference Manual for more information (U.S. Census Bureau 2005). Research is ongoing to identify additional diagnostics for practical use in model-based adjustment (Feldpausch, Hood, Wills 2004; McElroy 2005).

Besides considering model-based adjustment, we allowed additive decompositions. Some subject areas currently use only multiplicative decomposition because they prefer the properties of a multiplicative adjustment, and they want to combine series of the same type of decomposition. In addition, there are some complications of additive adjustments. For instance, if we directly adjust sums of

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component series for more stable overall results, using a multiplicative adjustment we intuitively understand that we can apply the adjustment factors from the direct adjustment to the components. If we sum series and then directly adjust the composite using additive decomposition, the implications for adjusting the components are not so clear. Factors for multiplicative adjustments vary about 1.0, and the multiplicative relationship holds whether calculating the component adjustments and summing or applying the factors to the composite series. Factors for additive adjustments vary about 0.0, and trying to decide what proportion of the factor to apply to the components is problematic.

Tables now available in X-12-ARIMA make it easier to use additive adjustments by providing alternate multiplicative factors in addition to the traditional additive factors. For appropriate series, additive decompositions may result in better seasonal adjustments than multiplicative decompositions, based on modeling and seasonal adjustment diagnostics (Farooque 2003).

2. Current Practices

Usually once a year reviewers check diagnostics carefully and set up input specification files designating seasonal adjustment settings. For concurrent adjustment, each month or quarter, subject matter analysts run specification files with the most recent data. The production processes occur in a short time frame with specific publication deadlines and little time to solve problems. Many subject matter areas choose not to ask for sliding spans and revision history diagnostics because they slow the run time. For many areas, the subject matter analysts who run production seasonal adjustment are not the reviewers who chose the adjustment settings. The subject matter analysts are not as familiar as the reviewers with the seasonal adjustment diagnostics. For those areas, the only clear indication of a problem is when the program cannot run to completion or when the adjusted values seem too different from already-published data. In the rare case of such a severe problem, the subject matter analysts have the reviewers check the adjustment.

To ensure that production problems are rare, reviewers choose seasonal adjustment settings that will provide consistent results. For concurrent seasonal adjustment at the Census Bureau, we specify the regARIMA model, and reestimate model coefficients as we add data points, allowing changes only for outliers in the most recent data. Also we set X-11 seasonal moving average filters, not allowing them to change from one month to the next.

With a model-based approach, the seasonal filter depends on the seasonal model parameters. Reestimating the model with each new data point means that the filters will probably change only slightly each time, but there is potential for substantial change.

3. Methods

For this study, we aggregated X-11 and SEATS types of adjustments, allowing both multiplicative and additive decompositions, and we looked for problems that might interfere with normal production and publication.

We used X-13 Build 107, compiled June 14, 2005. We ran the program on a Windows® 2000 operating system using the Windows Interface to X-12-ARIMA (Feldpausch 2003). Many Census Bureau subject areas produce official runs on a Unix platform, but most of the series that we concentrated on are run in a Windows environment. By running the program outside the production system, we were free from limitations placed on such things as number of output files saved and number of decimal places in the seasonally adjusted series or combined adjustment factors. We are aware that those limitations can hinder users from taking full advantage of all the options that we used, but we felt strongly that we should use X-13 to its fullest extent.

Our data were U.S. Census Bureau economic time series. We concentrated on three aggregate series, each with distinguishing characteristics: (1) Merchandise Trade Deficit, 15 years, January 1989 to December 2003, (2) Housing Starts, 15 years, January 1990 to December 2004, and (3) Manufacturing Net Income After Taxes, 17½ years, first quarter 1979 to second quarter 1996.

The Merchandise Trade Deficit series combines 144 Import series and 126 Export series. The large number of series and combination of addition (Imports) and subtraction (Exports) made the aggregation somewhat more complex.

The Housing Starts total combines five series, Northeast, Midwest, South, and West Single-Family Housing Starts and the U.S. Total Housing Starts for Two or More Units. The four regional single-family series have prior-adjustment factors that we apply before seasonally adjusting.

The two Net Income After Taxes series, Durable Manufacturing and Nondurable Manufacturing, are from one of the few quarterly surveys at the Census Bureau. Both series have negative values requiring additive seasonal adjustments.

We first ran separate X-11 and SEATS composite adjustments, and from the results we chose a preferred adjustment type for a composite run mixing X-11 and SEATS adjustments. For the Import and Export series we chose based on the spectral plots of the seasonally adjusted series and modified irregular (preferring no residual seasonal or trading-day effects) and on the revisions history (preferring smaller values of the average absolute revision of the seasonally adjusted series). See Soukup and Findley (1999) and U.S. Census Bureau

(2002) for descriptions of these diagnostics. Of the 212 Import and Export series, 86% had equivalent spectral results so revisions determined the type of adjustment. For the other aggregates our selection method preferred only SEATS adjustments, so we chose two Housing Starts series and one Manufacturing Net Income After Taxes series with X-11 adjustments that showed no evidence of residual seasonal or trading-day effects and whose revisions histories compared well to the SEATS adjustments. We wanted a sufficient number of each type of adjustment in the mixed composite runs. Table 1 shows the number of component series of each adjustment type.

Table 1. Component Series of Each Adjustment Type

	X-11	SEATS	Nonseasonal
Merchandise Trade Deficit	56 21%	156 58%	57 21%
Housing Starts	2 40%	3 60%	0
Manufacturing Net Income After Taxes	1 50%	1 50%	0
All	59 21%	160 58%	57 21%

For each series we used the same adjustment mode (multiplicative or additive) for the X-11 and SEATS adjustments. For all except the four Single-Family Housing Starts series, we chose the adjustment mode using the automatic transformation test that is available in X-13. The Single-Family Housing Starts series required multiplicative adjustments because of the prior-adjustment factors. For an additive seasonal adjustment, we could have applied the prior factors to the Single-Family series before running X-13.

We used the same seasonal adjustment decision for both adjustment types. Generally we kept the reviewers' adjustment decisions, but we seasonally adjusted some series that normally are not adjusted but had seasonal models and appeared seasonal according to the spectrum of the differenced, transformed, prior-adjusted data. We chose not to adjust one series that is normally adjusted because the automatic modeling procedure chose a nonseasonal model and there was no evidence of seasonality in the spectrum of the differenced, transformed, prior-adjusted data. For nonseasonal series we included the original series in the composite, or if appropriate, we included the trading-day adjusted series.

For the strictly X-11 types of adjustments we often used specification files that had been used in production because we knew reviewers had chosen quality adjustment settings. As described above, we changed some settings to include additive adjustments and occasionally to adjust series that are not currently adjusted. For Manufacturing Net Income After Taxes, we did not have production specification files, so we chose all settings.

For the strictly SEATS types of adjustments, we first ran the X-13 automatic modeling procedure that is based on TRAMO along with a test for the presence of trading-day effects (based on Akaike's Information Criterion corrected for sample size) and automatic outlier identification. Unlike our usual approach, we chose to prefer balanced ARIMA models – those whose autoregressive (AR) order summed with the order of differencing equals the moving average (MA) order. Balanced models are more likely to lead to admissible decompositions. We specified (hardcoded) those automatically-chosen models in the specification files when we ran the SEATS adjustments. We had to change some models for which the program could not calculate a seasonal adjustment. We were able to identify new models with decompositions, although they sometimes fit the series worse according to the sample autocorrelations of the model residuals.

We asked for revision history diagnostics for the last four years of each series, but because of the series lengths, we had history results for only the last two years of the Manufacturing Net Income After Taxes series. We set the start date for the history diagnostic because to calculate history diagnostics for the composite series, X-13 must have the same history start date for each component series.

To calculate sliding spans diagnostics for an aggregate, X-13 must run sliding spans for all component series, and all spans must be the same length. The default span length depends on the seasonal filter length, so unless all component series have the same seasonal filter it is necessary to set the same span length for each component. Currently there is no specific recommendation for choosing span length for indirect adjustments.

For SEATS adjustments, X-13 bases the spans length on the seasonal MA model parameter. SEATS seasonal filters are not of subseries lengths in the way that X-11 seasonal filters are, but MA parameters close to one imply a relatively stable seasonal filter at the ends of the series. Planas and Depoutot (2002) published airline model parameters that generated decompositions that corresponded closely to results of various X-11 filters. A seasonal MA parameter ranging from 0.72 to 0.73 corresponded to the 3×9 filter, generally the most stable X-11 seasonal filter that we use in production. A seasonal MA parameter of 0.82 to 0.83 corresponded to the 3×15 filter, an X-11 filter requiring 17 years, usually too long for our series.

Findley, Wills, Aston, Feldpausch, and Hood (2003) determined that for series whose model includes a seasonal difference and seasonal MA parameter between

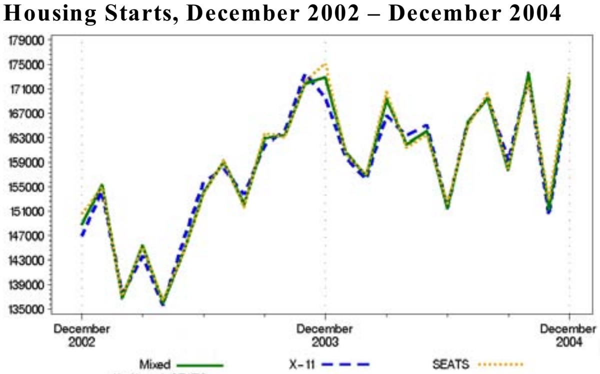
0.71 and 0.75 the sliding spans length should be 12 years. For the Merchandise Trade Deficit and Housing Starts series, this is the longest possible to have the recommended four sliding spans. For incremental increases in the value of the parameter, the span length increases, up to 19 years for seasonal MA parameters greater than or equal to 0.91.

In some initial SEATS adjustments, we did not have enough data to calculate sliding spans diagnostics because the desired span length was too long. For the Merchandise Trade Deficit and Housing Starts adjustments, we set the sliding-span length for all components to 11 years, corresponding to the normal sliding-span length for the 3×9 filter (the longest X-11 filter chosen for those components). For Manufacturing Net Income After Taxes we set the sliding-span length to eight years, corresponding to the normal sliding-span length for the 3×5 filter (the X-11 filter chosen for both components). Most SEATS default sliding-span lengths were longer, so generally we lengthened some X-11 span lengths and shortened most SEATS span lengths. The lengths are not optimal for reviewing the component series. The results are valuable only for assessing the composite adjustments, but it is far from clear what length is best for that purpose.

4. Results

Hood and Findley (2001) warn against looking for seasonal patterns when comparing different adjustments of the same series. We compared the adjustments looking only for general results or patterns. For the most part we found few substantial differences.

Figure 1. Indirect Seasonal Adjustment, U.S. Total Housing Starts, December 2002 – December 2004



The indirect Manufacturing Net Income After Taxes adjustments were indistinguishable when graphed. The indirect Merchandise Trade Deficit adjustments generally moved in the same direction each month. The largest differences were from U.S. Total Housing Starts, shown in Figure 1. From November to December 2003, the indirect SEATS adjustment increased 1.9% and the indirect X-11 adjustment decreased 2.3%. The indirect mixed adjustment fell between them with a slight increase of 0.6%. Other than that particular month, however, the indirect adjustments generally were very similar.

We were surprised to see how often the SEATS adjustment had smaller revisions. We think they were smaller because the SEATS seasonal filters were often more stable than the X-11 filters. Three of the five Housing Starts components had MA parameters greater than 0.998 (a value of 1.0 implies a perfectly stable filter). For comparison, the X-11 filters for those series were combinations of 3×9 and 3×5 filters. The more stable the seasonal filter, the less effect each new data value has on the adjustment, so revision diagnostics would be smaller. Generally reviewers prefer smaller revisions, but we are not sure of the full implications of this result.

We also saw that some indirect results depend on choices for the direct adjustment of the composite series. For SEATS adjustments there is no estimate of the indirect trend (and no estimate of the indirect irregular, meaning there is no spectrum diagnostic for the indirect irregular). For X-11 adjustments, the indirect trend is estimated by applying a Henderson trend filter to the indirect seasonal adjustment. See Ladiray and Quenneville (2001, chap. 3) for details of the Henderson trend filters typically used in X-11 seasonal adjustments. Choosing an X-11 adjustment for the composite of SEATS components would produce an indirect trend but is not a satisfactory solution.

Another direct adjustment implication involved the prior adjustment factors. The composite original series did not contain the prior-adjusted Single-Family data, so the direct adjustment of U.S. Total Housing Starts was not based on the prior-adjusted series that we expected. To adjust the U.S. Total directly, we could easily include the extra step of calculating the needed X-13 input values.

5. Conclusions

We did not see problems from combining the different adjustment types. The SEATS adjustments surprised us, having smaller revisions than the X-11 adjustments for a great number of series. But the SEATS adjustments were highly sensitive to ARIMA model choice, and sometimes we had to compromise model fit to calculate an adjustment.

The default sliding spans and history spans depend on the seasonal filter length, and reviewers will have to specify the same lengths for all series to see results for the aggregate adjustment. Reviewers may need to complete several runs to see all the necessary results.

6. Future Study

One topic we would like to investigate is indirect trend estimation for SEATS adjustments. There are several other areas to study, however, including impact of model span choice on SEATS adjustments and optimal sliding spans length for indirect adjustments.

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