Discussion Paper 3.0: Seasonal Adjustment of Index of Industrial Production

1. Introduction and objective

1.1. The Index of Industrial Production (IIP) is a key short-term economic indicator that measures changes in the volume of industrial output on a monthly basis. However, high frequency economic data like IIP are often characterized by seasonal and other calendar-related influences such as days of the week, days in the month, holiday shoppings that can obscure the underlying economic signal. Seasonal adjustment, also called deseasonalisation, is therefore, often undertaken to remove predictable seasonal and calendar effects so that underlying movements in industrial activity can be more accurately assessed.

1.2. National Statistics Office, India has not attempted to publish seasonally adjusted IIP series so far. It was left to users requiring seasonally adjusted indicators to undertake such analysis separately on their own using methods and tools of their choice. This, however, was beyond the realms of ordinary users who are not equipped with sophisticated econometric skills to do this on their own. However, many official statistical agencies are now disseminating seasonally adjusted IIP series in light of an increasing demand for a such data and also in view of the multilateral institutions making explicit recommendations in favour of this practice. Therefore, the issue was deliberated at length in the Technical Advisory Committee for Base Year Revision of All-India Index of Industrial Production (TAC-IIP).

1.3. Industrial production is significantly influenced by seasonality and calendar effects. In addition, festivals in India generally do not align with the Gregorian calendar, which poses unique challenges for the seasonal adjustment of industrial production data and their influence on production cannot be overlooked. These aspects, along with the challenges in the seasonal adjustment process have been brought out in this Discussion Paper.

1.4. Before delving into the methodological aspects of seasonal adjustment, this discussion paper outlines the international guidelines/ recommendations and the country practices in this regard. The merits and demerits of seasonal adjustment have also been discussed in this paper.

2. International Recommendations

2.1. The International Recommendations of Index of Industrial Production (IRIIP 2010) brought out by the **UNSD states that "*Countries should consider producing and***

***disseminating seasonally adjusted series as an integral part of their long-term programme of quality enhancement of their industrial production statistics*”**. The OECD and the Eurostat also recommends seasonal adjustment of the IIP series.

2.2. The recommendations also stress that countries should consider all advantages and disadvantages of seasonal adjustment before starting the seasonal adjustment process. Seasonal adjustment must be performed only when there is clear statistical evidence and economic interpretation of the seasonal/calendar effects. Making any seasonal and/or calendar adjustment on time series which do not show any evidence of such effects is an inappropriate statistical treatment.

2.3. While seasonal adjustment is recommended because it provides users an understanding of the underlying economic phenomena that are impeded by the seasonal fluctuations and calendar related effects, this process comes with some drawbacks including:

i) **Subjectivity:** Seasonal adjustment depends on 'a priori' hypotheses/ assumptions about the components of the time series and the overall data generation process. These components are non-observable and can only be estimated. In particular, the seasonal and the seasonally adjusted components may vary from one software to another, and upon options chosen within the software;

ii) **Risks:** Inappropriate or low-quality seasonal adjustment can generate misleading results and increase the probability of false signals. Also, the presence of residual seasonality as well as over-smoothing can negatively affect the interpretation of seasonally adjusted data;

iii) **Burden:** Though it is now possible to carry out seasonal adjustment by several alternative econometric softwares, it does involve additional efforts and consumes significant time for computer and human resources. Most statistical agencies have set up dedicated units to carry out this task.

2.4. <u>Country practices</u>: Considering its need and importance, statistical organizations of many countries like the USA, China, France, United Kingdom, South Africa and members of the European Union are regularly bringing out seasonally adjusted IIP of their countries.

3. Conceptual Framework

3.1. Factors inducing seasonality in data

3.1.1. The impact of seasonality in economic data has long been recognized. Seasonality represents the composite effect of climate and institutional events which repeat more or less regularly every year. Major causes of seasonality may include weather, composition of the calendar, festivals and other holidays, decisions of the producers based on demand and supply scenario. These causes are mainly exogenous to economic systems but human intervention can modify their extent and nature.

3.1.2. High frequency economic data are often strongly affected by variations associated in the composition of the calendar. Industrial production is closely linked to the number of effective working days in a month. *Calendar effects* capture predictable, non-economic fluctuations caused by the way the calendar is organized, like the different number of working days over months, leap years, variations in week days, etc. These can distort short-term comparisons of production levels if they are not adjusted for.

3.1.3. The most intricate part of this exercise is the *moving holiday* effect that has to be captured in a seasonal adjustment exercise. These are holidays that occur every year but at different times in the Gregorian calendar (a solar calendar). Most of the Indian holidays like, Diwali, Holi, Dussehra, Id-ul-Fitr, etc., are based on lunar cycles and periodic solar adjustments resulting them to shift across Gregorian months. The influence of these moving holidays can include the loss of working days and changes in economic and social behavior. Such effects are usually country specific, making it difficult to build them into standards routines about the holiday.

4. Basic principles of seasonal adjustment

4.1. In order that the seasonal component may be removed from a time series, it should first be decomposed into its constituting components: the trend cycle (T_t), the seasonal component (S_t) and the irregular component (I_t). The seasonal variations can be distinguished from the trend by their oscillatory character, from the business cycle by having annual periodicity and from irregulars by being systematic.

4.2. The time series is a function of its constituting components which may be made up of several sub-components. That is

$$Y_t = f(T_t, S_t, I_t)$$

4.3. The most commonly used types of decomposition models are the additive decomposition model and the multiplicative decomposition model.

4.4. The *additive decomposition model* assumes that the components of a timeseries behaves independently of one another. This model is used if the irregular and the seasonal effects are independent of the trend behavior, i.e. if the seasonal effects are the same from year to year. Additive decomposition is represented in the following form

$$Y_t = T_t + S_t + I_t$$

4.5. The *multiplicative decomposition model* assumes that the components of the series are interdependent and thus the size of the seasonal variations increase or decrease with the level of the series. This model is generally taken as the default in most seasonal adjustment software packages since this is the characteristic of most seasonal economic timeseries. Additive decomposition is represented in the following form

$$Y_t = T_t . S_t . I_t$$

4.6. The trend component is the long-term, smooth, underlying direction of data – upward, downward or flat. The cyclical component is the long-term, non-fixed, and recurring fluctuations around a trend that typically lasts much more than a year. Unlike seasonality, cycles vary in length and amplitude, reflecting business cycles. The irregular component has the same unit as the data in an additive decomposition but is a unitless factor around unity in a multiplicative decomposition. It may arise from noise due to statistical errors or due to shocks such as economic, political, climatic or epidemiological.

4.7. Predictability, forecastability and capturing of underlying trends in industrial production is significantly impacted by factors beyond seasonality and calendar effects. A time series may be mathematically decomposed additively or multiplicatively. Prediction of irregular component is constrained by random, non-systematic and unforeseen variations and residuals have to be treated as pure Gaussian white noise with mean zero or have to be modelled by stochastic techniques. Deseasonalisation techniques can separate all other components of time series from the irregular component. It is important to carry out such exercise to meaningfully understand the underlying production trends.

4.8. **Quality of seasonal adjustment**

4.8.1. The most important requirement of seasonal adjustment quality is that the seasonally adjusted series should not have any estimable seasonal effect. The presence of estimable seasonal effects either in the seasonally adjusted series or in the de-trended seasonally adjusted series (i.e., the irregular component), is generally referred to as residual seasonality.

4.8.2. Another important characteristic of a good seasonal adjustment is the lack of bias in the level of the series, i.e., the level of the series will be similar for both the original series and the seasonally adjusted series. Stability of the estimates is another consideration while judging the quality of the seasonal adjustment. That is to say as new data become available and are incorporated into the estimation procedure, the revisions to the past estimates are small. Large revisions in past data can indicate that the estimates are misleading.

4.8.3. The detection and correction of outliers prior to implementation of the seasonal adjustment process are an important precondition for the quality of seasonal adjustment. *Outliers* are extreme or irregular observations in a time series that can distort seasonal adjustment and are explicitly identified and corrected during modelling. These outliers, if not treated adequately, may induce spurious or apparent seasonality. The main types of outliers include

– Additive Outliers (AO): one-time shocks affecting a single period;
– Level Shifts (LS): a permanent change in the level of the series from a specific point onward;
– Transitory Changes (TC): temporary shocks that gradually decay over time; and,
– Seasonal Outliers (SO): occur in specific seasonal periods.

5. Choice of Seasonal Adjustment method

5.1. To facilitate seasonal adjustment, several methods have been developed and applied internationally. Early approaches like the classical moving average decomposition method which uses fixed moving averages and simple averaging techniques; and the X-11 method which used iterative moving average filters for the purpose of decomposition were unable to explicitly model calendar effects and extreme observations. Later models that are more adequate and relevant for IIP are

– X-12 ARIMA: X-12-ARIMA extends the X-11 method by introducing Autoregressive Integrated Moving Average (ARIMA)-based pre-adjustment to model calendar effects and outliers.
– X-13ARIMA-SEATS: This is a further improvement on the X-12 ARIMA and combines regression-ARIMA (regARIMA) modelling with advanced seasonal and trend

extraction techniques. This offers enhanced diagnostics, improved stability analysis, and greater flexibility.

– TRAMO-SEATS: This is a fully model-based approach in which trend, seasonal, and irregular components are extracted as unobserved signals derived from the ARIMA model. While this method offers strong theoretical coherence and statistically optimal filters, it is more sensitive to model specification and less intuitive for non-technical users.

5.2. Choice of software for Seasonal Adjustment

5.2.1. Internationally there are a number of software options for seasonal adjustment of economic timeseries. These vary in their methodological coverage and level of automation. The most widely used and internationally accepted seasonal adjustment engines, X-13ARIMA-SEATS and TRAMO-SEATS, form the methodological backbone for seasonal adjustment. These engines are either implemented as standalone programs or through user-friendly interfaces.

5.2.2. The R environment offers flexible options like the "seasonal" package, which provides comprehensive interface to the X-13ARIMA-SEATS engine. The R-based tools allow greater customization, scripting and integration with analytical workflows, but require more user expertise and do not inherently impose standardized quality-control frameworks across series. Again, Python-based tools, like those available in "statmodels", support classical decomposition and STL methods[1], and are useful for exploratory analysis and modelling. However, they do not constitute a full replacement for X-13ARIMA-SEATS or TRAMO-SEATS.

5.2.3. Commercial statistical software, like SAS, Stata, EViews and MATLAB, provide seasonal adjustment capabilities. While these packages are user-friendly and efficient, their use involves licensing costs and may offer less transparency or flexibility compared to open-source platforms.

5.2.4. JDemetra+ is a prominent option which integrates X-13ARIMA-SEATS and TRAMO-SEATS methods into a standardized open-source platform. It is developed under the European Statistical System guidelines by the National Bank of Belgium with collaboration

[1] STL (Seasonal-Trend decomposition using Loess) is a flexible, non-parametric method that decomposes a time series into trend, seasonal and irregular components and allows the seasonal pattern to change gradually over time. While useful for exploratory analysis and short-term diagnostics, STL does not explicitly account for calendar effects or provide a model-based framework for forecasting and revision analysis.

from the Deutsche Bundesbank, Insee, and Eurostat. JDemetra+ provides a model-based framework for seasonal adjustment through regARIMA modelling. This allows explicit treatment of calendar effects (such as working days and leap years), moving holidays, and outliers. It also generates a comprehensive set of standard diagnostics, including residual seasonality tests, stability measures, revision analysis, and model adequacy checks. These features make the JDemetra+ particularly suitable for routine compilation of short-term indicators.

5.3. Developing Calendar Regressors

5.3.1. Calendar regressors are explanatory variables used in seasonal adjustment (particularly in regARIMA models such as those in JDemetra+ / X-13ARIMA-SEATS) to explicitly capture systematic calendar-related effects that influence a time series but are not part of true seasonality. A calendar regressor quantifies the impact of calendar structure on the observed value of a series. As discussed earlier, these effects arise because months differ in number of days, number of working days, distribution of weekends, occurrence of leap years, and timings of holidays and festivals. If not modelled, these effects may distort the estimation of seasonal factors. The main types of calendar regressors are:

- Trading day/ working day regressors: These capture variations in number of working days in a month.
- Leap year regressors: Accounts for an extra day in February of a leap year.
- Length-of-month regressor: captures the difference in total number of days in a month and is often implicitly handled through trading day regressor.
- Moving holiday regressor: Used when holidays do not fall in the same month every year. These regressors allocate the holiday effect across affected months.

5.3.2. In JDemetra+ (X-13ARIMA-SEATS) calendar regressors are included in the regARIMA pre-adjustment stage and their estimated effect is removed before seasonal adjustment. This ensures that Seasonal factors reflect only seasonal behaviour and Calendar distortions do not bias trend or seasonal estimates.

5.3.3. The pre-adjustment of calendar effects is particularly important for the seasonal adjustment of IIP since industrial output depends strongly on working days and festival months and months with many holidays may exhibit misleading trends.

6. Partial Concurrent Adjustment

6.1. In seasonal adjustment the model, i.e., ARIMA specifications, regressors, outliers, calendar effects, etc., are re-estimated every time a new observation is added. While this enables the model to continuously adapt to the latest data, this may also result in revisions in the entire past data. These revisions may cause instability in the series and confusion among users.

6.2. Again, keeping the model fixed over time would offer stability in the series by restricting revisions in the past data, but would constrain the model from adapting to new observations. This inflexibility may result in biased estimates and erroneous results.

6.3. Partial concurrent adjustment is a seasonal adjustment approach in which model identification is reviewed periodically, while parameter estimation and seasonal factors are updated with each new observation. Here the model structure is updated periodically, but not every month, while seasonal adjustment is still computed using all available data. In other words, the model identification is frozen for a certain period and the re-estimation occurs at predefined intervals. This method gives a distinct advantage because it balances stability and adaptability.

7. Direct and in-direct approaches to seasonal adjustment

7.1. Given that the IIP is a composite index derived from a weighted aggregation of several sectoral, industry-level, or item-level series, seasonal adjustment can be undertaken at different levels of aggregation. Broadly, two approaches are followed: the direct approach and the indirect approach.

7.2. Direct approach

7.2.1. Under the direct approach, seasonal adjustment is applied directly to the aggregate IIP series. The unadjusted IIP is first compiled by aggregating the component indices using the prescribed weights, and the resulting aggregate series is then seasonally adjusted as a single time series.

7.2.2. This approach is relatively simple to implement and maintain, as it involves the specification and estimation of only one seasonal adjustment model. It is therefore operationally efficient and often results in relatively stable seasonally adjusted estimates at higher levels of aggregation.

7.2.3. However, the direct approach does not explicitly account for the heterogeneous seasonal patterns present across different industries or sectors and, as a result, is less informative for detailed sectoral analysis and may obscure changes in the seasonal structure of individual components.

7.3. Indirect approach

7.3.1. In the indirect approach, seasonal adjustment is carried out at a disaggregated level, such as sectors, industry groups, or at 2-digit or higher level of disaggregation going up to item-level series. Each component series is seasonally adjusted individually using an appropriate model that reflects its specific seasonal and calendar characteristics. The seasonally adjusted aggregate IIP is then computed by aggregating the seasonally adjusted component series using their weights.

7.3.2. This approach allows the explicit modelling of diverse seasonal patterns across sectors/ industries and ensures internal consistency between seasonally adjusted aggregates and their components.

7.3.3. The indirect approach is, however, more demanding and requires careful model specification and monitoring for each series. This may also lead to larger revisions to the aggregate seasonally adjusted IIP as the component level models are updated.

8. Experimental Seasonal Adjustment of IIP 2011-12 series

8.1. Inputs

8.1.1. For the purpose of implementing seasonal adjustment methodology on past data of IIP, the monthly data for the base year 2011-12 up to March 2025 was used. Seasonal adjustment was done at the aggregated levels, i.e., the sectoral and general indices level.

8.1.2. For the purpose of developing calendar regressors, all Gazetted Holidays of the Government of India since April 2012 till March 2025 were plotted. This list was further supplemented by some other major regional holidays like Ganesh Chaturthi, Onam, Gudi Padwa that may have affected the production of the month. A total of 35 holidays were considered for the purpose of developing calendar regressors.

8.1.3. Partial Concurrent Adjustment: Given its hybrid approach and the policy sensitivity of IIP revisions, the partial concurrent adjustment is proposed to be used for the seasonal adjustment of IIP. The international recommendations also align to adopting a partial concurrent approach to seasonal adjustment.

8.2. Choice of Seasonal Adjustment method and software for IIP

8.2.1. Considering the monthly frequency and policy relevance of the IIP, X-13ARIMA-SEATS provides the most appropriate balance between statistical rigor, operational robustness, transparency, and international comparability. Its ability to explicitly model calendar effects, control revisions, and generate internationally comparable diagnostics makes it particularly well suited for the seasonal adjustment of IIP in accordance with UN and international best-practice recommendation.

8.2.2. The JDemetra+ software has been used for the seasonal adjustment exercise of IIP. This was done considering its model-based framework for seasonal adjustment through regARIMA modelling which allows explicit treatment of calendar effects, moving holidays, and outliers. JDemetra+ also provides diagnostic support to objectively assess the quality of the seasonally adjusted series.

8.3. Appropriate level for seasonal adjustment

8.3.1. Using the indirect approach for seasonal adjustment of IIP is difficult to maintain and has a higher computational and operational burden. Individual models have to be maintained and updated periodically at the component level. Moreover, this approach may also result in more frequent and higher levels of revision.

8.3.2. Further, the indirect approach was also evaluated, where the general index of IIP was computed from the seasonally adjusted sectoral indices using the sectoral weights of IIP. This however did not improve the smoothness of the aggregate IIP and seasonality was still observed in the general index of IIP so computed.

8.3.3. Considering the above, one very practical option that trades off information need with computational costs an d burden is to carry out this exercise at the sectoral and general indices of IIP and disseminate seasonally adjusted numbers at that or an aggregate level. The tradeoffs also involve the divergent interpretations by users since the additivity of disaggregated seasonalization will differ from that if applied at a headline IIP number.

8.4. Results

8.4.1. The sectoral indices and the general index for the 2011-12 series were adjusted for seasonality using the X-13ARIMA-SEATS in the JDemetra+ software. The results from the seasonal adjusted exercise are presented in the table below.

	Mining	**Manufacturing**	**Electricity**	**General**
Seasonality	Present	Present	Present	Present
Calendar Effect	No	No	No	No
Decomposition Type	Additive	Additive	Multiplicative	Additive
ARIMA model	(1,1,1) (0,1,1)	(0,1,1) (0,1,1)	(1,1,1) (0,1,1)	(0,1,1) (0,1,1)
Calendar Type	NA	NA	NA	NA
No. of Outliers	1	7	3	3
Outliers	TC (04/2020)	TC (03/2020), TC (04/2020), AO (04/2020), TC (06/2020), TC (05/2021), TC (07/2021), AO (10/2022)	AO (03/2020), TC (04/2020), TC (05/2021)	AO (03/2020), TC (04/2020), TC (05/2021)
Seasonal Filter	3X5	3X5	3X5	3X5
Trend Filter	13 term Henderson	13 term Henderson	13 term Henderson	13 term Henderson
Residual Seasonality on SA	No	No	No	No
Residual Seasonality on Irregular	No	No	No	No
Q[2]	0.379	0.711	0.472	0.727
Q2[3]	0.408	0.428	0.448	0.466

Note: Outliers explained in para 3.1.4

8.4.2. The following observations are made from the above results

– There is no statistically significant calendar effect in any of the components for which seasonal adjustment was carried out. However, in a separate exercise, when Diwali was taken as the only calendar regressor, it demonstrated significant calendar effect.

[2] Q statistic is a weighted composite measure that summarizes a range of diagnostics covering the quality of seasonal adjustment. It combines information on the stability and smoothness of the seasonal component, the relative size of the irregular component, the absence of residual seasonality in the adjusted series, and the stability of revisions. Lower values of Q indicate better overall quality and values below 1 are interpreted as acceptable or good seasonal adjustment.

[3] Q2 statistic summarizes diagnostics that specifically test whether seasonal patterns remain in the seasonally adjusted series or in the irregular component. Q2 assesses whether seasonal adjustment has been effective in removing seasonal effects without over- or under-adjustment Lower Q2 values (less than 1) indicate satisfactory seasonal adjustment.

- The decomposition type for all the series is “Additive”, except for the electricity sector where the decomposition type is “Multiplicative”.
- Most of the outliers in the series correspond with the COVID 19 period which experienced significant disruptions in industrial activity of the country. Hence, there are economic reasons for the outliers and they cannot be attributed to data errors.
- The quality of seasonal adjustment performed is good since there is no residual seasonality in the seasonally adjusted and irregular component series.

8.4.3. The seasonally adjusted series, trend cycle and the original series are plotted in Annexure.

8.4.4. This seasonal adjustment exercise was done on the 2011-12 series IIP data where the series spanned over several years. The IRIIP 2010 recommends that a minimum of five years timeseries is required to obtain properly seasonally adjusted estimates. Hence, for IIP with base year 2022-23, seasonal adjustment exercise can be undertaken after obtaining 5 years timeseries data.

9. Issues for Stakeholder consultation

9.1. Stakeholders are invited to provide their views on the following:

i) Use of X-13ARIMA-SEATS and JDemetra+ software for seasonal adjustment
ii) Identifying important holidays for the construction of calendar regressors
iii) Suitability of using the Partial Concurrent Approach for seasonal adjustment
iv) Appropriate IIP level for seasonal adjustment – direct vs indirect approach
v) Treatment of COVID 19 period in the seasonal adjustment process
vi) Dissemination process of seasonally adjusted series for IIP – minimum length of time series for seasonal adjustment

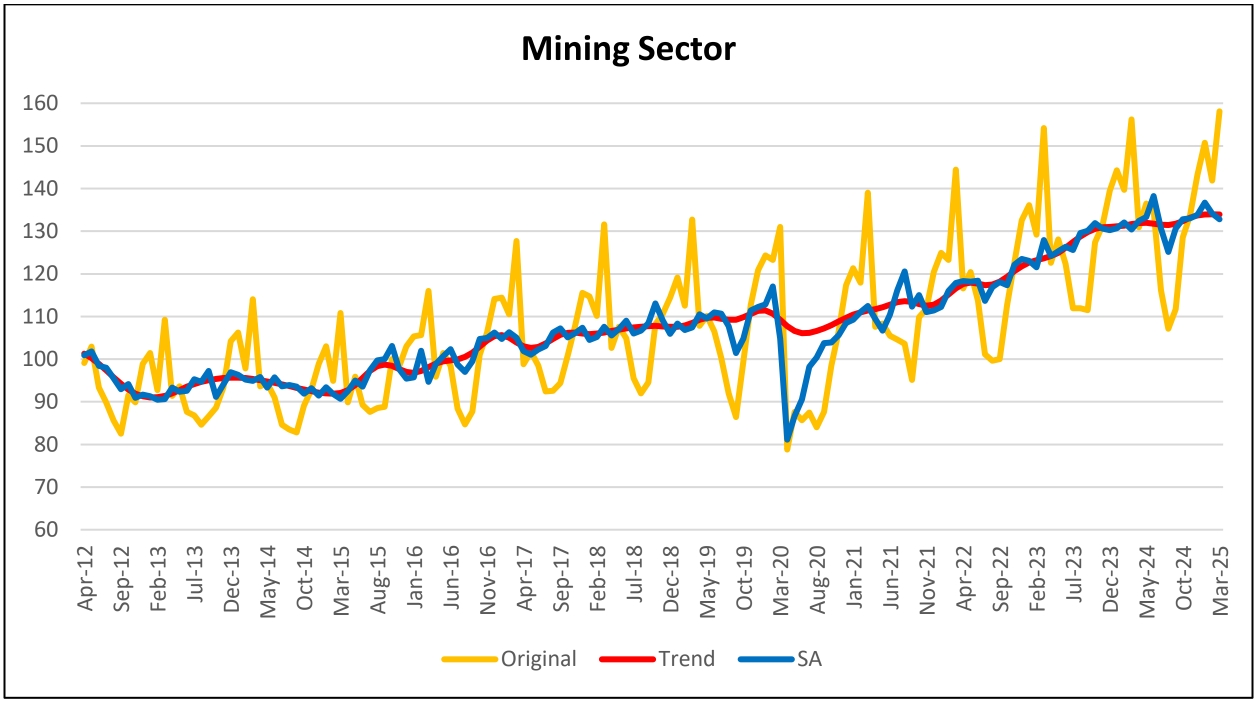
10. Conclusion

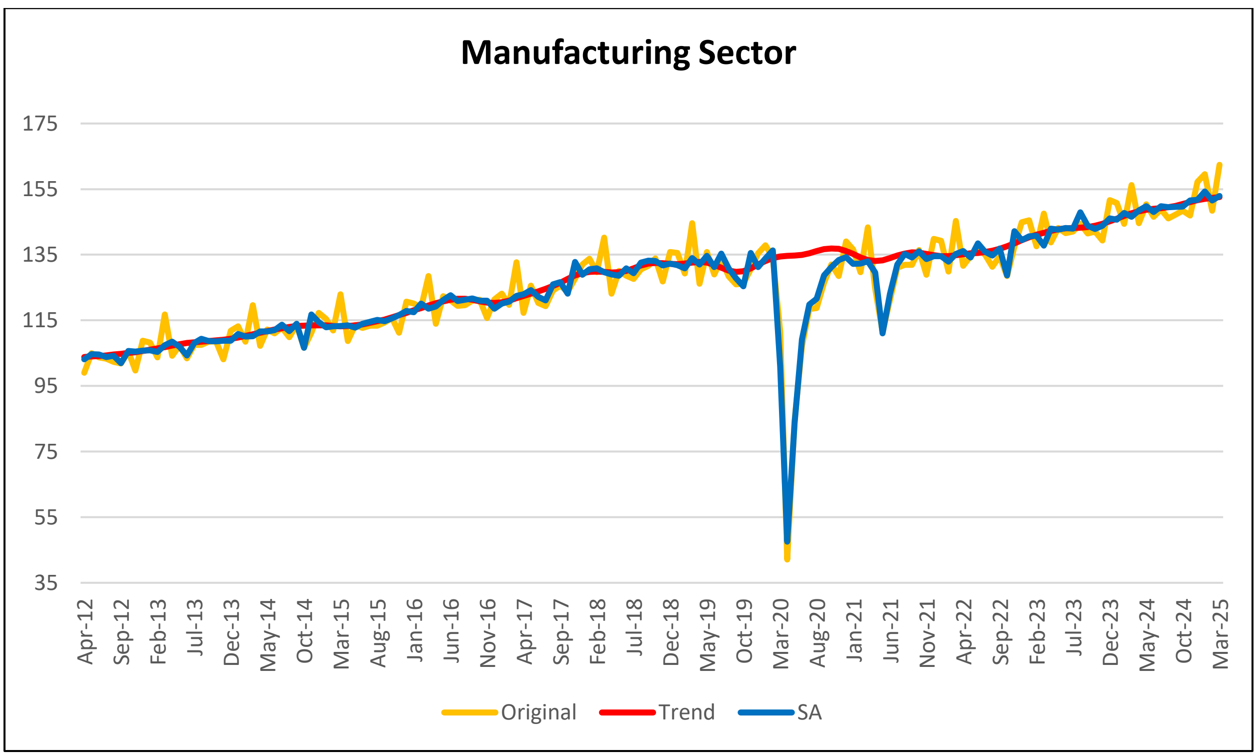
10.1. Seasonal adjustment is widely recognized as essential for enhancing the interpretability, reliability, and analytical usefulness of high-frequency economic indicators such as the IIP. By removing predictable seasonal patterns, seasonal adjustment helps ensure that short-term movements in the series more accurately reflect underlying economic developments rather than seasonal influences. At the same time, several methodological and operational issues require careful consideration before introducing regular seasonal adjustment of the IIP series. In this context, stakeholder consultation assumes particular importance in identifying the most appropriate approach for seasonal adjustment of IIP in India. The feedback received will be carefully examined and duly taken into account before finalizing the methodology and its implementation framework.

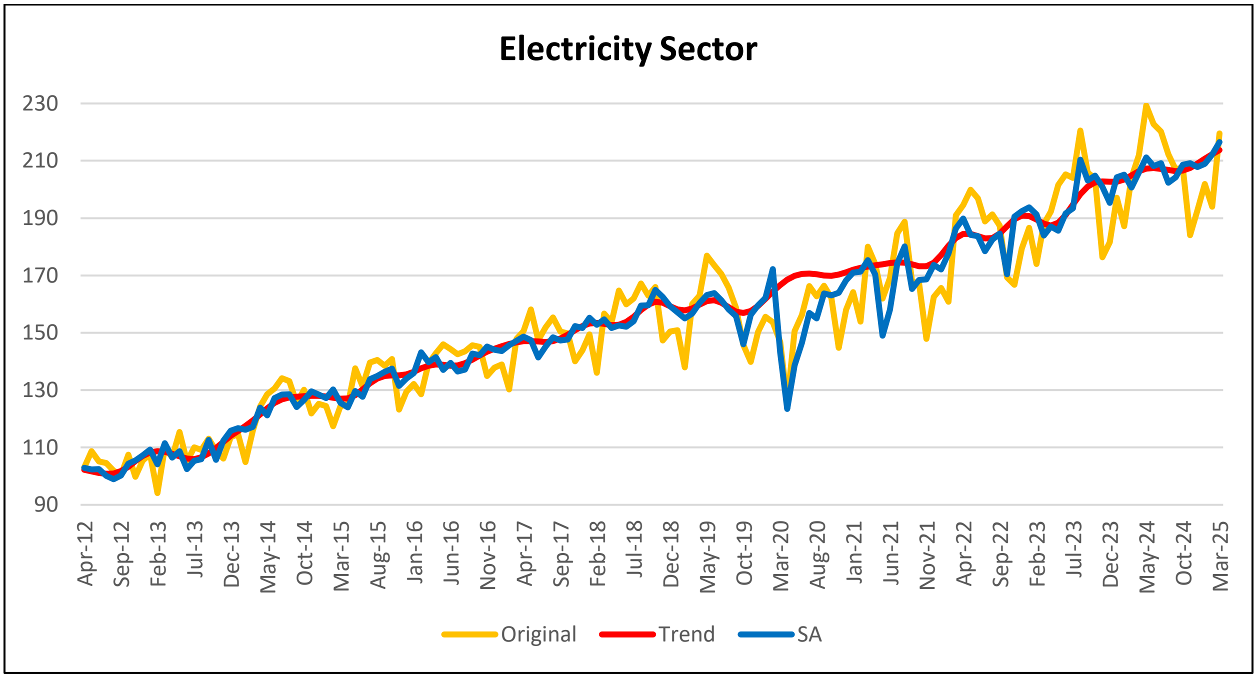
The feedback/comments are invited on the proposed methodologies for Seasonal Adjustment of IIP and may be sent at iipcso@nic.in by **12th February, 2026**.

Annexure

Results of Seasonal Adjustment of IIP






Electricity Sector
230
210
190
170
150
130
110
90
Apr-12
Sep-12
Feb-13
Jul-13
Dec-13
May-14
Oct-14
Mar-15
Aug-15
Jan-16
Jun-16
Nov-16
Apr-17
Sep-17
Feb-18
Jul-18
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May-19
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Aug-20
Jan-21
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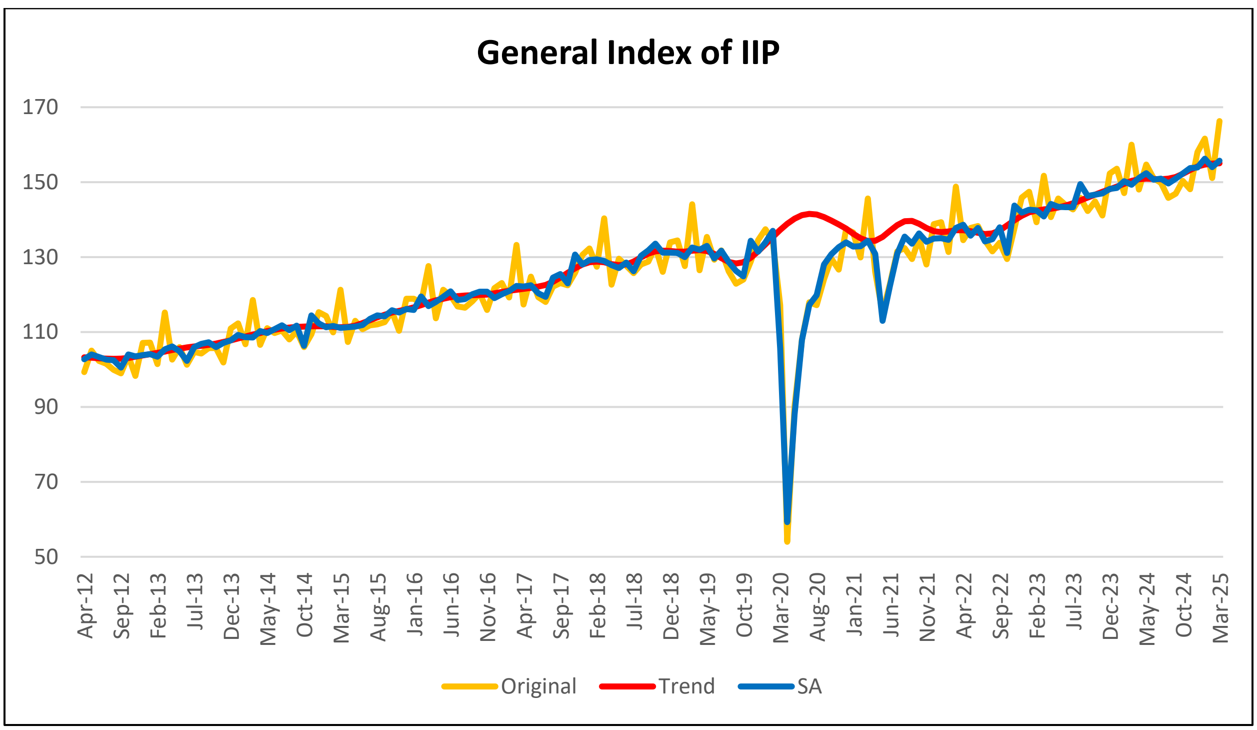
Mar-25
Original
Trend
SA


General Index of IIP
170
150
130
110
90
70
50
Apr-12
Sep-12
Feb-13
Jul-13
Dec-13
May-14
Oct-14
Mar-15
Aug-15
Jan-16
Jun-16
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May-24
Oct-24
Mar-25
Original
Trend
SA