Seasonal Adjustment of Time Series

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Introduction

Seasonal adjustment is a process of using analytical techniques to estimate and remove seasonal and calendar effects, which may otherwise conceal and distort the true underlying movement of time series.

This article provides a brief overview of seasonal adjustment and outlines the seasonal adjustment methodology adopted by the Singapore Department of Statistics (DOS).

Seasonality and Calendar Effects

Seasonality, or seasonal effect, is the intra-year periodic variation of a time series. This variation, which repeats itself in the same month or quarter every year, may be due to cultural festivals, social customs, or climatic changes. For example, visitor arrivals to Singapore tend to be higher in December which coincides with the month-long festive and vacation period.

Calendar effect refers to the variation in a time series arising from the composition of the calendar. The two main calendar effects are trading day effect and moving holiday effect.

Trading day effect arises from the difference in the number of working, or trading, days in a month. For example, industrial production tends to be higher in a particular January with 23 working days compared with another January with only 21 working days. Trading day effects are rarely evident in quarterly series, as the calendar composition over the quarters does not vary significantly.

Moving holiday effect arises from the shifting of holidays or festive periods in the calendar. Chinese New Year[1] and Hari Raya Puasa are two examples of moving holidays in Singapore.

Decomposition of Time Series

Generally, we can decompose a time series into three main components – the trend-cycle component, the seasonal component, and the irregular component.

(a) The trend-cycle (TC) component is the combined long-term trend and the business-cycle movement of the series.

(b) The seasonal (S) component includes both seasonality and calendar effects.

(c) The irregular (I) component, which is the residual after removing the trend-cycle and seasonal components, captures the random fluctuations of the short-term movement in the series.

Let X_t , TC_t , S_t and I_t denote respectively the original non-seasonally adjusted (NSA) data, the trend-cycle component, the seasonal component, and the irregular component at period *t*. In the seasonal adjustment process, decomposition models are mostly multiplicative or additive. The model generally adopted by DOS is the multiplicative one, although the additive model is applied to certain series.

[1] Chinese New Year effect can be ignored in quarterly series, as it always falls in the first quarter of each calendar year.

The multiplicative model can be expressed as $X_t = TC_t \cdot S_t \cdot I_t$. This model assumes that the absolute size of the seasonal and irregular variations depends on the level of the series – the higher the level, the greater the amplitude of oscillation. Empirical studies show that this is typical of most macroeconomic series.

The additive model can be expressed as $X_t = TC_t + S_t + I_t$. This model assumes that the size of the seasonal and irregular variations does not depend on the magnitude of the trend-cycle component.

As an illustration, the multiplicative model is more suitable for the series in Chart 1A, while the additive model is more appropriate for the series in Chart 1B.

Seasonal adjustment seeks to estimate and remove the seasonal component, leaving behind the trend-cycle and irregular components ($TC_t \cdot I_t$ for multiplicative model; $TC_t + I_t$ for additive model).

CHART 1A MULTIPLICATIVE MODEL

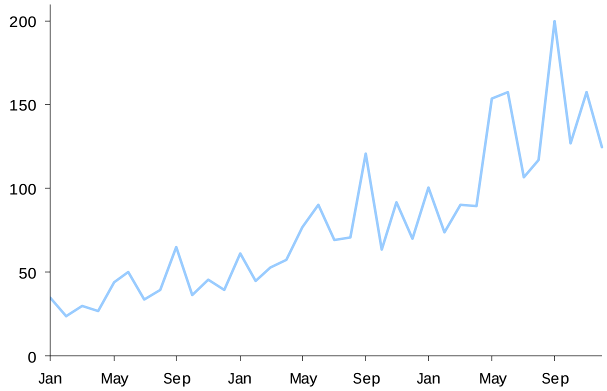
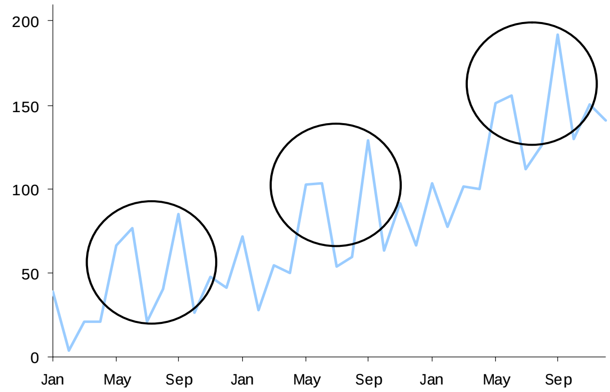


CHART 1B ADDITIVE MODEL



Note that the size of the 'spikes' in Chart 1A increases as the series moves upwards, while the size of the 'spikes' in Chart 1B remains constant.

How Seasonal Adjustment is Performed

DOS uses the X12-ARIMA method developed by the US Census Bureau to perform seasonal adjustment. X12-ARIMA is an enhancement to its predecessor, the X11-ARIMA method. X12-ARIMA has the improved capability of extending the series[2] using regARIMA modeling prior to the actual seasonal adjustment procedure. It also incorporates additional model diagnostics to better gauge the quality of the adjustment.

Conceptually, the TC and S components cannot be estimated simultaneously – estimation of the TC component cannot be done without prior knowledge of the S component, and estimation of the S component cannot be done without prior knowledge of the TC component. The X12-ARIMA method alternately estimates the TC and the S components through an iterative estimation procedure, by using series of moving averages, to derive the final seasonally adjusted (SA) figures.

[2] Studies show that extension of the series improves the estimates of the seasonal components and reduces future revisions as more data become available.

In principle, there are two approaches to perform seasonal adjustment – the *forward factors* method and the *concurrent adjustment* method.

For monthly data, DOS performs seasonal adjustment annually after the December figures become available. Forward factors, which are the estimates of the seasonal components for each of the next twelve months, are estimated during the annual seasonal adjustment. During the year, when the NSA figures become available, the SA figures are derived by dividing the NSA figures by the corresponding forward factors (or by subtraction if an additive model is used).

For quarterly series, DOS generally performs seasonal adjustment concurrently. In concurrent adjustment, when a new data point is available, the X12-ARIMA program is run on the entire series to obtain the SA series up to the current period. However, as concurrent adjustment results in frequent and significant revisions to the SA data, the forward factor adjustment method is used for important and closely monitored economic indicators like the quarterly GDP estimates.

Uses of Seasonally Adjusted Data

Traditionally, the monthly (quarterly) growth rates are computed as the percentage change from the corresponding month (quarter) in the previous year in the NSA data, giving what is termed the year-on-year growth rates. Year-on-year growth rates are simple to compute and easy to understand, but are not sensitive enough to quickly detect any changes in the growth momentum. They are also greatly affected by trading day and moving holiday effects.

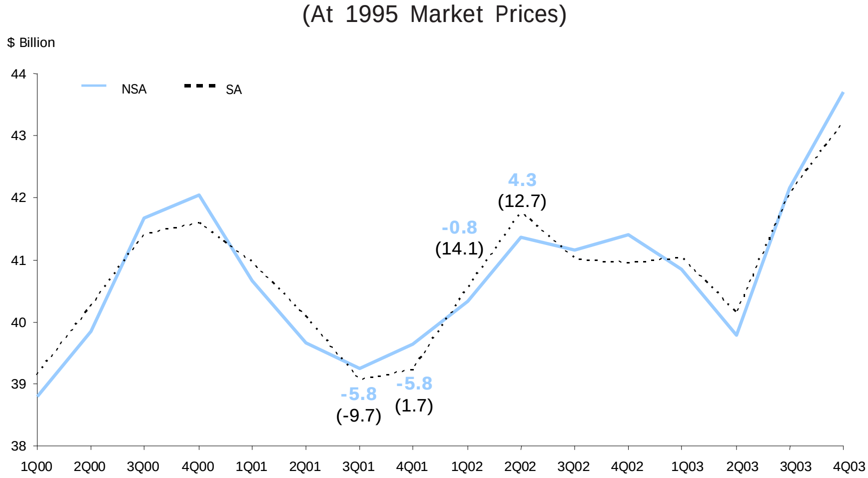
Month-on-month (or quarter-on-quarter) change – which is the percentage change over the previous month (or quarter) – of the SA data provides a more meaningful comparison over a shorter time frame, and is useful for early detection of turning points.

To facilitate comparison with the more conventional annual growth rates, month-on-month and quarter-on-quarter growth rates can be annualized, ie computed to show what the annual growth rate will be if the quarterly or monthly growth rates are maintained for a one-year period.

Chart 2 shows Singapore's real GDP over the period 2000–2003, together with the year-on-year and quarter-on-quarter (annualized) growth rates. The quarter-on-quarter growth rate was able to detect a turning point in 4Q01, but the year-on-year growth rate detected the turning point only in 2Q02, a lag of two quarters.

CHART 2 REAL GDP

(At 1995 Market Prices)



n year-on-year % change

(n) (annualized quarter-on-quarter % change)

Some Frequently Asked Questions

How is it possible that, for a particular month, the NSA data shows an increase over the previous month but the SA data shows a decrease?

This happens when the increase is less than the usual seasonal increase. To illustrate, consider the retail sales index (RSI) which tends to increase sharply in December during the festive season. Suppose that an economic downturn results in a weak performance of the retail sector, the unadjusted RSI for December might still show a moderate increase over November. But because this increase is lower than that for a typical December, the seasonally adjusted RSI for December would be lower than the corresponding seasonally adjusted RSI for November.

Why are there revisions to the SA data when no revisions are made to the NSA data?

This happens when new data points are used in the seasonal adjustment. For seasonal adjustment using the forward adjustment method, this takes place during the annual re-analysis of the data series. For concurrently adjusted data series, the entire SA series is revised with each new additional data point.

Why doesn't seasonal adjustment smooth out some spikes in the time series?

The purpose of seasonal adjustment is not to smooth the original time series (although very often, the SA series does appear to be smoother). Rather, the aim is to remove the seasonal component from the time series. One-time events, which may cause a sudden spike in the series, are not seasonal or calendar effects, and will not be removed by the seasonal adjustment procedure.

For example, the SARS (Severe Acute Respiratory Syndrome) episode in 2003 resulted in a sharp decline in tourist arrivals to Singapore from April to June. This outlier effect is temporarily adjusted for prior to seasonal adjustment in order not to skew the estimation of the seasonal factors. However, this effect is not removed in the SA data as the effect is not seasonal in nature.

Why are there no seasonally adjusted data for annual series?

Seasonal adjustment adjusts for the intra-year variation that repeats either periodically or in a systematic manner. This variation is not present in annual series. Hence, it is conceptually meaningless to seasonally adjust annual series.

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