X-12-ARIMA and its Application to Some Italian Indicator Series

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Introduction and Overview

X-12-ARIMA is the Census Bureau's new seasonal adjustment program. It belongs to the methodological lineage of the Census Bureau's X-11 program (Shiskin, 1967) and Statistics Canada's X-11-ARIMA and X-11-ARIMA/88 (Dagum, 1988) programs. These methods estimate seasonality mainly by applying moving average filters to a possibly modified version of the input series. The modifications might include adjustments for extreme values, trading day effects, or holiday effects also estimated by the program. The filters are chosen from a fixed set of filters, partially or—in X-11-ARIMA/88 and X-12-ARIMA, possibly completely—automatically, on the basis of certain signal-to-noise ratios. See also U.S. Bureau of the Census (1998).

The major improvements in X-12-ARIMA fall into four general categories: 1) new modeling capabilities using regARIMA models—regression models with ARIMA errors—for estimating other calendar or disturbance effects with built-in or user-defined regressors; 2) new diagnostics for modeling, model selection, adjustment stability, and for the quality of indirect as well as direct seasonal adjustment; 3) additional capabilities to make it easier to adjust large numbers of series and determine which have problematic adjustments; and 4) a new user interface. The article by Findley, Monsell, Bell, Otto, and Chen (1998) gives a detailed overview.

At times, we will compare the results from X-12-ARIMA to results from the programs TRAMO (Time series Regression with ARIMA noise, Missing observations, and Outliers) and SEATS (Signal Extraction in ARIMA Time Series) by Gomez and Maravall (1997a, 1997b). These are linked programs for seasonally adjusting time series using ARIMA model-based signal extraction techniques.

We begin by discussing the diagnostics we used in this paper to judge the quality of the X-12-ARIMA adjustment. We then will discuss some of the results from the default runs of both X-12-ARIMA and TRAMO/SEATS. Then we will discuss some of the options in X-12-ARIMA that help us deal with the problems we found in the series. We will contrast the available diagnostics and the available options in X-12-ARIMA with the diagnostics and options available in TRAMO/SEATS.

Methods

Running X-12-ARIMA

In a situation in which the number of series begin adjusted is small enough that there is time to give individual attention to each series, our basic procedure for running X-12-ARIMA is the following:

Step 1. Graph the series.
Step 2. Run the program in default mode on an appropriate span of the series determined by Step 1.
Step 3. Assess the adjustment and model obtained from Step 2 using available diagnostics from the program and graphs to look for deficiencies.
Step 4. Correct problems, when necessary and possible, using the available options.

We did not do Step 4 for all series, only the series where we saw problems in Step 3.

This paper reports the general results of research undertaken by Census Bureau staff. It has undergone a more limited review than official Census Bureau publications.

Specifically, for the 11 Italian indicator series, the steps involved the following:

Step 1. Graph the Series

Before we ran either X-12-ARIMA or TRAMO/SEATS, we graphed the series to look for visible problems with the series. Such problems can include abrupt changes in the seasonal pattern or obvious outliers. Changes in the seasonal pattern that occur sufficiently far back in the past can be avoided simply by advancing the starting date of the data used for adjustment or for modeling. Also, it is often clear from the graph that multiplicative adjustment is (or is not) appropriate, in which case a logarithmic transformation should (or should not) be used for modeling. (If, for example, there are zero or negative values, the log transform and multiplicative adjustment are not possible.)

Step 2. Run in Default Mode

Having no outside information for the 11 series considered in the paper, we had X-12-ARIMA do a single run to

- test if the log transformation should be used and a multiplicative adjustment performed;
- search for additive outliers, level shifts, and temporary change outliers;
- search for an acceptable ARIMA model among those found in x12a.mdl (the default model file);
  - (0 1 1)(0 1 1),
  - (0 1 2)(0 1 1),
  - (2 1 0)(0 1 1),
  - (0 2 2)(0 1 1), and
  - (2 1 2)(0 1 1);
- test for possible trading day effects (using six regression variables to get a coefficient for all seven days of the week, after a length of month correction for February);
- test for possible Easter effects (for either one, eight, or 15 days before Easter and ending the day before Easter);
- run the default seasonal adjustment procedure (which uses the automatic seasonal filter selection procedure of X-11-ARIMA/88);
- if the series is long enough, calculate a stability diagnostic, either sliding spans or a history of revisions. (The sliding spans might not be easy to interpret if the seasonal adjustment mode is additive or the seasonal factors are small.)

An example .spc file:

```
series{
  name="PPI"
  start=1981.1
  period=12
  file="ppigengp.dat"
  title="Producer Price Index (Default)"
}
transform{function=auto}
regression{aictest=(td easter)}
automdl{savelog=amd}
estimate{}
check{}
outlier{types=all}
forecast{maxlead=24 print=none}
x11{savelog=(m7 q q2 fd8 msf)}
slidingspans{savelog=percents}
history{estimates=(sadj sadjchng)  print=all}
```

Step 3. Assess the Adjustment

X-12-ARIMA diagnostics include the following:

- spectral plots (Cleveland and Devlin, 1980) to reveal residual seasonal or trading day effects,
- the M and Q statistics (Lothian and Morry, 1972) to indicate properties of the adjustment that are often associated with adjustments of poor quality, and
- two kinds of stability diagnostics,
  - sliding spans (Findley, Monsell, Shulman, and Pugh, 1990) and
  - revisions histories (Findley, Monsell, Bell, Otto, and Chen, 1998).

The most basic analysis of X-12-ARIMA runs consists of looking at the M statistics and their summary Q statistic and noting warning messages produced by the program regarding residual trading day and seasonal peaks in the seasonally adjusted series or the irregular.

Important graphical diagnostics can be obtained from X-12-Graph (Hood, 1998), a companion graphics package for X-12-ARIMA. Using X-12-Graph, we always produce graphs of the original series with the seasonally adjusted series and the trend, graphs of the seasonal factors by month, and, if the series is long enough, graphs of the revisions of the initial (concurrent) adjustments for the last few years.

For the indicator series, using X-12-Graph, we also looked at seasonal factor by calendar month graphs (to look for excessive movements of the seasonal factors), plots of revisions to the level and month-to-month changes, and SI ratio plots (Cleveland and Terpenning, 1982). These last-named plots show, for each calendar month and all years, the detrended series (SI ratios and replacement values for extreme SI ratios) and the seasonal factors. As we will illustrate below, unusually large numbers of replacement values for a specific calendar month is and indicator of calendar-month-specific heteroskedasticity, the situation in which some calendar months have more statistical variability than the other calendar months, as measured by the calendar month variances of the irregular series.

Calendar month heteroskedasticity might also be indicated in a revision histories graph when large revision occur mostly in one or two months.

Step 4. Correct Problems

We followed these steps to correct problems:

a. Reviewed choice for transformation.
b. Reviewed ARIMA model selection and selected an initial model.
c. Reviewed choices for trading day and Easter effects.
d. Reviewed choices for outliers.
e. Selected final model.
f. Reviewed X-11 options.

Step 4a. Reviewed choice for transformation

If the series values are all positive and *transform=auto* is used in the *transform* spec, X-12-ARIMA uses an AIC test to select the transformation. The series is log transformed unless, for an indicated model, the AIC of model fit to the untransformed data is smaller by at least 2.0 than the AIC obtained from fitting the model to the log transformed data. Since we did not specify a model with the *arima* (and *regression*) specs, the program uses the first model in *x12a.mdl*, by default, the airline model. We also make a visual choice by looking at the graph of the original. We also looked at the AIC and forecast error history statistics when the choice of the transformation seemed ambiguous.

Step 4b. Reviewed ARIMA model selection and selected an initial model

In some cases, the automatic identification procedure in X-12-ARIMA rejects all of the candidate models as being inadequate for the purpose of forecast extension. In this case it chooses a designated model, by default, the airline model, to provide regARIMA estimation of regression coefficients or selection of regressors, but not forecasts. We looked for messages in the *automdl* output (or the .log file) to find series for which no forecasting model was identified. For these series, we looked at model diagnostics to help us seek a better model. Sometimes, these diagnostics also suggest that the model selected for forecasting by *automdl* can be improved. For example, the values of some of the selected model's coefficients can be insignificant, or they can suggest a cancellation of AR and MA factors to simplify the model. Alternatively, the autocorrelation graphs, the suite of P-values for the Box-Ljung Q's, or the spectrum of the model's residuals can suggest that it is necessary to change the model from the one selected.

Step 4c. Reviewed choices for trading day and Easter effects

X-12-ARIMA prints out warnings if there are residual trading day peaks in the spectra either of the model residuals, the adjusted series, or the irregular series. Sometimes trading day peaks are found, even after trading day adjustment has been done, or after the *aictest* in the *regression* spec rejects the trading day regression model tested. We then consider alternative trading day models or reduce the number of regressors in the tested model by fixing the values of very insignificant coefficients at zero. We also use AIC histories and forecast error history diagnostics to compare various choices of TD and Easter regressors when there is some doubt about the choice.

Step 4d. Reviewed choices for outliers

We look at the list in the .out file of rejected outliers regressors whose t-statistics have magnitudes that are rather large even though they are below the critical value chosen. This can help us identify a need to lower the critical value. We also looked for series with too many outliers, indicating a problem with the model or the critical value we used.

4e. Selected final model

Once we've completed Steps 4a-4d, we run the program again with the new model. If no unfavorable diagnostics occur, we accept the model. Otherwise we repeat Steps 4a-4e, possibly fitting the models to a data span with a different starting date, until good diagnostics are obtained or not further improvements seem possible.

4f. Review X-11 options

The X-11 diagnostics we examine include the F statistics for stable seasonality and moving seasonality (associated with Table D8) and the M and Q statistics found in Table F2. To look for calendar-month heteroskedasticity, one can look at the X-11 values identified as extreme in Table C17 and at the SI ratios graphs to determine if there was a need to change the sigma limits used to identify X-11 extreme values. Alternatively, one can use the *calendarsigma=all* option of the *x11* spec to produce sample standard deviations for the irregulars of each calendar month.

Running TRAMO/SEATS

For the TRAMO/SEATS runs, we used the same data spans chosen for the adjustment by X-12-ARIMA. The results we present for TRAMO/SEATS will be from default runs, unless otherwise noted.

TRAMO/SEATS has an option, called RSA, for "routine treatment of perhaps a very large number of series." (Gomez and Maravall, 1997a) We used the RSA parameter set equal to six. This allows TRAMO/SEATS to

- test for a possible log transformation;
- search for additive outliers, level shifts, and temporary change outliers;
- search for an ARIMA model with
  - regular differences up to and including order 2,
  - seasonal differences up to and including order 1,
  - regular polynomials up to and including order 3, and
  - seasonal polynomials up to and including order 1;
- replace the model in SEATS when the model chosen by TRAMO does not accept an admissible decomposition;
- test for possible trading day effects (using six regression variables to get a coefficient for all seven days of the week); and
- test for possible Easter effects (for six days before Easter).

Results for the Indicator Series

By visual inspection, we found that the eleven series exhibit three different categories of seasonal movements: three series are very smooth, six are strongly seasonal, and two give the visual impression of being erratically seasonal, perhaps because of large movements in their trans. In the tables that follow, the series are grouped by these three categories.

Finding a good data span for modeling or adjustment

For six of the eleven series, we shortened the span of data used for the adjustment. For four series, this decision was based on a change of seasonal pattern seen in the graph of the original series. In the case of the two erratically seasonal series, omitting the first year of data for modeling gave much better Box-Ljung Q statistics. For the series whose movements are dominated by large troughs in August, as part of our visual inspection, we also looked at graphs of the series obtained by replacing August values with the averages of the neighboring July and September values. In this way, we obtained a graph in which the movements of all months had a similar size.

The example below shows a series with a change in the seasonal pattern beginning in January, 1986. For seasonal adjustment, we used only the data span beginning in January 1986.

Figure 1. Graph of Original Series with a Change in the Seasonal Pattern (CITGENGQ)

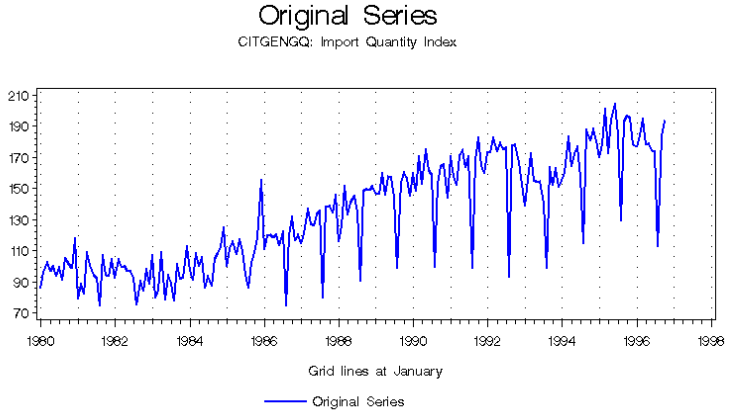


Table 1 below lists all eleven series with the start date for the series as it was given to us and the date we chosen for the span statement in the series spec.

Table 1. Original and Chosen Starting Dates

Name	Original Starting Date	New Starting Date
Smooth series		
LGOLTOGI: Index of Total Employment in Large Firms	1989	1989
PCOBENGP: Consumer Price Index, Goods	1989	1989
PPIGENGP: Producer Price Index, Total Industry	1981	1981
Strongly seasonal series		
CETGENGQ: Export Quantity Index	1980	1986
CITGENGQ: Import Quantity Index	1980	1986
IFAGENGE: Index of Industrial Turnover, Foreign	1985	1985
IFAGENGN: Index of Industrial Turnover, Domestic	1985	1985
IPIGENGT: Index of Industrial Production, Total	1981	1983
IPIINVGT: Index of Industrial Production, Investment Goods	1981	1983
Erratically seasonal series		
BDEGENGS: Balances of New Orders on Foreign Markets	1986	1987
BDIGENGS: Balances of New Orders on Domestic Markets	1986	1987

Running in default

In X-12-ARIMA's default transformation selection scheme, the log transformation is chosen (multiplicative adjustment instead of additive adjustment) unless AIC for specified regARIMA model fit to the untransformed data is smaller by at least 2.0 than the AIC for the same model fit to the log-transformed data. Because we did not specify a model, the program used the airline model, the first mdoel in the default model list file (x12a.mdl). For some series for which the choice of the transformation seemed ambiguous, we also looked at the AIC and forecast error history statistics for both transformation possibilities.

For two series (CETGENGQ and CITGENGQ) the choice of transformation differed from our visual impression, so we also looked at the AIC and forecast error history diagnostics. This enabled us to investigate the consistency of the AIC choice, and whether log transformation resulted in better out-of-sample forecasts than no transformation. For both series we chose no transformation.

Table 2 shows the transformation choices of X-12-ARIMA and TRAMO.

Table 2. Transformation choices of X-12-ARIMA and TRAMO

Name	X-12-ARIMA	TRAMO
Smooth series		
LGOLTOGI: Index of Total Employment in Large Firms	add	add
PCOBENGP: Consumer Price Index, Goods	add	add
PPIGENGP: Producer Price Index, Total Industry	add	log
Strongly seasonal series		
CETGENGQ: Export Quantity Index	add	log
CITGENGQ: Import Quantity Index	add	log
IFAGENGE: Index of Industrial Turnover, Foreign	log	log
IFAGENGN: Index of Industrial Turnover, Domestic	log	log
IPIGENGT: Index of Industrial Production, Total	add	log
IPIINVGT: Index of Industrial Production, Investment Goods	add	log
Erratically seasonal series		
BDEGENGS: Balances of New Orders on Foreign Markets	add	add
BDIGENGS: Balances of New Orders on Domestic Markets	add	add

Table 3 shows the results of automatic model, regressor, and outlier selections. Table 4 shows the final regARIMA models.

Table 3. Automatic RegARIMA Modeling Selections

Name	Model selected by *automdl*	Regressors chosen by *aictest* and *outlier*
Smooth series		
LGOLTOGI: Index of Total Employment in Large Firms	Airline	
PCOBENGP: Consumer Price Index, Goods	(1 1 0)(0 1 1)	
PPIGENGP: Producer Price Index, Total Industry	(2 1 0)(0 1 1)	TD, TC1991.1
Strongly seasonal series		
CETGENGQ: Export Quantity Index	Airline	Easter[15]
CITGENGQ: Import Quantity Index	(2 1 0)(0 1 1)	TD, Easter[8], LS1992.12
IFAGENGE: Index of Industrial Turnover, Foreign	Airline	TD, Easter[1], AO1992.8
IFAGENGN: Index of Industrial Turnover, Domestic	Airline	TD, Easter[8]
IPIGENGT: Index of Industrial Production, Total	Airline	TD, Easter[1]
IPIINVGT: Index of Industrial Production, Investment Goods	Airline	TD, Easter[8]
Erratically seasonal series		
BDEGENGS: Balances of New Orders on Foreign Markets	Airline *	LS1993.9 LS1996.3
BDIGENGS: Balances of New Orders on Domestic Markets	Airline *	

* Airline model was used as the default model. No model was chosen by the automatic model selection procedure.

Table 4. RegARIMA Models

Name	ARIMA Model	Regression Variables
Smooth series		
LGOLTOGI: Index of Total Employment in Large Firms	(1 1 0)(0 1 1)	
PCOBENGP: Consumer Price Index, Goods	(0 1 2)(0 1 1)	
PPIGENGP: Producer Price Index, Total Industry	(2 1 0)	Seasonal, TDstock[31], TC1991.1
Strongly seasonal series		
CETGENGQ: Export Quantity Index	Airline	Tdstock[31], AO1987.3, LS1987.7, AO1988.1, AO1993.8, LS1995.12
CITGENGQ: Import Quantity Index	Airline	TD, Easter[8], LS1992.12
IFAGENGE: Index of Industrial Turnover, Foreign	Airline	TD, Easter[8], AO1992.8
IFAGENGN: Index of Industrial Turnover, Domestic	Airline	TD, Easter[8]
IPIGENGT: Index of Industrial Production, Total	(0 1 1)(1 0 0)	Seasonal, TDstock[31], Easter[1]
IPIINVGT: Index of Industrial Production, Investment Goods	Airline	TD, Easter[8]
Erratically seasonal series		
BDEGENGS: Balances of New Orders on Foreign Markets	Airline	LS1993.9 LS1996.3
BDIGENGS: Balances of New Orders on Domestic Markets	(4 1 0)(0 1 1)	

X-12-ARIMA options to improve the adjustments

Problem: Residual Trading Day Peaks in the Spectrum Plots after Trading Day Adjustment
Solution: Stock Trading Day Option

When run in default mode both with X-12-ARIMA and with TRAMO/SEATS, the Export Quantity Index (CETGENGQ) had residual trading day effects in the regression residuals, seasonally-adjusted series, and the irregulars as indicated by the spectra of these series. In default mode, we asked both programs to test for possible trading day effects using six regression variables to obtain coefficients for the seven days of the week. In both X-12-ARIMA and TRAMO/SEATS, the AIC preferred the model with no trading day. (Most, but not all, of the day-of-week coefficients were statistically insignificant.)

Note: The TRAMO/SEATS output gave us no indication that there was a problem with the adjustment. We calculated spectral plots of the TRAMO/SEATS adjustments and irregulars by inputting these series into X-12-ARIMA. (Using only a series spec in the *.spc* file, one can obtain the spectrum of the input series, together with warning messages about visually significant trading day and seasonal peaks in the spectrum.)

By trying all of the types of trading day models of X-12-ARIMA, we found the end-of-month stock trading day model, tdstock[31], gave the best spectrum results (and also the lowest AIC value if we fixed some negligible coefficient values to be zero). Figures 2 and 3 below show the spectrum plot of the irregular series from X-12-ARIMA with no trading day adjustment (Figure 2) and with a stock trading day adjustment (Figure 3).

Figure 2. Spectrum of the Seasonally-Adjusted Series from X-12-ARIMA For CETGENGQ with No Trading Day Variables

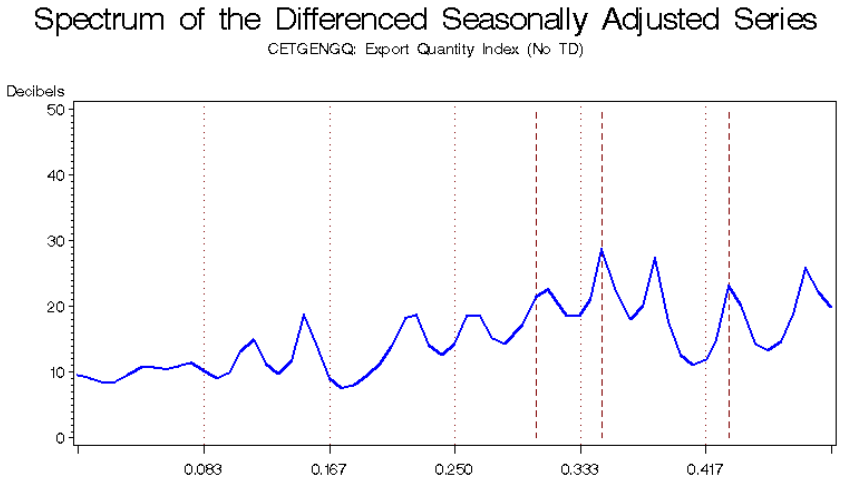
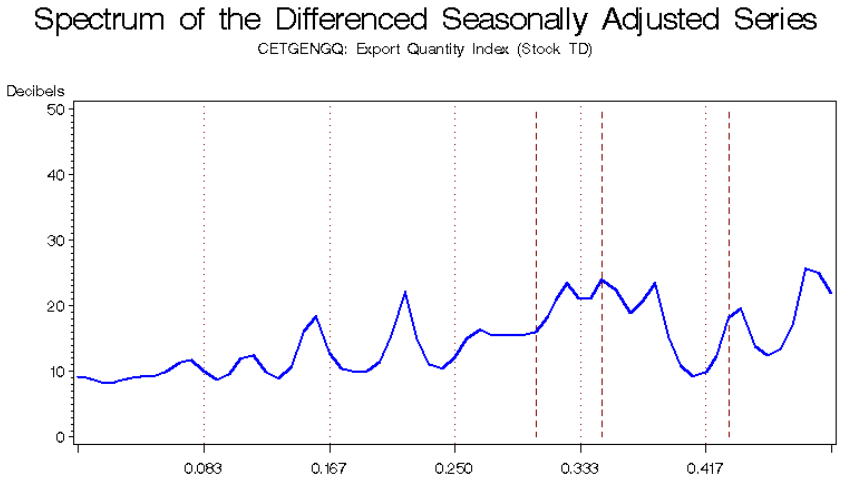


Figure 3. Spectrum of the Seasonally-Adjusted Series from X-12-ARIMA For CETGENGQ with Stock Trading Day Variables



We used the forecast error histories available in X-12-ARIMA's *history* spec to obtain differences of the accumulating sums of squared forecast errors between the pairs of competing models at forecast leads 1 and 12. We then used X-12-Graph to produce graphs of these accumulating differences. In the graphs below, the direction of the accumulating differences is predominantly downward, especially at lead 12. Thus the forecast errors are persistently smaller for the first model, the regARIMA model with Stock TD. Therefore, we prefer

Stock TD over all other trading day options, including no adjustment. Of course, a model designed by a knowledgeable user could be better.

Figure 4. Stock TD Versus No TD for CETGENGQ

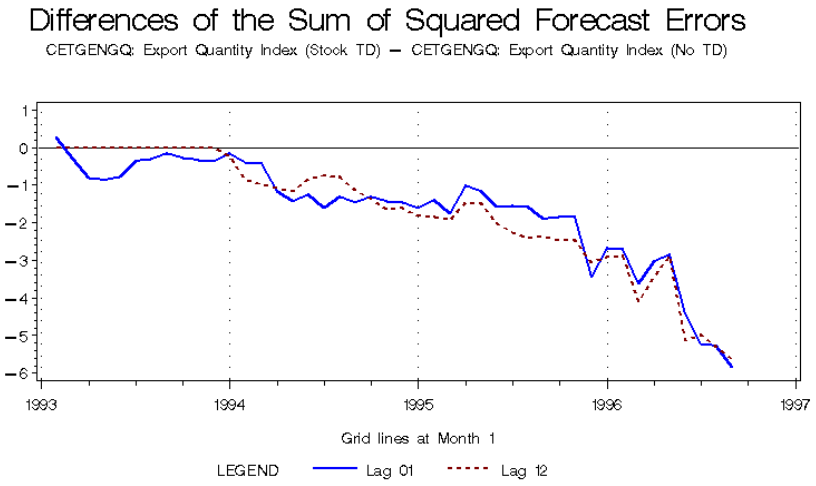


Figure 5. Stock TD Versus Flow TD for CETGENGQ

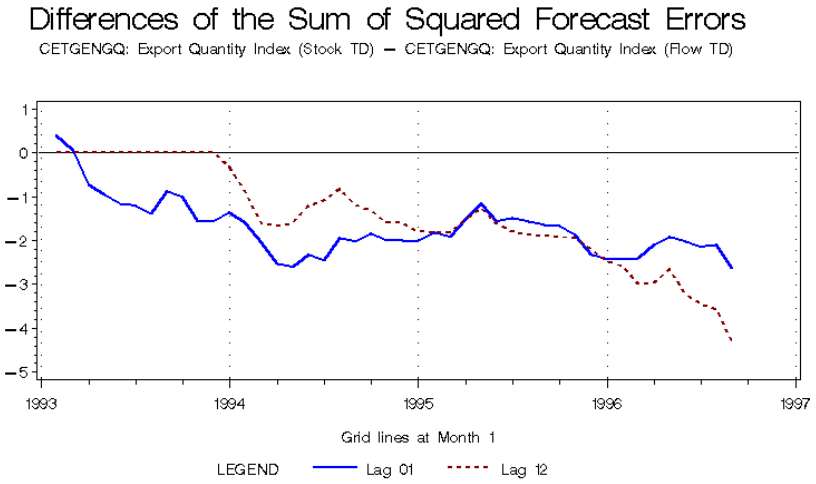
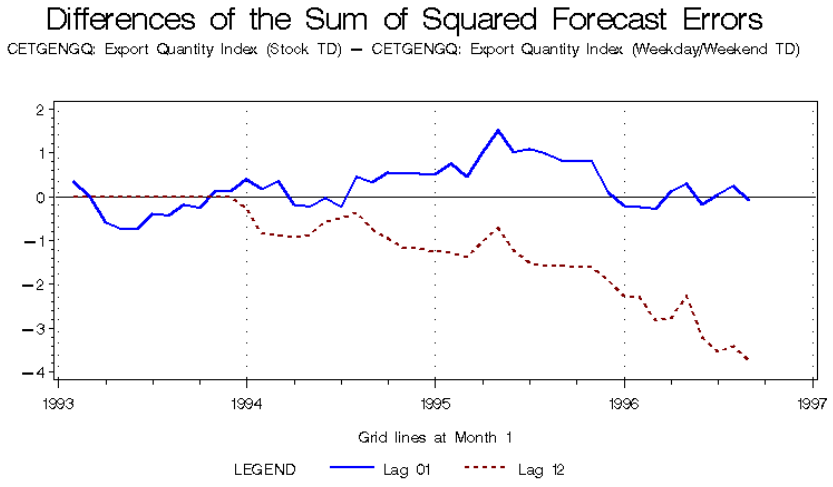


Figure 6. Stock TD Versus Weekday/Weekend TD for CETGENGQ



Besides eliminating the residual trading day effect in the seasonal adjustment and giving us smaller forecast errors, the adjustment with Stock trading day also gave us a smoother seasonal adjustment and smaller revisions.

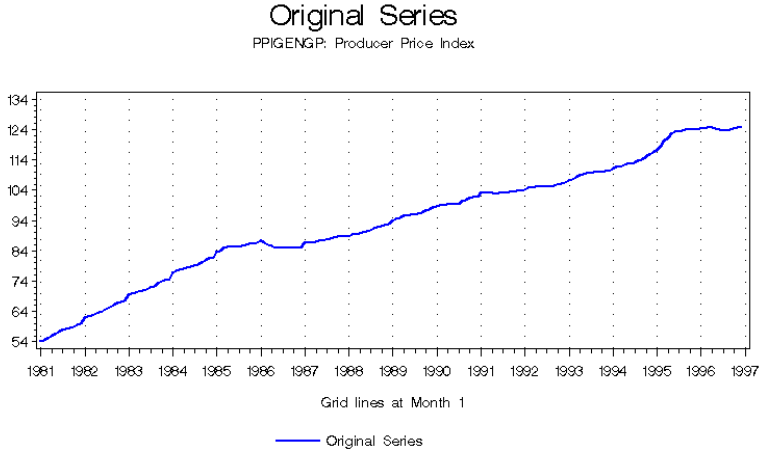
Given a choice between the one-coefficient weekday/weekend trading day model and no trading day model, TRAMO chose the trading day model. TRAMO/SEATS does not have a stock trading day variable.

Problem: Evidence of Heteroskedasticity
Solution: Calendar Sigma and Different Seasonal Moving Average Filters Lengths

For several of the series, we found there was a calendar month with more statistical variability than the other calendar months. We will give two quite different examples of such series: one very smooth series, the Producer Price Index for Total Industry (PPIGENGP), and one very seasonal series, the Index of Industrial Turnover of Domestic Markets (IFAGENGN).

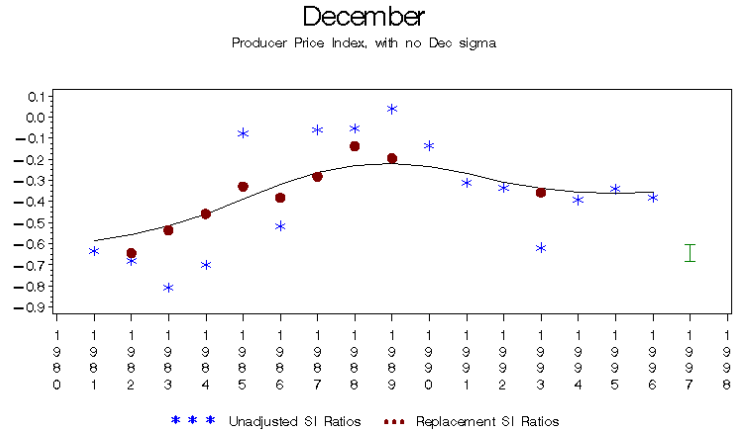
Example 1. Large number of replacement values in December

Figure 7. The Producer Price Index for Total Industry (PPIGENGP)



For every adjustment, we look at the SI Ratios graphs. SI Ratio graphs show the relationship between the detrended series (SI ratios) and the seasonal factors. The replacement values of the SI ratios show the effect of the extreme value adjustment procedure in X-12-ARIMA. For PPIGENGP, we noticed a large number of replacement values for December.

Figure 8. SI Ratio Graph for December for PPIGENGP



Setting *calendarsigma=all* in the *x11* spec produces a table of standard deviations for each month at the bottom of Table C17. For PPIGENGP, the variance for the Decembers is much higher than for the other months.

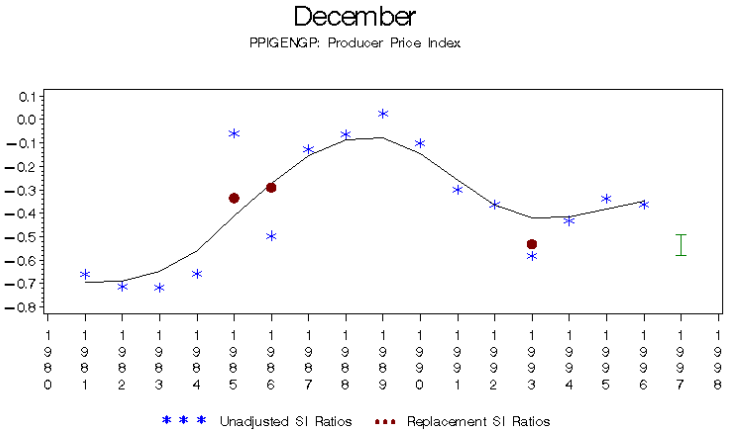
```
 C 17  Final weights for irregular component
  From  1981.Jan to 1996.Dec
  Observations        192
  Lower sigma limit   1.5
  Upper sigma limit   2.5
-------------------------------------------------------------------
               Jan      Feb      Mar      Apr      May      Jun
               Jul      Aug      Sep      Oct      Nov      Dec
-------------------------------------------------------------------

 S.D.          8.72     6.01     4.57     5.55     7.83     5.66
               7.86     6.96     5.92     7.04     6.46    10.16
```

So that fewer Decembers are thrown out as outliers, we can change the sigma limits for December only. We do this with the *calendersimga=select* option in conjunction with the *sigmavec* option.

```
x11{
  mode=add
  calendarsigma=select
  sigmavec=dec
}
```

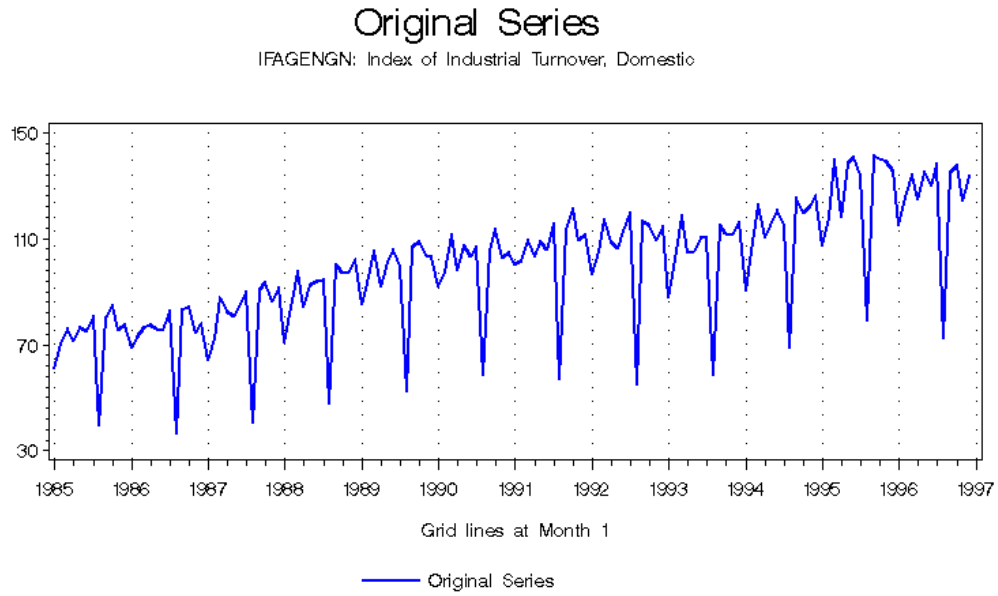
Now fewer December SI's receive extreme value adjustments. As a result, the seasonal factors estimates for December show more movement and the adjustment around the year 1990 is smaller.

Figure 9. SI Ratio Graph for December with Calendar Sigma
PPIGENGP



Example 2. Large revisions of August and September adjustments

Figure 10. The Index of Industrial Turnover for Domestic Markets (IFAGENGN)



First of all, we noticed for this series that the August value of the moving seasonality ratios found in Table D9A was very low. Frequently, a low value is an indication of highly variable seasonal movements that are best estimated with a short seasonal filter.

D 9.A Moving seasonality ratio

	Jan	Feb	Mar	Apr	May	Jun
I	1.446	0.910	1.424	1.087	1.217	1.222
S	0.310	0.180	0.220	0.182	0.144	0.186
RATIO	4.666	5.061	6.476	5.979	8.480	6.567

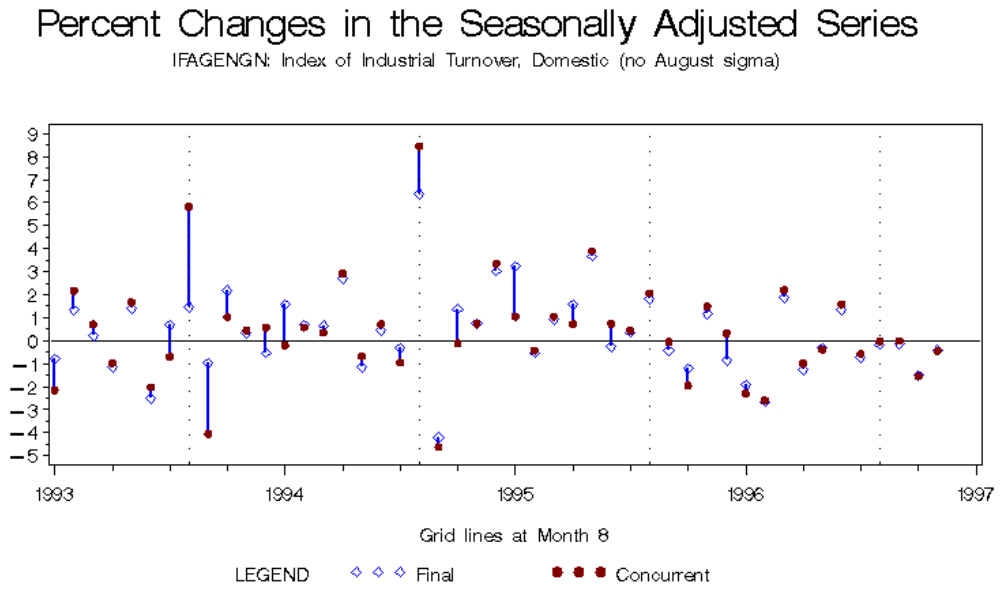
	Jul	Aug	Sep	Oct	Nov	Dec
I	1.088	0.907	1.144	0.889	1.267	0.681
S	0.147	0.983	0.166	0.307	0.212	0.274
RATIO	7.407	0.924	6.903	2.897	5.983	2.487

Therefore we shortened the seasonal-moving-average filter from 3x5 to 3x3 for the month of August as shown in the following *x11* spec.

```
x11{
  seasonalma=(s3x5 s3x5 s3x5 s3x5 s3x5 s3x5
              s3x5 s3x3 s3x5 s3x5 s3x5 s3x5)
}
```

Even with this change, there are very large revisions in the August and September adjustment. The initial and last adjustment for each date is graphed below. Note that the vertical dotted lines mark the August dates.

Figure 11. Revisions from Initial to Full-Series Adjustment For IFAGENGN with No Calendar Sigma Option



We then looked for heteroskedasticity by using the *calendarsigma=all* option in the *x11* spec. The standard deviations for August were the highest among all months.

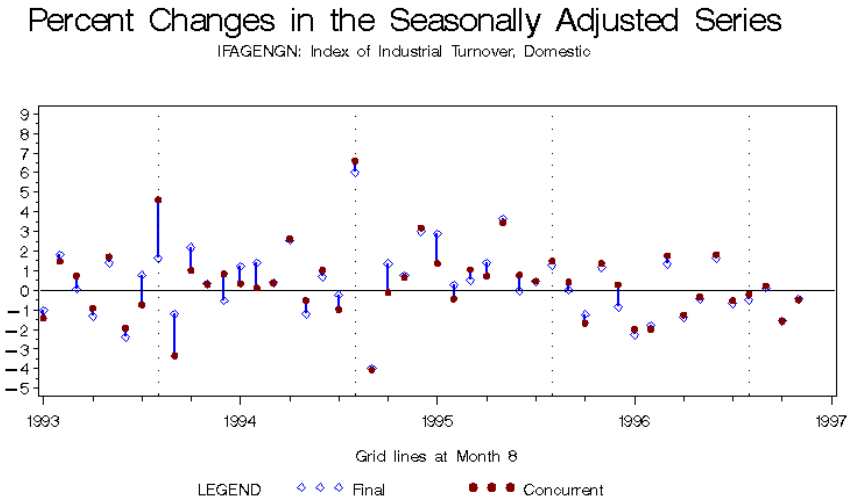
```
C 17  Final weights for irregular component
 From  1985.Jan to 1996.Dec
 Observations        144
 Lower sigma limit   1.5
 Upper sigma limit   2.5
-------------------------------------------------------------------------
              Jan      Feb      Mar      Apr      May      Jun
              Jul      Aug      Sep      Oct      Nov      Dec
S.D.
-------------------------------------------------------------------------

 S.D.          1.3      1.0      0.8      1.0      0.7      0.7
               0.9      1.4      0.8      0.5      1.0      0.9
```

Then we tried the *calendarsigma=select* option for August, as shown below.

```
x11{
  calendarsigma=select
  sigmavec=aug
  seasonalma=(s3x5 s3x5 s3x5 s3x5 s3x5 s3x5
              s3x5 s3x3 s3x5 s3x5 s3x5 s3x5)
}
```

While the revisions for August are still large, using the *calendarsigma=select* option did decrease the size of the revisions.

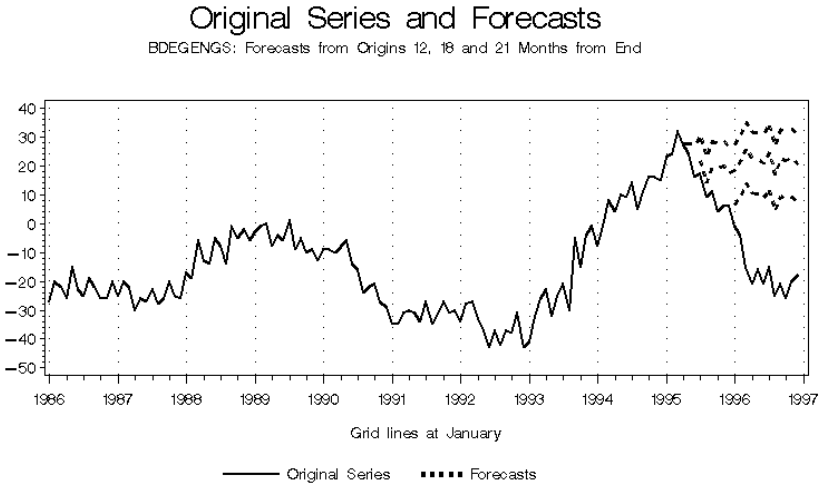
Figure 12. Revisions from the Initial to Full-Series Adjustment For IFAGENGN with Separate Sigma Values for August



Problem: Identifying the Series that are Difficult to Adjust
Solution: Quality-Control Diagnostics

The M8, M10, and M11 diagnostics of X-12-ARIMA suggest that the series BDEGENGS could be a problematic series to adjust because the seasonal pattern might be changing too rapidly, especially in the last three years. The diagnostics in TRAMO/SEATS give no evidence of a problem, but the graph of the series shows a large upward and downward movement late in the series that a regARIMA model might not be able to capture. That is, the model used for model-based seasonal adjustment with SEATS may fit the data badly. To investigate this, we looked at forecasts from the regARIMA model with parameters estimated from the full series starting from various forecast origins in the last three years. The series and three sets of forecasts, from origins 12, 18, and 21 months from the end of the series, are shown in Figure 13. The forecasts are poor, indicating some inadequacy of the model. The situation with BDIGENGS was similar.

Figure 13. Original Series and With-In Sample Forecasts for Balances of New Orders on Foreign Market (BDEGENGS)



Non-default adjustments of TRAMO/SEATS

TRAMO/SEATS users often lower the critical value for outlier detection to improve the diagnostics for normality of the residuals found in TRAMO/SEATS (a Chi-square test, skewness, kurtosis, Ljung-Box Q statistics for the residuals and the squared residuals). For the 11 indicator series, when the option files provided to us by Agustin Maravall had significantly more outliers specified than the default run found, the resulting SEATS adjustments usually had some much larger revisions of initial estimates than either the default adjustment of the X-12-ARIMA adjustment. Thus the practice of adding outlier variables to improve normality diagnostics is problematic with a program, like TRAMO/SEATS in its present form, that cannot provide information about observable consequences for revisions — information that the history diagnostic of X-12-ARIMA makes easily available.

Direct versus indirect adjustments and adjustments of large numbers of series

Unlike X-12-ARIMA, TRAMO/SEATS does not have any diagnostics to provide information about the quality of indirect adjustments for a series that is a composite of other series that are seasonally adjusted. It also does not have a log file that can capture the diagnostics in a compact way when adjusting many series.

REFERENCES

Cleveland, W.S. and S.J. Devlin (1980), "Calendar Effects in Monthly Time Series: Detection by Spectrum Analysis and Graphical Methods," *Journal of the American Statistical Association*, 75, 487-496.

Cleveland, W.S. and I. Terpenning (1982), "Graphical Methods for Seasonal Adjustment," *Journal of the American Statistical Association*, 77: 52-72.

Dagum, E.B. (1988), "X-11-ARIMA/88 Seasonal Adjustment Method - Foundations and Users' Manual," Statistics Canada.

Findley, D.F., B.C. Monsell, W.R. Bell, M.C. Otto and B.-C. Chen (1998), "New Capabilities and Methods of the X-12-ARIMA Seasonal Adjustment Program" (with discussion), *Journal of Business and Economic Statistics*, 16: 127-176.

Findley, D.F., B.C. Monsell, H.B. Shulman, and M.G. Pugh (1990), "Sliding Spans Diagnostics for Seasonal and Related Adjustments," *Journal of the American Statistical Association*, 85:345-355.

Gomez, V. and A. Maravall (1997a), "Program TRAMO and SEATS: Instructions for the User, Beta Version," Banco de Espana.

Gomez, V. and A. Maravall (1997b), "Guide for Using the Programs TRAMO and SEATS, Beta Version," Banco de Espana.

Hood, C.C. (1999), "X-12-Graph: A SAS/GRAPH® Program for X-12-ARIMA Output, User's Guide for the X-12-Graph Interactive for PC/Windows, Version 1.1," Bureau of the Census, U.S. Department of Commerce

Lothian, J. and M. Morry (1978), "A Test of Quality Control Statistics for the X-11-ARIMA Seasonal Adjustment Program," Research Paper, Seasonal Adjustment and Time Series Staff, Statistics Canada.

Shiskin, J., A.H. Young and J.C. Musgrave (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.

U.S. Bureau of the Census (1999), *X-12-ARIMA Reference Manual, Final Version 0.1*, Washington, DC: U.S. Bureau of the Census.