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Analysis of growth, instability and time series decomposition of price indices of pulses in India

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ABSTRACT

Price analysis of pulses helps to understand trends, variability and seasonality in price series which is useful for different stakeholders such as farmers, consumers, traders and policy makers. Monthly Wholesale Price Indices (WPI) from the Office of the Economic Adviser, Ministry of Commerce & Industry and Monthly Consumer Price Indices (CPI) from the Ministry of Statistics and Programme Implementation were retrieved and analyzed using R software. Time series decomposition was carried out to estimate trends, variability and seasonal components in both WPI and CPI series. Seasonal indices revealed that price indices of pulses were higher during the months of October and November along with higher variability during these months.

Key words: Decomposition, Growth, Instability index, Pulses, Seasonality

Pulses are important food crops that enrich soils and are grown mostly under rainfed conditions in India (81% - 2015-16) which contribute to the instability in pulses production (Reddy, 2013). Pulses are important both from economic and environmental sustainability points of view (Chand et al 2015). As prices often indicate and guide farmers in choosing the crop, variability in prices affect profitability, increases the risk of pulse growers who already bear substantial production risk owing to rainfed cultivation. Price analysis is useful to understand the behaviour of prices at wholesale and retail levels. It provides an overview on trends, variability and seasonality in prices of pulses. Understanding price scenario is useful for policy makers, producers, traders, consumers and the government. In this study, using the time series data on price indices of pulses, an attempt was made to estimate growth rates, variability and to decompose the price series to understand trends and seasonality in pulses in India at wholesale and at retail levels.

Price analysis in pulses has been attempted previously. Darekar and Reddy (2017) forecasted pigeonpea prices by using time series data of monthly average prices (January 2006 to December 2016) using Auto Regressive Integrated Moving Average (ARIMA) models for price forecast using the R programming software. Bisht and Kumar (2019) studied the variability in the prices of pulses in India and noted that fluctuation in prices of pulses was a major concern for decision makers. Authors pointed out that volatility in the price series of pigeonpea was persistent and explosive in recent periods. Sekhar et al (2018) analyzed behaviour of food prices in India at a disaggregate level. After performing econometric analysis authors found that effects of supply and demand factors appeared almost equal in case of prices of pulses. However, cereal and edible oil prices were mainly driven by supply-side factors like production, wage rates, and minimum support prices. But to understand the price scenario both at wholesale and retail level simultaneously, this study used price series at both these levels. This gives additional information about price behaviour at various stages of supply chain and provides information regarding marketing efficiency.

MATERIALS AND METHODS

In India, inflation is being measured using two indices: Wholesale Price Index (WPI) and Consumer Price Index (CPI). CPI captures the price change from the perspective of the purchaser (consumer) while the WPI measures the price changes at wholesale stage. In nutshell, CPI captures the retail prices while WPI is closer to farm prices (farm gate prices plus transport and other handling cost to market). In WPI, the weight given for food items is 24 while it is 39 in case of CPI. In WPI, pulses have the weightage of 0.64 while in CPI, it is 2.38. Both the measures are currently used in India. For CPI the base year is 2012 i.e. 2012=100 and for WPI it is 2011-12. The monthly WPI were collected from the Office of the Economic Adviser, Ministry of Commerce & Industry. The monthly CPI were collected from the Ministry of Statistics and Programme Implementation. Both these two series were collected from the new base year (WPI- 2011-12 series and CPI - 2012 series).

Exponential growth rates were estimated for area, production and yield of pulses over years. The functional form is,

$$y_{(t)} = ab^t e^u$$

Where, $y_{(t)}$ is Dependent variable for which growth rate is estimated

a = intercept

b = regression coefficient

t = time variable (year)

e = error coefficient

u = disturbance term

The growth rate coefficient (b) was computed by transforming the above equation to the log linear form as equation:

Ln $y_{(t)}$ = ln a +t ln b+ u

The method of ordinary least squares was adopted to estimate the coefficients. The compound growth rates (g's) in percentage was computed using the relationship:

g = {(Anti ln of ln b)-1} x 100

The significance of the regression co-efficient was tested using the Student's t-test as

$$t = \frac{b_i}{SE(b_i)}$$

Where, bi is the regression co-efficient of the independent variable

SE (bi) is the standard error of the regression co-efficient bi

t is the calculated t- value.

To measure the instability, Cuddy-Della Valle index (Cuddy and Valle, 1978) was used. This index overcomes the problems associated with coefficient of variation when there is a time trend in the data series. The Instability Index is given by,

Instability Index = CV * $(1-R^2)^{0.5}$

Where, CV is the Coefficient of Variation and is equal to standard deviation/mean

R^2 is the coefficient of determination from time trend regression.

Time series decomposition was carried out to decompose the price series into different time series components such as trend, seasonality and remainder or the noise assuming a multiplicative model (Hyndman & Athanasopoulos (2018). The analysis was carried out using R programming software.

RESULTS AND DISCUSSIONS

Both in terms of Wholesale Price Index (WPI) and Consumer Price Index (CPI) based measures, price indices of pulses were on decline since the peak during 2016 as depicted in Figure 1 and Figure 2. As depicted in both figures, prices of pulses started to increase gradually after the peak during 2016.

Results of growth and instability analysis

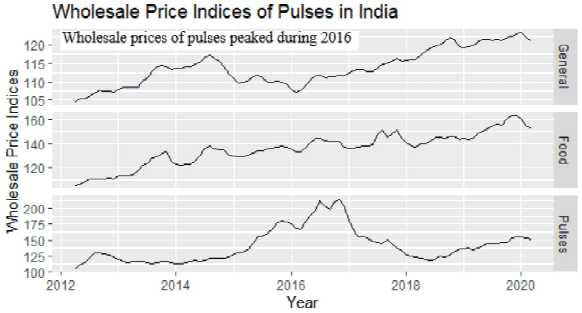

Fig. 1. Monthly Wholesale Price Indices of Pulses in India (April-2012 to March-2020)

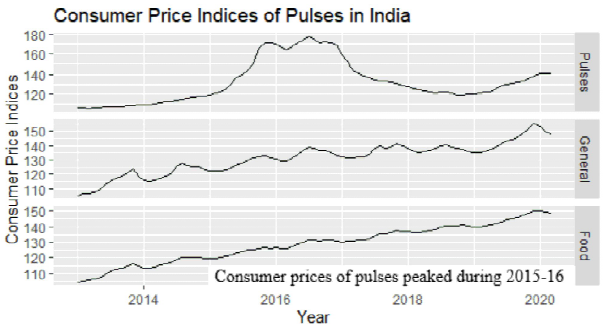

Fig. 2. Monthly Consumer Price Indices of Pulses in India (Jan-2013 to March-2020)

of monthly wholesale and consumer price indices for general, food and pulses categories are presented in Table 1. The monthly compound growth rates were significant for these three categories across CPI and WPI measures. The monthly compound growth rates in pulses indices were lying between the growth rates of general and food categories.

Table 1. Growth and instability in monthly price indices in India (Jan-2013 to March-2020)

Particulars	WPI based measures			CPI based measures		
	General	Food	Pulses	General	Food	Pulses
Growth rate (%)	0.31 ***	0.37 ***	0.21 ***	0.12 ***	0.29 ***	0.23 ***
Instability Index (%)	3.27	1.56	15.23	2.58	3.48	18.07

Note: ***, ** and * indicate significance at 1, 5 and 10 per cent, respectively

The growth and instability analysis of monthly wholesale and consumer price indices for different pulses are presented in Table 2. The results indicated that among pulses, instability in price indices of gram, arhar and urad were on the higher sides in both WPI and CPI based measures.

Monthly inflation rate (%) based on Wholesale Price Indices in India from April-2013 to March-2020 have been depicted in Figure 3. The inflation rates in pulses slipped

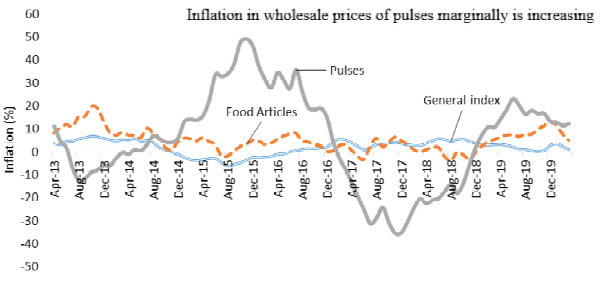

Fig. 3. Monthly inflation rate (%) based on Wholesale Price Indices in India (April-2013 to March-2020)

Table 2. Growth and instability in monthly price indices of pulses in India (Jan-2014 to Feb-2020)

Pulses		Growth rate (%)	Instability Index (%)
WPI based	Gram	0.41 ***	25.41
	Arhar	-0.17 NS	23.76
	Moong	-0.27 ***	12.75
	Masur	-0.4 ***	13.62
	Urad	-0.1 NS	25.51
	Peas/Chawali	0.57 ***	11.66
	Rajma	-0.37 ***	5.04
CPI based	Arhar (Tur)	-0.12 NS	23.29
	Besan	0.44 ***	14.43
	Gram products	0.47 ***	8.70
	Gram split	0.36 ***	17.04
	Gram whole	0.37 ***	15.70
	Khesari	0.28 ***	7.70
	Masur	-0.1 NS	12.08
	Moong	-0.16 ***	9.47
	Other pulses products	0.36 ***	4.34
	Other pulses	0.28 ***	4.41
	peas [Pulses]	0.47 ***	7.69
	Urd	-0.01 NS	20.28

Note: ***, ** and * indicate significance at 1, 5 and 10 per cent, respectively

to negative territory from February-2017 to November-2018. Since December-2018, the inflation rates in pulses were on the positive side.

In Figure 4, monthly inflation rate (%) based on Consumer Price Indices in India from Jan-2014 to March-2020 have been shown. Here, inflation in pulses in percentage terms were negative from December 2016 to April-2019. Since May-2019, the inflation rate in pulses were positive and increasing.

Year-wise seasonal plot of Wholesale Price Indices of pulses in India from April-2012 to March-2020 has been presented in Figure 5. The Wholesale Price Indices of pulses were

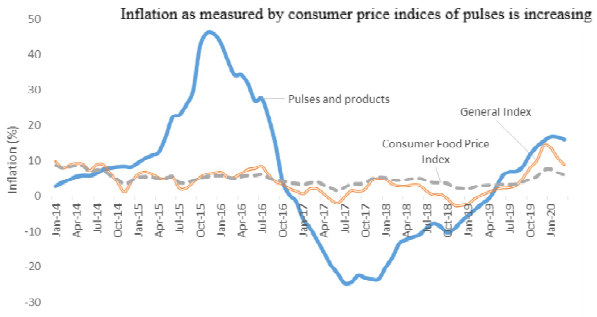

Fig. 4. Monthly inflation rate (%) based on Consumer Price Indices in India (Jan-2014 to March-2020)

plotted against months in year-wise fashion to understand underlying seasonal patterns and to identify years in which the patterns deviate. During the year 2016 and 2015, prices were unusually higher than the rest of the years./ Year-wise seasonal plot of Consumer Price Indices of pulses in India from January-2013 to March-2020 have been presented in Figure 6. In case of Consumer Price Indices as well, the year 2015 and 2016 were on the higher side compared to other years.

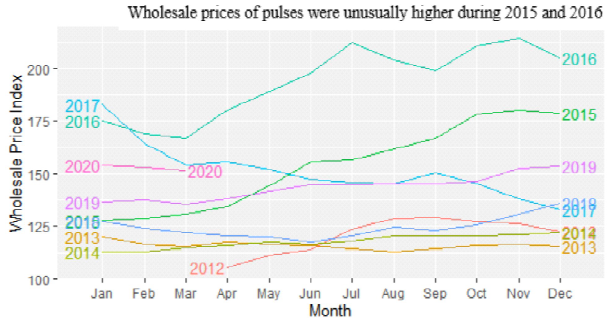

Fig. 5. Year-wise seasonal plot of Wholesale Price Indices of pulses in India (April-2012 to March-2020)

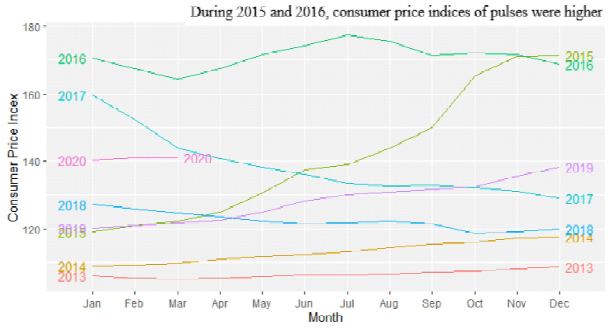

Fig. 6. Year-wise seasonal plot of Consumer Price Indices of pulses in India (Jan-2013 to March-2020)

Boxplot of Wholesale Price Indices of pulses in India (April-2012 to March-2020) is depicted in Figure 7./ Boxplot visually depicts the variability in the series across months. The variability as indicated by boxplots were on the higher side during the months from September to December and from April to June.

Boxplot of Consumer Price Indices of pulses in India (Jan-2013 to March-2020) is depicted in Figure 8. It can be noted that variability was lower during the months from April to August.

Decomposition of multiplicative Wholesale Price Indices of pulses in India (April-2012 to March-2020) have been depicted in Figure 9

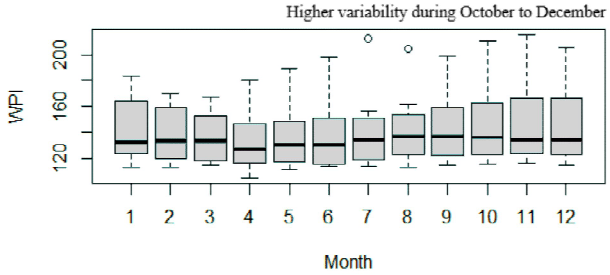

Fig. 7. Boxplot of Wholesale Price Indices of pulses in India (April-2012 to March-2020)

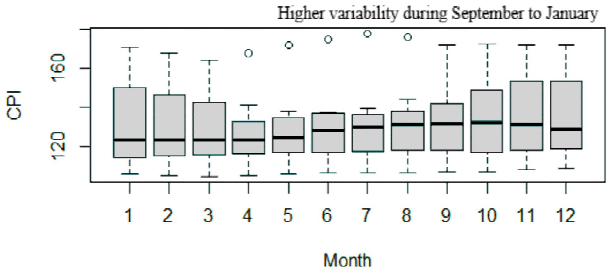

Fig. 8. Boxplot of Consumer Price Indices of pulses in India (Jan-2013 to March-2020)

and decomposition using consumer price indices have been shown in Figure 10. Assuming the multiplicative time series model, wholesale price indices of pulses were decomposed. From Figure 9, it can be observed that price series has been decomposed into trend, seasonal components and the remaining reminder for the noise was separated from these two components. This time series decomposition is helpful in estimating the seasonal indices after removing the trend components. Similar analysis was also carried out for the consumer price index of pulses in India.

Seasonal indices were estimated using the multiplicative decomposition model. Seasonal indices (%) for Wholesale Price Indices of pulses in India (April-2012 to March-2020) have been

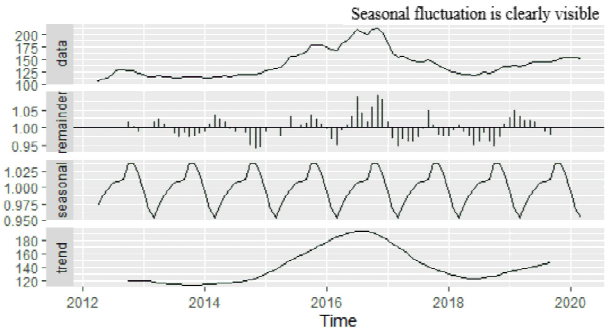

Fig. 9. Decomposition of multiplicative Wholesale Price Indices of pulses in India (April-2012 to March-2020) please add observatory statement in legend

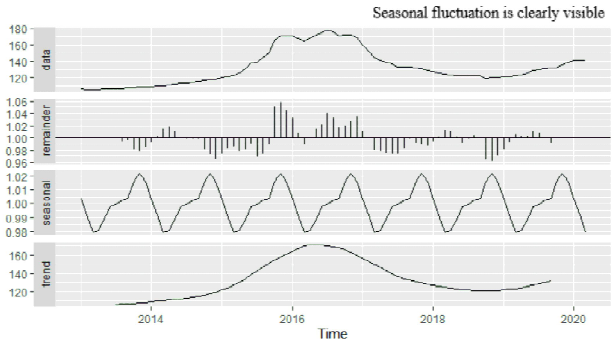

Fig. 10. Decomposition of multiplicative Consumer Price Indices of pulses in India (Jan-2013 to March-2020)

graphically presented in Figure 11. The months of October and November recorded higher levels of seasonal indices whereas the month of March recorded lowest seasonal index.

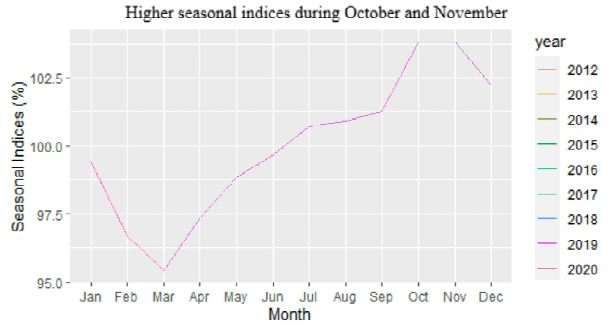

Fig. 11. Seasonal indices (%) for Wholesale Price Indices of pulses in India (April-2012 to March-2020)

Seasonal indices (%) for Consumer Price Indices of pulses in India (Jan-2013 to March-2020) have been presented in Figure 12. As indicated in the Figure 12, from the March onwards till November, price indices were on the rise, whereas price indices declined from November onwards till March. It can be noted that the period from October to December coincides with major festival season in India.

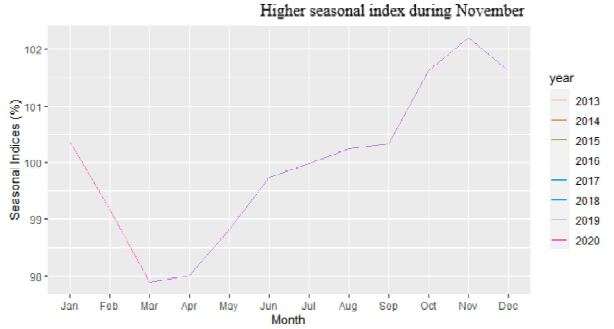

Fig. 12. Seasonal indices (%) for Consumer Price Indices of pulses in India (Jan-2013 to March-2020) please add observatory statement in legend

CONCLUSION

Time series analysis of both consumer and wholesale price indices were carried out, along with time series decomposition to breakdown the time series components into trends and seasonality. This study estimated trends, growth and instability in prices. The inflation rates in pulses based on both consumer and wholesale price were increasing after a period of negative inflation rates in India. The analysis revealed that the major festival period in India, from October to December, coincided with higher levels of prices in pulses in both consumer and Wholesale based price indices clubbed with higher variability during this period. This suggests a need for policy measures to improve the marketing efficiency in pulses to help both consumers and also producers to realize better prices and to establish a stable pulses price regime. Recent policy changes to agricultural marketing in India, have the potential to increase competition among traders which in turn leads to more transparent and efficient markets for pulses in India.

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