

Extraction and Characterization of Price Cycles in the Indian Commodity Market

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Abstract

Characterization of classical and deviation cycles in commodity prices is significant for people involved in the commodity market trade. This paper borrows techniques employed in business cycle literature to extract both classical and deviation cycles present in prices of four agricultural (sugar, tea, rubber, and cotton) and five metal commodities (copper, tin, zinc, lead, and aluminium) traded in the Indian commodity market. Bry-Boschan procedure was used to date the classical cycles; whereas three filtering techniques were used to extract the deviation cycles. Parameters such as the number of cycles as well as the average duration of booms and slumps in classical cycles and deviation cycles were determined and reported. Parameters of the classical cycles were compared with corresponding parameters of cycles in prices of the respective commodities traded in the international market.

Keywords: commodity market, classical cycles, deviation cycles, filtering techniques, Bry-Boschan procedure, duration dependence

JEL Classification : C22, C41, E32

Commodity prices in general show cyclical movements. Knowledge of the average duration of upward or downward price movement of a particular commodity would help policy makers in countries relying on commodity market trade frame efficient counter cyclical stabilization policies. Moreover, it is important to know how much the probability of an end to a period of price boom or slump depends on the duration of the respective period. The importance of identifying deviation cycles stems from the formation of short term counter measures.

Two types of cycles are studied in the literature: classical cycles and deviation cycles. The former reflects the variation of absolute values of economic variables, and the latter reflects the variation of economic variables from which the trend components are removed. For classical cycles, the important properties include: (i) average duration of cycles, (ii) average amplitude of booms (price increase), (iii) average duration of slumps (fall in prices), (iv) correlation between the duration and amplitude of a phase, and (v) the duration dependence of the various phases. For the deviation cycles, important characteristics are the number and average duration of the boom and slump phases, in addition to the number of peaks or troughs.

Methodologies adopted to extract the cycles are those primarily used in the business cycle literature to study the presence of cycles in various economic variables such as the gross domestic product (GDP) (Estrella, 2007; Bonenkamp, Jacobs, & Kuper, 1999). The first methodology used is the Bry-Boschan procedure, a classical cycle dating method used to extract the business cycles and identify their properties (Bry & Boschan, 1971; Cashin, McDermott, & Scott, 1999). Using the same procedure, classical cycles are also extracted from the international commodity prices and properties of these cycles are compared with those of classical cycles present in the Indian commodity prices. The deviation cycles are extracted by first employing different filtering techniques such as the Hodrick-Prescott filter (HP-filter), the Baxter-King filter (BK-filter), and the Cristiano-Fitzgerald filter (CF-filter) to detrend the price data, and then dating the peaks and troughs in the detrended series. The results of applying these techniques to identify the properties of deviation cycles present in the data pertaining to the Indian commodity market are presented in the present study.

Commodity prices in general show cyclical movements. Hence, knowledge of the average duration of an upward or downward price movement of commodities would help policy makers in countries relying on commodity market trade to frame efficient counter cyclical stabilization policies. The speed with which the commodity prices change in

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booms in comparison with slumps can be determined from the relative monthly amplitudes. Moreover, it is important to know how much the probability of an end to a period of price boom or slump depends on the duration of the respective period. As far as exporters are concerned, boom and slump phases induce wide fluctuations in the earnings. The importance of identifying deviation cycles stems from the need to formulate short term counter measures. In this paper, techniques used in business cycle literature are adopted to extract classical and deviation cycles in the prices of four agricultural commodities such as sugar, tea, rubber, and cotton and five metals such as copper, tin, zinc, lead, and aluminium traded in the Indian commodity market.

Classical and Deviation Cycles

If the economic variable $y(t)$ is continuous, the peaks and troughs in the variable plotted against time are simply identified by setting the first derivative of the economic variable with respect to time to zero. As the collected data are discrete in nature, the peaks and troughs are identified by observing that in this case if the variable peaks at time t , $y(t) - y(t-1) > 0$ and $y(t) - y(t+1) > 0$. This can be expressed as $\Delta y(t) > 0$ and $\Delta y(t+1) < 0$. If, on the other hand, the variable attains a minima (trough) at time t , $\Delta y(t) < 0$ and $\Delta y(t+1) > 0$.

Depending on whether the interest lies in finding out variation in the absolute value of y , or the variation about some trend, the cycles are known as classical cycles or deviation cycles. Suppose the economic variable is represented as :

$$y(t) = a + bt + c(t) + e(t) \quad (1)$$

where the variable a represents the drift component, bt represents the trend component, $c(t)$ represents the cyclic component, and $e(t)$ is the error term. If the trend component is filtered out following certain technique, only the pure cyclic component would be left along with the error term. These constitute the deviation cycles.

Methodology Adopted

Two fundamental approaches have been used here to study the cyclic nature of commodity prices. These are, **(i)** the Bry-Boschan procedure to extract the classical cycles, and **(ii)** different filtering techniques, such as the Hodrick-Prescott filter (HP filter), Baxter-King filter (BK filter), and the Christiano-Fitzgerald filter (CF filter) to extract the deviation cycles present in various commodity price times series data.

❖ **The Bry-Boschan Procedure :** The Bry-Boschan procedure automatically generates the turning points in an economic time series and thus, identifies its cyclical properties. This procedure first generates information regarding the basic cyclical movements and then removes those cycles that do not satisfy certain constraints. The basic steps followed in the Bry-Boschan procedure (Bry and Boschan, 1971) are as follows:

❖ **Step 1- Go through the data points in the time series selecting the peaks and troughs as follows:** If $y(t-k) < y(t)$ and $y(t+k) < y(t)$, or if a period of positive growth from time ' $t-k$ ' to ' t ' is followed by a period of negative growth from time ' t ' to ' $t+k$ ', then the value at time ' t ' is identified as a peak; similarly if a period of negative growth from time ' $t-k$ ' to ' t ' is followed by a period of positive growth from time ' t ' to ' $t+k$ ', then we identify a trough at time ' t '.

❖ **Step 2 - Replace the outliers with 12-month moving average:** The outliers are replaced by the moving average values. This step helps in eliminating any noise present in the time series. Later, enforce alteration of peaks and troughs by selecting the highest of multiple peaks or lowest of multiple troughs in the smoothed data series.

❖ **Step 3 - Replace the extreme values by corresponding values in the Spencer curve.** Also, enforce alteration of peaks and troughs and the minimal peak to peak or trough to trough period.

❖ **Step 4 - Refine peaks and troughs with moving average determined by the number of months of cyclical dominance (MCD).** Enforce alteration of peaks and troughs.

❖ **Step 5 - Determine the turning points in the original series:** Refine peaks and troughs with values in the actual series. Also, enforce alternating peaks and troughs and a minimum peak to peak or trough to trough period.

❖ **Filtering Techniques :** Different filtering techniques are used to extract different time domain or frequency domain

components of a time series. In the frequency domain, high-pass filters are those which allow only frequency components above a particular cutoff frequency. So, these effectively remove the low frequency trend component. On the other hand, bandpass filters pass frequency components within a particular frequency band. These remove the trend component as well as the high frequency noise. In the present study, one high-pass filter, that is, the HP filter, and two band pass filters, that is, the symmetric BK filter and the CF filter, were used to extract the cyclic components present in the commodity market data for four agricultural products and five metals. A brief description is given below for each of the filtering techniques and the methodology used for extracting the price cycles. A more detailed description is beyond the scope of this paper, but may be obtained from the cited references.

❖ **The Hodrick-Prescott filter** : The Hodrick-Prescott (HP) filter (Bonenkamp et al., 1999) is used to obtain a smoothed non-linear representation of a time series, which is more sensitive to long-term fluctuations than to short-term fluctuations. Any time series can be represented as a combination of a trend component (τ) and a cyclic component $c(t)$, i.e. :

$$y(t) = \tau(t) + c(t) \quad (2)$$

The effect of short-term fluctuations on the trend component is governed by the parameter λ , which in other words gives a measure of the smoothness of the trend. The equation governing the Hodrick-Prescott filter is one that tries to minimize the cyclical component in the loss function given by :

$$L = \sum_{t=1}^T [y(t) - \tau(t)]^2 + \lambda \sum_{t=2}^{T-1} [\{\tau(t+1) - \tau(t)\} - \{\tau(t) - \tau(t-1)\}]^2 \quad (3)$$

The first part of the right hand side in (3) is the sum of the squared deviations, which penalizes the cyclical component and the second part is λ times the sum of the squares of the second difference of the trend component. To investigate the presence of cycles in a time series using the HP-filter, we use the residuals obtained after smoothing the time series with the HP-filter. As these residuals contain both the cyclic component and the irregular noise component, we identify the cyclic component by applying the Bry-Boschan procedure to the residuals.

❖ **The Baxter-King filter** : The Baxter-King filter (BK filter) is a bandpass filter that separates periodic components of a time series having periods between two distinct values, and by far is the best representation of an ideal filter, which preserves the cyclic components, filtering out all other components (Bonenkamp et al., 1999; Stock & Watson, 1999). The BK filter derives an approximation such that the frequency domain representation of this approximation is closest to the frequency domain representation of the ideal frequency domain filter.

While applying the Baxter-King filter to extract the price cycles, one needs to ascertain the lower and upper limits such that both the trend and the noise components are filtered out, whereas the true cycles present in the commodity price series are preserved. In the present study, we use our knowledge of the price cycles regarding the maximum and minimum duration of a time series, for extracting the deviation cycles.

❖ **The Christiano - Fitzgerald filter** : The Christiano-Fitzgerald filter (CF filter) is another bandpass filter that tries to minimize the same objective function as the BK filter, the only difference being that the objective function is now weighted with the spectrum of the time series (Christiano & Fitzgerald, 2003). The CF filter approaches the ideal filter for a large value of the sample size (ideally, an infinite sample size).

❖ **Statistical Measures** : The statistical measures utilized to study the specific characteristics of the commodity price cycles are briefly explained below :

❖ **Spearman's Rank Correlation Coefficient** : The following procedure is adopted to calculate the Spearman's Rank correlation coefficient between two series - X and Y.

- 1) Convert the elements of the two series to ranks x_i and y_i , $1 \leq i \leq N$.
- 2) Compute the differences, $d_i = x_i - y_i$, $1 \leq i \leq N$.
- 3) Compute the Spearman's rank correlation coefficient as :

$$\rho = 1 - \frac{6 \sum d_i^2}{n(n^2 - 1)}$$

❖ **Brain-Shapiro Test** : The Brain-Shapiro test statistic is a simple non-parametric measure used in business cycle literature to check for duration dependence of the expansion phase (boom phase) and the contraction phase (slump phase) of business cycles or of complete business cycles (Diebold & Rudebusch, 1990). Tests for duration dependence generally estimate a hazard function $h(\tau)$, which gives the conditional probability of a phase ending at a duration τ , given that it has not ended till that time. An increase or decrease in the value of the hazard function respectively indicates positive or negative duration dependence.

❖ Suppose, any phase has an observed set of durations, $\tau_1, \tau_2, \dots, \tau_N$. The Brain-Shapiro statistics for this phase is computed as follows:

i) The durations are sorted in ascending order and are renumbered such that τ_1 is the minimum and τ_N is the maximum duration.

ii) The differences between each pair of durations is estimated as :

$$Y_i = \tau_i - \tau_{i-1}, 2 \leq i \leq N.$$

The Brain-Shapiro test statistic is,

$$Z = \frac{\sum_{i=1}^{N-1} \bar{i} Y_{i+1}}{\sum_{i=1}^{N-1} Y_{i+1} \left[\sum_{i=1}^{N-1} \bar{i}^2 / N(N-1) \right]^{1/2}}$$

Under the null hypothesis that a particular phase does not exhibit duration dependence, the distribution of Z approaches the normal distribution $N(0,1)$ even in small samples (Brain & Shapiro, 1983).

Results and Discussion

Different cycle extraction techniques were applied to Indian commodity prices obtained from the MCX commodity market database obtained from the Indian infoline site (<http://www.indiainfoline.com/Markets/Commodity/>). These are first deflated with the corresponding Indian consumer price index (CPI), and the cycle extraction techniques are applied to the deflated prices. International commodity prices obtained from the website of IMF (<http://www.imf.org/external/np/res/commod/index.aspx>) were also analyzed to extract the classical cycles present therein. These prices were deflated with the US CPI for the corresponding months. The results are as follows:

❖ **Classical Cycle Extraction** : A modified form of the Bry-Boschan procedure was used to identify the classical cycles. The modifications incorporated into the original Bry-Boschan procedure are as follows: both Step-2 and Step-4, where either a 12-month moving average or a short term moving average is taken respectively to eliminate outliers and to refine the peaks and troughs depending on the months of cyclical dominance (MCD), were eliminated from the original procedure. Also, the restriction on the minimum boom or slump duration or the minimum duration between two consecutive booms or two consecutive slumps was removed. These modifications were incorporated in order to identify the characteristics of the commodity price cycles, so that none of the true peaks or troughs are missed. However, Step 3 of the algorithm where Spenser smoothing is applied to the time series data, was used with a view to eliminate the effect of noise.

The Bry-Boschan procedure was applied to the time series data for the prices of four agricultural commodities, such as sugar, tea, rubber, and cotton, and 5 metals, such as copper, tin, zinc, lead, and aluminium. The algorithm was implemented in Matlab. For each of the commodities, the monthly commodity prices were first deflated by dividing them by the CPI of the corresponding month and then, the Bry-Boschan procedure was applied to these deflated prices. The results are depicted in the Figures 1(a) - 1(d) for two agricultural commodity prices and prices of two

Figure 1: Peaks and Troughs in Two Log Deflated Agricultural and Two Log Deflated Metal Commodity Prices in the Indian Commodity Market; the Slump Phases are Shown as Shaded Areas

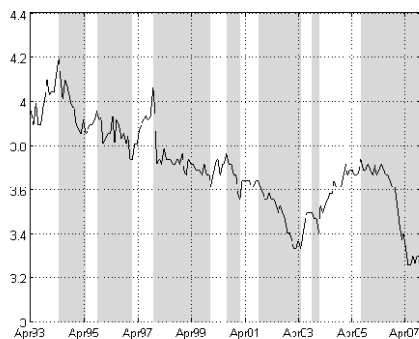


Figure 1 (a) : Log Deflated Sugar Prices

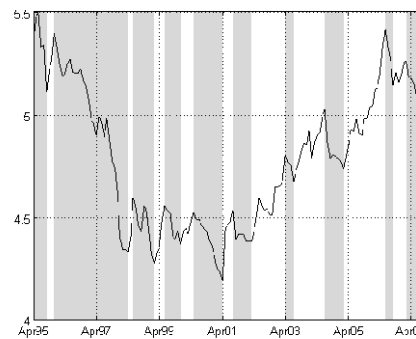


Figure 1(b) : Log Deflated Rubber Prices

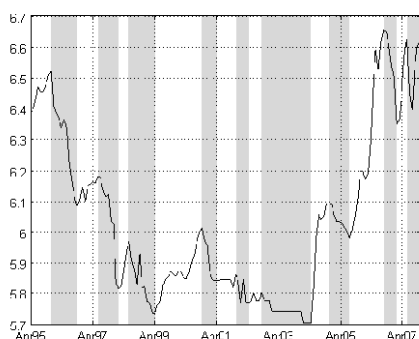


Figure 1(c) : Log Deflated Copper Prices

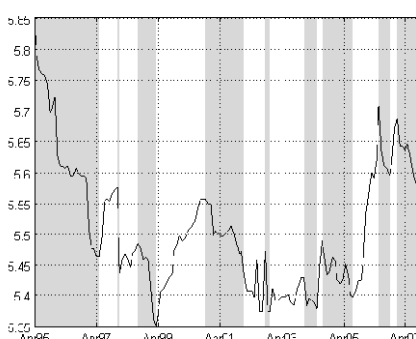


Figure 1(d) : Log Deflated Aluminium Prices

Source: Authors' Research

metals, that is, for sugar, rubber, copper, and aluminium. It is observed from the figures that our implementation of the Bry-Boschan procedure does not identify all of the rises in the commodity prices as booms or all the falls as slumps.

In the Figure 1, the slump phases, that is, peak-to-trough regions, are shown shaded; whereas the boom phases or trough-to-peak regions are shown without any shading. Some of the key observations of the study on Indian commodity market prices are presented in the Table 1. In the Table 1, the column 2 represents the number of identified peaks and troughs. The percentage of the sample period for a commodity in the slump phase (SP) is presented in the column 3. The maximum and average amplitudes of a slump phase, expressed as a percentage of the peak price, are presented in the column 4. Similarly, the period corresponding to the slump phase having the maximum amplitude is shown in the column 5. The maximum and average amplitudes of a boom phase, also expressed as a percentage of the peak price, are presented in the column 6. The period corresponding to the boom phase having the maximum amplitude is presented in the column 7.

The Spearman rank correlation between the durations and amplitudes of the slump phases (SRC_PT) are presented in the column 8. Whereas, the Spearman rank correlation between the durations and amplitudes of the boom phases (SRC_TP) are presented in the column 9. The Spearman rank correlation coefficient gives an idea regarding the extent to which the duration of a boom or slump is related to the corresponding amplitude. To be exact, it shows whether or not there is a corresponding increase/decrease in the amplitude with an increase/decrease in the duration of a phase, and if it is so, then it is up to what extent. Finally, columns 10 and 11 present some statistical data regarding the skewness exhibited by the price data and the excess kurtosis present in them. These are obtained following the methodology presented in Davidson and MacKinnon (1983). First, the residuals are obtained from an ordinary least square regression of the price series against a time trend, and then the formulations presented in the above cited reference are used to estimate the skewness and excess kurtosis. The values of these higher order moments are mostly

Table 1: Log Deflated Commodity Price Classical Cycle Statistics (Prices are Deflated with Indian CPI)										
Commodity/ Sample Period	#Peaks /#Troughs	SP	PT Amp. Maximum/ Average	Duration From-To	TP Amp. Maximum/ Average	Duration From-To	SRC_PT	SRC_PT	Skew- ness	Kurtosis
Sugar/ 04:93-11:07	7/7	62.3	-42.9/-25.9	05:8-07:11	28.6/17.5	04:01-05:08	-0.90	0.69	1.29	7.32
Tea/ 04:97-01:08	8/8	62	-45.1/-30.4	97:12-99:04	39.8/27.9	97:04-97:12	-0.31	0.83	-1.06	6.86
Rubber/ 04:95-09:07	10/10	57	.0-65.4/-24.5	95:12-98:04	49.1/26.6	05:02-06:06	-0.61	0.57	1.28	4.70
Cotton/ 01:98-09:04	4/4	53.7	-21.4/-9.1	00:12-02:05	16.1/10.9	03:04-03:12	-0.80	0.50	-0.36	4.44
Copper/ 04:95-11:07	9/9	51	-35.2/-18.7	95:12-96:10	48.8/18.9	05:07-06:08	-0.14	0.32	3.05	5.18
Tin/ 04:95-11:07	8/8	47.7	-37.1/-19.2	04:10-06:01	44.3/20.5	03:01-04:10	-0.74	0.39	0.29	6.83
Zinc/ 04:95-11:07	8/8	50.3	-48.5/-22.0	06:12-07:11	69.1/24.0	04:09-06:12	-0.68	0.74	2.27	6.84
Lead/ 04:95-11:07	7/7	41	-39.9/-17.8	96:06-98:01	57.0/23.1	05:02-07:10	-0.68	0.69	4.59	8.63
Aluminium/ 04:95-11:07	9/9	54.3	-31.2/-14.0	95:04-97:05	26.6/11.06	05:07-06:05	-0.28	0.22	4.01	7.06
Source: Compiled by the Authors										

Table 2: Log Deflated International Commodity Price Classical Cycle Statistics (Prices are Deflated with US CPI)										
Commodity/ Sample Period	#Peaks /#Troughs	SP	PT Amp. Maximum/ Average	Duration From-To	TP Amp. Maximum/ Average	Duration From-To	SRC (PT)	SRC (PT)	Skew- ness	Kurtosis
Sugar/ 01:80-06:10	18/18	52.0	-85.8/ -38.3	1980:10- 1982:09	67.5/ 39.9	2004:2- 2006:2	-0.67	0.44	3.30	15.60
Tea/ 01:80-06:10	21/21	44.6	-56.8/ -27.6	1984:10- 1985:7	56.3/29.2	1983:6- 1984:1	-0.52	0.35	7.76	16.52
Rubber/ 01:80-06:10	15/15	52.2	-65.66/ -29.06	1995:12- 1999:8	64.8/29.6	2001:12- 2004:4	-0.58	0.77	-0.19	10.46
Cotton/ 01:80-06:10	19/19	56.3	-59.22/ -24.65	1983:8- 1986:8	57.2/ 23.6	1986:8- 1987:8	-0.70	0.61	-2.93	12.64
Copper/ 01:80-06:10	18/18	50.7	-64.37/ -26.73	2008:4- 2008:12	81.6/26.9	2002:9- 2006:5	-0.80	0.68	0.68	9.49
Tin/ 01:80-06:10	14/14	51.4	-57.84 / -28.41/	1985:7- 1986:6	74.1/ 26.1	2005:11- 2008:5	-0.54	0.85	5.13	9.11
Zinc/ 01:80-06:10	21/21	56.40	-74.6/ -24.11	2006:12- 2008:12	72.7/27.9	2005:7- 2006:12	-0.74	0.78	5.80	14.39
Lead/ 01:80-06:10	17/17	50.68	-73.99/ -29.67	2007:10 2008:12	74.1/ 32.5	2006:6- 2007:10	-0.81	0.83	4.84	12.02
Aluminium/ 01:80-06:10	15/15	53.6	-59.36/ -29.63	1988:6- 1990:2	73.4/ 28.9	1985:11- 1988:06	-0.70	0.84	6.26	12.15
Source: Compiled by the Authors										

positive and are found to be greater than 1.96, thus indicating significant positive skewness and excess kurtosis in the price series. The Table 2 compiles the results of identical studies on international prices corresponding to the same commodities obtained by applying the Bry-Boschan procedure. Averaging across all the nine commodities, the following key characteristics of these commodity prices are observed from the Table 1 and Table 2.

i) In the Indian market, there were about six completed cycles in the selected commodity prices on the average of which about 53% of the total time was spent in the slump phases with 41% for lead and 62.3% for sugar. However, in the international market, there were about 16 completed cycles on an average. Out of this, about 52% of the total time was spent in the slump phases, with 44.6% for tea and 56.4% for zinc.

ii) The average of maximum amplitudes for the slumps was about 40%, and the maximum slump amplitude being

65.4% for rubber in the Indian market. However, in the international market, the average of maximum amplitudes for the slumps was about 66.4%, the maximum slump amplitude being 85.8% for sugar. The average amplitude of the price slumps have been expressed as a percentage of the boom prices.

iii) In the Indian market, the average slump amplitude across all the nine commodities was 21%, which was 28.7% in the international market.

iv) In the Indian market, the average slump amplitude for the agricultural commodity prices was about 24%, and that for the metal prices was about 19%. However, in the international market, the average slump amplitude for the agricultural commodity prices was about 29.9%, and that for the metal prices was about 27.7%.

v) In the Indian market, the average of maximum amplitudes for the price booms was about 44%, the maximum boom amplitude being 69.1% for zinc. Similarly, in the international market, the average of maximum amplitudes for the price booms was about 69%, the maximum boom amplitude being 81.6% for zinc. The average amplitude of the price booms have also been expressed as a percentage of the boom prices.

vi) In the Indian market, the average amplitude of price booms across all the nine commodities was about 20%. In the international market, the average amplitude of price booms across all the nine commodities was about 29.4%.

vii) In the Indian market, the average boom amplitude for the agricultural commodity prices was about 24%, and that

Table 3: Average Duration and Duration Dependence of Various Price Cycles in the Indian Commodity Market								
Commodity	Average Duration (months)				Brain-Shapiro Z Statistics			
	Boom Phase	Slump Phase	Peak-Peak Cycles	Trough-Trough Cycles	Boom Phase	Slump Phase	Peak-Peak Cycles	Trough-Trough Cycles
Sugar	10	15.6	22.5	25	-0.33	-1.69	-0.69	-1.63
Tea	7.6	10	16.4	16.1	-1.25	0.39	-0.72	-0.27
Rubber	6.6	8.5	15.8	14.9	-0.57	0.51	-0.64	-1.44
Cotton	9.7	10.7	23.7	20	-0.59	0.90	-1.05	0.21
Copper	9.7	8.6	17.1	16.8	-0.47	0.81	-0.95	-1.03
Tin	10.0	9.0	19.7	18.9	-0.87	-0.05	-1.49	-0.78
Zinc	6.9	9.5	20	18.9	-0.53	0.05	-0.60	0.78
Lead	11.8	8.9	22.7	21.6	-0.17	-0.53	-0.79	-1.01
Aluminium	8.2	9.1	17.5	16.8	-1.04	-0.54	-0.68	-0.18

Source: Compiled by the Authors

Table 4: Average Duration and Duration Dependence of Various International Commodity Price Cycles								
Commodity 1980:1 - 2010:6	Average Duration (months)				Brain-Shapiro Z Statistics			
	Boom Phase	Slump Phase	Peak-Peak Cycles	Trough-Trough Cycles	Boom Phase	Slump Phase	Peak-Peak Cycles	Trough-Trough Cycles
Sugar	9.72	10.56	20.65	20.28	-1.20	-0.38	-1.18	-1.39
Tea	9.62	7.76	17.80	17.38	0.05	-1.41	-1.91	0.63
Rubber	11.07	12.07	24.36	23.13	-0.24	0.53	-1.72	-1.47
Cotton	8.05	10.37	18.78	18.42	-0.32	-1.19	-1.41	-1.46
Copper	9.5	9.8	19.9	19.3	0.62	-0.82	-1.18	-0.50
Tin	12.14	12.86	26.15	25.00	-0.29	-1.52	-0.32	-0.14
Zinc	9.00	8.81	18.00	18.00	1.30	0.41	1.95	2.09
Lead	10.6	10.9	22.5	21.5	-0.37	0.10	-2.74	-1.47
Aluminium	10.80	12.47	24.43	23.27	-0.46	-0.99	-1.51	-0.75

Source: Compiled by the Authors

for the metal prices was about 19%. Whereas, in the international market, the average boom amplitude for the agricultural commodity prices was about 30.57%, and that for the metal prices was about 28.4%. This indicates that there was a comparatively lesser price volatility in the Indian commodity markets.

viii) In the Indian market, the average duration of boom phases was over 9 months, and the average duration of slump phases was about 10 months. While in the international market, the average duration of boom phases was over 10.6 months, and the average duration of slump phases was about 10 months. Thus, the cycles are not symmetric.

ix) In the Indian market, the average rate of decrease of commodity prices during the slump phase was 2.1% per month, and the average rate of increase in commodity prices during booms was 2.3% per month. In the same way, in the international market, the average rate of decrease of commodity prices during the slump phase was 2.7% per month, and the average rate of increase in commodity prices during booms was 2.9% per month.

x) The Spearman's rank correlation coefficient in column 8 and column 9 indicates that except for sugar and cotton in the Indian commodity market, and the metal prices in the international market, there was little or no correspondence between the durations and amplitudes of the boom and slump phases.

The Table 3 and Table 4 compile the value of the Brain-Shapiro test-statistics (z - values) obtained for each of the examined commodity price series. The values were computed for the expansion phase, for the contraction phase, for peak-to-peak cycles, as well as for the trough-to-trough cycles, in the various price data. Assuming a 5% confidence interval under a two-tailed test, if the absolute value for the Brain-Shapiro test statistics is below 1.96, it implies that there is no duration dependence (Cashin et al., 1999). Thus, it is clear from these tables that there is little or no evidence of any duration dependence in the different phases of the commodity prices examined.

❖ Deviation Cycle Extraction

❖ **HP- Filter** : The deviation cycles present in the various commodity prices were extracted by using the three filtering

Figure 2: Deviation Cycles in Log Deflated Sugar Prices in the Indian Commodity Market using HP, BK, and CF Filters; The Slump Regions are Depicted as Shaded Areas

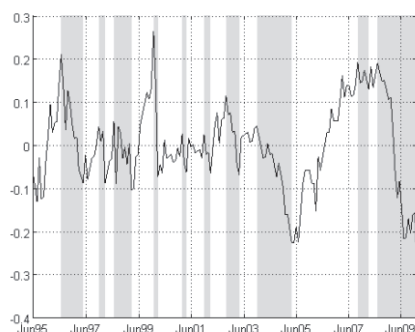


Figure 2(a) : HP filtered sugar price

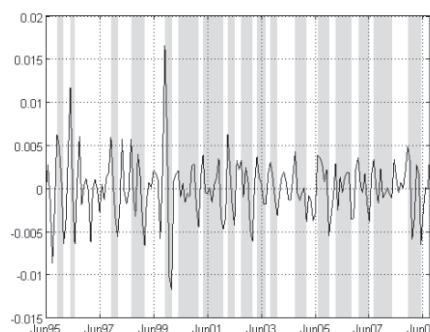


Figure 2(b) : BK sugar price

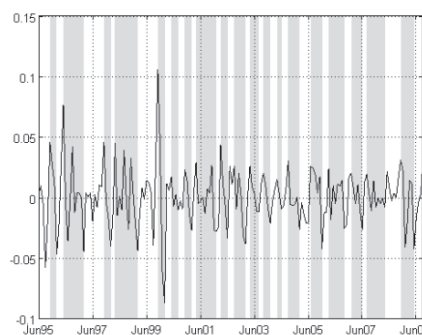


Figure 2(c) : CF filtered sugar price

Source: Authors' Research

techniques implemented by using the Eviews econometric package. The value of the parameter λ was chosen to be 129600 (Ravn & Uhlig, 2002). As discussed before, the Hodrick-Prescott filter is a high pass filter used to detrend a time series. The residues obtained by subtracting the filter output from the original time series gives the cyclic component. Then, a dating technique, which identifies dates at which the price is higher or lower than any other price within four months to either side of the current observation was applied to these residues in order to extract the

Table 5: Characteristics of Deviation Cycles Extracted using Different Filtering Techniques						
Commodity/ #Observations	Number of Peaks	Number of Troughs	Number of +ve Peaks	Number of -ve Troughs	Average Duration of Boom Phases	Average Duration of Slump Phases
Sugar/176						
HP	10	10	10	9	10.2	7.3
BK	17	17	17	17	4.8	5.1
CF	19	19	19	19	3.7	5.0
Tea/130						
HP	11	11	11	11	5.2	6.5
BK	12	12	12	12	4.2	6.2
CF	12	12	12	12	3.8	6.6
Rubber/150						
HP	13	13	12	10	6.0	5.9
BK	15	15	15	15	5.9	4.2
CF	15	15	15	15	5.9	4.2
Cotton/81						
HP	4	4	2	3	16.3	6.5
BK	8	8	8	7	6.9	3.5
CF	9	9	9	8	5.5	3.5
Copper/152						
HP	8	8	7	7	9.6	10.0
BK	14	14	13	14	4.8	5.9
CF	13	13	13	13	5.9	5.7
Tin/152						
HP	9	9	8	7	9.9	8
BK	15	15	15	15	5.1	4.9
CF	15	15	15	15	4.8	5.1
Zinc/152						
HP	9	9	6	9	10.1	7.8
BK	17	17	17	17	4.5	4.0
CF	17	17	17	17	3.9	4.5
Lead/152						
HP	9	9	7	8	8.1	7.8
BK	18	18	18	17	4.1	4.3
CF	16	16	16	15	5.5	4.0
Aluminium/152						
HP	11	11	9	9	7.1	7.3
BK	13	13	13	13	7.7	3.6
CF	13	13	13	13	7.9	3.5
Source: Compiled by the Authors						

Table 6: Classical and Deviation Cycle Characteristics of Selected Commodity Prices using Bry-Boschan Procedure and Different Filtering Techniques										
Commodity/ #Observations	#Peaks (P)	#Troughs (T)	#P BB	#T BB	#P HP	#T HP	#P BK	#T BK	#P CF	#T CF
Sugar/176										
BB	7	6	7	6	6	2	4	4	4	3
HP	10	10	6	2	10	10	4	5	4	5
BK	17	17	4	4	4	4	17	17	16	16
CF	19	19	4	3	4	5	16	16	19	19
Tea/130										
BB	8	7	8	7	8	6	2	2	2	2
HP	11	11	8	6	11	10	3	4	3	4
BK	12	12	2	2	3	4	12	12	11	12
CF	12	12	2	2	3	4	11	12	12	12
Rubber/150										
BB	10	9	10	9	6	8	5	2	5	2
HP	13	13	6	8	13	13	5	2	5	2
BK	15	15	5	2	5	2	15	15	15	15
CF	15	15	5	2	5	2	15	15	15	15
Cotton/81										
BB	4	4	4	4	4	3	1	1	0	1
HP	4	4	4	3	4	4	2	1	0	1
BK	8	8	2	1	1	1	8	8	7	8
CF	9	9	0	1	0	1	7	8	9	9
Copper/152										
BB	9	9	9	9	6	5	2	4	1	4
HP	8	8	6	5	8	8	3	4	2	4
BK	14	14	2	4	3	4	14	14	11	13
CF	13	13	1	4	2	4	11	13	13	13
Tin/152										
BB	8	7	8	7	6	7	3	4	2	3
HP	9	9	6	7	9	9	3	3	3	4
BK	15	15	3	4	3	3	15	15	12	15
CF	15	15	2	3	3	4	12	15	15	15
Zinc/152										
BB	7	7	7	7	5	6	6	3	5	1
HP	9	9	5	6	9	9	6	2	4	1
BK	17	17	5	6	6	2	17	17	14	12
CF	17	17	5	1	4	1	14	12	17	17
Lead/152										
BB	7	7	7	7	5	4	2	1	2	1
HP	9	9	5	4	7	7	2	1	4	4
BK	18	18	2	1	2	1	18	18	16	13
CF	16	16	2	1	4	4	16	13	16	16
Aluminium/152										
BB	8	9	8	9	7	6	3	3	3	2
HP	11	11	7	6	11	11	4	3	4	2
BK	13	13	3	3	3	3	13	13	13	10
CF	13	13	3	2	4	2	13	10	13	13
Source: Compiled by the Authors										

deviation cycles and obtain their specific characteristics.

❖ **Bandpass Filters** : Both the BK filter and CF-filter are also implemented in Eviews. Based on the prior information obtained regarding the classical cycles, the lower and upper cutoff frequencies were chosen to correspond to time periods of eight months and 96 months respectively. Both the BK and CF filtered series directly give the cyclic components. In these cases also, a similar dating technique is applied to the filtered time series to obtain the deviation cycles. The Figure 2 depicts the deviation cycles extracted from the sugar prices in the Indian commodity market using the three filtering techniques. The deviation cycles were extracted by first applying the filtering techniques to remove the time trend and then applying the earlier specified dating rule. The results obtained for the selected agricultural and metal commodity prices in the Indian commodity market are compiled in the Table 5 and Table 6.

Column 1 of Table 5 gives the particular commodity and the filtering technique used. Column 2 and column 3 of this table respectively list the number of peaks and troughs identified. Deviation cycle peaks and troughs should have positive and negative amplitudes respectively. Column 4 records the number of positive peaks and column 5 records the number of negative troughs extracted by the different filtering techniques. It was observed that these two columns are identical or nearly identical respectively to the column 2 and column 3. Thus, it is concluded that the three filtering techniques are able to retrieve the deviation cycles more or less accurately. Column 6 and column 7 give the average durations of booms and slumps in the deviation cycles extracted by using the different filtering techniques. In addition to the number of peaks and troughs identified by each of the filtering techniques, the Table 6 also lists the number of times any two techniques extract the same sample as a peak or a trough. The correspondence between the deviation cycle peaks or troughs extracted by using any of these filtering techniques, and the peaks or troughs in classical cycles extracted by using the Bry-Boschan procedure is also recorded in this table. The specific characteristics of deviation cycles observed in the nine selected commodity prices are listed below :

i) The HP filter just removes the trend components. It, however, cannot remove the noise present. As a result, the shape of deviation cycles extracted by using the HP filter resembles the classical cycles extracted by using the Bry-Boschan procedure. They are, of course, devoid of any positive or negative trend. The maximum amplitude of peaks or troughs extracted by using the CF-filter is almost half of the maximum amplitudes of peaks or troughs extracted by using the HP-filter. And, the maximum amplitudes of peaks and troughs extracted by using the BK-filter is almost one order less than the maximum amplitudes of peaks and troughs extracted by using the CF-filter. Thus, it is concluded that out of the three filtering techniques, the detrending property of the BK-filter is the best.

ii) The number of deviation cycles extracted by the CF filter for any commodity price series closely matches the number of deviation cycles extracted by the BK filter for that commodity. This number of deviation cycles extracted by using the HP filter is always less than this. The average number of deviation cycles extracted by the HP-filter is about eight, whereas the average number of deviation cycles extracted by the BK and CF filter each is about 13. On the other hand, the average duration of the deviation cycles extracted by the HP filter is 16.7 months, whereas the average duration of the deviation cycles extracted by using the BK and CF filter each is 9.9 months.

iii) The average number of deviation cycles observed in the commodity prices is greater than the average number of classical cycles. Consequently, the average duration of the deviation cycles present is smaller than the average duration of the classical cycles.

iv) There is good correspondence between the peaks and troughs extracted by the Bry-Boschan procedure and those extracted by the Hodrick-Prescott filter. Each of the two bandpass filters, that is, the Baxter-King filter and the Christiano-Fitzgerald filter identifies almost the same peaks or troughs as the other.

Conclusion

In this paper, we study the characteristics of classical cycles present in monthly prices of four agricultural and five metal commodities, both in the Indian and the international commodity market. Following the business cycle literature, the Bry-Boschan procedure is employed to extract the classical cycles. Typical characteristics of the classical cycles are presented for data pertaining to both the markets. It is observed that the average duration of the boom phase, the slump phase, peak-to-peak cycles, and slump-to-slump cycles in the commodity prices in the Indian

market is slightly less than what it is in the international market. The average rate of increase or decrease in commodity prices in the Indian market is also less than what it is in the international market.

Specifically for the selected commodities in the Indian market, deviation cycles are also extracted by using three filtering techniques, such as the Hodrick-Prescott filter, the Baxter-King filter, and the Christiano-Fitzgerald filter, along with a dating technique to generate the peaks and troughs in the price data. Out of the three filtering techniques, the Baxter-King filter is concluded to be the best in extracting the deviation cycles. Furthermore, the average number of complete deviation cycles is found to be seven more than the number of complete classical cycles. The average duration of classical cycles is 19 months; whereas, the average duration of deviation cycles is 9.9 months. The average rate of decrease in commodity prices is found to be almost the same as the average rate of increase in the commodity prices. It is finally observed that the commodity price cycles do not have any duration dependence. This is important as with this knowledge, people in the commodity market trade will not misinterpret the movement in commodity prices.

A number of important characteristics of commodity prices have been established in the present paper. With reference to the classical cycles, it is observed that most of the characteristics observed by Cashin et al., (1999) in their work involving the study of the prices of 36 commodities taken from the IMF's international financial database over a period of nearly 42 years are also observed to be true for the Indian commodity market over a shorter period. It is, however, observed that the average amplitude and duration of the boom and slump phases are nearly half of those observed in the international commodity prices.

Future studies can be extended to other important commodities such as energy commodities and precious metals. The various exogenous and endogenous factors affecting the movement in prices in the Indian commodity market can be identified and their effect quantified. In particular, the effect of supply and demand on commodity prices can be measured. Also, co-movement of prices of different commodities and inter-linkages across commodity markets need to be unraveled.

References

- Bonenkamp J., Jacobs, J., & Kuper, G. H. (1999). "Measuring Business Cycles in the Netherlands, 1815-1913: A Comparison of Business Cycle Dating Methods." Research Report No 01C25, University of Groningen, Research Institute SOM.
- Brain, C.W., & Shapiro, S.S. (1983). "A Regression Test for Exponentiality: Censored and Complete Samples." *Technometrics*, 25 (1), 69-76.
- Bry, G., & Boschan, C., (1971). "Cyclical Analysis of Time Series: Selected Procedures and Computer Programs." Technical Paper 20, National Bureau of Economic Research, New York.
- Cashin, P. C., McDermott, C. J., & Scott, A. (1999). "Booms and Slumps in World Commodity Prices." IMF Working Paper, WP/99/155. Washington, DC: IMF, pp. 1-24.
- Christiano, L. J., & Fitzgerald T. J., (2003). "The Band Pass Filter". *International Economic Review*, 44(2), 435-465, DOI: 10.1111/1468-2354.t01-1-00076
- Davidson, R., & MacKinnon, J.G. (1983). "Estimation and Inference in Econometrics." New York: Oxford University Press.
- Diebold, F. X., & Rudebusch, G. D. (1990). "A Nonparametric Investigation of Duration Dependence in the American Business Cycle". *The Journal of Political Economy*, 98 (3), 596-616.
- Estrella, A., (2007). "Extracting Business Cycle Fluctuations: What Do Time Series Filters Really Do?" No. 289, Staff Reports, Federal Reserve Bank of New York, 1-34.
- IMF (2010, August 8). "Primary Commodity Prices." Retrieved from <http://www.imf.org/external/np/res/commmod/index.aspx>
- India Infoline (2009, November 28). "Spot Prices in Commodity." Retrieved from <http://www.indiainfoline.com/Markets/Commodity/>
- Ravn, M. O., & Uhlig, H. (2002). "On Adjusting the Hodrick-Prescott Filter for the Frequency of Observations". *The Review of Economics and Statistics*, 84 (2), 371-380.
- Stock, J. H. & Watson, M. W. (1999). "Business Cycle Fluctuations in U.S. Macroeconomic Time Series." Handbook of Macroeconomics, In: J. B. Taylor & M. Woodford (Eds.), "Handbook of Macroeconomics." Edition 1, Volume 1, Chapter 1, 3-64, Elsevier.
- Wikipedia (2010, April 4). "Hodrick-Prescott Filter." Retrieved from http://en.wikipedia.org/wiki/Hodrick-Prescott_filter