ISSN 0971-1554

JOURNAL OF QUANTITATIVE ECONOMICS

New Series Volume 10, No.1	***January, 2012***
Old Series Volume 26, No. 1	*January, 2010*

Ravindra H. Dholakia & Amey A. Sapre	Speed of Adjustment and Inflation – Unemployment Tradeoff in Developing Countries – Case of India
Indrajit Roy & Dipankar Biswas	Construction of Leading Index of Indian Economy: A Weighted-Cumulative Density Function Approach
Feng Yao	Efficient Semiparametric Instrumental Variable Estimation under Conditional Heteroskedasticity
Radhey S. Singh & Lichun Wang	A Note on Estimation in Seemingly Unrelated Semi-Parametric Regression Models
Chin Wen Cheong, Ng Sew Lai, Nurul Afidah Mohmad Yusof & Khor Chia Ying	Asymmetric Fractionally Integrated Volatility Modelling of Asian Equity Markets under the Subprime Mortgage Crisis
T.V.S. Ramamohan Rao	Firm Specific Monopoly Power in Differentiated Oligopoly
Mohamed El Hedi Arouri, Jamel Jouini, Nhu Tuyen Le & Duc Khuong Nguyen	On the Relationship between World Oil Prices and GCC Stock Markets
Tran Van Hoa	ASEAN-India Economic, Trade and Integration Relations: Modelling the Challenges and Opportunities
Vikash Gautam	Asset Sales by Manufacturing Firms in India
Anup Kumar Bhandari	Global Crisis, Environmental Volatility and Expansion of the Indian Leather Industry
Short Paper	
Suresh K G & Aviral Kumar Tiwari	Long Run and Short Run Linkages between Stock Indices in Bombay Stock Exchange: A Structural Cointegration Approach

JOURNAL OF QUANTITATIVE ECONOMICS

(Journal of the Indian Econometric Society)

New Series Volume 10, No. 1	***January, 2012***
Old Series Volume 26, No. 1	*January, 2010*

Managing Editor: **D.M. Nachane** and *Joint Managing Editors:* **G. Mythili and Rupayan Pal**

CONTENTS **Page**

		Page
Ravindra H. Dholakia & Amey A. Sapre	Speed of Adjustment and Inflation – Unemployment Tradeoff in Developing Countries – Case of India	1
Indrajit Roy & Dipankar Biswas	Construction of Leading Index of Indian Economy: A Weighted-Cumulative Density Function Approach	17
Feng Yao	Efficient Semiparametric Instrumental Variable Estimation under Conditional Heteroskedasticity	32
Radhey S. Singh & Lichun Wang	A Note on Estimation in Seemingly Unrelated Semi-Parametric Regression Models	56
Chin Wen Cheong, Ng Sew Lai, Nurul Afidah Mohmad Yusof & Khor Chia Ying	Asymmetric Fractionally Integrated Volatility Modelling of Asian Equity Markets under the Subprime Mortgage Crisis	70
T.V.S. Ramamohan Rao	Firm Specific Monopoly Power in Differentiated Oligopoly	85
Mohamed El Hedi Arouri, Jamel Jouini, Nhu Tuyen Le & Duc Khuong Nguyen	On the Relationship between World Oil Prices and GCC Stock Markets	98
Tran Van Hoa	ASEAN-India Economic, Trade and Integration Relations: Modelling the Challenges and Opportunities	121
Vikash Gautam	Asset Sales by Manufacturing Firms in India	136
Anup Kumar Bhandari	Global Crisis, Environmental Volatility and Expansion of the Indian Leather Industry	156

Short Paper

Suresh K G & Aviral Kumar Tiwari	Long Run and Short Run Linkages between Stock Indices in Bombay Stock Exchange: A Structural Cointegration Approach	177

Journal of Quantitative Economics, Vol. 10, No. (1), January 2012

CONSTRUCTION OF LEADING INDEX OF INDIAN ECONOMY: A WEIGHTED-CUMULATIVE DENSITY FUNCTION APPROACH

INDRAJIT ROY[1]
DIPANKAR BISWAS[2]

Abstract

This paper constructs a composite index of leading indicator (CILI) for the monthly Index of Industrial Production (IIP) of Indian Economy, using large number of important economic indicators exhibiting leading capability to the target series. These indicators are transformed to percentile-scores by using empirical cumulative density function and CILI is constructed as weighted average. The weights are calculated using linear regression of the target series on the lag values of the individual indicators; thereafter, adjusted R-square values are used as the respective weights. The CILI was constructed based on both growth cycle (using Hodrick-Prescott Filter, and the frequency filters viz., Baxter-King, Christiano-Fitzerald Filters), as well as growth rate cycle techniques. It is observed that, the CILI based on growth rate cycle tracked the movement of IIP cycle well, as compared to the growth cycle method.

Keywords: Business Cycle, Leading Indicators, Cumulative Density Function

JEL Classifications: C1, E3

1. Introduction

The study of business cycles has become increasingly important for the Indian economy in view of its growing inter-linkages with the world economy as well as the changing internal dynamics of the economy. Identification of turning points has become crucial input for the formulation of the monetary and fiscal policy of the country. There have been a large number of studies on indicators for the Indian economy, generally on individual basis (Chitre 1982, 1991, 2001; Hatekar 1994; Dua and Banerji 1999, 2001; etc.). In 2007, the Reserve Bank of India developed composite index of leading indicators for both monthly Index of Industrial Production (IIP) and quarterly Non-agricultural GDP. Moreover, Organisation for Economic Co-operation and Development (OECD) (2005, 2006) is developing a Composite Leading Index on monthly basis, taking the Indian IIP as the reference series.

---

[1] Director, DSIM, RBI, BKC, Bandra (E), Mumbai – 400051, Email: iroy@rbi.org.in

[2] Assistant Adviser, DSIM, RBI, BKC, Bandra (E), Mumbai – 400051, Email: dbiswas@rbi.org.in

The views expressed in this paper are those of the authors' alone and not of the institution to which they belong. An earlier draft of this paper was presented in the 46th Annual Conference of the Indian Econometric Society, held at University of Jammu, Jammu (J&K), during March 4 - 6, 2010. Authors are thankful to the participants of that conference for helpful comments and suggestions. The authors are also thankful to the anonymous referees for their valuable comments and suggestions.

This paper constructs a composite index of leading indicators (CILI) by way of weighted average of important economic indicators which exhibits leading capability to the selected target series, monthly Index of Industrial Production (IIP), for the Indian economy. The empirical Cumulative Density Function (CDF) method was used to translate the cyclical component (obtained through both growth cycle and growth rate cycle methods) of each selected leading indicator series as well as the reference series to a percentile score that make all the indicators as unit free as well as all these indicators follow the same uniform probability density function U(0,1). Moreover, to quantify the strength of leading capability of these indicators, the target series was regressed on the lag values of the individual indicator and, thereafter, adjusted R-square value was used as the measurement of leading capabilities of the individual indicator to the target series. These R-square values were used as weights while combining the CDF values of the selected leading indicators into a composite index. The CILI was constructed based on both growth cycle (using Hodrick-Prescott Filter, and the frequency filters viz., Baxter-King, Christiano-Fitzerald Filters), as well as growth rate cycle techniques.

The rest of the sections is summarised as follows. Section 2 describes the literature review. The methodology for extracting cyclical components and construction of CILI are described in Section 3. The data coverage and empirical analyses are given in Section 4. Lastly, Section 5 presents summary and conclusions.

2. Literature Review

In order to identify turning points of business cycle well in advance, the leading indicators approach was originated from the works of Burns and Mitchell (1946) at the National Bureau of Economic Research (NBER) in the US in the mid-1930. Over the years, the approach was developed at the NBER under the leadership of G.H. Moore, who later founded the Economic Cycle Research Institute (ECRI). The ECRI, based on growth rate cycle methodology, compiles leading, coincidental and lagging indicators for twenty countries all over the world, including India by taking real GDP as the reference series. In the early 1980s, the Organization of Economic Cooperation and Development (OECD) developed its system of composite leading indicators to provide early signals of turning points in economic activity. Currently the OECD compiles composite leading Indicators for 29 of its 30 member countries and for six non-members countries including India, based on growth cycle approach. In the case of Indian economy, OECD used monthly industrial production (IIP) as the reference indicator, and eight economic indicators, *viz.*, Business Confidence Index (quarterly survey by National Council for Applied Economic Research (NCAER)), Imports, Money Supply, Exchange rate (Indian Rupee per US Dollar), Deposit interest rate, stock prices (Bombay Stock Exchange SENSEX based on 30 scrips), production of basic goods and production of intermediate goods were identified as the leading indicators for constructing the composite leading index.

Most of the studies in India on business cycles have followed the growth cycle methodology, though few studies have attempted the growth rate cycle also. Some important studies are mentioned below. Hatekar (1994) described individual historical path of major macroeconomic variables and their co-movements with other variables, for the period 1951-85, based on growth cycle methodology. Dua and Banerji (1999) followed the traditional National Bureau of Economic Research (NBER) methodology for determining the dates of the classical business cycle and growth rate cycles for the Indian economy. A coincidental Index was constructed based on five economic indicators *viz.*, real GDP at factor cost, Index of Industrial Production (IIP), wages to workers in the factory sector, registered unemployment and industrial production of consumer goods. They also constructed a Composite Index of Leading Indicators (CILI) covering broadly three sectors of the economy, *viz.*, monetary, construction and the corporate sectors (Dua and Banerji 2001). Chitre (2001) analysed 94-monthly indicators to study the business cycles in India for the period 1951-1982. The study identified five leading economic indicators for the peaks, and seven leading indicators were identified for the trough. In the Reserve Bank of India (RBI) Report (2007) on Composite Index of Leading Indicators for Indian Economy, the monthly industrial production and quarterly Non-agricultural GDP (NAGDP) were considered as the reference series. The study adopted both the growth cycle and growth rate cycle methodologies and identified four indicators each for IIP growth rate cycle, IIP growth cycle and NAGDP growth rate cycle and five indicators for NAGDP growth cycle (Table A in Annex). The report also suggested construction of Composite Index of Leading Indicators (CILI) after taking simple average of the cyclical component of those selected variables. Ghate, Pandey, and Patnaik (2011) presented a comprehensive set of stylised facts for business cycles in India from 1950 - 2009.

3. Methodology

3.1 Business Cycle Analysis - Approaches

There are two widely-used main approaches to business cycle analysis, viz., Growth Cycles and Growth Rate Cycles. A growth cycle traces the ups and downs through deviations of the actual growth rate of the economy from its long-run trend rate of growth. The classical business cycles are measured in the level of time series, while growth cycles are measured in the deviation-from-trend series. Growth rate cycles are simply the cyclical upswings and downswings in the growth rate of economic activity. The most common form of the growth rates is the month-to-month changes or the same-month-year-ago growth rates. As the former yields relatively noisy series, generally, the year-on-year is preferred in growth rate cycle.

3.2 Selection of Reference Series

In view of tracking the movement of the economic activities at a higher frequency, the monthly Index of Industrial Production (IIP) has been considered as a reference series in this study.

3.3 Estimation of Cycles

In order to extract the cyclical component from a series, two widely-used methods, *viz.*, *Growth Cycle* and *Growth Rate Cycle* methods, applied in this study, are mentioned below.

3.3.1 Growth Cycle

The extraction of cyclical component based on the growth cycle method comprises the following steps:

1. Adjustment for seasonality, using X-12-ARIMA methodology, developed by US Census Bureau (2007).

2. Estimation of trend component, using Hodrick and Prescott (1997) filter; Baxter and King (1999) band-pass filter; and Christiano and Fitzgerald (2003) band-pass filter.
3. Elimination of trend component from the seasonally adjusted series to obtain the cyclical component.
4. Elimination of short-term irregular component, by applying weighted moving average technique (RBI Report 2007).

3.3.2 Growth Rate Cycle

Growth rate cycles are the cyclical upswings and downswings in the growth rate of the economic activity, and hence, the simple annual point-to-point growth rates series is considered as the growth rate cycle. As the growth rate series is expected to be quite volatile, smoothing technique, as described in sub-section 3.3.1, was used to eliminate the short-term volatile components.

3.4 Identifying the Turning Points

For identification of the turning points, Bry and Boschan (1971) rule is followed in this study. The Bry and Boschan procedure suggests the following rules for identification of the turning points:

- Peaks (troughs) are always followed by troughs (peaks).
- The duration of an upswing and downswing regime to be at least six months.
- The minimum length required for any two alternate turning points (a cycle of peak to peak or trough to trough) is 15 months to distinguish business cycle from seasonal cycles.
- Turning points within 6-months of the beginning or at the end of the time series are eliminated.
- A turning point is the most extreme value between two adjacent regimes. If there are two or more equal values satisfying the first three requirements, the most recent is chosen as the turning point of the regime.

3.5 Selection of Leading Indicators

After identification of the turning points, the next step is the selection of the appropriate leading indicators from the set of all indicators. In this study, the list of potential variables, which includes list of indicators, reported by various researchers and agencies together with some forward looking indicators, were thoroughly reviewed on their leading indicator capabilities to the target series. These indicators were of different magnitude in identifying the turning points of the reference series. This was primarily judged by the cross correlation between the reference series and the indicator, as it gives an idea about the information contained in the indicator about the reference series. A higher magnitude of the correlation co-efficient at some lag period indicates the existence of better information contained in the indicator on that period. However, the power of leading capabilities of these indicators changes over the time. To quantify the strength of leading capability of these indicators, the target series were regressed on the lag values of the individual indicators and, thereafter, adjusted R-square value were used as the measurement of leading capabilities of the individual indicator to the target series and used as weights while combining these indicators into a composite index of leading indicators for monthly IIP. For the reference period, the regression equation (1) was built.

$$Y_t = \alpha + \beta_1 X_{t-1} + \beta_2 X_{t-2} + \cdots + \beta_{t-p} X_{t-p} + \varepsilon_t \qquad \text{... (1)}$$

where,

Y_t = Reference series cycle at time 't',

X_{t-i} = Leading indicator cycle at time 't-i', i = 1, 2, ---, p,

p = Maximum lag corresponding to significant coefficient of X, and

ε_t = Error term.

3.6 Translation of Cyclical Components using Cumulative Density Function (CDF) Approach

In probability theory and statistics, the Cumulative Density Function (CDF) completely describes the probability distribution of a real-valued random variable X. For every real number x, the CDF of a real-valued random variable X is given by

$$F(x) = \int_{-\infty}^{x} f(t)dt.$$

In case of sample observations, the popular use of distribution function is empirical distribution function, or empirical cumulative density function, or simply empirical CDF. It is a cumulative probability distribution function that concentrates probability 1/n at each of the 'n' numbers in a sample. By the strong law of large numbers,

$$\hat{F}_n(x) \xrightarrow{a.s.} F(x) \quad \text{for fixed x}$$

where, a.s. denotes almost sure convergence and

$$\hat{F}_n(x) = \frac{\text{number of elements in the sample} \le x}{n} = \frac{1}{n}\sum_{i=1}^{n} I(X_i \le x), \qquad \text{... (2)}$$

is the empirical CDF. In other words, $\hat{F}_n(x)$ is a consistent unbiased estimator of the cumulative density function $F(x)$.

A simple example for translation of cyclical values into percentile score using CDF approach is presented in Table 1. Let, the sample size is 20 and the corresponding cyclical values of a series X are extracted using filtering technique (Column 2 of Table 1). In order to compute the CDF of X, all the 20 values are arranged in increasing order of magnitude, and thereafter, the ordered index (Column (3) of Table 1) for each value is generated. For example, the value '0.000910' corresponds to time '1' is the 9^{th} value in the arrangement, and hence the ordered index is 9. According to Eq. 2, the corresponding CDF is 9/20 i.e. 0.45. Chart 1 displays the similar movement of cyclical series and percentile score over time.

In this study, the empirical CDF method is used for the cyclical component (obtained through both growth cycle and growth rate cycle methods) of each selected leading indicator series as well as the reference series. The CDF method translates cyclical value of each selected time series to the percentile score. The advantage of using CDF method is to bring the indicator series and reference series under same footing so that, comparison as well as aggregation become simpler.

Table 1. Generation of Percentile Score using CDF – An Example

Time (1)	*Cyclical Value (X = x) (2)*	*Ordered Index (3)*	*CDF (4)*	*Percentile Score (5)=(4)*100*
1	0.000910	9	0.45	45
2	0.001495	11	0.55	55
3	0.002288	12	0.60	60
4	0.003171	14	0.70	70
5	0.004020	15	0.75	75
6	0.004712	17	0.85	85
7	0.005138	19	0.95	95
8	0.005212	20	1.00	100
9	0.004875	18	0.90	90
10	0.004106	16	0.80	80
11	0.002916	13	0.65	65
12	0.001353	10	0.50	50
13	-0.000503	8	0.40	40
14	-0.002549	7	0.35	35
15	-0.004663	6	0.30	30
16	-0.006714	5	0.25	25
17	-0.008572	4	0.20	20
18	-0.010116	3	0.15	15
19	-0.011244	2	0.10	10
20	-0.011876	1	0.05	5

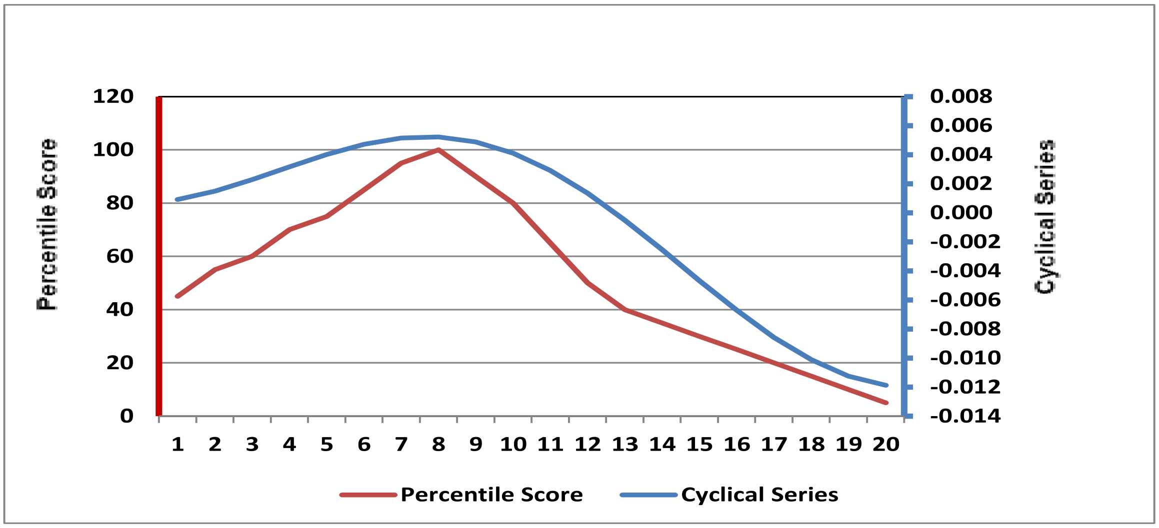

Chart 1. Movement of Cyclical Series and corresponding Percentile Score

3.7 Construction of the Composite Index of Leading Indicators (CILI)

There are two ways to construct a composite leading index. One is to attach different weights to different indicators depending on their relative ex-post predictive power. The other is to give equal weights to all the indicators. In this study, the first approach i.e., weighted aggregation of the CDF values of selected leading indicators was considered. As mentioned in sub-section 3.5, the resultant adjusted R-square values were used as weight.

4. Data Coverage and Empirical Analysis

In order to select indicators based on their leading capabilities, the existing information base was used in the present study. The information base includes national income aggregates, index of industrial production, capital markets, monetary and banking statistics, price statistics, fiscal statistics, trade data, etc. The reference period for this study is 'April 1993 to September 2011'. From the information base and applying the procedure described in sub-section 3.5, eight indicators were finally chosen for the target series IIP (Table B in Annex). Thereafter, the procedures, as described in sub-sections 3.6 and 3.7, were applied to generate the percentile scores of the selected leading indicators and for aggregation, respectively.

4.1 Extraction of Cyclical Components – Monthly IIP and Indicators

The empirical analysis for extracting the cyclical components of monthly IIP and the corresponding leading indicators was carried out for the reference period "April 1993 to September 2011", based on both growth rate cycle as well as growth cycle approaches. In case of extracting growth cycle, the trend component was eliminated from the series (or, seasonally adjusted series, whenever seasonality was significant based on parametric F-test and Non-parametric Kruskall-Wallis test) based on each of four filtering techniques viz., Hodrick-Prescott (HP) filter, Baxter-King (BK) fixed sample symmetric band-pass filter, Christiano-Fitzgerald (CF) fixed sample symmetric band-pass filter, and Christiano-Fitzgerald (CF) full sample asymmetric band-pass filter. The results obtained from different cyclical extraction procedures for IIP are discussed in the sub-sections 4.1.1 and 4.1.2.

4.1.1 Growth Cycles

4.1.1.1 Application of Hodrick-Prescott (HP) filter

The Hodrick-Prescott Filter is a smoothing method that is widely used among macroeconomists to obtain a smooth estimate of the long-term trend component of a series. It is a two-sided linear filter that computes the smoothed series *'S'* of *'Y'* by minimizing the variance of *'Y'* around *'S'*, subject to a penalty that constrains the second difference of *'S'*. The HP filter chooses *'S'* to minimize the expression (3)

$$\sum_{t=1}^{T}\left(Y_t - S_t\right)^2 + \lambda\sum_{t=2}^{T-1}\left(\left(S_{t+1} - S_t\right) - \left(S_t - S_{t-1}\right)\right)^2 \quad \text{... (3)}$$

The penalty parameter λ controls the smoothness of the series. The larger the λ, the smoother is the 'S'. For $\lambda \to \infty$, 'S' approaches to a linear trend.

Before applying HP filter, the presence of seasonality in the IIP and its indicator series was tested, based on parametric F-test and Non-parametric Kruskall-Wallis tests. If the seasonality is present, then the filter was applied on seasonally adjusted series, otherwise on the actual series. The value of λ was selected based on the time domain approach as suggested by Ravn and Uhlig (2002).[3] The CDF values of cyclical components of the indicators were aggregated with weights, to construct the CILI. The growth cycles of IIP and the CILI, based on HP filtering technique, are presented in Chart 2. It is observed that, the peak of IIP couldn't be captured by CILI in two occasions (viz., October 1997 and April 2010), and trough in one occasion (viz., September 2010). In March 1997 and August 1997, the CILI gave false signal of possible occurrences of peak and trough in near future, respectively. Moreover, the peak of IIP cycle in March 2008 was captured in May 2008 by CILI, i.e., 2 months lag. Similarly, the troughs of IIP cycle in January 1997 and October 1998 were captured by CILI with 3 and 2 months lag, respectively. However, the average lead months of CILI for capturing the possible occurrences of peak and trough of IIP cycle were approximately 2 months and 1 month, respectively (Table 2).

Table 2. IIP and CILI Peak and Trough Analysis (Growth Cycle HP Filter)

IIP		*CILI*		*Lead/Lag (Months)*	
Peak Month	*Trough Month*	*Peak Month*	*Trough Month*	*Peak Lead/Lag*	*Trough Lead/Lag*
	Apr-94		Nov-93		5
Apr-96	Jan-97	Feb-96	Apr-97	2	**-3**
Oct-97	Oct-98	**Can't capture**	Dec-98	--	**-2**
May-00	Jun-03	Feb-00	May-03	3	1
Dec-04	Nov-05	Oct-04	Jul-05	2	4
		Mar-07	Aug-07	**false signal**	**false signal**
Mar-08	May-09	May-08	Mar-09	**-2**	2
Apr-10	Sep-10	**Can't capture**	**Can't capture**	--	--
Mar-11		Dec-10		3	
Average	--	--	--	**1.6**	**1.2**

4.1.1.2 Application of Baxter-King (BK) Fixed Sample Symmetric Filter

The Baxter-King (BK) filter is a band-pass filter designed to isolate business cycle fluctuations with a period of length ranging between 18 to 96 months. The resulting filter is a centered moving average with symmetric weights,

$$W_i = W_{-i}$$

[3] Most researchers used the value of 1600 for the smoothing parameter, at the time of using Hodrick and Prescott (1997) filter, while using quarterly data, but there was less agreement in the literature when moving to the other frequencies. In their manuscript, Ravn and Uhlig (2002) provided an analytical investigation into how the smoothing parameter, λ, of HP filter should be adjusted when changing the frequency of observations. The major conclusion was that, the λ parameter should be adjusted according to the fourth power of a change in the frequency. They focussed on the ratio of variance of cyclical component to the variance of the second difference of the trend component. For a particular benchmark stochastic process, it was shown that the time aggregation changed this ratio by the fourth power of the observation frequency. Given that, $\lambda_{quarterly}$ = 1600, the values of λ for annual and monthly frequencies would be $\lambda_{annual} = (1600/4^4) = 6.25$, and $\lambda_{monthly} = (1600*3^4) = 129600$, respectively.

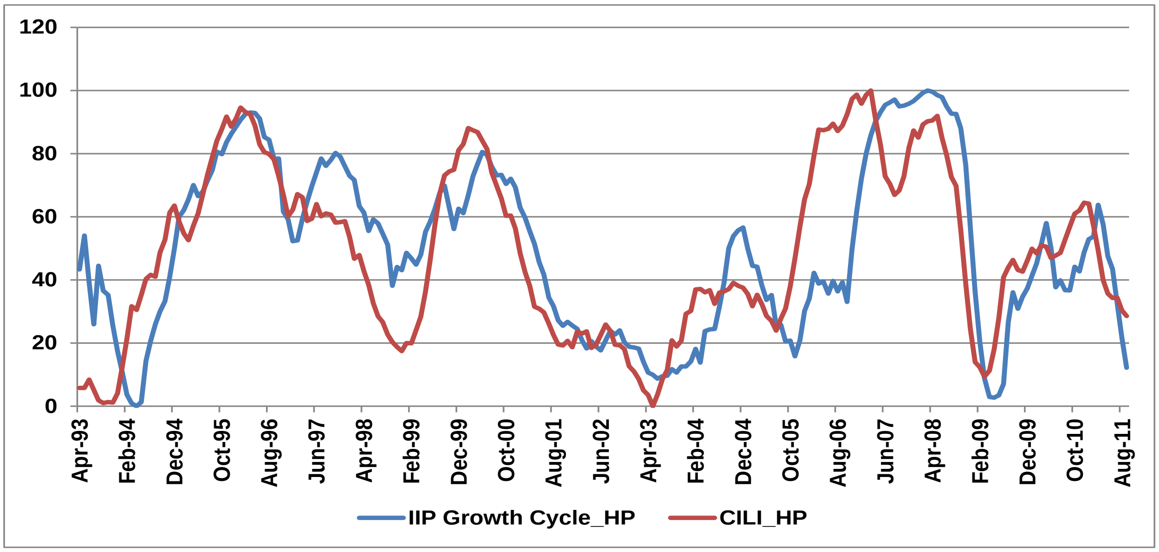

Chart 2. Cumulative Density Function - Growth Cycle for IIP and CILI (HP Filtering Technique)

and, the centered moving averages are,

$$y_t^T = \sum_{i=K}^{K} w_i y_{t-i}$$

Like all moving average smoothers, K observations at the beginning and at the end of the sample are lost in the computation of the filter. Based on this filtering technique, the IIP growth cycle and corresponding CILI are obtained for the period “April 1996 to September 2008” (Chart 3). Here, K = 36 months, and the range of cyclical period is considered as “18 to 36 months”.

It is observed that, based on BK filtering technique, the average lead months of CILI for capturing peak and trough occurrences of IIP cycle were approximately 3 months and 4 months, respectively. However, two false signals by CILI were observed in July 2006 (i.e., peak) and April 2007 (i.e., trough) (Table 3).

Table 3. IIP and CILI Peak and Trough Analysis (Growth Cycle BK Fixed Sample Symmetric Filter)

IIP		*CILI*		*Lead/Lag (Months)*	
Peak Month	*Trough Month*	*Peak Month*	*Trough Month*	*Peak Lead/Lag*	*Trough Lead/Lag*
	Feb-97		Jan-97		1
Oct-97	Oct-98	Aug-97	Oct-98	2	0
May-00	Jan-02	Dec-99	Jun-01	5	7
Aug-02	Jul-03	Mar-02	Jan-03	5	6
Oct-04	Nov-05	Jun-04	Apr-05	4	7
		Jul-06	Apr-07	**false signal**	**false signal**
Jan-08		Dec-07		1	
Average	--	--	--	**3.4**	**4.2**

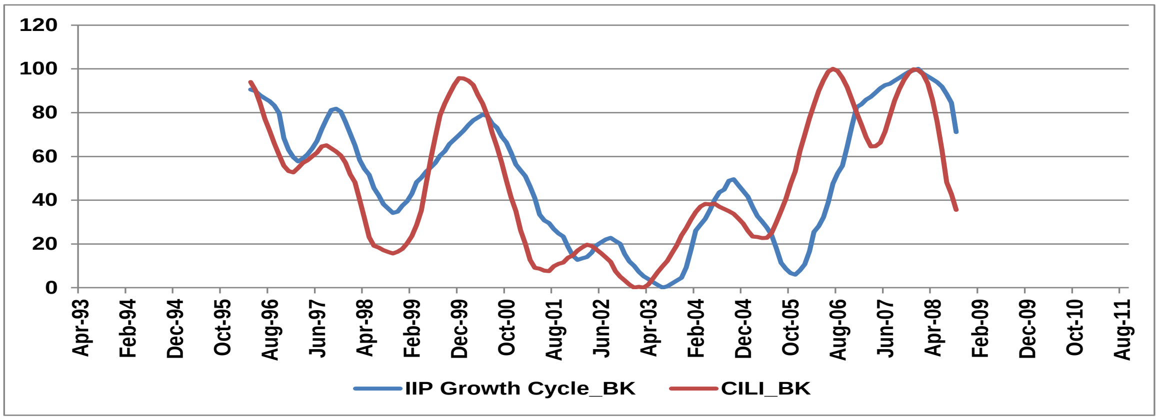

Chart 3. Cumulative Density Function - Growth Cycle for IIP and CILI (BK Fixed Sample Symmetric Filtering Technique)

4.1.1.3 Application of Christiano-Fitzerald (CF) Fixed Sample Symmetric Filter

The filter of Christiano and Fitzgerald (2003) employs a two-sided moving average filter with different weights for every time period. The optimal weights are chosen so that the mean squared error between the ideally filtered series and the finite-sample approximation is minimized. In terms of frequency domain, it may be stated that, the filter weights are adjusted according to the importance of the spectrum at a given frequency. This filter is optimal, in a mean-squared-error sense, for every observation in the sample. The filter can be applied to I(0) and I(1) series. Based on this filtering technique, the IIP growth cycle and corresponding CILI are obtained for the period “April 1996 to September 2008” (Chart 4).

Table 4 displays the average lead months of CILI for peak and trough of IIP cycle to be approximately, 3 months and 6 months, respectively. Similar to BK filter, the CILI indicated two false signals, one for peak in September 2006, and the other for trough in April 2007.

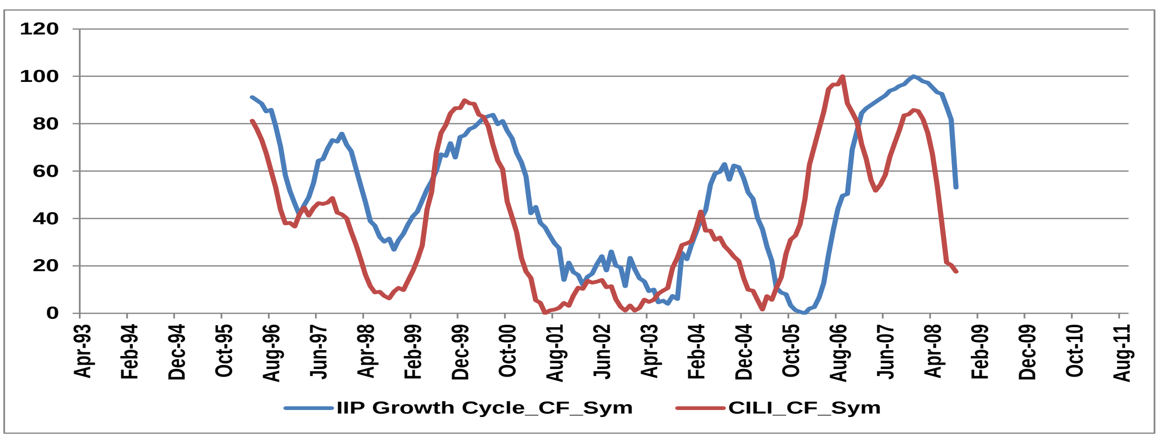

Chart 4. Cumulative Density Function - Growth Cycle for IIP and CILI (CF Fixed Sample Symmetric Filtering Technique)

Table 4: IIP and CILI Peak and Trough Analysis (Growth Cycle CF Fixed Sample Symmetric Filter)

IIP		*CILI*		*Lead/Lag (Months)*	
Peak Month	*Trough Month*	*Peak Month*	*Trough Month*	*Peak Lead/Lag*	*Trough Lead/Lag*
	Feb-97		Jan-97		1
Sep-97	Oct-98	Sep-97	Sep-98	0	1
Jul-00	Feb-02	Jan-00	Jun-01	6	9
Aug-02	Aug-03	Jun-02	Nov-02	2	9
Aug-04	Jan-06	Mar-04	Apr-05	5	9
		Sep-06	Apr-07	**false signal**	**false signal**
Dec-07		Dec-07		0	
Average	--	--	--	**2.6**	**5.8**

4.1.1.4 Application of Christiano-Fitzerald (CF) Full Sample Asymmetric Filter

In case of asymmetric filtering technique, the CF filter uses all the observations in the sample for filtering at every time point. Based on this filtering technique, the IIP growth cycle and corresponding CILI are obtained for the period “April 1993 to September 2011” (Chart 5).

The average lead months of CILI for peak and trough of IIP cycle came out to be approximately, 3 months and 5 months, respectively. Moreover, the CILI indicated two false signals; for peak in July 2006, and for trough in May 2007 (Table 5).

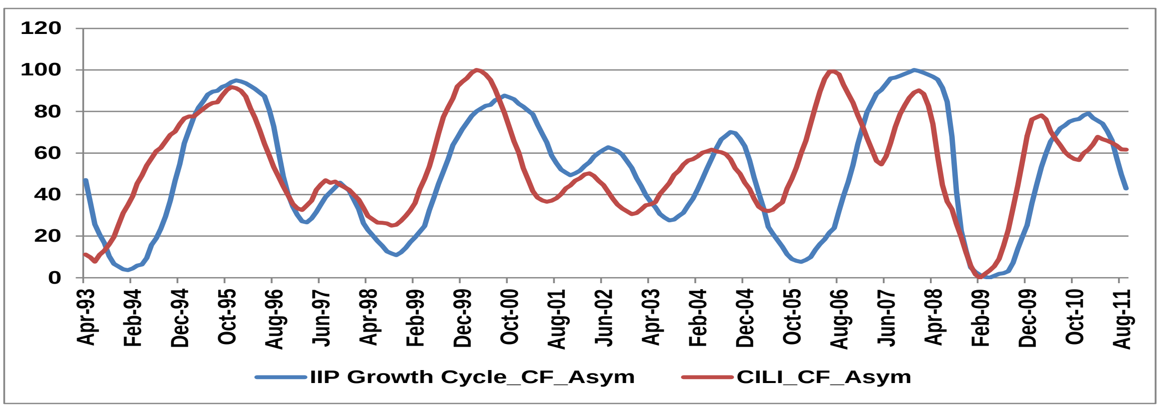

Chart 5. Cumulative Density Function - Growth Cycle for IIP and CILI (CF Full Sample Asymmetric Filtering Technique)

4.1.2 Growth Rate Cycles

Based on the methodology discussed in sub-section 3.3.2, the IIP Growth rate cycle and corresponding CILI were constructed for the period “April 1994 to September 2011” (Chart 6).

The average lead for both of the peak and trough of IIP growth rate cycle was observed as 3 months, approximately (Table 6). No false signal was indicated by CILI. However, in three occasions, the CILI tracked the turning points with one/two months lag.

Table 5. IIP and CILI Peak and Trough Analysis (Growth Cycle CF Full Sample Asymmetric Filter)

IIP		*CILI*		*Lead/Lag (Months)*	
Peak Month	*Trough Month*	*Peak Month*	*Trough Month*	*Peak Lead/Lag*	*Trough Lead/Lag*
	Jan-94		Jun-93		7
Dec-95	Mar-97	Nov-95	Jan-97	1	2
Oct-97	Oct-98	Jul-97	Sep-98	3	1
Sep-00	Nov-01	Apr-00	Jun-01	5	5
Jul-02	Aug-03	Mar-02	Jan-03	4	7
Sep-04	Dec-05	May-04	Apr-05	4	8
		Jul-06	May-07	**false signal**	**false signal**
Dec-07	Apr-09	Jan-08	Feb-09	-1	2
Aug-10		Feb-10		6	
Average	--	--	--	**3.1**	**4.6**

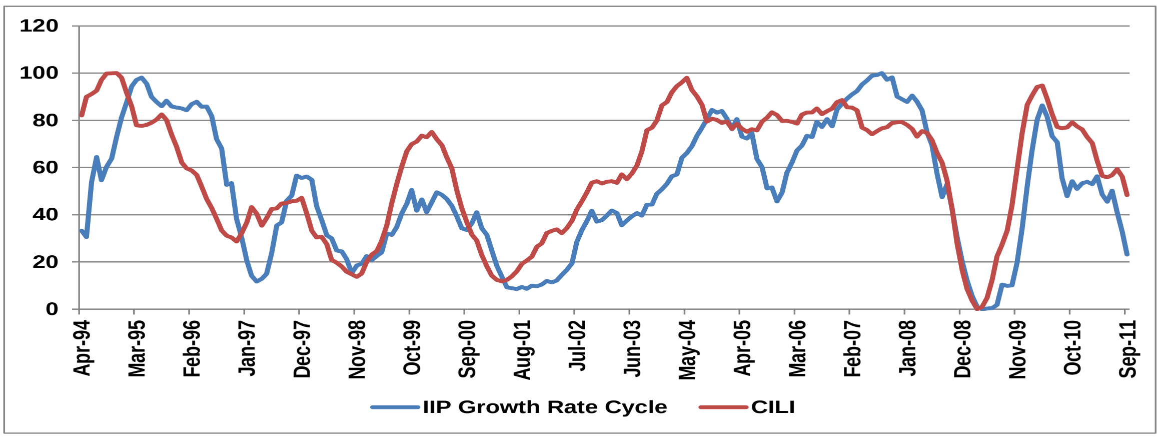

Chart 6. IIP Growth Rate Cycle and CILI

Table 6. IIP and CILI Peak and Trough Analysis (Growth Rate Cycle)

IIP		*CILI*		*Lead/Lag (Months)*	
Peak Month	*Trough Month*	*Peak Month*	*Trough Month*	*Peak Lead/Lag*	*Trough Lead/Lag*
Apr-95	Mar-97	Nov-94	Nov-96	5	4
Nov-97	Oct-98	Dec-97	Nov-98	-1	-1
Oct-99	Jul-01	Dec-99	Apr-01	-2	3
Oct-04	Nov-05	May-04	May-05	5	6
Aug-07	Apr-09	Dec-06	Mar-09	8	1
Apr-10		Apr-10		0	
Average	--	--	--	**2.5**	**2.6**

4.2 Peak and Trough - Summarization

Based on five cyclical extraction methods (four for growth cycle and one for growth rate cycle), discussed in sub-sections 4.1.1 and 4.1.2, the various combinations of turning points of IIP cycle are obtained (Table 7). From these combinations, we now try to notice whether there is any similarity in turning points or not, and hence, the average lead months of CILI for capturing possible occurrence of peak and trough of IIP cycles. It is observed that during the period (1997-2010), the peak/trough as identified by the five different methods fall in the same year but in close vicinity (0-5 months apart).

Table 7. Peak and Trough Months – Five Cyclical Extraction Methods

Year	*Peak Months of IIP Cycle*					*Trough Months of IIP Cycle*				
	HP	*BK*	*CF_sym*	*CF_asym*	*Growth Rate*	*HP*	*BK*	*CF_sym*	*CF_asym*	*Growth Rate*
1994						Apr			Jan	
1995				Dec	Apr					
1996	Apr									
1997	Oct	Oct	Sep	Oct	Nov	Jan	Feb	Feb	Mar	Mar
1998						Oct	Oct	Oct	Oct	Oct
1999					Oct					
2000	May	May	Jul	Sep						
2001									Nov	Jul
2002		Aug	Aug	Jul			Jan	Feb		
2003						Jun	Jul	Aug	Aug	
2004	Dec	Oct	Aug	Sep	Oct					
2005						Nov	Nov		Dec	Nov
2006								Jan		
2007			Dec	Dec	Aug					
2008	Mar	Jan								
2009						May			Apr	Apr
2010	Apr			Aug	Apr	Sep				
2011	Mar									

5. Summary and Conclusions

This paper constructs a composite index of leading indicator based on both growth cycle and growth rate cycle approaches for monthly IIP series, for the period "April 1993 to September 2011", by way of weighted combination of a large number of important economic indicators which exhibits leading capability to the target series. From a large information set, 8 indicators were finally chosen as the leading indicators for IIP. The empirical CDF method was used to translate the cyclical component (obtained through both growth cycle and growth rate cycle methods) of each selected leading indicator series as well as the reference series to a percentile score that make all the indicators as unit free as well as all these indicators follow the same uniform probability density function U(0,1). Moreover, to quantify the strength of leading capability of these indicators, the target series was regressed on the lag values of the individual indicators. Thereafter, adjusted R square value were used as the measurement of leading capabilities of the individual indicator to the target series and used as weights while combining those CDF values of the selected leading indicators into a composite index of leading indicators for IIP.

The paper studied five different techniques (HP filter, BK filter, CF-Symmetric filter, CF-Asymmetric filter and YoY growth rate) to estimate cyclical components. The growth rate cycle methodology was found to be the best methods (out of five selected methods) in constructing the CILI for IIP as it did not produce any false signal of possible peak/trough. The CILI so constructed based on growth rate cycle methodology has average three months lead period for IIP cycle.

References

Baxter, M. and R. G. King (1999) "Measuring Business Cycles: Approximate Band-Pass Filters for Economic Time Series", *The Review of Economics and Statistics,* 81(4), 575–593.

Bry, G. and Boschan, C. (1971) *Cyclical Analysis of Time Series: Selected Procedures and Computer Programs*, NBER Technical Paper No. 20, National Bureau of Economic Research, New York.

Burns, A.F. and W.C. Mitchell (1946) *Measuring Business Cycles*, National Bureau of Economic Research, New York.

Chitre, V. (1982) "Growth Cycles in the Indian Economy", *Artha Vijnana*, Special Issue- Journal of the Gokhale Institute of Politics and Economics, Pune, India, 24(4), 290-450.

-------------- (1991) "Fluctuations in Agricultural Income, Public Sector Investment, World Economic Activity and Business Cycles in India", in Osada, H. and D. Hiratsuka (Eds.), *Business Cycles in Asia*, University Tokyo Press, Tokyo.

-------------- (2001) "Indicators of Business Recessions and Revivals in India: 1951 –1982", *Indian Economic Review*, 36(1), 79- 105.

Christiano, L. J. and T. J. Fitzgerald (2003) "The Band Pass Filter", *International Economic Review*, 44(2), 435-465.

Dua, P. and A. Banerji (1999) "An Index of Coincident Economic Indicators for the Indian Economy", *Journal of Quantitative Economics*, 15(2), 177-201.

------------------------------------- (2001) "An Indicator Approach to Business and Growth Rate Cycles: The Case of India", *Indian Economic Review*, 36(1), 55- 78.

Ghate, C., Pandey, R. and Patnaik, I. (2011) *Has India Emerged? Business Cycle Stylized Facts from a Transitioning Economy*, NIPFP Working Paper No. 88, National Institute of Public Finance and Policy.

Hatekar, N. (1994) "Historical Behaviour of the Business Cycle in India: Some Stylized Facts for 1951-1985", *Journal of Indian School of Political Economy*, 6(4), 684-706.

Hodrick, R. J. and E. C. Prescott (1997) "Postwar U.S. Business Cycles: An Empirical Investigation, *Journal of Money, Credit and Banking*, 29(1), 1-16.

OECD (2005) *Handbook on Constructing Composite Indicators: Methodology and User Guide*, OECD Statistics Working Paper No. 13–2005/3, Organisation for Economic Co-operation and Development.

--------- (2006) *Composite Leading Indicators for Major OECD non-members Economies: Brazil, China, India, Indonesia, Russian Federation and South Africa*, OECD Statistics Working Paper No. 16 – 2006/1, Organisation for Economic Co-operation and Development.

Ravn, M.O. and H. Uhlig (2002) "On Adjusting the Hodrick-Prescott Filter for the Frequency of Observations", *The Review of Economics and Statistics*, 84(2), 371-376, published by The MIT Press.

Reserve Bank of India (2007) *Report on Composite Index of Leading Indicators for Indian Economy*, Reserve Bank of India, Mumbai.

US Census Bureau (2007) *X-12-ARIMA Reference Manual, Version 0.3*, Time Series Staff, Statistical Research Division, Washington, DC 20233-9100, USA.

Annex

Table A. List of Variables Suggested by RBI's Report (2007)

	Index of Industrial Production (IIP)	
	Growth rate cycle	Growth cycle
1	Non-Food Credit	Currency with the Public
2	WPI food article	WPI-Manufactured products
3	Cement production	IIP Electricity
4	US GDP	Cargo handled at Major Ports
	Non-Agricultural GDP (NAGDP)	
	Growth rate cycle	Growth cycle
1	Non-Food Credit	Currency with the Public
2	WPI Food Article	WPI Manufactured Product
3	IIP Capital Goods	Production of Commercial Motor Vehicles
4	US GDP	IIP Electricity
5		Non-oil Import

Table B. List of Variables Selected to Construct CILI for IIP: Monthly Series

Sl. No.	*Indicators*	*Weight for growth rate cycle (in per cent)*
1.	Production of Commercial Motor Vehicles	11.9
2.	Commercial Paper Spread	4.5
3.	Rupees Vs. Dollar Exchange Rate	13.7
4.	Narrow Money (M_1)	19.3
5.	Non-Oil Imports	10.6
6.	Revenue on Railways Freight Traffic	6.0
7.	BSE SENSEX	15.6
8.	Production of Steel	18.6