Explanatory Notes - Monthly Seasonal Adjustment of Statistical Time Series

Introduction

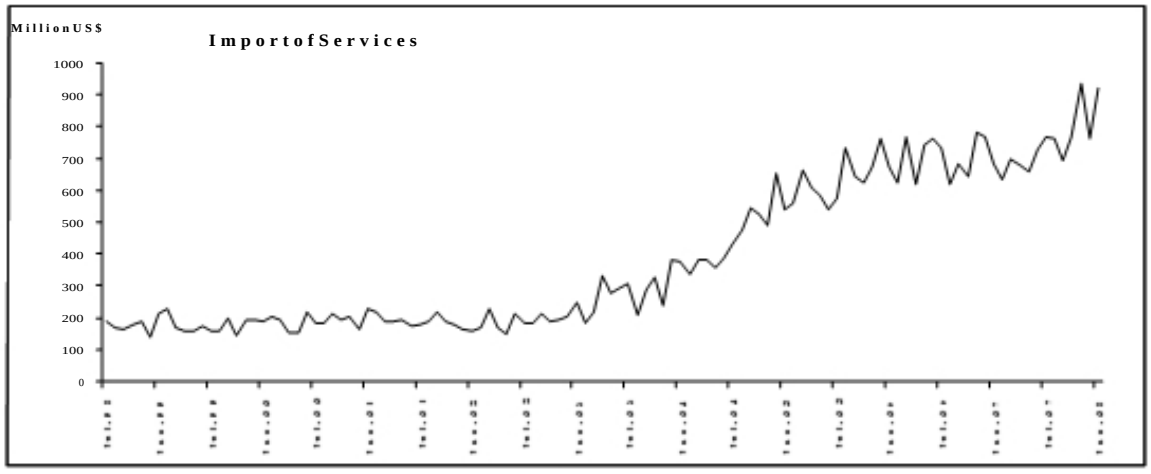
Economic and financial data series are often subject to seasonal variation. Seasonal fluctuations in data make it difficult to analyze whether the changes in data for a specified period reflect increases or decreases in the level of the data, or otherwise due to regularly occurring variation. Use of raw data in such cases can be quite misleading. In an economic analysis, the early assessment of overall business conditions, especially the identification of business cycle turning points, is possible only if the analysis is based on the most recent months of a time series. Critically, however, a reliable assessment of the overall trend depends on the series being free of seasonality and of effects attributable to calendar variations. If seasonality and calendar effects exist in a time series, information relevant for short-term economic analysis is obtained only after seasonal adjustment (which normally includes calendar adjustment as well).

Seasonal adjustment is the process of estimating and removing seasonal effects from a time series. Seasonally adjusted data therefore facilitate analysis of short-term dynamics and the identification of changes in trends. Seasonally adjusted data is useful for financial institutions, government, statisticians, econometricians and economists working in macroeconomics, forecasters, and researchers in universities.

Generally, seasonal adjustment is based on time series models which decompose an unadjusted series into the sum or the product of four unobservable components: trend- cycle, seasonal, calendar and irregular components. It is a process of estimating and removing seasonal effects from a time series in order to better reveal certain non-seasonal features. The seasonal component in time series corresponds to the regular movements observed in quarterly and monthly time series during a twelve-month period. The aim of the seasonal adjustment is to eliminate seasonal and working day effects that under normal circumstances are expected to reappear at definite times each year; and makes it easier to compare the values of a time series with one another; irrespective of when the effects occur during the year. Therefore, there are no seasonal and working day effects in a perfectly seasonally adjusted series. The seasonally adjusted data, gives more readily interpretable measures of changes occurring in a specified period, reflects real economic movements without the misleading seasonal changes.

Why do we seasonally adjust time series?

There are many factors that drive movements in a statistical time series. Take the total Imports of Services in Pakistan's Balance of Payments as an example (shown in figure 1).



Actual Import of Services in Pakistan's Balance of Payments June 1998 - January 2008

There are two factors that drive this time series:

- Over the past 10 years there has been an overall increase in the total imports of services. Imports of services grew steadily between 1998 and 2003, and then steady growth can be seen.
- Every year, there seems to be a "blip" in the series: there is a sharp increase in the January, February, March, September, November and December followed by a sharp decrease in the remaining month of the year. This pattern is persistent throughout the series.

Untangling these two different effects is important to understand how imports of services have changed over time, both in the short and long term. There may also be one-off effects that are not due to either factor (such as the impact of strikes). However, it is very difficult to isolate each of these effects using the actual series.

Seasonal Adjustment Process at SBP

The seasonally adjusted series of the total balance of payments (BOP), current account and its main sub items (goods, services, income, and current transfers, workers' remittances), capital account, and financial account are obtained by removing the seasonal and calendar effects (if significant) from the raw series. The approach used to seasonally adjust the series utilizes a multiplicative decomposition using the Census X-12-ARIMA method, Version 0.2.10. Outliers are taken into consideration in order to minimize distortions to the estimated seasonal components.

X-12 ARIMA program is run after availability of bi-annual data i.e. each April and November, program is executed independently and each time appropriate X-12-ARIMA model is chosen for each of the data series. On the basis of the selected model, the seasonal factors are re-estimated for the complete time range and forecasted for the following six months. This means that all the seasonally adjusted data series is revised on the basis of new seasonally adjusted factors due to revision of the selected data series and inclusion of new data. In the following six months, seasonal adjustment is based on the forecasted factors. For seasonal adjustments during the year, forecast seasonal factors are used and seasonal factors are reestimated twice a year. In addition, seasonal factors can be reviewed in the case of large data revisions.

As described above that the seasonal factors are estimated for the complete time range and forecasted for the following six months and all the data series is revised on the basis of new seasonally adjusted factors. These new seasonally adjusted values of each data series may differ from previously calculated value but not significantly. *Thus forecasted seasonal factors will be recalculated semi-annually in April & November and projected factors for the next six month are used to calculate seasonally adjusted figures. In other words, X-12 ARIMA is not executed till next six month for these series.*

The Basic Model Used for Seasonal Adjustment

The model used for seasonal adjustment is quite simple. The basic principle is that an observed or actual time series is made up of three components:

- The long-term direction of the series removing all short-term fluctuations is referred to as the trend. The underlying upward movement in imports of services is an example of a trend. Trends can be upward, downward or cyclical. Detecting turning points in the trend is important for cyclical series.
- Short term fluctuations in the series that are calendar related are called the seasonal component. The increase in the months of November and December of the imports of services series is an example of a seasonal effect.
- One-off effects which are neither seasonal nor long term but these can be due to a variety of reasons: abnormal weather, natural disasters, strikes, or imperfections in the data (such as sampling error). This component is called the irregular, as we do know when it will appear, how long it will affect the series, and what the magnitude of this component will be. The total Imports of Services series has a very small irregular component, indicating that the model fits this time series well.

These components can be combined by multiplication or addition, giving the multiplicative or additive model shown below. The relationship between the original series and its trend-cycle, seasonal, and irregular components can be modeled as additive or multiplicative. That is, the time-series model can be expressed as

The multiplicative model:

Actual = Trend-cycle x Seasonal x Irregular

and **the additive model** is:

Actual = Trend-cycle + Seasonal + Irregular

Most adjusted series use a multiplicative decomposition however a multiplicative model cannot be implemented if there is zero or negative observed values in the series. The seasonally adjusted series is the combination of the trend and irregular series, which is the same as the actual series once seasonal components are removed (as the name suggests).

For the multiplicative model:

Seasonally Adjusted = Trend (T) x Irregular (I)

and the additive model:

Seasonally Adjusted = Trend (T) + Irregular (I)

In practice we can inspect the graph of the original data series to investigate the appropriate decomposition model. X-12-ARIMA provi[1]des a test to indicate whether the seasonality of a series is multiplicative or additive.

Seasonal Adjustment Methodology

Seasonally adjustment of economic time series is usually carried out with X-12-ARIMA[1], the program developed by the U.S. Bureau of the Census. The method is based on a moving-average technique and is more sophisticated and able to provide adjustments customized to the characteristics of individual series.

The components of a time series are estimated using weighted moving averages on the series, or filters. Trend filters smooth the short-term fluctuations out of a time series, leaving the long-term movements - the trend. Seasonal filters are applied to the same calendar times in different years (each January month, for example) to estimate the seasonal factor.

The X-12-ARIMA uses an iterative approach to estimate the seasonal, trend and irregular components.

1. Initial estimates of trend are produced using a centered 12-term moving average. This estimate of trend is removed from the original series to produce an estimate of the combined seasonal/irregular component. Initial preliminary seasonal factors are produced by performing a 3X3 seasonal moving average. The initial preliminary seasonal factors are then used to create more refined seasonal factors by estimating and removing the difference between the initial preliminary seasonal factor and a 3X3 moving average of the initial preliminary seasonal factor. Seasonal factors are obtained from procedures that decompose the time series into seasonal, trend-cycle, and irregular components. This first iteration produces initial estimates of trend and seasonal factors.

2. Trend estimates are refined in the second iteration by using the initial seasonal factors in combination with a symmetric Henderson filter. This refined trend is then used to create refined seasonal factors using essentially the; same process outlined in iteration. This second iteration produces final estimates of the seasonal component in the form of seasonal factors.

3. The third iteration uses the final seasonal factors produced in the second iteration combined with a Henderson filter to estimate a final trend component. Lastly, using final estimates of trend and seasonal components, an estimate of the irregular component is produced.

[1] Seasonal Adjustment software developed by US Census Bureau http://www.2010census.biz/srd/www/x12a/

Outliers are identified from the estimates of irregular component and the actual value is replaced by an imputed value. A new trend cycle is obtained from the modified actual series. A seasonally adjusted series is then obtained by removing the seasonal factors from the modified actual series. X-12 method is also capable of removing effects of explanatory variables, trading day adjustments, and holiday / strike day effects and performs a series of diagnostics to ensure the quality of seasonal adjustment. X-12-ARIMA generates a series of diagnostics which tests how well the seasonal model fits on the data. Methodologists review these diagnostics to ensure the quality of any seasonal adjustment.

It is important to note that the seasonally adjusted and trend series are both subject to revisions. Revisions can occur for a variety of reasons. One of the common criticisms of seasonally adjusted and trend series is that revisions can occur when new data becomes available (i.e. Monthly figure of June can be adjusted when we know the result of July). Revisions of this type are due to the end point problem. At the end of the time series we cannot be certain whether movements are due to movements in the trend, or seasonal, or irregular components.

Some Key Features of X-12 ARIMA

- X-12-ARIMA contains a regARIMA time-series-modeling component, which aids the identification of outliers, shifts in the level of a series and calendar effects (all of which could distort the seasonal adjustments), and the estimation of seasonality at the start and end of the series.
- Filters of several different lengths, ranging from 3 to 17 years (or the full length of the series, if desired), are readily available to identify the seasonality appropriate to each series.
- X-12-ARIMA can provide multiplicative (proportionate) seasonal adjustments, if this is appropriate for an individual series.
- X-12-ARIMA has wide-ranging statistical diagnostics, available graphically if desired, enabling the nature, robustness and stability of the seasonal adjustments to be easily monitored. Besides aiding the method's use, these diagnostics facilitate greater understanding and analysis of series.

Preadjustments

The series may have to be preadjusted before entering the filtering procedure. For the seasonal moving average, the series may have to be preadjusted to temporarily remove the following effects:

1. outliers;
2. level-shifts (including ramps);
3. some calendar-related effects, particularly moving holidays like Eid, Ramadan etc, and leap-years;
4. unseasonable weather changes and natural disasters; and

5. strikes and irregular sale campaigns.

Preadjustments can be conducted in a multitude of ways. The user may adjust the data directly based on particular knowledge about the data before feeding them to the program, or, in the case of X-12ARIMA, use the estimation procedures built into the program. Separate regressors for holidays, strike days and movements in lunar calendar based on Ramadan, Shawal and Dul-Haj have been developed and tested on all data series.

Direct & Indirect Approach

In seasonal adjustment, the direct approach refers to the adjustment of aggregated raw components and the indirect approach is the aggregation of seasonally adjusted components. Although no conclusive theoretical research has been done, some criteria to discriminate between the direct and the indirect approaches are as under:

- Stochastic properties of the components must be examined. The indirect approach should be used if the components portray different stochastic properties.
- Indirect approach should be utilized if the data sources of the components are different.
- If the components convey different working / trading day effects, using of the indirect approach is appropriate again.
- If there exists high correlation between the components, the direct approach in seasonal adjustment should be used.

The above stated criteria should be considered in the selection of the appropriate approach.

Diagnostic Checking & Quality Measures

X-12-ARIMA has wide-ranging statistical diagnostics and set of quality measures to monitor the seasonal adjustment process. Besides facilitating the appropriate choice of seasonal adjustment model, these diagnostics help greater understanding of X-12 process. X-12-ARIMA diagnostics include the following:

- ACF, PACF, ACF of squared residuals, and histogram of standardized residuals are used for diagnostically checking regARIMA modelling,
- Outlier detection is used to detect additive outliers (AO), temporary outliers (TO), and level shifts (LS),
- The spectrum can be used to detect remaining seasonal or trading-day effects in the residual,
- The M and Q quality diagnostics are a set of eleven numbers that help the users see possible problems in the quality of the adjustments. There were designed so that any number greater than 1.0 signals a possible problem.
- Two kinds of stability diagnostics are the sliding spans and revision history diagnostics. X-12-ARIMA also contains diagnostics for month-to-month (or quarter-to-quarter) percent changes to compare the smoothness of two adjustments.

- Akaike's Information Criterion Corrected for sample size (AICC) and out-of-sample forecast performance can be used for model selection and various properties of the seasonal adjustment obtained after adjusting for the holiday effects can be used for diagnostic checking. Among models, the model having the smallest AICC value is preferred. The out-of-sample forecast error (OSFE) can be used for comparing the forecasting ability of the models. The model having the smallest accumulated forecast error is better.

Revisions Policy of Seasonal Factors and Series

In a broad context, the post-estimation analysis includes the policies and procedures for revision of the seasonally adjusted data. Standard practice is to re-estimate the seasonal factors when additional time series observations become available. Re-estimation and revision of the seasonally adjusted data can be performed on an annual basis or more or less frequently. The data revision policy—an important component of the seasonal-adjustment framework—may call for several revisions of the seasonally adjusted time series, leading up to the seasonally adjusted series in final form.

The revision of seasonal factor estimation can be carried out either as soon as a new observation becomes available (concurrent adjustment) or seasonal factors can be projected on predetermined longer intervals such as a year (factor projected adjustment).

From a purely theoretical point of view, the use of concurrent adjustment is preferable since new data always contribute new information and should therefore be used. The problem with this argument is that recent data are often not as reliable as historical data as they will undergo a specific revision process. For this reason the factor projected adjustment can be preferred. To use the restrictive factor projected approach, some criteria are as under:

- If the series demonstrate deterministic seasonality, i.e., the seasonal component displaying a constant movement over the time period focused, the seasonal factors can be projected.
- The large size of irregular component leads to large revisions for such a case a factor projected seasonal adjustment can be preferable.
- If the average percentage reduction of the residual mean square error when performing concurrent seasonal adjustment compared to projecting seasonal factors is quite low, then projected adjustment can be chosen again.