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Presence and strength of seasonality in CPI (IW)

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Abstract

Background/Objectives: In official statistics, seasonal adjustment technique is usually employed to explore the seasonality characteristic of a time series. This paper attempts to analyse the seasonality characteristics of Consumer Price Index Numbers for Industrial Workers (CPI-IW base 2001=100). This is commonly used for calculation of inflation and dearness allowance fixation of government employees as well as industrial workers all around the country.
Method/Statistical Analysis: United States' Bureau of the Census developed a model called X-12 ARIMA intended to explore seasonality of a time series. This econometric model helps the economist to determine the presence and strength of seasonality of a time series.
Findings: The results of X-12 ARIMA indicate that the Consumer Price Index Numbers for Industrial Workers (CPI-IW base 2001=100) contains identifiable seasonality, whereas the series have no indication of substantial moving seasonality.
Improvement/ Applications: To study the underlying trends of the time series, one can make use of the model's output such as seasonally adjusted series, trend cycle, etc. to explore the underlying developments in the economy in a different perspective. Another scope of this study is to explore the monthly growth rate of original series as well as component series. Hence, enable one to study and understand short span of series, detect change in trend, etc.
Keywords: X – 12 ARIMA, Seasonal Adjustment, CPI (IW).

1 Introduction

A recurring seasonal pattern is a general format of an economic time series which complicates the fundamental behaviour and trends. Seasonal adjustment process helps to extract the underlying trends and movements of a time series by removing its seasonal effect. Time series data without seasonality (seasonally adjusted series) helps to identify the recent movements and can be easily correlated with the changes in the economy which helps to recognize the changes eventually [1].

1.1. Seasonality and Seasonal Adjustment

A yearly pattern that reoccurs at regular interval is called seasonality. The changes in data for a specific period which reflects significant rise or fall in its level or the regularly occurring variations result in periodic variations in data which makes the analyse more complex. Generally, economic measures at successive time periods contain misleading seasonal fluctuations. However, one can easily understand the real movement of the measure after seasonal adjustments. In order to produce seasonally adjusted data series, one has to process the economic measures or time series to remove the seasonal factors.

Various methods have been developed by different agencies which provide interpretable measures for a time period. Seasonal adjustment is a statistical technique usually employed for eliminating the influences of weather, festival, the vocations and other events which are seasonally recurring from the time series measure. This process allows the researchers to analyse and interpret the components of time series such as cyclical, trend, non-seasonal changes, etc. of a time series measure. Seasonal oscillations are eliminated; the comparison of monthly or quarterly data becomes easier using the seasonally adjusted series.

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Time series of economic measures are often having an effect of events which reappear annually. Such data series have an effect of seasonality pertaining to that event. While analysing such seasonally affected data series, the scale of seasonality can spoil the statistical interpretations and may led to wrong conclusions. Therefore, it is necessary to eliminate the seasonal fluctuations through seasonal adjustment process. Statistical and research agencies of foreign countries have established methods to eliminate the periodic oscillations from time series. The time series with seasonal fluctuations can hide the central tendency of the series which makes complexity in trend identification, intra-year comparisons of trend, etc. and further point to point decision.

1.2. Seasonal Decomposition

In a time series, seasonality is a time interval specific impact. This influence can make a variation in time series which can be identified in comparison with its long-term central tendency. For example, in a monthly series month specific influence or seasonality can be derived as deviation of the monthly series from its month specific long-term central tendency. Components of a time series are factors that are responsible for change in series namely Seasonal Movements, Cyclical Movements and Irregular Fluctuations. Mathematical expression of the components of time series ($Y_{[k]}$) is as follows:

$Y_{[k]}$ = Trend cycle($C_{[k]}$) ×Seasonal factors ($S_{[k]}$) ×Irregular components ($I_{[k]}$) ----------- (1)

In the above equation, $I_{[k]}$component is irregular in nature and has random effect over $Y_{[k]}$. The predictable components $S_{[k]}$ is associated with festivals, climatic change over a year, other recurring events over calendar year, etc. $C_{[k]}$is the trend component which is the resultant of long-term fluctuation due to structural change like demographic, technological, etc. As the seasonal adjustment process eliminates seasonal $S_{[k]}$ components of $Y_{[k]}$. The equation (1) becomes:

$Y'_{[k]}=C_{[k]}\times I_{[k]}$ --------------(2)

A time series generally have fixed seasonality pattern based on different factors. For example, consumer price indices are usually linked with seasonal factors like festival, weather pattern, etc. The stochastic seasonality changes are eventually associated with governing changes.

The trading day may affect the time series pattern. Working days and off days of a month can also affect the original series because of the tendency of the consumer to do shopping more often at the week end.

1.3. X-12 ARIMA

Different methods are available to remove seasonality from time series. Selection of a good seasonal adjustment method is so particular. One of the commonly used methods for seasonal adjustment process is X-11 ARIMA model which is developed by Statistics, Canada. In order to overcome the decencies of X-11 ARIMA, US Bureau of Census introduced X-12 ARIMA. TRAMO/SEATS package by Bank of Spain is also a prominent method in this area. In this study, to analysis the presence and strength of seasonality in CPI (IW), X-12 ARIMA method was used.

X12 ARIMA model mainly consists of two processes. Firstly, X12 ARIMA incorporated a Box-Jenkins ARIMA model which can overcome the effect of asymmetrical weights applied during X-11 ARIMA process. Secondly, X-12 ARIMA model forecast the original series before performing seasonal correction using X-11 model by using an ARIMA.

The X-12 ARIMA consists of two parts. The first part is linear regression model with ARIMA time series error model (reg ARIMA) which is used to identify and removes outliers and calendar effects and also to forecast and back cast series. The improved X-11 model is the second part which is used for decomposition of non-liner components such as seasonal change, trend cycle and irregular changes [2]. The flow diagram of X-12 ARIMA model is as shown in Figure 1. The CPI (IW) based 2001=100 series data between January, 2006 to September, 2012 were used for seasonality analysis. The monthly CPI (IW) data up to December, 2014 were used to compare the projected CPI (IW) series.

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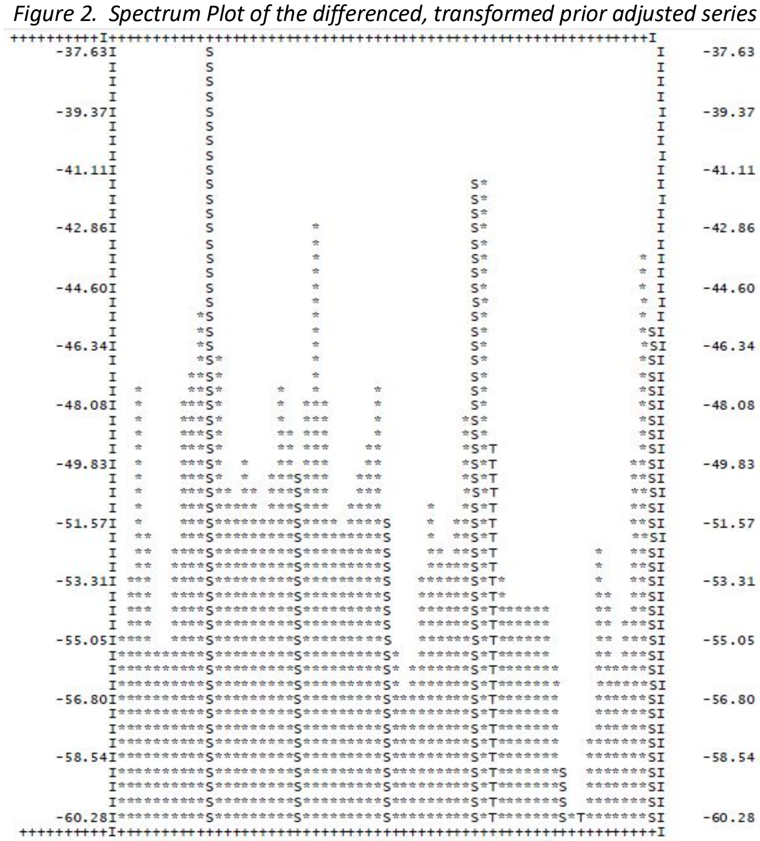
Figure 1. Flow diagram for seasonal adjustment X-12 process in multiplicative models

2.1. Presence of seasonality in CPI (IW)

Presence of seasonality are diagnosed through spectral graph, M7 and F test which are obtained from X 12 ARIMA model. The relationship across the frequencies is analysed with the help of spectral graph. As a monthly series, the seasonal components of CPI (IW) is the maximum extent of a variation that influence over frequencies 1/12, 2/12, 3/12, 4/12, 5/12 & 6/12. The spike at 1/12 of spectral plot indicates the occurrence of regular annual components.

Figure 2. Spectrum Plot of the differenced, transformed prior adjusted series



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The peaks in the spectral plot are really flags for visually significant and may be determined based on following rules. Firstly, the seasonal (S)/Trading day (T) frequencies must be higher than six stars (*) when compared with either of the neighbouring frequencies. Secondly, the seasonal (S)/Trading day (T) peaks must be higher than medium of all frequencies [3]. Spectrum plot (Figure 2) exhibits a peak in the seasonal frequencies at 1/12 which infers the visual significance. No other seasonal cycles are evident at other frequencies such as 2/12, 3/12, 4/12, 5/12 & 6/12.

The ANOVA test as part of X-12-ARIMA output, evaluates the presence of stable and moving seasonality of the time series. Since the time series data points are mutually correlated, the X-12-ARIMA model kept 7 as cut-off value of F statistics instead of usual value four [4]. ANOVA test of deviations between months by assuming stability is used to explore the presence of seasonality and the results are presented in Table 1. The presence of moving seasonality of the given series is also analysed using ANOVA test and is presented inTable2.

Table 1. ANOVA: Presence of seasonality

	SS (Sum of Sq.)	DF (Deg. of Freedom)	MSS (Mean Sq.)	F value
Between months	55.5245	11	5.04768	32.711[##]
Residual	10.6475	69	0.15431	
Total	66.1720	80		

[##]F value at 0.1% level significant shows presence of Seasonality

It is observed from the result of ANOVA analysis presented in Table 1, the F value of 32.71 indicates that the seasonality presents in CPI (IW) series is statistically valid at 0.1% level of significance. The ANOVA analysis result shown in Table 2 indicates that there is no indication of moving seasonality in CPI (IW) series.

Table 2. ANOVA: Presence of moving seasonality

	SS (Sum of Sq.)	DF (Deg. of Freedom)	MSS (Mean Sq.)	F value
Between Years	0.2576	5	0.051517	0.476
Error	5.9574	55	0.108316	

F value at the 0.5% percent level of significance there is no evidence of moving seasonality

The M statistics indicates the features of the time series which may lead to issues while adjusting the time series. The M7 statistics indicates the possibility to determine seasonality by comparing F value greater than 7 in stable seasonality and also three times of F value under moving seasonality. The value of M7 less than 1 is an indication of identifiable seasonality.

Table 3. M Statistics: Presence of identifiable seasonality

1	Proportionate improvement of irregular components over three month's period of CPI (IW).	M_1 = 0.139
2	Proportionate improvement of irregular component to stationary share of variance	M_2 = 0.156
3	Comparison of monthly change in irregular component vs monthly change in trend-cycle	M_3 = 0.000
4	Autocorrelation of irregular components	M_4 = 0.689
5	No. of months CPI(IW) takes to change trend-cycle to outdo the amount of change in irregular components	M_5 = 0.000
6	Irregular components change to seasonal component change during year to year	M_6 = 0.862
7	Volume of moving seasonality proportional to volume of stable seasonality	M_7 = 0.359
8	Magnitude seasonal fluctuations in CPI (IW).	M_8 = 0.603
9	Mean linear movement in seasonal component in CPI (IW).	M_9 = 0.515
10	Magnitude of seasonal fluctuations during recent years	M_{10} = 0.454
11	Mean linear movement in seasonal component in CPI (IW)for recent years	M_{11} = 0.410
The M statistics are between 0 and 3 with an acceptance region from 0 to 1. Accepted at the level 0.35 Q = 0.37 Accepted (except M_2)		

The M statistics results are presented in Table 3, M_7, the volume of moving seasonality comparatively to the volume of stable seasonality, is found to be 0.359. This value is less than 1.0 which indicates that the CPI (IW) series contains identifiable seasonality.

3. Strength of seasonality

The original and seasonally adjusted data of CPI (IW) from January, 2016 to September, 2012 are plotted in Figure 3. It is clear from the figure that the outliers of the original series due to seasonality and periodical/calendar effects are visible in the original series in comparison with the adjusted series.

Figure 3. Original and seasonally adjusted CPI(IW) (Base 2001=100) series

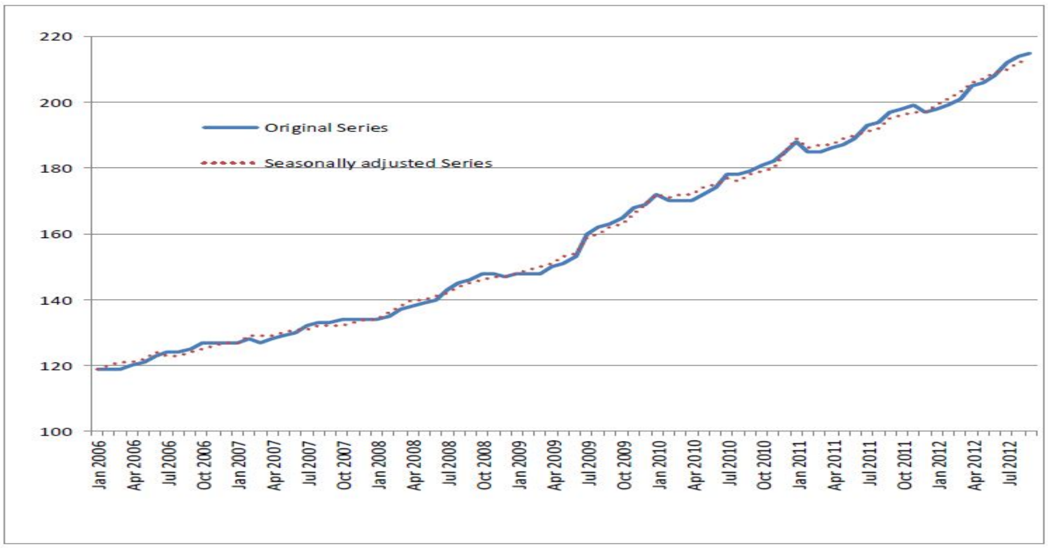
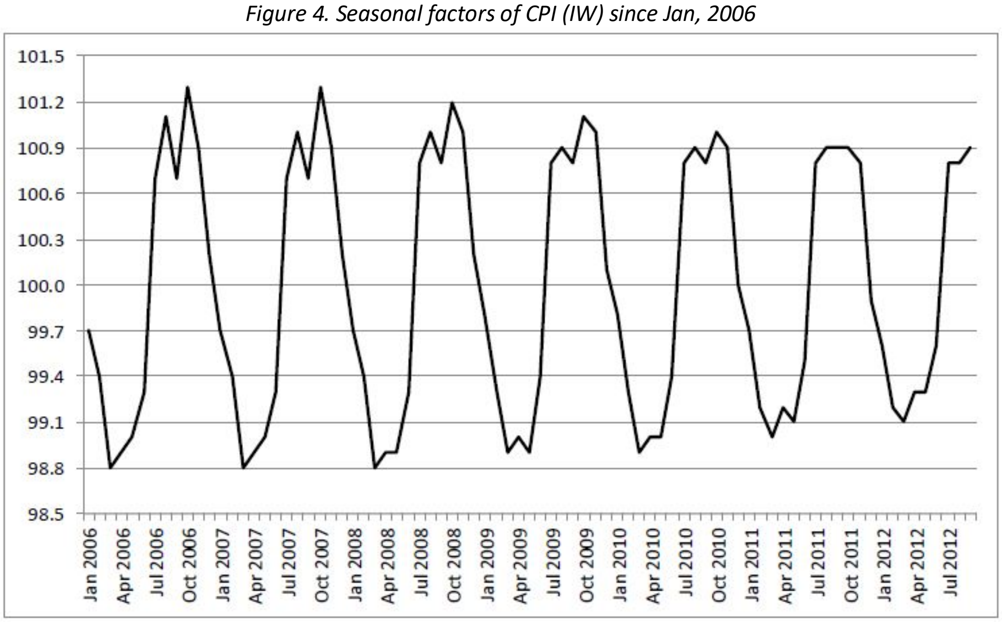


Figure 4 shows the seasonality of CPI (IW) series from January, 2016 to September, 2012. Though the annual seasonality pattern is similar during the study period, the magnitude of seasonality is found decreasing gradually.

Figure 4. Seasonal factors of CPI (IW) since Jan, 2006



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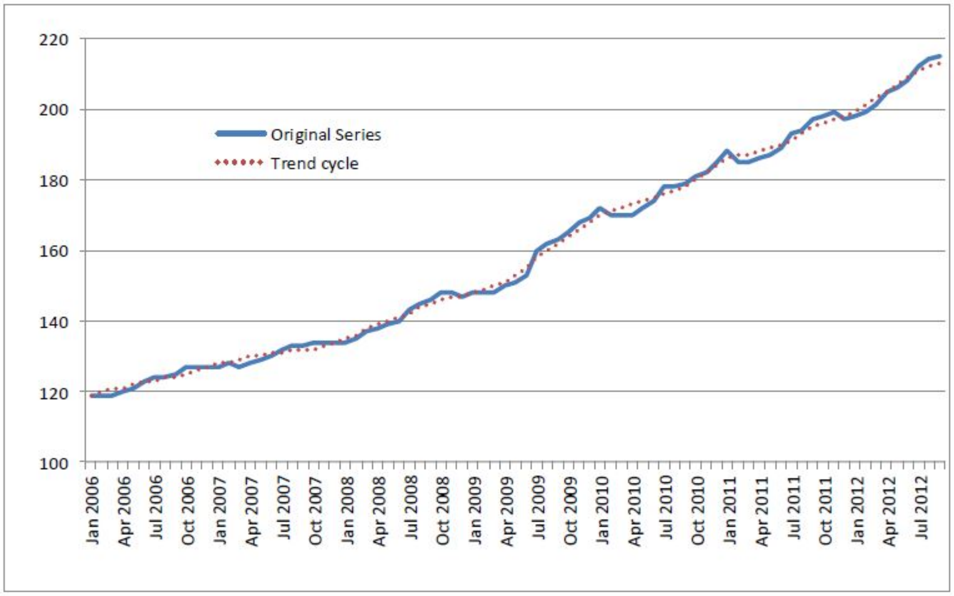
Trend is a long-term tendency of a time series. If a time series is more exposed to random variations than seasonal fluctuations, such cases one can better use trend series instead of seasonally adjusted series as shown in Figure 5.

Figure 5. Original series and trend cycle of CPI (IW) (Base 2001=100) series



Irregular components are often referred as unexpected variations of time series and it is different from trend or seasonal components. Unlike trend or seasonal components, Irregular components are non-systematic. Because of this characteristic, it can't be predicted. Figure 6 shows the irregular components of CPI (IW) series since January, 2006. Month to month percent change in CPI (IW) series, seasonally adjusted series and trend series is also analysed and a comparative analysis is shown in Figure 7.

Figure 6.Irregular components of CPI (IW) since Jan, 2006

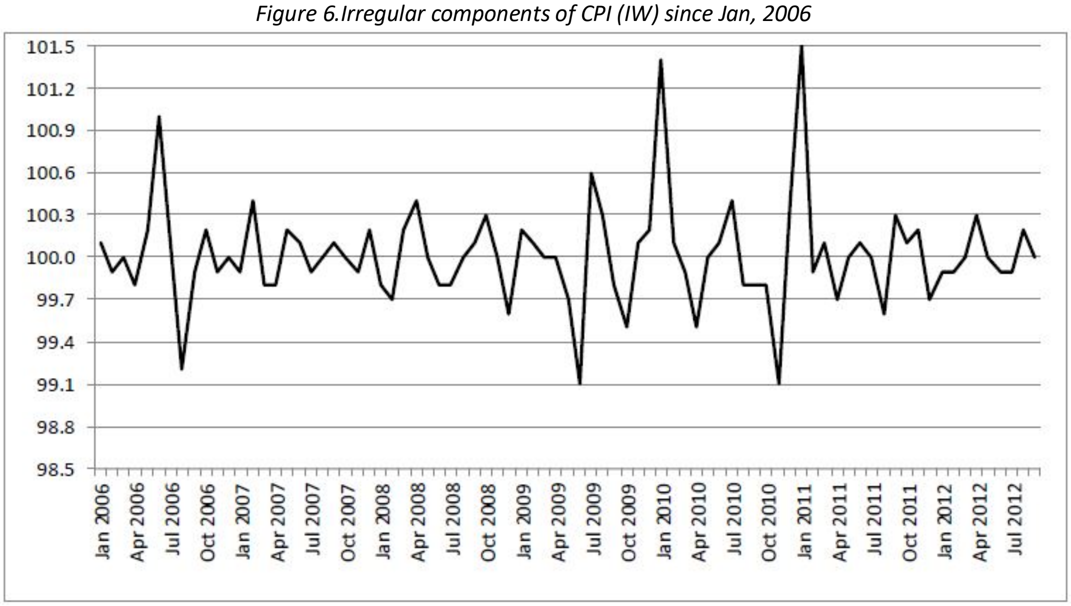


Figure 7. Month to month percent change in CPI (IW) (Base 2001=100) original seasonally adjusted and trend series

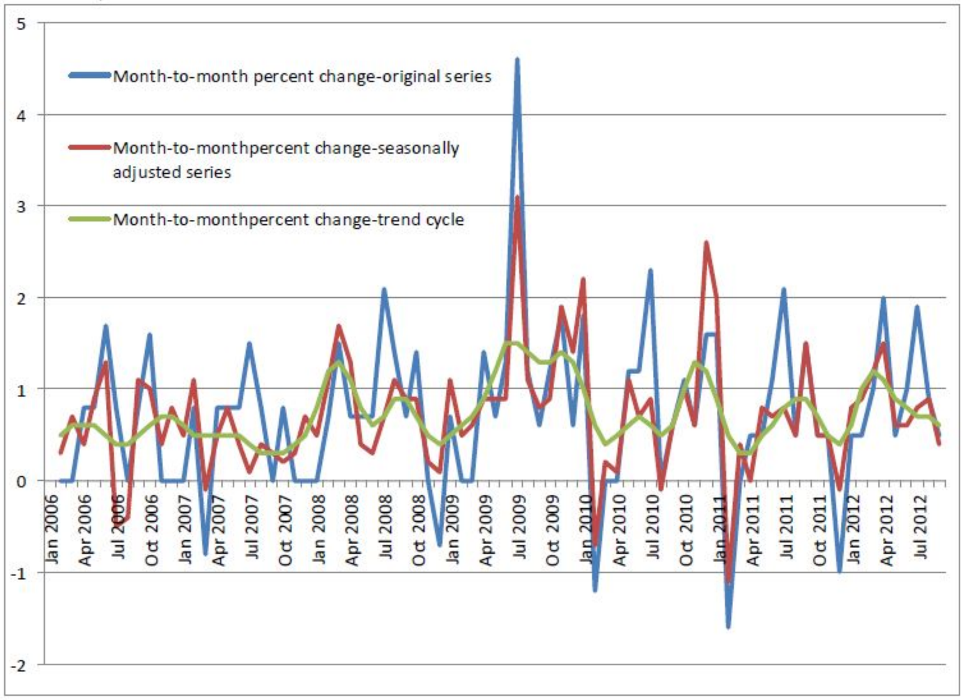
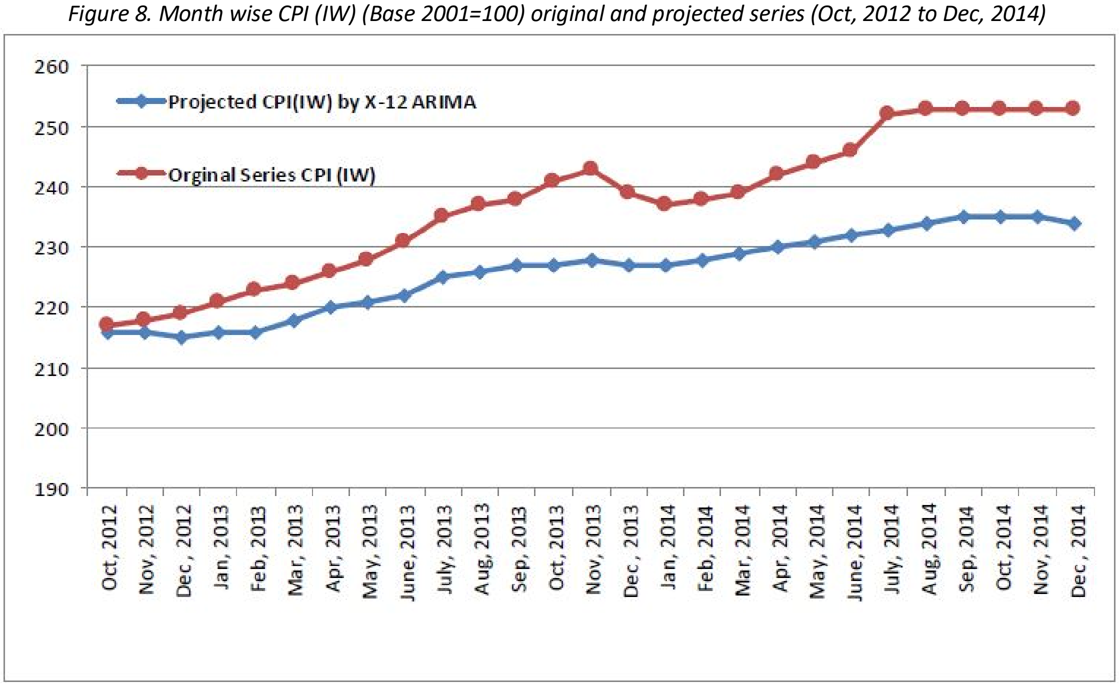


Figure 8 exhibits the projected monthly CPI series using X-12 model and the original series from Oct, 2012 to Dec, 2014. Though, the actual series shows a higher growth when compared with projected series over the period, the pattern of movement over the time period is found to be same [5].

Figure 8. Month wise CPI (IW) (Base 2001=100) original and projected series (Oct, 2012 to Dec, 2014)



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4. Conclusion

In this paper, CPI (IW) base 2001=100 series was analysed using X-12 ARIMA program and the results indicated the presence of seasonality. As part of the result, the model extracted seasonal and irregular components and further estimated the seasonally adjusted series. This procedure supplements the non-seasonally adjusted series with actual changes and seasonally adjusted series along with trend cycle which exhibit underlying developments that provides another dimension for economic analysis. The trend cycle of original series is also generated by X-12 ARIMA. The growth rates of different series namely original seasonally adjusted and trend cycle helps to analysis and compare short span of a series and can also easily detect trend changes.

5. References

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