Technical note on seasonal adjustment for Gross domestic product

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1   Gross domestic product

We analyse the quarterly data for Gross domestic product from the 1st quarter of the fiscal year 2004-05. Figure 1 shows the original plot of the series. It shows seasonal pattern. In such a non-seasonally adjusted series, it is difficult to discern a trend as the seasonal variations may mask the important characteristics of a time series.

Figure 1 Gross domestic product (Non seasonally adjusted)
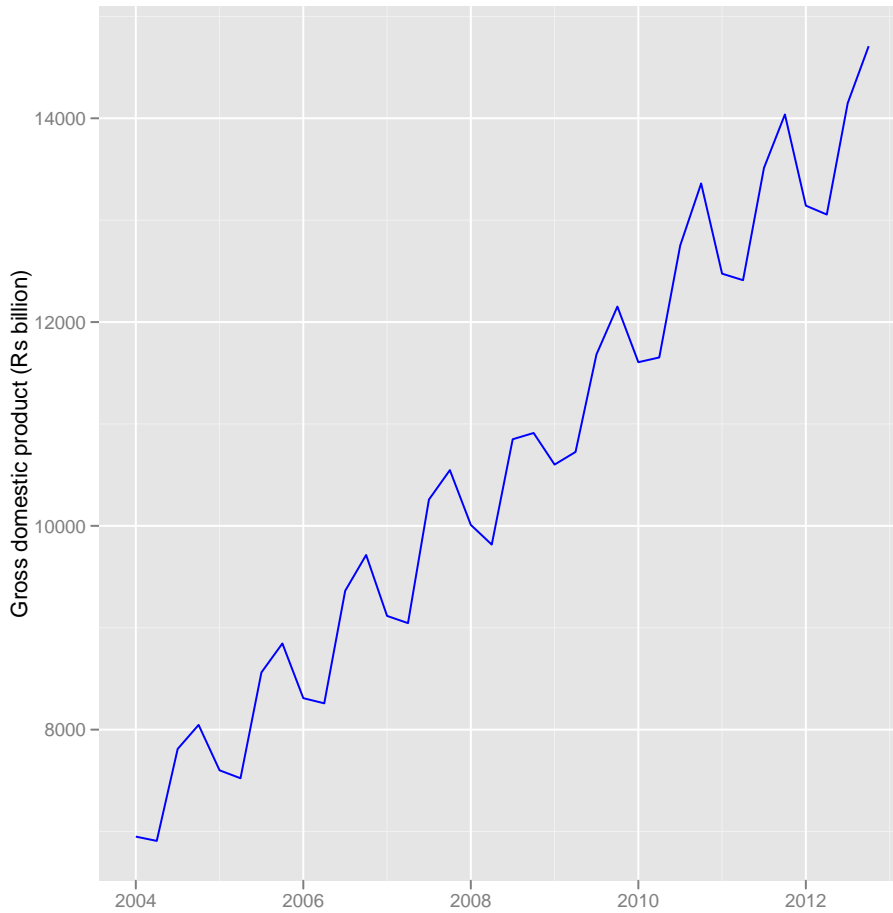
1.1   Additive versus multiplicative seasonality

X-12-ARIMA has the capability to determine the mode of the seasonal adjustment decomposition to be performed i.e whether multiplicative or additive seasonal adjustment decomposition is appropriate for the series. For Gross domestic product, multiplicative seasonal adjustment is considered appropriate on the basis of the model selection criteria.

2 Steps in the seasonal adjustment procedure

Given that seasonality exists, it is important to model seasonality before the application of seasonal adjustment procedure. Seasonality in time series can be deterministic or stochastic. Stochastic seasonality can be stationary or non-stationary.

A visually appealing way of looking at the raw data is to plot the growth rates in each of the quarters across the years i.e the growth of 2nd quarter (July-September) over 1st quarter (April-June) in each of the years from the fiscal year 1999 onwards. This gives us some idea of the presence of seasonal peaks, if any in the series.

The nature of seasonality can also be inferred intutively from the plot before the application of the testing procedures.

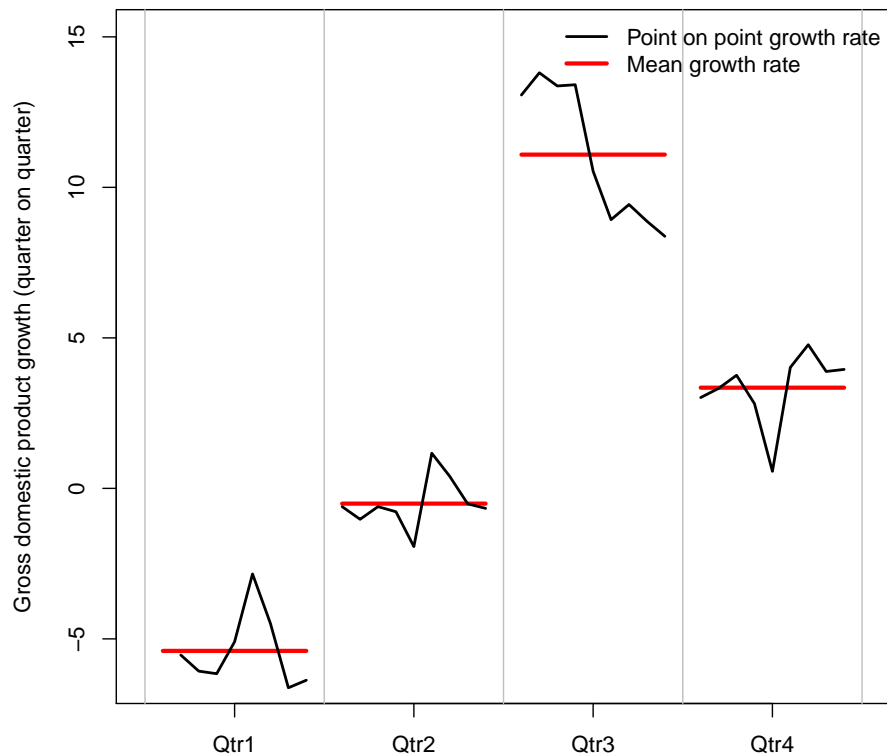**Figure 2** Quarterly growth rates across the years

Figure 2 shows that mean growth rate in quarter 3 (October-December) is higher than the growth rate in other quarters.

2.1 Seasonal adjustment with X-12-ARIMA

Seasonal adjustment is done with X-12-ARIMA method.

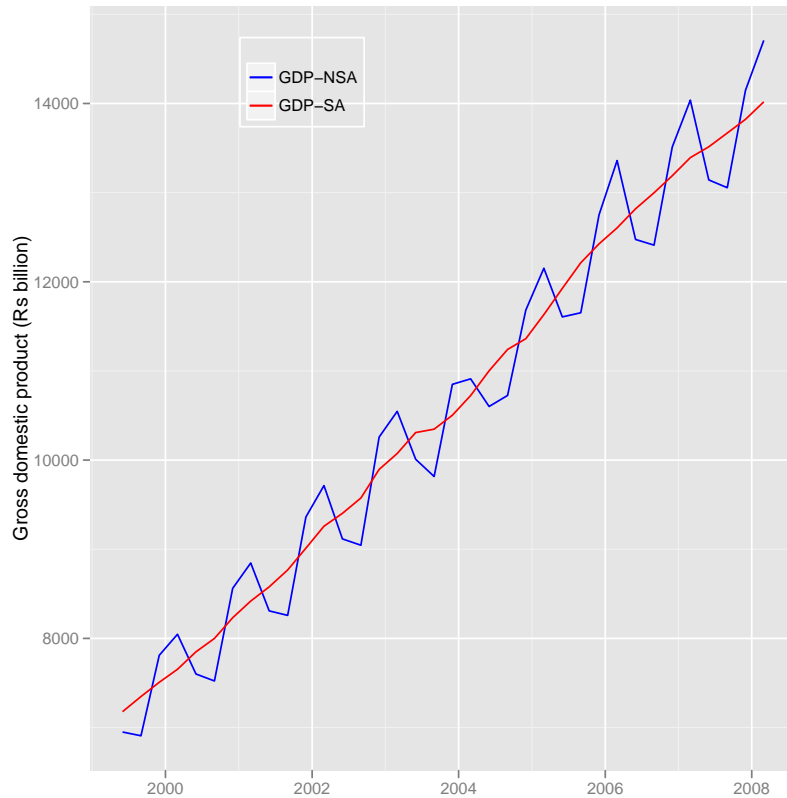**Figure 3** Gross domestic product (NSA and SA)

Figure 3 shows the non-seasonally and seasonally adjusted Gross domestic product. The seasonal peaks are dampened after seasonal adjustment.

2.2 Diagnostic checks

After seasonal adjustment, a series of diagnostic checks are performed through relevant tests and quality assessment statistics.

2.2.1 Validation of the automodel choice by X-12-ARIMA

A test of validation of the auto model choice by X-12-ARIMA is the randomness of the residuals of the ARIMA model. The Ljung-Box test is conducted on the residuals of the fitted ARIMA model to check whether or not the residuals are white noise. The ACFs of the residuals are plotted to check for randomness.

Figure 4 does not reveal significant autocorrelation amongst the residuals.

Figure 4 ACF of residuals

Series GDP_activity.residuals
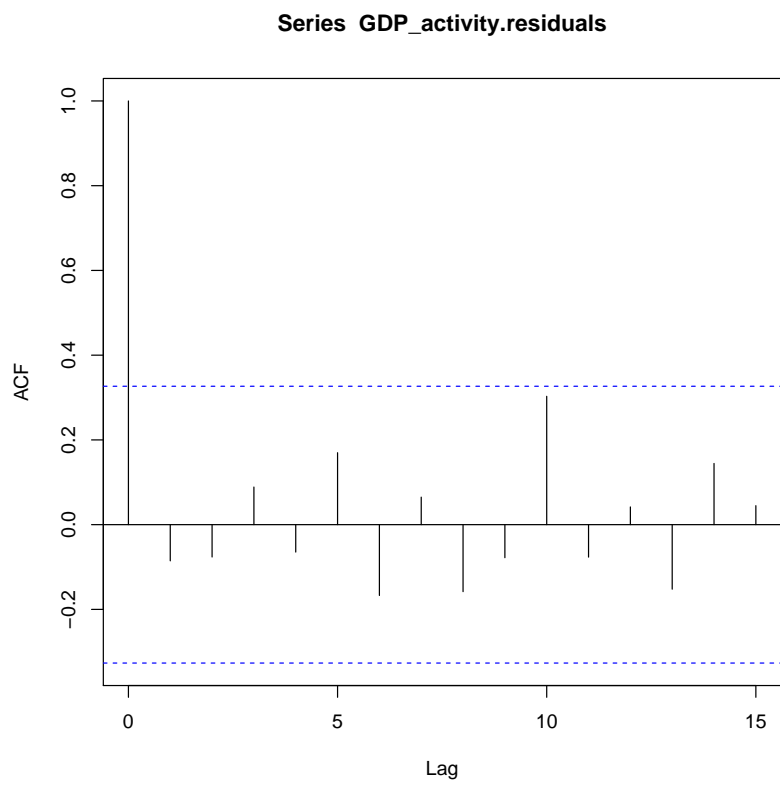
2.2.2 Presence of identifiable seasonality

The statistic M7 shows the amount of moving seasonality present relative to stable seasonality. It shows the combined result for the test of stable and moving seasonality in the series. A value lesser than 0.7 is desirable to show identifiable seasonality in the series. The value of M7 statistic for Gross domestic product is 0.078.

Gross domestic product shows identifiable seasonality on the basis of the M7 statistic.

3 Year on year growth versus seasonally adjusted point on point growth

Growth rates can be computed either year on year or point on point. The year on year growth rate is computed as the percentage change with respect to the corresponding quarter in the preceding year, while the point on point growth rate is computed as the percentage change with respect to the preceding period.

Table 2 shows the year on year growth and seasonally adjusted annualized rate in percent, point on point.

4 Spectral representation

Figure 5 shows the spectral plot of the growth rate of the unadjusted and seasonally adjusted series. Spectral plot, an important tool of the frequency domain analysis shows the portion of variance of the series contributed by cycles of different frequencies.
In case of quarterly series, the seasonal frequencies are pi/2 and pi which correspond to periods of 4 quarters and 2 quarters. Figure shows that seasonal adjustment removes the peaks at seasonal frequencies.

5 Sliding spans diagnostics

Sliding span diagnostics are descriptive statistics of how the seasonal adjustments and their quarter-to-quarter changes vary when the span of data used to calculate them is altered in a systematic way.
It is based on the idea that for a quarter common to more than one overlapping spans, the percent change of its adjusted value from the different spans should not exceed the threshold value and for a quarter common to more than one span, the difference between the quarter on quarter change from the different spans should not exceed the threshold value (the threshold value being 0.03).
Sliding span gives the percentage of quarters (A%) for which the seasonal adjustment is unstable (the difference in the seasonally adjusted values for a particular quarter from more than one span should not exceed 0.03). It also gives the percentage of quarters (MM%) for which the quarter on quarter changes of the seasonally adjusted values is unstable i.e exceeding the threshold value. The seasonal adjustment produced by the procedure chosen should not be used if A% > 25.0 (> 15.0 is considered problematic) or if M M % > 40.0. For Gross domestic product both A% and MM% is 0.

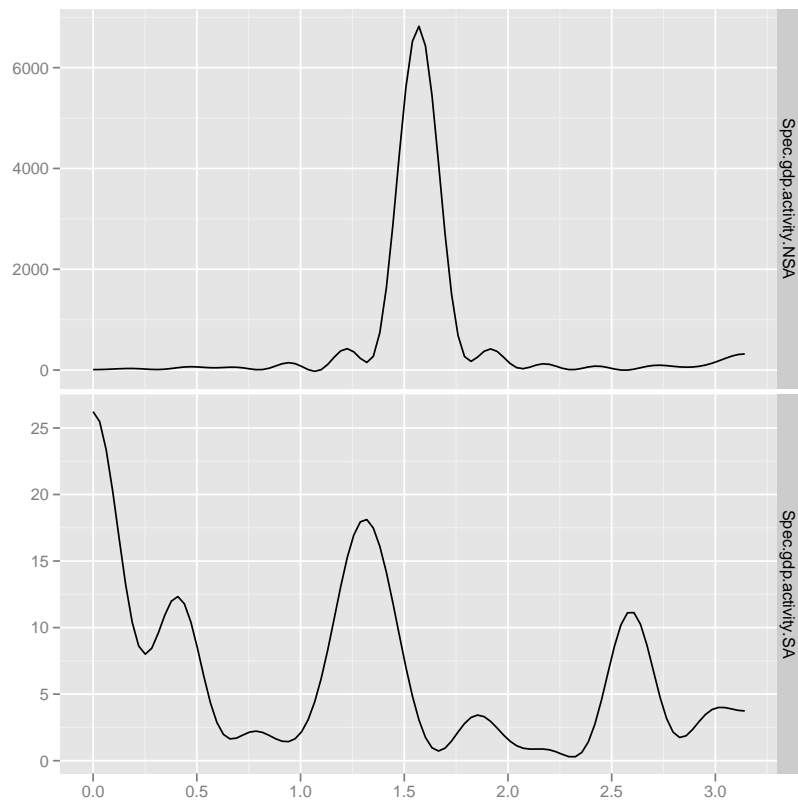**Figure 5** GDP Spectral plot (NSA and SA)

Table 1 Year on year and point on point growth rates

	Y.o.Y.growth	Point.on.point.growth
2004 Q2		9.37
2004 Q3		8.61
2004 Q4		7.68
2005 Q1	9.36	10.12
2005 Q2	8.90	7.56
2005 Q3	9.61	11.46
2005 Q4	9.94	8.98
2006 Q1	9.31	7.51
2006 Q2	9.78	8.73
2006 Q3	9.36	11.01
2006 Q4	9.82	10.78
2007 Q1	9.72	6.19
2007 Q2	9.53	7.26
2007 Q3	9.57	13.18
2007 Q4	8.57	7.15
2008 Q1	9.80	9.22
2008 Q2	8.52	1.48
2008 Q3	5.77	6.00
2008 Q4	3.46	8.32
2009 Q1	5.91	10.22
2009 Q2	9.26	8.61
2009 Q3	7.67	4.29
2009 Q4	11.37	9.38
2010 Q1	9.48	10.00
2010 Q2	8.65	9.53
2010 Q3	9.15	6.88
2010 Q4	9.94	5.72
2011 Q1	7.49	6.74
2011 Q2	6.51	5.56
2011 Q3	5.97	5.85
2011 Q4	5.07	6.11
2012 Q1	5.35	3.61
2012 Q2	5.19	4.54
2012 Q3	4.71	4.48
2012 Q4	4.78	5.63

The sliding span diagnostics is not reliable when the range of the seasonal factors in a particular span is low (less than 5).

6   Direct and indirect seasonal adjustment

If a time series is a sum (or other composite) of component series that are seasonally adjusted, we can sum the seasonally adjusted component series to get an indirect adjustment for the aggregate series. This kind of adjustment is called an **indirect adjustment** of the aggregate series. On the other hand, application of seasonal adjustment procedure directly to the aggregate data is called **direct seasonal adjustment.**

The choice between direct and indirect adjustment depends on how similar or distinct are the seasonal patterns of the composite series. In general, when component series have distinct

seasonal pattern, indirect adjustment is more appropriate than direct adjustment. On the other hand, when component series are noisy, but have similar seasonal pattern, aggregation of the series may cancel out noise and direct seasonal adjusment will be of better quality.

We look at the diagnostics to check the quality of the direct and indirect seasonal adjustment procedure. The most fundamental requirement is that there should not be any estimable seasonal effect still present in the seasonally adjusted series. In addition, the M and Q quality diagnostics, residual seasonality and spectral plots are prominent determinants to judge the quality of seasonal adjustment.

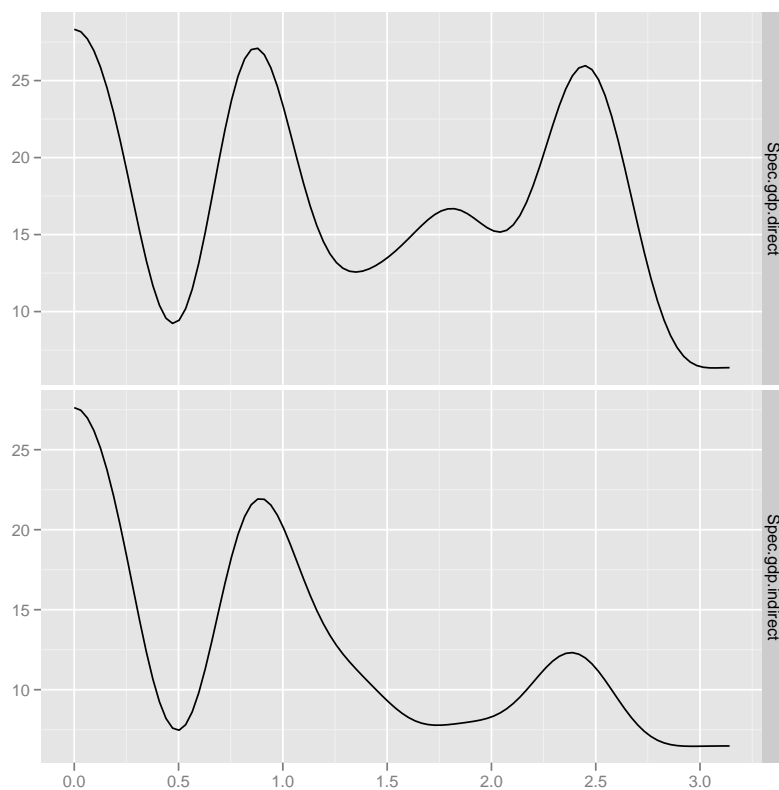**Figure 6** Spectral plot of indirect and direct seasonal adjustment

Figure 6 shows the spectral plot of the growth rate of the seasonally adjusted GDP through direct and indirect seasonal adjustment. The upper panel deals with direct seasonal adjustment and the lower panel with indirect mode.

As seen in the previous sections, in case of quarterly series, seasonal adjustment removes the peaks at the seasonal frequencies of pi/2 and pi. Comparing the two graphs we see that the seasonal peaks at pi/2 (1.57 on the X-axis) are more effectively reduced through indirect seasonal adjustment. Hence indirect seasonal adjustment is appropriate for GDP. The same inference is derived if we compare the M7 statistics through both modes.