Asian Development Policy Review
ISSN(e): 2313-8343
ISSN(p): 2518-2544
DOI: 10.18488/journal.107.2019.73.171.190
Vol. 7, No. 3, 171-190

URL: www.aessweb.com

AN ATTEMPT TO PREDICT RECESSION FOR THE INDIAN ECONOMY USING LEADING INDICATORS

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Article History
Received: 4 February 2019
Revised: 7 March 2019
Accepted: 23 April 2019
Published: 17 June 2019

Keywords
Business cycles
Bry-Boschan procedure
Principal component analysis.

JEL Classification:
E32; C38.

ABSTRACT

Every economy is subject to cyclical fluctuations, so it is desirable for policy makers to explore measures that may be taken in advance to ameliorate them. This paper attempts to do so for Indian economy. Growth Cycles and Growth Rate Cycles have been identified with the help of the Bry-Boschan (BB) Procedure, using data for the Index of Industrial Production (IIP). The corresponding Composite Index of Leading Indicators (CILI) for the growth cycle reference series has been constructed using Euro area Leading Indicator Index (EURO_LI), Bombay Stock Exchange-30 price index (BSE_SENSEX), United States Leading Indicator Index (US_LI), Index of Industrial Production- Manufacturing (IIP_MANF), Spread calculated as the difference between Monthly Average of secondary market yield on Government Securities with residual maturity of 10 years and 15-91 days (SPREAD_10_15_91), and Non-oil Imports (NOIL_IMPORTS). And CILI for the growth rate cycle reference series is constructed with leading indicators like Aggregate Deposits of Scheduled Commercial Banks (ADSCB), Bank Credit of Scheduled Commercial Banks (BCSCB), Gold Price (GP_MUMBAI), Index of Industrial Production- Manufacturing (IIP_MANF), and Broad Money (M3). Both composite indices are constructed by employing Principal Component Analysis (PCA). The results indicate that the Indian economy has experienced six growth cycles and five growth rate cycles during the period 1997:06 to 2017:06. The average duration of leads for peak and trough in growth cycles is reported to be 6.4 months and 7.8 months respectively, while the same for growth rate cycles is five months for peaks and three months for troughs. The probability of witnessing a recession in growth and growth rate cycles with forecast horizons of three, six, nine and 12 months, is in the vicinity of 0.4.

Contribution/ Originality: This study contributes to the existing literature by documenting the role of leading indicators in the prediction of business cycles. Its major contribution is in the preliminary testing and scrutiny of candidate variables in the recognition of lead profiles, and the ultimate construction of a composite index of leading indicators.

1. INTRODUCTION

The rationale for dating and predicting business cycles comes from a recognition that cyclical phases such as expansions, contractions, recessions and the like allow economic agents to make necessary adjustments, so minimizing the negative impact of macroeconomic fluctuations. Moreover, macroeconomic policies rely heavily on the prevailing phase of the business cycle (Shah and Patnaik, 2010). Having in view the volatile nature of economic activity (especially in the industrial sector), there is an on-going need to monitor movements within the Indian economy using business cycle analysis. Predicting these cycles is also desirable, in order for appropriate, preventative measures to be taken ahead of time. For policy makers, this means that the identification of expansion and contraction phases is of utmost significance, allowing macroeconomic stabilization to be achieved by implementation of the most appropriate policies.

Accordingly, the leading indicator approach has achieved prominence in the context of business cycle analysis. Its growing significance in the early detection of turning points enables episodes of recession and recovery to be identified ahead of time. This approach places indicators in specific categories. For instance, variables including industrial production, output, and employment levels are used to capture a snapshot of the current state of the economy. These are characterised as "coincident variables". Turning points are identified from a composite index of coincident indicators. There is another set of variables that possess lead profiles. This indicates that they identify the upturn or downturn before the coincident activity. They are, therefore, termed "leading indicators" because they forecast turning points in the reference series, and so may be used for early detection of recession. The third set of variables comprise "lagging indicators" that respond to turning points in the reference series with an element of delayed effect. These serve to firm-up predictions of subsequent episodes of recession and recovery.

In the present context, however, a single series is used as a reference series. Emphasis is then laid on the identification and selection of leading indicators with regard to that reference series. These indicators, then form the composite index of leading indicators, and eventually the employment of that composite index to forecast the reference series, and compute the probability of recession. Subsequently, the predictive ability of the composite index of leading indicators (CILI) and forecast evaluation of the reference series will be undertaken. Nevertheless, the rationale for conducting this study stems from the fact that, although extensive research has been carried out in the area of business cycles at the international level, the evidence is nonetheless scarce with respect to the Indian economy. More clearly, the identification of turning points has been done by many researchers, but the prediction of the probability of recession has been attempted by a few researchers at both national and international levels. Thus, the major contribution of this work is that it contributes to the existing literature by projecting the cyclical activity for the Indian economy, and also sheds light on the role of leading indicators as major tool for predicting the probability of recession.

2. LITERATURE REVIEW

Before proceeding with the empirical analysis, it is pertinent to revisit the literature available on the dating and prediction of business cycles in India and other economies. Several Indian and international researchers have attempted to date and predict business cycles by constructing composite indices and out of those, some important studies have been reviewed for this paper.

Chitre (1982) selected 15 indicators for the Indian economy and constructed a composite index and a diffusion index for dating the growth cycles. Five growth cycles were identified in India from 1951 to 1975 by use of such indices. Gangopadhyay and Wadhwa (1997) analyzed the monthly IIP series for the period 1975 to 1995 and formulated a chronology of Indian business cycles. Mall (1999) examined the cyclical behavior of real GDP, NAGDP, GDP from manufacturing, GDP from a trade, IIP, and the index of sales from the private corporate sector, and concluded that NAGDP can be taken as a reference series for business cycle analysis in India. Dua and Banerji (1999) dated the classical and the growth rate cycles by constructing a coincident index for the Indian economy, following the traditional NBER procedure for the time period 1964 to 1997. The study identified six recessions and five expansions in the Indian economy during that period. In a subsequent paper, Banerji and Hiris (2001) showed that the classical indicator forecasting approach can be refined and applied in a consistent fashion to many economies within a multidimensional framework, allowing for more in-depth analysis, as well as greater breadth of application. This framework can be extended to foreign trade and important domestic sectors like manufacturing, service and construction. For the major 18 economies, business cycle and growth rate cycle reference chronologies have been determined for the period 1948 to 1998. Boehm (2001) reviewed the development of economic indicator analysis (EIA) and its contribution to identifying, understanding, explaining and forecasting business cycles, initially for the US, and then for other countries in North America, Europe and the Asia-Pacific. By contrast, Dua and Banerji (2001) applied a classical leading indicator approach for predicting business and growth rate cycles in India. The indicator approach (attributed to Geofferey H. Moore) was described and the distinction was made amongst classical, growth and growth rate cycles.

Dua and Banerji (2001) constructed a composite leading index covering the monetary, construction and corporate sectors to anticipate business cycles' and growth rate cycles' upturns and downturns. Chitre (2001) analyzed 94 monthly indicators to study business cycles in India for the period 1951 to 1982. The reference series was based on eleven economic indicators. The methodology adopted comprised three different techniques: diffusion index; composite index; and the first principal component. Mohanty *et al.* (2003) attempted the dating of business cycles in India and the construction of a composite leading indicator for forecasting the cyclical turning points. The CLI forecasted the turning points of the reference series with a lead period of about 6 months. OECD (2006) dated growth cycles for the Indian economy between 1978 and 2004 using data on monthly IIP, and identified seven growth cycles with an average duration of 38 months. OECD further developed a CILI for India by selecting eight leading indicators from the initial set of 30. These registered a median lead of only one month for all turning points. Dua and Banerji (2012) described business and growth rate cycles with special reference to the Indian economy. Their study employed the classical NBER approach to determine the timing of recessions and expansions, as well as the chronology of growth rate cycles based on a consensus between coincident indicators. It also described the performance of the leading index: a composite of leading economic indicators, designed to anticipate business cycle and growth rate cycle fluctuations. Aastveit *et al.* (2014) have compared the non-parametric B-B rule with the parametric autoregressive MS model using quarterly mainland Norwegian GDP from the 1980s to 2011 as the business cycle indicator. A forecasting exercise where both methods are augmented by financial indicators and survey data were used. This led to the conclusion that the BB rule applied to a density forecast of GDP, augmented with either the consumer confidence index, or a financial condition index, provided the timeliest predictions of peak while troughs augmented with surveys or financial indicators does not increase forecast ability.

3. DATA SOURCES AND CONSTRUCTION OF VARIABLES

In constructing the composite index of leading indicators, and the prediction of the phases of business cycles in India, turning points in the reference series (i.e. IIP) were first identified, and then 52 leading indicators from all the four sectors: real sector, financial sector, monetary sector, and external sector, for the period 1997:M6 to 2017:M6 were analyzed. Data on these series was obtained from the Handbook of Statistics on Indian Economy, the Reserve Bank of India, the Bureau of Economic Indicators, and the Organization for Economic Co-operation and Development (OECD). The description of all candidate indicators along with their sources are at Appendix 1. Bearing in mind the presence of a positive trend in the growth trajectory of the Indian economy, classical business cycles are not predicted. Rather, the focus has been on dating and prediction of growth and growth rate cycles. Accordingly, the data series are adjusted as per the business cycle approach to which the data is being applied. For instance, the trend adjusted data series are used for growth cycle analysis, while the annual point-to-point growth rate series has been utilized for the growth rate cycle analysis. It is worth noting here that the variables used for growth cycle analysis are suffixed with *"cy"*, while the variables used for growth rate cycle analysis are suffixed with *"gr"*. The upcoming sub-sections report the preliminary analyses used for screening the variables for their leading capabilities and for inclusion in the composite index. For instance, before carrying out any analysis with respect to such screening, it is pertinent to test the presence of seasonality and, in case of affirmative results, the respective variable series are de-seasonalised using the X-12 ARIMA method, developed by U.S. Census Bureau. The examination of seasonality is significant, bearing in mind the monthly frequency of the data at hand. Fisher's test and the Kruskal-Wallis Chi-Squared test of stable seasonality have been employed for testing the presence of seasonality, and for concluding whether the series are seasonal or non-seasonal in nature. The results[1] of both the tests clearly signify that a null hypothesis of significant stable seasonality is rejected at one, five and ten per cent of significance for *ADSCB, BCSCB, CWP, DDSCB, EURO_LI, EXPORT, FCA, FORWARD6, GP_MUMBAI, IIP_BASIC, IIP_CAPITAL, IIP_CD, IIP_CG, IIP_CND, IIP_ELEC, IIP_INT, IIP_MANF, IMPORT_NOIL, IMPORT, INT_OIL, M3, M1, M0, NFC, NIFTY50, REAL_NAGDP, SPREAD_10_1YRC, SPREAD_10_15_91,REALM1, REALM3, RS_DOLLAR, SP_MUMBAI, TDSCBC, USGDP, WPI_ALL, WPI_FA, WPI_MIN, WPI_MP, YIELD_10YR, YIELD_1YR, YIELD_15_91, CEMENT, COAL, ELECTRICITY, RAILWAY, FOODGRAINS, USLI, IIP.* However, *BSE_SENSEX, NET_FII, REAL_YIELD_10YR, REAL_YIELD_1YR, REAL_YIELD_15_91* are found to be non-seasonal in nature. Consequently, there is no need for seasonal adjustment in these series, and the remaining series have been de-seasonalised through the X-12 ARIMA procedure.

For the construction of CILI, all the candidate indicators from different sectors were exposed to cross-correlation analysis and other econometric methods such as unit root testing, bivariate granger causality, VAR granger causality, bivariate cointegration tests, and point to point turning point analysis. All these preliminary analyses are reported in the following sub-sections.

3.1. Cross-Correlation Analysis

Cross-correlation analysis has been utilized in analyzing the lead/lag structure of the candidate series viz-a-viz the reference series. his is done to filter out the leading indicators, which will further enhance the quality of CILI as the potential leading indicator of IIP cycles. The cross-correlation has a very significant role in separating the variables into different categories as leading, coincident and lagging. In so doing, the cross-correlogram has been used. The first approximation of the lead/lag structure of candidate series is done with cross-correlation coefficients and cross-correlograms.

Equation 1 and Equation 2 reflect that the cross-correlation for IIP and the candidate series can be estimated as:

$$crosscorr_{IIP,x}(\rho) = \frac{c_{IIP,x}(\rho)}{\sqrt{c_{IIP,IIP}(0)}.\sqrt{c_{x,x}(0)}} \;, \quad \text{where, } \rho = 0, \pm 1, \pm 2 \tag{1}$$

And,

$$c_{IIP,x}(\rho) = \left\{ \begin{array}{ll} \sum_{t=1}^{T-\rho} ((IIP_t - \overline{IIP})(x_{t+\rho} - \overline{x}))/T & \rho=0,1,2 \\ \sum_{t=1}^{T-\rho} ((x_t - \overline{x})(IIP_{t-\rho} - \overline{IIP}))/T & \rho=0,-1,-2 \end{array} \right\} \tag{2}$$

where, ρ=0,1,2,...... are the lead periods and ρ=0,-1,-2,..... signify the lag periods.

The selection of the lead period involves the comparison of the correlation coefficient with the critical value 0.1059 which corresponds to a five per cent level of significance. The critical value has been computed through the

[1]The interested readers may contact the author for detailed results of Fisher's test and the Kruskal-Wallis Chi-Squared test statistics.

formula $0.1059=1.645/\sqrt{n}$ (where "*n*" represents the total number of observations=241). The cross-correlation coefficients for both the categories are reported in Appendix 2 and Appendix 3 respectively. Ideally, out of all the statistically significant cross-correlation coefficients, the maximum value of the coefficient corresponding to an IIP lag shall be considered as a lead for that indicator, after considering the turning point analysis of specific series against reference series.

3.2. Unit Root Analysis

The augmented Dickey-Fuller (ADF) test has been employed for unit root analysis. The ADF test measures the null hypothesis, *viz*: that a time series process is *I(1)* against the alternative that it is *I(0)*, with the assumption that the series at hand has an Auto-Regressive Moving Average (ARMA) structure. It is worth mentioning here that this technique has been used as a criterion for selection of the appropriate variables for a composite index, with those variables selected from all 52 series that have the same order of integration as the IIP series.

Unit root analysis[2] finds that the reference series for growth cycles - IIP - is stationary at level, and all other candidate series share their level of integration with IIP, i.e. they are integrated at order zero *I(0)*. However, for growth rate cycles, IIP is stationary at first, but the candidate series displays a mix of *I(0)* and *I(1)* orders of integration. For instance, the growth rate series of *M3gr*, *BCSCBgr*, *NFCgr*, *ADSCBgr*, *TDSCBgr*, *GP_MUMBAIgr*, *SP_MUMBAIgr*, *IIP_MANFgr*, *IMPORTgr*, *IMPORT_NOILgr*, and *FCAgr* are stationary at first difference, while all other series are stationary at level. The summary of unit root testing for all the candidate series is reported in Table 1.

3.3. Bivariate Granger Causality

Further, for ascertaining the changes in the candidate series to precede changes in the reference series, the Granger Causality has also been estimated. Conceptually, a variable x Granger causes another variable y if and only if past values of x can help "explain" y over and above what past values of y can already explain. It is worth noting here that Granger Causality offers the bivariate/two-way cause and effect relationship by posing questions such as x Granger causes y, and y Granger causes x, but it itself does not indicate causation in the more common sense. In the context of the business cycle reference series and the candidate leading indicator, Granger causality will be tested in a bivariate regression framework for the pairs of x and IIP series in a group, as explained below:

$$IIP_t = a_0 + a_1 IIP_{t-1} + a_2 IIP_{t-2} + \dots\dots\dots + a_\rho IIP_{t-\rho} + b_1 x_{t-1} + b_2 x_{t-2} + \dots\dots\dots + b_\rho x_{t-\rho} + \varepsilon_t$$

$$x_t = a_0 + a_1 x_{t-1} + a_2 x_{t-2} + \dots\dots\dots + a_\rho x_{t-\rho} + b_1 yIIP_{t-1} + b_2 IIP_{t-2} + \dots\dots\dots + b_\rho IIP_{t-\rho} + \mu_t \quad (3)$$

In Equation 3, IIP is the business cycle reference series and "x" is the candidate series. The null hypothesis as reflected in Equation 4 of x does not Granger cause. IIP is tested against the alternative that x Granger causes IIP and vice versa for each equation. The reported F-statistics are the Wald-statistics for the joint hypothesis:

$$H_0 = b_1 = b_2 = \dots\dots\dots = b_\rho = 0$$
$$H_1 = b_1 \neq b_2 \neq \dots\dots\dots \neq b_\rho \neq 0 \quad (4)$$

Since the Granger Causality is tested for a level stationary series, therefore for the growth cycle reference and candidate series, the pairwise Granger Causality has been used. But for the growth rate cycle reference and candidate series, there is a mixture of *I(1)-I(0)* and *I(1)-I(1)*, so VAR Granger Causality-Wald exogeneity test and

[2] The interested readers may contact the author for the detailed unit root results for both approaches.

VEC granger causality-Wald exogeneity test have been used respectively in those cases. The summary results for both the categories are reported in Table 1.

3.4. Bivariate Cointegration tests

Finally, to establish a relationship between the candidate and the reference series, the bivariate cointegration is tested with the Johansen Test for *I(1)* pairs, and with the ARDL technique for *I(1)* and *I(0)* pairs. However, for the variables which are *I(0)* meaning integrated at the level, cointegration techniques cannot be used since the concept of cointegration applies to level non-stationary series only. So, for level stationary variables, the VAR can be estimated with the optimal lag length and then the VAR Granger Causality or the Block Exogeneity Wald Test can be estimated to establish the short-run relationship between the *I(0)* variables. So, VAR Granger Causality or the Block Exogeneity Wald Test can be used in lieu of cointegration tests with the objective of defining a relationship between the underlying level of stationary variables. For *I(0)-I(1)* pairs, the presence of bivariate cointegration can be inferred from the results of Bound's Test through the value and significance of F-statistic. The existence of long run relationship is inferred from the comparison of F-statistic against the lower and upper bound values corresponding to ten per cent, five per cent, 2.5 per cent and one per cent. However, the being of bivariate cointegration for *I(1)-I(1)* pairs is tested through the Johansen Technique of cointegration. The estimation of cointegration vectors demands knowing the rank of the matrix $\hat{\partial}$. In the case of zero ranks of this matrix, zero cointegration vector in the model is concluded which suggests a lack of cointegrating relationship. Otherwise, when the rank of $\hat{\partial}$ is greater than zero, it attests to the existence of cointegration relationship and cointegrating vectors more than 1. For attaining the information regarding the rank of a matrix $\hat{\partial}$, two techniques, namely Eigen Values and Trace Test, are used.

The summary of results in the order of integration, pairwise Granger Causality in case of growth and growth rate cycles wherein the candidate series Granger causes the reference series, and bivariate cointegration, is reported below in Table 1 in order to scrutinize the variables to be included in the construction of CILI for both approaches.

As per the criteria suggested by Simone (2001) a series will be rejected from the candidacy of leading indicators when its order of integration does not match the order of integration of the reference series, and when it fails to Granger Cause the target variable. However, if the series is not individually cointegrated with the target variable but Granger Causes it and shares its order of integration, then it will be kept for index purposes. Accordingly, it can be inferred from Table 1 that in case of growth cycles, 15 variables, namely, *BSE_SENSEX*, *EURO_LI*, *IIP_BASIC*, *IIP_CAPITAL*, *IIP_CD*, *IIP_MANF*, *IMPORT*, *NIFTY50*, *NOIL_IMPORT*, *RS_DOLLAR*, *SP_MUMBAI*, *SPREAD_10_15_91*, *US_LI*, *YIELD_1YR*, and *YIELD_10YR*, satisfy the criterion laid out by Simone (2001) and therefore they shall be deemed suitable for inclusion in composite index construction. And in case of growth rate cycles, nine variables meet the criterion for sharing the same order of integration and indicator series. Granger Causing the reference series, though, series two does not satisfy the cointegration , but they are also retained as per Simone (2001). Those series selected for growth rate cycles are *ADSCB*, *BCSCB*, *FCA*, *GP_MUMBAI*, *IIP_MANF*, *IMPORT*, *M3*, *NFC*, and *TDSCB*. Of these nine variables, *FCA* and *IMPORT* do not satisfy the cointegration condition.

Table-1. Summary for an order of integration, Granger Causality, and Cointegration: Growth Cycle and Growth Rate Cycle Approach.

Sector to which the variable Belong	Variable	Order of Integration		Granger Causality XgcIIP		Cointegration	
		Growth Cycle	Growth Rate Cycle	Growth Cycle	Growth Rate Cycle	Growth Cycle	Growth Rate Cycle
Monetary and Banking Indicators	M0	I(0)	I(0)	NO	NO	NO	NO
	M1	I(0)	I(0)	NO	YES	NO	YES
	M3	I(0)	I(1)	NO	YES	NO	YES
	REAL M1	I(0)	I(0)	NO	NO	NO	NO
	REAL M3	I(0)	I(0)	NO	NO	NO	NO
	CWP	I(0)	I(0)	NO	YES	NO	YES
	BCSCB	I(0)	I(1)	NO	YES	NO	YES
	NFC	I(0)	I(1)	NO	YES	NO	YES
	ADSCB	I(0)	I(1)	NO	YES	NO	YES
	DDSCB	I(0)	I(0)	YES	YES	YES	NO
	TDSCB	I(0)	I(1)	NO	YES	NO	YES
Financial Indicators	NET FII	I(0)	I(0)	NO	YES	NO	NO
	RS_DOLLAR	I(0)	I(0)	YES	YES	YES	NO
	FORWARD6	I(0)	I(0)	NO	NO	NO	NO
	BSE_SENSEX	I(0)	I(0)	YES	YES	YES	NO
	NIFTY50	I(0)	I(0)	YES	YES	YES	NO
	YIELD_10YR	I(0)	I(0)	YES	NO	YES	NO
	YIELD_1YR	I(0)	I(0)	YES	NO	YES	NO
	YIELD_15_91	I(0)	I(0)	NO	NO	NO	YES
	REAL_YIELD_10YR	I(0)	I(0)	NO	NO	NO	YES
	REAL_YIELD_1YR	I(0)	I(0)	NO	NO	NO	YES
	REAL_YIELD_15_91	I(0)	I(0)	NO	NO	NO	YES
	SPREAD_10_1YR	I(0)	I(0)	NO	NO	NO	NO
	SPREAD_10_15_91	I(0)	I(0)	YES	NO	YES	YES
Price Indicators	WPI_ALL	I(0)	I(0)	NO	NO	NO	NO
	WPLI_FA	I(0)	I(0)	NO	NO	NO	NO
	WPI_MIN	I(0)	I(0)	NO	NO	NO	NO
	WPI_MP	I(0)	I(0)	NO	NO	NO	NO
	GP_MUMBAI	I(0)	I(1)	NO	YES	NO	YES
	SP_MUMBAI	I(0)	I(1)	YES	NO	YES	NO
Real Sector Indicators	IIP_BASIC	I(0)	I(0)	YES	YES	YES	YES
	IIP_CAPITAL	I(0)	I(0)	YES	YES	YES	NO
	IIP_CD	I(0)	I(0)	YES	YES	YES	NO
	IIP_CND	I(0)	I(0)	NO	NO	NO	NO
	IIP_CG	I(0)	I(0)	NO	YES	NO	NO
	IIP_ELEC	I(0)	I(0)	NO	YES	NO	NO
	IIP_MANF	I(0)	I(1)	YES	YES	YES	YES
	IIP_INT	I(0)	I(0)	NO	YES	NO	YES
	REAL NAGDP	I(0)	I(0)	NO	NO	NO	NO
	FCA	I(0)	I(1)	YES	YES	YES	NO
	COAL	I(0)	I(0)	NO	YES	NO	YES
	CEMENT	I(0)	I(0)	NO	YES	NO	YES
	ELECT	I(0)	I(0)	NO	YES	NO	YES
	STOCK_FOOD	I(0)	I(0)	NO	NO	NO	NO
	RAILWAYS	I(0)	I(0)	NO	NO	NO	NO
External Sector Indicators	EXPORT	I(0)	I(0)	NO	NO	NO	NO
	IMPORT	I(0)	I(1)	YES	YES	YES	NO
	NOIL_IMPORT	I(0)	I(1)	YES	NO	YES	NO
	USGDP	I(0)	I(0)	NO	NO	NO	NO
	US_LI	I(0)	I(0)	YES	YES	YES	NO
	EURO_LI	I(0)	I(0)	YES	YES	YES	NO
	INTL_OIL	I(0)	I(0)	NO	NO	NO	NO

Source: Author's Elaborations.

Thus, 15 variables are selected for the construction of CILI for growth cycles, and nine variables are selected for constructing the CILI of growth rate cycles from the unit root and econometric testing procedures. Nonetheless, these selected variables will now be subjected to point to point analysis in order to designate them as leading indicators with sufficient lead profiles.

4. TURNING POINT ANALYSIS OF SELECTED VARIABLES

The identification of turning points in the variables chosen in the previous section, and then the comparison of their turning points with those in IIP growth cycle and IIP growth rate cycle respectively, help in ascertaining the lead/lag characteristic of the candidate variables. Point to point analysis[3] of the growth cycle series show that *BSE_SENSEX* had an average lead of 1.7 and 1.9 months, *NIFTY50* a lead of 4.3 and 2.6 months, *SPREAD_10_15_91* a lead of eight and 3.7 months, *IIP_BASIC* a lead of 3.6 and 4.2 months, and *IIP_MANF* a lead of 1 and 4.3 months. *NOIL_IMPORT* reflected the average lead of 3.4 and 2.2 months, *US_LI* registered the average lead of 4.2 and 0.5 months and *EURO_LI* showed the average lead of 2.6 and 0.8 months for peaks and troughs respectively identified in the reference series IIP. However, variables such as *RS_DOLLAR*, *YIELD_1YR*, *YIELD_10YR*, *SP_MUMBAI*, *IIP_CAPITAL*, *IIP_CD*, and *IMPORT* administered a lag relationship with the reference series in respect of peaks and troughs. However, of the seven chosen series as lead indicators, finally, series six, *BSE_SENSEX*, *EURO_LI*, *IIP_MANF*, *NOIL_IMPORT*, *SPREAD_10_15_91*, and *US_LI*, are selected with an average lead[4] of four, four, six, six, six and four months respectively, to be included in the construction of a composite index. *NIFTY50* was dropped to avoid double accounting, with *BSE_SENSEX* and *IIP_BASIC* also excluded given *IIP_MANF* was a more suitable candidate for inclusion.

For growth rate cycles, eleven series were initially chosen, and of them six series - *ADSCB*, *BCSCB*, *GP_MUMBAI*, *IIP_MANF*, *M3* and *TDSCB* - exhibit an average lead of ten and 5.6 months, 6.2 and 11.8 months, five and 7.5 months, 1.8 and 1.6 months 5.3 and two months and 10.2 and 13.5 months respectively for peaks and troughs identified in IIP. The other three series - *FCA*, *NFC*, and *IMPORT* - registered a lag behavior with respect to turning points identified in growth rate cycle reference series IIP. Finally, five series - *ADSCB*, *BCSCB*, *GP_MUMBAI*, *IIP_MANF*, and *M3* - were chosen for constructing the CILI with an average lead of nine months, six months, five months, six months and seven months respectively. *TDSCB* was dropped to avoid double counting with *ADSCB*.

5. CONSTRUCTION OF CILI FOR GROWTH CYCLE AND GROWTH RATE CYCLE THROUGH PCA

After carrying out the cross-correlation analysis, unit root testing, bivariate Granger Causality, bivariate cointegration testing and turning point analysis, eventually, *EURO_LI*, *BSE_SENSEX*, *US_LI*, *IIP_MANF*, *SPREAD_10_15_91*, and *NOIL_IMPORTS* were selected to form a composite index for predicting the growth cycles in IIP. *ADSCB*, *BCSCB*, *GP_MUMBAI*, *IIP_MANF*, and *M3* were chosen to form a composite index to predict growth rate cycles in IIP. Composite index construction is accomplished through Principal Component Analysis (PCA). Thus, PCA has been applied to attain weights for the final selection of leading indicators, and the weighted average has then been computed to construct the composite leading index. PCs with eigen values greater than one are considered to explain the variation in data. For instance, for *"k"* variables to be combined together, a corresponding new set of *"k"* principal components need to be obtained. That means:

[3] The interested readers may contact the author for the detailed results of turning point analysis for both approaches.

[4] The average leads are chosen from the maximum coefficient of cross-correlation analysis and cross-correlogram analysis.

$$\begin{aligned} P_1(t) &= \alpha_{11}X_1 + \alpha_{12}X_2 + \dots\dots\dots\dots\dots + \alpha_{1k}X_k(t) \\ P_2(t) &= \alpha_{21}X_1 + \alpha_{22}X_2 + \dots\dots\dots\dots\dots + \alpha_{2k}X_k(t) \\ &\vdots \\ P_k(t) &= \alpha_{71}X_1 + \alpha_{72}X_2 + \dots\dots\dots\dots\dots + \alpha_{kk}X_k(t) \end{aligned} \quad (5)$$

In Equation 5, $P(t)$ is the principal component, and α is the factor loading within the principal component. These factor loadings are used as weights for the construction of principal components. They are chosen so the constructed principal components satisfy the condition of zero multicollinearity amongst PCs (that is orthogonal transformation) thereby creating linearly uncorrelated principal components. Further, the first PC shall account for the maximum possible proportion of variance within the set of variables, with the second PC accounting for the maximum of the remaining variance, and so on until the point where the last PC absorbs the leftover variance. Generally, the first or first few principal components explain appropriate variation to represent the multivariate data. The principal components with eigen values[5] greater than one will be considered for the formation of the composite index. Suppose there are k leading indicators selected for forming the composite index, and let ρ_j j=1,2,…,k; be the lead period of *jth* indicator series. Then all the indicator series must be so transformed as to account for the lead found in them. The next step calls for combining all the lead transformed indicator series to construct a composite index through the weighted average method. The weights are assigned by taking in to account the variation explained by the kth component and the factor loading of the *ith* variable, reflecting the highest correlation of its variance and the component. Hence, CILIs for growth cycle and growth rate cycle will be obtained in the manner such that the weights will be first computed from the principal component analysis. The weights are computed by taking in to account the variation explained by the kth component, and the factor loading of the *ith* variable, reflecting the highest correlation of its variance and the component.

$$W_i = \left| F_{ik} \right| \lambda_k \quad (6)$$

In Equation 6, W_i is the weight assigned to the variable, F_{ik} is the factor loading of the *ith* variable which has the highest correlation of its variance with the respective component, and λ_k is the variation explained by the kth component. After ascertaining the weights for all the variables through the method described above, the next step is to construct the index by taking the weighted average of the selected variable as explained below:

$$CILI_t = \frac{\sum_{i=1}^{k} W_{it} Z_{it}}{\sum_{i=1}^{k} W_{it}} \quad (7)$$

[5] Eigen values are the variances accounted by the principal components. So a smaller eigen value means little variance is being explained. That is why principal components with Eigen values greater than one are chosen and the ones with eigen values less than one are left out.

In Equation 7, $CILI_t$ is the composite index of leading indicators, W_{it} is the weight of the *ith* variable, Z_{it} standardized form of the *ith* variable and $\sum_{i=1}^{k} W_{it}$ is the sum of weights of *"i"* variables at a time *"t"*.

Thus, the composite indices for growth and growth rate cycles are computed through the weighted average computed from Equation 8 and Equation 9 respectively.

$$CILI_t(GC) = 0.513 \times EURO\_LI_{t+4} + 0.505 \times BSE\_SENSEX_{t+4} + 0.478 \times US\_LI_{t+4} + 0.423 \times IIP\_MANF_{t+6} + 0.164 \times \text{SPREAD\_10\_15\_91}_{t+6} + 0.109 \times \text{NOIL\_IMPORTS}_{t+6} \quad (8)$$

$$CILI_t(GRC) = 0.516 \times ADSCB_{t+9} + 0.470 \times BCSCB_{t+6} + 0.316 \times GP\_MUMBAI_{t+5} + 0.325 \times IIP\_MANF_{t+6} + 0.502 \times M3_{t+7} \quad (9)$$

6. IDENTIFICATION OF TURNING POINTS IN INDIAN GROWTH CYCLES AND GROWTH RATE CYCLES

The identification of turning points in the reference and indicator series employs a computer algorithm developed by Bry and Boschan in 1971 based on the procedures and rules developed at the NBER. Table 2 and Table 3 represent the results of peak and trough analysis to draw inferences for the lead/lag relationship of growth and growth rate cycles of IIP and CILI series.

The growth cycles in IIP series and CILI have been identified for the period 1997:M6 to 2017:M6; IIP series has experienced six complete growth cycles while CILI has registered five complete growth cycles, dated from trough to trough. The growth rate cycle chronology for IIP series and CILIGRC is for the period 1997:M6 to 2017:M6. It can be inferred from these demonstrations that IIP and CILIGRC have recorded five growth rate cycles each. For growth cycle approach, the results indicate that reference series (IIP) has experienced six peaks i.e. 2000:M6, 2004:M11, 2008:M4, 2011:M4, 2012:M3 and 2015:M3, and seven troughs i.e. 1998:M10, 2003:M7, 2005:M11, 2009:M4, 2011:M11, 2014:M4 and 2016:M5. On the other hand, indicator series (CILI) has seen a peak five times i.e. 1999:M12, 2004:M3, 2007:M10, 2010:M10 and 2014:M9, and six troughs, i.e. 1998:M8, 2003:M1, 2005:M2, 2008:M11, 2012:M7 and 2016:M1. It can be observed from this summarization that 2011:M11 trough and 2012:M3 peak of IIP could not be captured by CILI and there were two occasions of no signal. Nonetheless, there is no occasion of an extra/false signal by CILI. All other turning points were well captured by CILI. On an average, CILI has provided leads of 6.4 months and 7.8 months for peaks and troughs of the IIP series respectively.

Table-2. IIP and CILI Lead/Lag Analysis (Growth Cycle).

Reference Cycles		CILI Cycles		Lead(-)/Lag(+)	
Peak	**Trough**	**Peak**	**Trough**	**Peak**	**Trough**
-	1998 M10	-	1998 M8	-	-2
2000 M6	2003 M7	1999 M12	2003 M1	-6	-6
2004 M11	2005 M11	2004 M3	2005 M2	-8	-9
2008 M4	2009 M4	2007 M10	2008 M11	-6	-5
2011 M4	2011 M11	2010 M10	-	-6	N.S.
2012 M3	2014 M4	-	2012 M7	N.S.	-21
2015 M3	2016 M5	2014 M9	2016 M1	-6	-4
Average Lead				-6.4	-7.8
Median Lead				-6	-5.5

Note: N.S. stands for No Signal.
Source: Author's Calculations.

And for the growth rate cycle approach, it can be seen that the reference series IIP has experienced six peaks i.e. 2000:M4, 2004:M12, 2007:M8, 2010:M4, 2013:M9 and 2015:M7, and six troughs i.e. 2001:M7, 2005:M11, 2009:M4, 2013:M4, 2014:M9 and 2016:M8. On the contrary, indicator series (CILI) has reported a peak five times i.e. 2000:M6, 2002:M3, 2006:M5, 2010:M9 and 2013:M7, and registered six troughs, i.e. 1999:M4, 2001:M7, 2003:M3, 2009:M12, 2013:M1 and 2015:M3. It can be perceived from this that the peak of 2004:M12 and 2015:M7 and the trough of 2005:M11 and 2014:M9 in IIP could not be captured by CILI. Besides these four instances of no signal, three extra/false signals were also reported by CILI as the trough of 1999:M4 and 2003:M3, and the peak in 2002:M3. All other turning points were well captured by CILI. On an average, CILI has provided leads of five and three months respectively for peaks and troughs in the IIP series.

Table-3. IIP and CILI Lead/Lag Analysis (Growth Rate Cycle).

Reference Cycles		CILI Cycles		Lead(-)/Lag(+)	
Peak	**Trough**	**Peak**	**Trough**	**Peak**	**Trough**
-	-	-	1999 M4	-	E.S.
2000 M4	2001 M7	2000 M6	2001 M7	2	0
		2002 M3	2003 M3	E.S.	E.S.
2004 M12	2005 M11	-	-	N.S.	N.S.
2007 M8	2009 M4	2006 M5	2009 M12	-15	8
2010 M4	2013 M4	2010 M9	2013 M1	-5	-3
2013 M9	2014 M9	2013 M7	-	-2	N.S.
2015 M7	2016 M8	-	2015 M3	N.S.	-17
Average Lead				-5	-3
Median Lead				-1.5	-1.5

Note: N.S. stands for No Signal and E.S. stands for Extra Signal.
Source: Author's Calculations.

7. PREDICTION EVALUATION OF CILI

Next, a probit model is estimated for evaluating the predictive power of CILI for forecasting the different phases of the economy. Probit analysis is used to analyze many kinds of dose-response or binomial response experiments in a variety of fields. The probit approach is regularly applied in economics and econometrics. In the present context, probit is used for assessing the usefulness of the CILI constructed by PCA in forecasting the turning points in the reference series. The probit analysis has been widely utilized for business cycle forecasting by researchers such as Estrella and Hardouvelis (1991); Estrella and Mishkin (1996; 1998); Bernard and Gerlach (1998); Gaudreault and Lamy (2001) and Krystalogianni *et al.* (2004).

Under the probit framework, the dependent variable, D can be defined as:

$$D_t = \begin{cases} 1, \text{ for a period of recession in time "t"} \\ 0, \text{ otherwise} \end{cases}$$

In the context of the present endeavor, a constructed composite index of leading indicators – CILI – from the chosen set of leading indicators proposed for inclusion in the composite index is evaluated for its predictive capabilities using the probit approach and the specified equations: thus, Equation 10 and Equation11are framed as:

$$D_t = \alpha + \beta CILI \qquad (10)$$

Such that, $P(D_t = 1/cili) = F(\alpha + \beta CILI)$. Where, β is the coefficient of CILI with F as,

$$F(CILI) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{cili} e^{-\frac{1}{2}z^2} d_z, \qquad z \sim N(0,1) \qquad (11)$$

The estimated probabilities can be used to get some idea regarding the possibility of future movements in the direction of the reference series. The possibility of a turning point in the IIP is reflected by a rising or a falling trend in probabilities. An increasing trend in the estimated probabilities may be deemed to be a signal for the possibility of a slowdown that may ultimately lead to recession, and vice-versa. However, for a formal determination, one may choose a threshold level of these probabilities to determine possible movement in the economy. If the forecast probability generated by the model exceeds this threshold level, a signal is generated for a possible decline (slowdown) in economic activity. Thus, one can determine how accurately the model has been able to forecast different phases.

For evaluating the predictive power of CILI for forecasting the different phases of the economy, three threshold probability levels are taken into consideration: 40 per cent, 50 per cent and 60 per cent. Table 4 presents a summary of the predictive ability of a CILI constructed for forecasting growth and growth rate cycles in IIP. Its forecasting capacity is evaluated by classifying the different phases as correctly forecasted for the respective threshold probabilities.

For instance, in case of a growth cycle approach corresponding to a threshold probability of 0.4, 79 out of 111 expansion cases and 111 out of 120 recession cases were correctly classified by the growth cycle model. This makes for a probit model for CILI that correctly forecasts 71.17 per cent of observations for an expansion phase, and 92.5 per cent for a recession phase. Overall the model correctly forecast, 82.25 per cent of total observations. Similarly, for the threshold probability of 0.5, the growth cycle model correctly forecast 85 out of 111 expansion cases, and 95 out of 120 recession cases. In total, the model correctly forecast 180 out of 231 cases, which is a forecasting accuracy of 77.92 per cent. Further, for an even higher threshold probability level, the accuracy in predicting economic expansions increased to 93 of 111, while that for recessions decreased to 87 out 120. and In total, the growth cycle model correctly forecast 77.92 cases with accuracy. Therefore, with increments in the levels of threshold probability, the overall accuracy in the prediction of different phases decreased from 82.25 per cent to 77.92 per cent with respect to 0.4 and 0.5 threshold probabilities. However, with a further increase to 0.6, the overall predictive capacity remained at 77.92 per cent.

Table-4. Prediction Evaluation of CILI constructed for IIP-Growth Cycle and IIP -Growth Rate Cycle.

Approach		**Growth Cycle**			**Growth Rate Cycle**		
Threshold Probability		**0.4**	**0.5**	**0.6**	**0.4**	**0.5**	**0.6**
Expansion	No. of cases correctly forecasted	79	85	93	59	80	96
	Total no. of cases	111	111	111	113	113	113
	Percentage of correct forecast	71.17	76.58	83.78	52.21	70.80	84.96
Recession	No. of cases correctly forecasted	111	95	87	89	76	61
	Total no. of cases	120	120	120	107	107	107
	Percentage of correct forecast	92.5	79.17	72.5	83.18	71.03	57.01
Total	No. of cases correctly forecasted	190	180	180	157	156	148
	Total no. of cases	231	231	231	220	220	220
	Percentage of correct forecast	82.25	77.92	77.92	71.36	70.91	67.27
LR Chi-Squared Statistic		124.52* (0.000)			3.24** (0.072)		

Source: Author's Calculations.
Note: Coefficients marked with * and ** are statistically significant at 1 per cent and 10 per cent, respectively.

And for a growth rate cycle approach corresponding to a threshold probability of 0.4, 0.5 and 0.6, 59 of 113, 80 of 113, and 96 of 113 expansion cases were correctly predicted. However, for recession cases the accuracy of prediction declined from 89 of 107 to 76 of 107, and then further to 61 of 107 corresponding to the threshold probability level of 0.4, 0.5 and 0.6. Looking at this trend in percentage terms, it can be seen that the correct forecast reported an increasing trend in case of expansionary episodes, and a declining trend the in case of recessionary episodes. For instance, the model's accuracy for predicting expansions has increased from 52.21 per cent to 70.80 per cent, and further to 84.96 per cent with subsequent rises in the threshold probability. By contrast, in the case of recessions the increase in threshold probabilities has reflected a fall in predictive accuracy from 83.18 per cent to 71.03 per cent, and then to 57.01 per cent. However, considering the total number of cases; *viz*: expansions and recessions combined, the model correctly forecast 157 out of 220 with a forecast accuracy of 71.36 per cent. Further, for a higher threshold probability level of 0.5, the predictive accuracy declined to 71.36 per cent. However, with a further increase in threshold probability level to 0.6, the overall accuracy of prediction slipped to 67.27 per cent. It can be concluded, therefore, that the model is relatively accurate in terms of its predictive abilities. However, the null hypothesis of the insignificant difference between actual and predicted phase has been rejected in this instance.

The exactitude of the probit model's fit may be estimated by applying the LR Chi-Squared statistic. The significance of LR statistics for the growth cycle model is inferred from the fact that this statistic is significant at one per cent, while the growth rate cycle's LR statistic is significant at 10 per cent. Thus, it can be maintained that both the models fit well.

8. PREDICTION OF RECESSION

The CILIs constructed for growth cycles and growth rate cycles are also used to perform dynamic forecasts for the probability of recession with a future horizon. Table 5 displays dynamic forecasts performed with four different future forecasts horizons: three months, six months, nine months, and twelve months ahead. The computed results for both approaches are shown in the table. It can be observed that the probability of a recession in a growth cycle tends to decline over the forecast horizon. That is, for a three month forecast, the probability of recession is 0.46, for six months 0.43, for nine months 0.41, and for twelve months 0.40. Thus, there is a diminished probability of recession where the growth cycle shows a declining trend against future forecast horizons.

As far as the growth rate cycle is concerned, the probability of recession hovers around 0.40. So, for a forecast three months ahead the probability of recession is 0.39, for six months 0.40, for nine months also 0.40, and for twelve months 0.39.

Table-5. Prediction of the Probability of Recession in Future Forecast Horizon (Dynamic Forecasts).

Future Forecast Horizon (in months)	Probability of Recession	
	Growth Cycle Approach	Growth Rate Cycle Approach
3 months ahead Forecast	0.46	0.39
6 months ahead Forecast	0.43	0.40
9 months ahead forecast	0.41	0.40
12 months ahead Forecast	0.40	0.39

Source: Author's Calculations.

9. FORECAST EVALUATION OF IIP

As with the probability of recession, the reference series IIP can also be forecasted from the constructed CILI for both the approaches, and the turning points in the reference cycle can also be dated from the forecast reference series. An endeavor has been made to forecast the IIPcy and IPgr series from their respective CILIs through an estimation equation. In the case of IIPcy and CILIgc, they both at a stationary level so a regression equation is made by applying the ordinary least squares (OLS) method. However, where CILIgr is at a stationary level, IIPgr becomes stationary at first difference. Therefore, in the case of a growth rate cycle approach, there is a combination of the *I(0)* and *I(1)* series which calls for the estimation of a regression equation with the application of the ARDL technique.

Next, the IIPcy and IIPgr are forecast through these estimated equations for a twelve-month horizon. The next step calls for the forecast evaluation of IIPcyF and IIPgrF. There are four different measures which can be used for evaluating the IIP forecast, the reference series from the composite index of leading indicators. These measures provide the statistics showing the distance between forecast and the actual values. The four measures of forecast evaluation are: root mean squared error (RMSE), mean absolute error (MAE), mean absolute percentage error (MAPE) and the Theil inequality coefficient The variables which are considered for the computation of these forecast evaluating measures are the forecast horizon, the actual value, and the forecast value of the variable being forecast. The results appear in Table 6.

Table-6. Forecast Evaluation of IIP.

Evaluation Measure	Growth Cycle Series (IIPcyF)	Growth Rate Cycle Series (IIPgrF)
RMSE	0.022880	0.326946
MAE	0.017873	0.256349
Theil Inequality Coefficient	0.075461	0.024765

Source: Author's Calculations.

A value approaching zero implies an accurate forecast as it signifies a smaller distance between true and forecast values. Thus, a value equal to zero for any of these forecasts signifies that its evaluation is completely accurate. Larger values in these statistics reflect the distance between actual and forecast values.

10. CONCLUDING REMARKS

This study has attempted to date monthly growth and growth rate cycles by taking IIP as a proxy variable for overall economic activity, and to construct a composite index of leading indicators (CILI) from the four broad sectors of the economy. For both the approaches, the period examined is 1997:06 to 2017:06. As far as the construction of CILI is concerned, the criteria suggested by Simone (2001) is followed. In case of growth cycles, 15 variables: *BSE_SENSEXcy, EURO_LIcy, IIP_BASICcy, IIP_CAPITALcy, IIP_CDcy, IIP_MANFcy, IMPORTcy, NIFTY50cy, NOIL_IMPORTcy, RS_DOLLARcy, SP_MUMBAIcyc, SPREAD_10_15_91cy, US_LIcy, YIELD_1YRcy,* and *YIELD_10YRcy* were initially taken up. In case of growth rate cycles, nine variables, namely, *ADSCBgr, BCSCBgr, FCAgr, GP_MUMBAgr, IIP_MANFgr, IMPORTgr, M3gr, NFCgr,* and *TDSCBgr,* have qualified for the laid criterion of sharing the same order of integration and indicator series as the Granger causing reference series. However, of these nine variables, *FCA* and *IMPORT* do not satisfy the cointegration condition, but they are retained as per Simone (2001). So, to begin with, 15 variables were selected for the construction of a CILI for growth cycles, and nine variables for constructing the CILI for growth rate cycles from unit root and econometric testing procedures.

For the construction of CILI, from a set of 52 information variables, six growth cycle variables were chosen as leading indicators for IIPcy, and five growth rate cycle variables were chosen as leading indicators for IIPgr on the basis of cross-correlation analysis, econometric testing procedures, and turning point analysis. For instance, after performing point to point analysis of these specific series against the reference series, six series, *BSE_SENSEXcy, EURO_LIcy, IIP_MANFcy, NOIL_IMPORTcy, SPREAD_10_15_91cy,* and *US_LIcy,* were carefully chosen with average lead of four, four, six, six and four months respectively, to be included in the construction of composite index for the growth cycle approach. For the growth rate cycle approach, five series were chosen: *ADSCBgr, BCSCBgr, GP_MUMBAIgr, IIP_MANFgr,* and *M3gr*; with an average lead of nine, six, five, six, and seven months respectively, to construct the CILI. Finally, the respective CILIs for both approaches were constructed by computing the weighted average after ascertaining the weights for all variables through the PCA method.

It was evident from the peaks and troughs reported through application of the BB procedure - in both reference and indicator series – that CILI, constructed for both approaches, is a leading indicator for IIP growth cycles and IIP growth rate cycles,. The average duration of lead for peaks and troughs is reported as 6.4 (approximately, six) months and 7.8 (approximately eight) months respectively in the case of growth cycles. Growth rate cycles registered average leads for peaks and troughs at five and three months respectively. The leads reported are a clear indication of a strong relationship between economic activity and CILI in the context of this study. An evaluation of the predictive capability of probit models for both the CILIs was also performed by defining three threshold probability levels: 40 per cent, 50 per cent and 60 per cent, which also indicate their accuracy in predicting the phases of business cycles. In the case of the growth cycle approach, with increments around the levels of threshold probability, overall accuracy in predicting different phases of economy decreased from 82.25 per cent to 77.92 per cent. With a further increase to 0.6, the overall prediction ability remained the same at 77.92 per cent. And for the growth rate cycle approach, the model correctly forecast 157 out of 220, an accuracy rate of 71.36 per cent. Further, for a higher threshold probability level of 0.5, the accuracy of prediction declined to 71.36 per cent. However, with further increase in the threshold probability level to 0.6, the overall prediction ability fell to 67.27 per cent. It is contended that these indicators may be usefully employed in economic policy formulation and refinement.

Moreover, it is apparent that the probability of a recession in a growth cycle tends to decline over the forecast horizon: i.e. for three months ahead of forecast the probability of recession is 0.46; for six months 0.43, for nine months a 0.41, and for twelve months 0.40. In the case of a growth rate cycle, the probability of recession hovers around 0.40: for three months ahead forecast the probability of recession is 0.39, for six months 0.40, for nine months also 0.40, and for twelve months again 0.40. In summation, the ensuing twelve months will likely be a recovery period with the probability of recession below 50 percent, yet high enough at 40 percent to urge caution. Put simply, policy planners are advised to closely monitor economic fundamentals so as to facilitate the application of corrective measures ahead of time. Finally, the significance of the composite leading index for forecasting cyclical business activity suggests that the CILI must be appropriately used to predict business cycles and incorporate stabilization measures to counteract episodes of disequilibrium in advance.

Funding: This study received no specific financial support.
Competing Interests: The author declares that there are no conflicts of interests regarding the publication of this paper.

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Appendix-1. Description of Variables.

Broad Sector	Variable	Source	Definition
Monetary and Banking Indicators	M0	RBI	Reserve Money (in Rs. Crore)
	M1	RBI	Narrow Money (in Rs. Crore)
	M3	RBI	Broad Money (in Rs. Crore)
	CWP	RBI	Currency with the Public (in Rs. Crore)
	REAL_M1	RBI	M1 deflated by WPI
	REAL_M3	RBI	M3 deflated by WPI
	NFC	RBI	Non-Food Credit (in Rs. Crore)
	BCSCB	RBI	Bank Credit-Scheduled Commercial Banks (in Rs. Crore)
	ADSCB	RBI	Aggregate Deposits- Scheduled Commercial Banks (in Rs. Crore)
	DDSCB	RBI	Demand Deposits- Scheduled Commercial Banks (in Rs. Crore)
	TDSCB	RBI	Time Deposits- Scheduled Commercial Banks (in Rs. Crore)
Financial Indicators	BSE_SENSEX	RBI	Bombay Stock Exchange-30 price index, monthly average of daily closing prices.
	NIFTY50	RBI	NIFTY-50 price index, monthly average of daily closing prices.
	YIELD_15_91TB	RBI	Monthly Average of secondary market yield on Treasury Bills with residual maturity of 15-91 days
	YIELD_1YR	RBI	Monthly Average of secondary market yield on Government Securities with residual maturity of 1 year.
	YIELD_10YR	RBI	Monthly Average of secondary market yield on Government Securities with residual maturity of 10 years.
	REAL_YIELD_1591TB	RBI	YIELD_15_91TB-WPI Inflation
	REAL_YIELD_1YR	RBI	YIELD_10YR-WPI Inflation

	REAL_YIELD_10YR	RBI	YIELD_1YR-WPI Inflation
	SPREAD_10_15_91	RBI	YIELD_10YR-YIELD_15_91TB
	SPREAD_10_1	RBI	YIELD_10YR-YIELD_1YR
	RS_DOLLAR	RBI	Exchange rate of Rupees vs. US Dollar
	FORWARD6	RBI	Interbank Forward Premia of US Dollar (6-months)
	FCA	RBI	Foreign Currency Assets
	NET_FIIs	RBI	Net Foreign Institutional Investments
Price Indicators	WPI_MP	RBI	Index of Manufactured Products-WPI based
	WPI_FA	RBI	Index of Food Article prices-WPI based
	WPI_MIN	RBI	Index of Mineral Oil Prices-WPI based
	WPI_ALL	RBI	Index of all Commodity Prices-WPI based
	GP_MUMBAI	RBI	Gold Price- Monthly average in Domestic Market
	SP_MUMBAI	RBI	Silver Price- Monthly average in Domestic Market
Real Sector Indicators	IIP_BASIC	RBI	Index of Industrial Production- Basic Goods
	IIP_CAP	RBI	Index of Industrial Production- Capital Goods
	IIP_INT	RBI	Index of Industrial Production- Intermediate Goods
	IIP_CONG	RBI	Index of Industrial Production- Consumer Goods
	IIP_CD	RBI	Index of Industrial Production- Consumer Durables
	IIP_CND	RBI	Index of Industrial Production- Consumer Non-Durables
	IIP_METAL	RBI	Index of Industrial Production- Basic Metal and Alloy Industries
	IIP_ELEC	RBI	Index of Industrial Production- Electricity
	IIP_MANF	RBI	Index of Industrial Production- Manufacturing
	IIP_GENERAL	RBI	Index of Industrial Production- General Index
	NAGDP	RBI	Non-Agricultural GDP
	COAL	INDIA STAT	Production Coal
	CEMENT	INDIA STAT	Production of Cement
	ELECTRICITY	INDIA STAT	Production of Electricity
	RAILWAY	INDIA STAT	Railway Gross Earnings
	FOODGRAINS	INDIA STAT	Stock of food grains with the government
External Sector Indicators	EXPORT	RBI	Total value of exports in US$ million.
	IMPORT	RBI	Total value of imports in US$ million.
	NOIL_IMPORT	RBI	Total value of non-oil imports in US$ million.
	USGDP	BEA	United States GDP in US$ Billion chained at base-2007
	US_LI	OECD	United States Leading Indicator Index
	EURO_LI	OECD	Euro Area Leading Indicator Index
	INT_OIL	ST. LOIUS FRED	International Brent Crude oil Price

Note: RBI- Reserve Bank of India, BEA- Bureau of Economic Indicators, OECD-Organization of Economic Co-operation and Development.

Appendix-2. Cross-Correlation in cyclical component of candidate series with IIPcy lags.

IIP LAGS	1	2	3	4	5	6	7	8	9	10	11	12
ADSCBcy	0.13*	0.13*	0.17*	0.18*	0.19*	0.24*	0.27*	0.27*	0.32*	0.29*	0.30*	0.33*
BCSCBcy	0.30*	0.34*	0.37*	0.36*	0.34*	0.36*	0.36*	0.36*	0.38*	0.34*	0.34*	0.33*
BSE_SENSEXcy	0.36*	0.30*	0.23*	0.14*	0.07	0.02	-0.03	-0.09	-0.14*	-0.18*	-0.19*	-0.23*
COALcy	0.00	-0.04	-0.13*	-0.09	-0.08	-0.05	-0.02	-0.01	-0.07	-0.12*	-0.07	-0.12*
CEMENTcy	0.00	0.01	-0.02	0.02	0.08	0.03	0.10	0.13	0.10	0.10	0.16*	0.05
CWPcy	0.00	0.03	0.02	0.00	0.01	0.05	0.06	0.03	-0.01	-0.02	0.01	0.01
DDSCBcy	0.19*	0.07	0.06	-0.02	-0.04	-0.03	-0.02	-0.04	-0.02	-0.07	-0.07	-0.06
ELECTRICITYcy	0.12*	0.12*	0.07	0.13*	0.14*	0.16*	0.16*	0.17*	0.19*	0.16*	0.20*	0.08
EURO_LIcy	0.43*	0.37*	0.29*	0.20*	0.11	0.01	-0.08	-0.17*	-0.24*	-0.31*	-0.36*	-0.41*
EXPORTcy	0.46*	0.52*	0.49*	0.44*	0.40*	0.34*	0.30*	0.24*	0.19*	0.14*	0.13*	0.09
FOODGARINScy	-0.11	-0.14*	-0.16*	-0.19*	-0.21*	-0.21*	-0.23*	-0.23*	-0.22*	-0.22*	-0.21*	-0.20*
FCAcy	-0.01	0.03	0.08	0.09	0.09	0.09	0.08	0.07	0.07	0.07	0.09	0.08
FORWARD6cy	0.12*	0.11	0.10	0.08	0.07	0.08	0.05	0.03	0.04	0.05	0.07	0.10
GP_MUMBAIcy	0.10	0.12*	0.14*	0.16*	0.18*	0.16*	0.16*	0.15*	0.16*	0.17*	0.20*	0.20*
IIP_BASICcy	0.41*	0.40*	0.37*	0.27*	0.23*	0.13*	0.17*	0.10	0.09	0.04	0.03	-0.06
IIP_CAPITALcy	0.48*	0.50*	0.45*	0.40*	0.36*	0.36*	0.25*	0.25*	0.13*	0.09	0.10	0.01
IIP_CDcy	0.39*	0.40*	0.31*	0.25*	0.20*	0.15*	0.14*	0.14*	0.11	0.11	0.11	0.05
IIP_CGcy	0.35*	0.35*	0.26*	0.18*	0.14*	0.10	0.10	0.08	0.06	0.03	0.05	-0.04
IIP_CNDcy	0.30*	0.29*	0.22*	0.14*	0.10	0.07	0.08	0.06	0.05	0.01	0.04	-0.05
IIP_ELECcy	0.08	0.08	0.07	-0.01	-0.02	-0.08	-0.02	-0.04	-0.01	0.00	-0.03	-0.04
IIP_INTcy	0.31*	0.30*	0.17*	0.10	0.04	-0.06	-0.10	-0.13*	-0.13*	-0.16*	-0.16*	-0.24*
IIP_MANFcy	0.58*	0.59*	0.51*	0.41*	0.37*	0.31*	0.23*	0.22*	0.14*	0.08	0.10	-0.02
IMPORT_NOILcy	0.39*	0.43*	0.42*	0.37*	0.35*	0.34*	0.32*	0.26*	0.18*	0.12*	0.04	-0.03
IMPORTcy	0.49*	0.51*	0.49*	0.43*	0.41*	0.39*	0.36*	0.30*	0.23*	0.17*	0.10	0.05
INT_OILcy	0.41*	0.38*	0.37*	0.34*	0.32*	0.29*	0.26*	0.23*	0.19*	0.18*	0.16*	0.15*
M1cy	0.13*	0.09	0.06	0.01	0.00	0.03	0.04	0.00	-0.02	-0.06	-0.03	-0.03
M3cy	0.13*	0.14*	0.17*	0.18*	0.19*	0.24*	0.27*	0.26*	0.29*	0.26*	0.29*	0.33*
M0cy	0.31*	0.34*	0.33*	0.33*	0.32*	0.33*	0.33*	0.28*	0.20*	0.17*	0.12*	0.09
NET_FIIcy	0.06	0.07	-0.01	0.06	-0.09	-0.04	-0.01	0.01	-0.11	0.03	-0.01	-0.08
NFCcy	0.32*	0.34*	0.36*	0.35*	0.33*	0.34*	0.33*	0.32*	0.33*	0.29*	0.28*	0.27*
NIFTY50cy	0.37*	0.31*	0.24*	0.15*	0.08	0.04	-0.01	-0.07	-0.12*	-0.16*	-0.17*	-0.21*
RAILWAYcy	-0.06	-0.05	-0.02	-0.02	0.00	0.02	-0.01	0.01	0.05	0.05	0.05	0.12
REAL_NAGDPcy	0.11	0.06	0.01	-0.04	-0.08	-0.09	-0.10	-0.09	-0.08	-0.05	-0.03	-0.01
REAL_YIELD_10YRcy	-0.28*	-0.30*	-0.31*	-0.31*	-0.30*	-0.26*	-0.22*	-0.18*	-0.10	-0.04	0.01	0.06
REAL_YIELD_15_91cy	-0.22*	-0.22*	-0.22*	-0.23*	-0.21*	-0.17*	-0.14*	-0.09	-0.03	0.03	0.08	0.11
REAL_YIELD_1YRcy	-0.24*	-0.25*	-0.25*	-0.26*	-0.25*	-0.22*	-0.18*	-0.13*	-0.06	0.00	0.04	0.09
REALM1cy	0.06	0.05	0.03	0.03	0.04	0.06	0.07	0.08	0.07	0.06	0.05	0.06
REALM3cy	0.04	0.04	0.04	0.05	0.07	0.09	0.10	0.11	0.12	0.11	0.10	0.11
RS_DOLLARcy	-0.46*	-0.44*	-0.38*	-0.31*	-0.27*	-0.21*	-0.17*	-0.12*	-0.04	0.03	0.10	0.18*

SP_MUMBAIcy	0.42*	0.40*	0.38*	0.34*	0.29*	0.23*	0.18*	0.14*	0.11	0.08	0.07	0.07
SPREAD_10_15_91cy	-0.17*	-0.22*	-0.24*	-0.36*	-0.41*	-0.37*	-0.35*	-0.33*	-0.26*	-0.27*	-0.24*	-0.18*
SPREAD_10_1YRcy	-0.22*	-0.26*	-0.22*	-0.29*	-0.28*	-0.24*	-0.28*	-0.24*	-0.17*	-0.21*	-0.09	-0.05
TDSCBcy	0.07	0.11	0.14*	0.18*	0.20*	0.24*	0.27*	0.28*	0.32*	0.31*	0.33*	0.36*
USA_LIcy	0.43*	0.36*	0.28*	0.19*	0.10	0.01	-0.07	-0.14*	-0.21*	-0.26*	-0.30*	-0.34*
USGDPcy	0.36*	0.34*	0.30*	0.26*	0.21*	0.15*	0.10	0.04	0.00	-0.04	-0.08	-0.12*
WPI_ALLcy	-0.03	-0.03	-0.02	-0.03	-0.05	-0.06	-0.06	-0.08	-0.08	-0.08	-0.07	-0.07
WPI_FAcy	-0.05	-0.05	-0.05	-0.07	-0.09	-0.11	-0.13*	-0.14*	-0.14*	-0.13*	-0.12*	-0.11
WPI_MINcy	0.04	0.05	0.07	0.07	0.06	0.06	0.08	0.07	0.07	0.08	0.10	0.09
WPI_MPcy	-0.03	-0.03	-0.02	-0.03	-0.05	-0.06	-0.07	-0.08	-0.08	-0.08	-0.07	-0.08
YIELD_10YRcy	0.34*	0.34*	0.34*	0.33*	0.30*	0.27*	0.22*	0.18*	0.15*	0.11	0.10	0.11
YIELD_15_91cy	0.43*	0.48*	0.49*	0.49*	0.49*	0.44*	0.42*	0.37*	0.35*	0.29*	0.27*	0.20*
YIELD_1YRcy	0.48*	0.51*	0.51*	0.50*	0.47*	0.42*	0.38*	0.34*	0.28*	0.25*	0.21*	0.17*

Note: "*" denotes the significance of cross-correlation coefficient at 5 per cent level of significance.
Source: Author's Calculations.

Appendix-3. Cross-Correlation in growth rates of candidate series with IIPgr lags.

IIP LAGS	1	2	3	4	5	6	7	8	9	10	11	12
ADSCBgr	0.54*	0.54*	0.54*	0.54*	0.54*	0.57*	0.59*	0.59*	0.60*	0.59*	0.60*	0.60*
BCSCBgr	0.65*	0.67*	0.69*	0.69*	0.69*	0.70*	0.69*	0.69*	0.69*	0.67*	0.66*	0.64*
BSE SENSEXgr	0.35*	0.31*	0.25*	0.18*	0.13*	0.09	0.06	0.01	-0.03	-0.06	-0.07	-0.10
COALgr	0.11	0.10	0.07	0.01	0.06	0.07	0.10	0.13*	0.14*	0.09	0.02	0.05
CEMENTgr	0.25*	0.20*	0.19*	0.18*	0.21*	0.23*	0.21*	0.23*	0.25*	0.23*	0.22*	0.26*
CWPgr	0.32*	0.34*	0.34*	0.34*	0.34*	0.36*	0.37*	0.35*	0.34*	0.31*	0.32*	0.33*
DDSCBgr	0.33*	0.24*	0.22*	0.17*	0.14*	0.14*	0.14*	0.11*	0.10	0.07	0.05	0.04
ELECTRICITYgr	-0.07	-0.12*	-0.10	-0.13*	-0.06	-0.07	-0.04	-0.05	-0.04	-0.08	-0.08	-0.07
EURO_LIgr	0.31*	0.27*	0.21*	0.15*	0.08	0.01	-0.07	-0.13*	-0.19*	-0.25*	-0.29*	-0.32*
EXPORTgr	0.60*	0.64*	0.62*	0.62*	0.57*	0.54*	0.51*	0.46*	0.43*	0.40*	0.38*	0.34*
FCAgr	0.35*	0.36*	0.39*	0.37*	0.36*	0.35*	0.32*	0.30*	0.28*	0.28*	0.28*	0.27*
FOODGRAINSgr	0.01	0.03	0.05	0.08	0.10	0.13*	0.15*	0.17*	0.19*	0.21*	0.23*	0.25*
FORWARD6gr	0.08	0.08	0.09	0.08	0.09	0.10	0.07	0.06	0.05	0.04	0.05	0.06
GP_MUMBAIgr	0.27*	0.28*	0.31*	0.32*	0.33*	0.31*	0.31*	0.29*	0.31*	0.34*	0.37*	0.39*
IIP_BASICgr	0.42*	0.44*	0.40*	0.32*	0.33*	0.25*	0.28*	0.24*	0.24*	0.18*	0.19*	0.09
IIP_CAPITALgr	0.63*	0.65*	0.61*	0.57*	0.54*	0.54*	0.46*	0.47*	0.36*	0.33*	0.31*	0.21*
IIP_CDgr	0.46*	0.49*	0.43*	0.39*	0.36*	0.32*	0.30*	0.29*	0.24*	0.23*	0.20*	0.15*
IIP_CGgr	0.37*	0.38*	0.31*	0.27*	0.24*	0.21*	0.20*	0.18*	0.14*	0.09	0.09	0.01
IIP_CNDgr	0.30*	0.29*	0.24*	0.20*	0.18*	0.15*	0.15*	0.13*	0.09	0.04	0.05	-0.03
IIP_ELECgr	-0.13*	-0.11*	-0.11*	-0.15*	-0.14*	-0.19*	-0.13*	-0.14*	-0.11*	-0.12*	-0.13*	-0.17*
IIP_INTgr	0.40*	0.39*	0.32*	0.26*	0.21*	0.13*	0.09	0.05	0.04	0.00	-0.01	-0.10
IIP_MANFgr	0.67*	0.70*	0.63*	0.57*	0.55*	0.50*	0.45*	0.44*	0.35*	0.30*	0.30*	0.18*

IMPORT_NOILgr	0.53*	0.55*	0.55*	0.52*	0.51*	0.51*	0.50*	0.47*	0.41*	0.34*	0.27*	0.23*
IMPORTgr	0.63*	0.64*	0.62*	0.60*	0.58*	0.57*	0.55*	0.51*	0.45*	0.39*	0.33*	0.29*
INT_OILgr	0.50*	0.49*	0.49*	0.47*	0.45*	0.42*	0.40*	0.36*	0.32*	0.29*	0.28*	0.26*
M0gr	0.53*	0.55*	0.56*	0.56*	0.57*	0.57*	0.56*	0.53*	0.48*	0.44*	0.40*	0.39*
M1gr	0.51*	0.49*	0.48*	0.44*	0.43*	0.44*	0.45*	0.42*	0.39*	0.35*	0.34*	0.35*
M3gr	0.55*	0.55*	0.56*	0.56*	0.56*	0.58*	0.60*	0.60*	0.60*	0.59*	0.60*	0.61*
NET_FIIsgr	0.08	0.10	0.04	0.09	-0.01	0.02	0.03	0.05	-0.02	0.07	0.02	-0.03
NFCgr	0.65*	0.67*	0.69*	0.69*	0.68*	0.69*	0.68*	0.67*	0.67*	0.65*	0.64*	0.61*
NIFTY50gr	0.35*	0.30*	0.25*	0.18*	0.13*	0.10	0.06	0.01	-0.03	-0.06	-0.07	-0.10
RAIKWAYgr	-0.01	0.03	0.05	0.07	0.09	0.14*	0.13*	0.13*	0.17*	0.20*	0.21*	0.23*
REAL_NAGDPgr	0.01	-0.01	-0.02	-0.05	-0.06	-0.06	-0.06	-0.06	-0.06	-0.05	-0.05	-0.04
REAL_YIELD_10YRgr	-0.24*	-0.26*	-0.27*	-0.28*	-0.28*	-0.25*	-0.21*	-0.17*	-0.11*	-0.07	-0.02	0.01
REAL_YIELD_15_91gr	-0.22*	-0.22*	-0.23*	-0.24*	-0.23*	-0.20*	-0.16*	-0.12*	-0.06	-0.02	0.02	0.04
REAL_YIELD_1YRgr	-0.22*	-0.23*	-0.25*	-0.25*	-0.25*	-0.22*	-0.18*	-0.14*	-0.09	-0.04	-0.01	0.02
REALM1gr	0.13*	0.11*	0.11*	0.11*	0.11*	0.12*	0.12*	0.11*	0.10	0.08	0.06	0.07
REALM3gr	0.09	0.08	0.08	0.08	0.09	0.10	0.10	0.10	0.10	0.08	0.07	0.07
RS_DOLLARgr	-0.51*	-0.50*	-0.46*	-0.41*	-0.38*	-0.34*	-0.31*	-0.28*	-0.22*	-0.17*	-0.12*	-0.06
SP_MUMBAIgr	0.44*	0.44*	0.43*	0.41*	0.38*	0.35*	0.31*	0.27*	0.26*	0.26*	0.27*	0.28*
SPREAD_10_15_91gr	-0.14*	-0.17*	-0.22*	-0.30*	-0.33*	-0.29*	-0.28*	-0.28*	-0.21*	-0.24*	-0.20*	-0.17*
Spread_10_1gr	-0.16*	-0.17*	-0.14*	-0.18*	-0.19*	-0.17*	-0.20*	-0.18*	-0.12*	-0.14*	-0.06	-0.02
TDSCBgr	0.45*	0.47*	0.48*	0.50*	0.51*	0.53*	0.55*	0.56*	0.57*	0.57*	0.59*	0.60*
USA_LIgr	0.32*	0.27*	0.21*	0.15*	0.08	0.01	-0.05	-0.11*	-0.16*	-0.21*	-0.25*	-0.27*
USGDPgr	0.21*	0.19*	0.16*	0.13*	0.09	0.04	-0.02	-0.07	-0.11*	-0.14*	-0.18*	-0.21*
WPI_ALLgr	-0.01	0.01	0.01	0.00	0.00	-0.01	0.00	-0.01	0.00	0.01	0.02	0.02
WPI_FAgr	-0.07	-0.06	-0.06	-0.06	-0.08	-0.08	-0.09	-0.09	-0.08	-0.07	-0.05	-0.04
WPI_MINgr	0.23*	0.26*	0.26*	0.27*	0.27*	0.28*	0.29*	0.28*	0.27*	0.28*	0.29*	0.29*
WPI_MPgr	-0.02	-0.01	-0.01	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.01	0.00	0.00
YIELD_10YRgr	0.27*	0.28*	0.29*	0.29*	0.28*	0.26*	0.22*	0.18*	0.15*	0.11*	0.12*	0.12*
YIELD_15_91gr	0.30*	0.33*	0.34*	0.37*	0.38*	0.36*	0.34*	0.30*	0.29*	0.24*	0.22*	0.16*
YIELD_1YRgr	0.35*	0.37*	0.39*	0.40*	0.39*	0.35*	0.32*	0.28*	0.24*	0.21*	0.18*	0.14*

Note: "*" denotes the significance of cross-correlation coefficient at 5 per cent level of significance.
Source: Author's Calculations.