Dating business cycles in India

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Abstract

Dates of business cycle turning points are a critical input for academic and policy work in macroeconomics. In this paper, we use contemporary techniques to date the Indian business cycle in the post reform period. An array of robustness checks are employed, using diverse methods. We uncover three recessions in this period. This work helps lay the foundations for downstream macroeconomic research in academics and government.

JEL Classification: E32, E66

Keywords: Business cycles, Growth cycles, Stabilisation

*We thank Joshua Felman for useful comments.

Contents

1 Introduction

Stabilising business cycles is a key objective of macroeconomic policy. The analysis of past experiences of the economy requires an agreed chronology of business cycle turning points. In the U.S, the National Bureau of Economic Research (NBER) performs this role. All researchers and policy makers use the NBER dates. Most graphs of macroeconomic series in the US use shaded bars to represent the periods of a recession based on dates identified by the NBER. Similarly the CEPR Euro Area Business Cycle Dating Committee establishes the chronology of recessions and expansions of Euro Area member countries.

As a developing country becomes more market-dominated, the working of the macroeconomy changes substantially. In India, earlier, macroeconomic shocks were about droughts and oil prices. The economic reforms have led to an interplay of a market economy, financial globalisation, and the decisions of private firms to undertake investment and hold inventory. This has changed the working of the business cycle (Shah, 2008; Shah and Patnaik, 2010; Ghate *et al.*, 2013).[1]

This has given fresh salience to concerns about business cycle stabilisation, and shaped the institutions of macroeconomic policy. In 2015, India established an inflation target as the objective of monetary policy and in 2016 shifted the power for rate setting to a Monetary Policy Committee. These developments call for a commensurate development of a macroeconomics literature. This research agenda, in turn, requires foundations of measurement about business cycle phenomena. One element of this is the identification of dates of business cycle turning points.

The existing literature on business cycle measurement in India has been grounded in three approaches – the classical business cycle (Dua and Banerji, 2012), the growth cycle (Chitre, 1982, 2004; Mall, 1999) and the growth rate cycle (Dua and Banerji, 2012).[2] Hatekar (1994) presents business cycle stylised facts using annual data from 1951 to 1985 using 64 different time-series. Mall (1999) uses filtered output to examine the cyclical behaviour of the Indian economy since 1950. The author identifies six sets of turning

[1] Appendix A presents an overview of changes in the Indian economy in the post-reform period.

[2] The "classical approach" uses *levels* of output to identify turning points. The "growth cycle" approach uses deviation of output from its long term trend, i.e., the cyclical component, to identify periods of peaks and troughs in the business cycle. Finally, the "growth rate cycle" approach identifies turning points based on the growth rate of output.

points in IIP-Manufacturing as the peaks and troughs of the cycle in the period.

These papers have largely worked on the pre-1991 period, and their results are less useful in the contemporary setting. Few papers have examined the post-1991 period (Mohanty *et al.*, 2003; Dua and Banerji, 2006). The OECD has applied its standard methods for India OECD (2016). For the purpose of contemporary macroeconomic research in academics and policy, there is a need to establish a robust set of dates, using contemporary techniques of business cycle measurement, with careful evaluation of every decision in the modelling process. The release of quarterly data for GDP only began in 1996, and in this paper, for the first time we are able to subject 72 observations of quarterly GDP data to this analysis.

In the post-1991 period, we have not seen an actual fall in output, as was seen in the pre-1991 years. Hence, the classical approach is not appropriate for identifying business cycle turning points. For the post-reform period in India, the growth cycle or growth rate cycle approaches are more appropriate (Patnaik and Sharma, 2002; Mohanty *et al.*, 2003; Dua and Banerji, 1999, 2006). When identification of business cycle dates is desired, rather than monitoring and forecasting cycles in real time, the growth cycle approach is appropriate (Boschan and Banerji, 1990).

In this paper, we use the growth cycle approach to identify turning points for the Indian business cycle in the post-reform period using quarterly GDP series. This work runs in three steps. The first step is seasonal adjustment, where we use our previous work (Bhattacharya *et al.*, 2016).

The next step is the extraction of the cyclical component. Most of the existing literature on Indian business cycle measurement has used the Hodrick-Prescott filter (Hodrick and Prescott, 1997). In the last 20 years, many concerns have been expressed about this filter (Hamilton, 2016). We use the Christiano-Fitzgerald filter (CF) to separate the trend and the cyclical component of output (Christiano and Fitzgerald, 2003) at the NBER defined business cycle periodicity of 2–8 years. Hamilton (2016) offers an attractive alternative approach to extracting the de-trended series. We find these results broadly concur with those from the CF filter. We also use multiple different reference series and establish a robust result.

The third step is to identify dates in the cyclical component series. We do this using Bry and Boschan (1971) and Harding and Pagan (2002).

When we apply this three-part process to the 1996–2014 period[3], we find three episodes of recession. The first recession was from 1999-Q4 to 2003-Q1. The second recession was from 2007-Q2 to 2009-Q3. The third recession ran from 2011-Q2 till 2012-Q4. These results are robust to the choice of filter and to the choice of the measure of business cycle indicator. These dates suggest that on average, expansions in India are 12 quarters long and recessions run for 9 quarters.

India's experience, with the changed nature of the business cycle in the post-1991 period, is not unique. A number of emerging economies have undergone changes in the policy environment resulting in structural transformation of the economy. One strand of the business cycle literature examines the changes in stylised facts in response to structural transformation (Kim *et al.*, 2003; Alp *et al.*, 2012; Ghate *et al.*, 2013). We contribute to this thinking by offering evidence of change in the average duration of cycle. Drawing on the analysis by Plessis (2006) and Hall and McDermott (2009), we supplement the descriptive analysis by reporting the coefficient of variation (CV) in amplitude and duration across expansions and recessions. We find that the phases of expansion and recession have become more diverse in the post-reform period.

The contribution of this paper lies in the following elements. We offer robust estimation of the business cycle turning points in the post-reform period. We use contemporary techniques and examine robustness to alternative reference series. We offer evidence of change in the nature of the Indian business cycle before and after 1991.

In the interests of reproducible research, all the data and the software used in this paper are freely available on the web.[4] This makes it possible for other researchers to utilise this work, and build on it. The results of this work, i.e. the dates, would be updated on the web in the years to come.

The rest of the paper is organised as follows. Section 2 outlines our methodology for detection of turning points, Section 3 presents the empirical analysis and our findings on growth cycle turning points. Section 4 assesses the robustness of our findings on business cycle chronology to the choice of the filter and to the choice of the reference series. Section 5 concludes the paper and outlines areas for future research. The technical details and related analysis is placed at the appendix. In the Appendix, Section A presents an overview

[3]This is the period for which the quarterly GDP series is available

[4]These materials are at the URL `http://macrofinance.nipfp.org.in/releases/PPS2016_india_dating.html`.

of the changes in the economy in the post-reform period. Section B presents a snapshot of trough and peak dates identified in the Indian business cycle literature. Section C presents technical details of the detrending methodologies. Section D describes the Bry-Boschan algorithm for detection of turning points. Section E presents a brief description of the macroeconomic conditions during the phases of expansion and recession identified using the dating methodology.

2 Methodology

The detection of turning points begins with defining the concept of a *cycle*. In the *classical cycle*, fluctuations in the absolute level of the series are identified. The early NBER approach identified cycles as recurrent sequences of alternating phases of expansion and contraction in the *levels* of a large number of economic time series (Burns and Mitchell, 1946; Bry and Boschan, 1971).

During the 1960s, the occasional real decline in economic activity in major industrial economies gave way to slowdowns in the *pace* of expansion. Accelerations and slowdowns in *growth* rather than expansion and contraction in the *levels* of variables became a prominent feature of business cycles. This led to the concept of a growth cycle (Mintz, 1974): the ups and downs in the *deviations* of the actual growth rate of the economy from the long-run trend growth rate.

In the Indian data, we do not see an absolute decline in levels, in the post-1991 period. Hence, the growth cycle approach is suitable for the present analysis.

2.1 Seasonal Adjustment and adjustment for outliers

The first step is to adjust the series for seasonal fluctuations. In India, the official statistics do not feature seasonal adjustment. We use the methods developed in Bhattacharya *et al.* (2016). This involves a stylised model selection procedure. There are concerns about errors in the official Indian GDP data. Hence, we use robust statistics in the seasonal adjustment process.[5]

[5]We seasonally adjust the series using the X-13-ARIMA-SEATS seasonal adjustment program. The seasonal adjustment program also extracts the seasonally adjusted series adjusted for extreme values (outliers). The program provides a set of regression variables

2.2 Extraction of cycles

The next step is the extraction of the cyclical component. The seasonally adjusted series is filtered to extract the cyclical component.

One tool that is widely used for this purpose is the Hodrick-Prescott filter. In recent years, it has become increasingly clear that this filter, while elegant and readily implemented, has important shortcomings. The business cycle facts that emerge from HP-filtered data are sensitive to the different values of the smoothing parameter (Bjornland, 2000). Alp *et al.* (2011) find that the choice of the smoothing parameter in the HP filter has important implications for the volatility of the trend term and average business cycle length observed in the data.

OECD (2016) addresses this limitation by aligning the λ parameter to the frequency domain framework. This is done to filter out cycles in a certain frequency range with the help of the transformation into the frequency domain. They apply the HP filter twice to achieve a smoothed de-trended cycle (referred to as the double HP filter). First they remove the long term trend by setting λ to a high value, to preserve the business cycle frequencies and the high frequency components. Second, they apply the H-P filter with a smaller λ to preserve the trend part of the filter. The first step de-trends the series and the second step smooths. This is a relatively unusual approach which diverges from the mainstream literature.

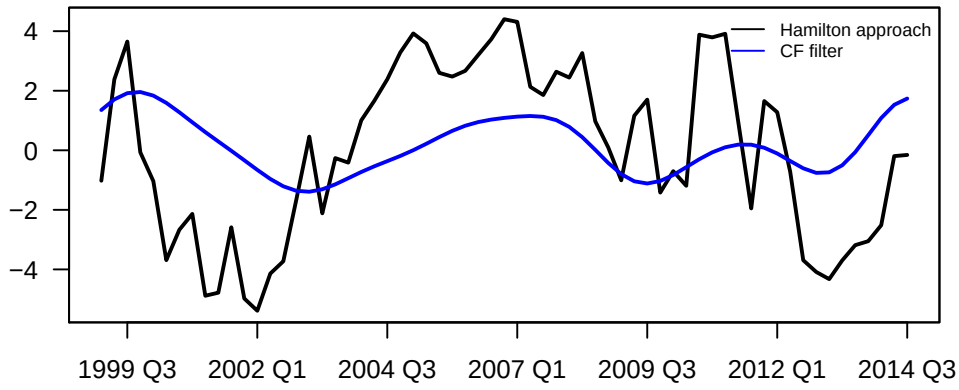
Hamilton (2016) shows that the HP filtered series produces spurious dynamic relations that have no relation with the underlying data-generating process. The literature has increasingly come to rely on alternatives to the HP filter.

The workhorses of the literature are the band-pass filters proposed by Baxter and King (Baxter and King, 1999) and Christiano-Fitzgerald (CF) (Christiano and Fitzgerald, 2003). Band-pass filters eliminate slow moving trend components and high frequency components while retaining the intermediate business cycle fluctuations. These filters approach the de-trending and smoothing problem in the frequency domain.

In a recent advance, Hamilton (2016) proposes a simple and robust estimator of the cyclical component. This is based on an estimate of an OLS regression

to deal with these outliers. These are additive outliers (AOs), temporary change outliers (TCs) and level shifts (LSs), seasonal outliers (SOs) and ramps. Adjustment for outliers along with seasonal adjustment enables us to get a relatively smoother series for trend-cycle decomposition. For more details on the treatment of outliers see the program's reference manual: `https://www.census.gov/ts/x13as/docX13AS.pdf`

Figure 1 GDP cyclical component: CF filter and Hamilton method



of y_{t+h} on a constant and the 4 most recent values of y as of date t. Hamilton (2016) shows that the residual from this regression provides a reasonable de-trended approximation for a broad class of underlying processes. The residuals from the following OLS regressions:

$$y_{t+h} = \beta_0 + \beta_1 y_t + \beta_2 y_{t-1} + \beta_3 y_{t-2} + \beta_4 y_{t-3} + v_{t+h}$$

are the cyclical component of the series.

$$\hat{v}_{t+h} = y_{t+h} - \hat{\beta}_0 - \hat{\beta}_1 y_t - \hat{\beta}_2 y_{t-1} - \hat{\beta}_3 y_{t-2} - \hat{\beta}_4 y_{t-3}$$

In our work, we first use the asymmetric Christiano-Fitzgerald filter (CF) to isolate the trend and cyclical component. The NBER defines business cycles as fluctuations having periodicity ranging between 8 to 32 quarters. We use this definition. The cyclical component is standardised before the application of the dating algorithm.[6]

In addition, we also use the methods of Hamilton (2016). Figure 1 superposes the cycles extracted from the CF filter and the Hamilton (2016) methodology. We will apply all the steps of the dating procedures through these two methods.

[6]For a detailed analysis of the detrending techniques see Appendix C.

2.3 The dating algorithm

The standardised cyclical component forms the input series for the application of the dating algorithm by Bry and Boschan (1971). The procedure was subsequently improved by Harding and Pagan (2002).

An alternative approach to identifying turning points applies the parametric dynamic factor time model. This approach characterises expansion and recession phases as unobserved regime shifts in the mean of the common factor. This common factor is modelled as following a Markov switching model by Hamilton (1989). This model endogenously estimates the timing of regime shifts in the parameters of a time series model. This model further developed by Chauvet (1998) produces a probability that the economy is in a recession or expansion at any point in time. These probabilities can be used to establish turning point dates using an algorithm for converting probabilities into a binary state variable that defines the business cycle phase at any particular time (Chauvet and Hamilton, 2006).

Chauvet and Piger (2008) apply these two approaches to a real time dataset of the four coincident indicators identified by the NBER. The authors' analysis suggest that both the approaches are capable of identifying turning points in real time with reasonable accuracy. The turning points identified through both the methods are close to the official chronology established by the NBER. Hence, in this paper, we do not pursue this line of thought further. It can be carried forward in future research.

3 Empirical analysis

We use the quarterly GDP series (Base year 2004-05) to identify the chronology of business cycle turning points.[7] This series is available from 1996-Q2 (Apr-Jun) to 2014-Q3 (Jul-Sep).

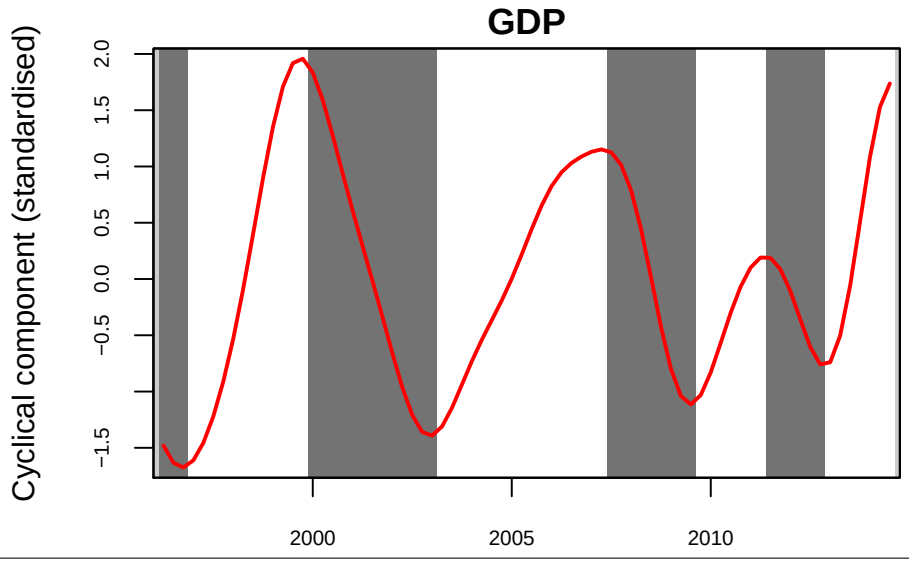
3.1 Business cycle turning points

First, we extract the cyclical component of GDP using the NBER business cycle periodicity of 2-8 years and then apply the dating algorithm by Harding

[7]The Central Statistical Organisation revised the GDP series with a new base year of 2011-12. The revised series is available only from 2011-Q2. Hence we stick to the series with the old base year for our analysis.

Figure 2 Turning points in GDP

This figure shows the turning points in the cyclical component of GDP. Here the cyclical component is extracted using the CF filter using the NBER definition of business cycle periodicity of 2 to 8 years.



and Pagan (2002).

Figure 2 and Table 1 shows three episodes of recession in the economy during the period 1996-2014. Using GDP as the reference series, the first episode of recession was in the period: 1999-Q4 to 2003-Q1, the second recession was in the period 2007-Q2 to 2009-Q3, and the third recession in the period 2011-Q2 to 2012-Q4.

Table 2 shows the average amplitude and duration of phases (recession and expansion) extracted from these dates. The average duration of expansion is 12 quarters and the average duration of recession is 9 quarters. In addition to reporting the average numbers for duration and amplitude of phases, Table 2 also reports coefficient of variation (CV) which is a measure of diversity in duration (CV_D) and amplitude (CV_A) of expansion and recession phases (Plessis, 2006; Hall and McDermott, 2009). This measure shows how diverse are the duration and amplitude of expansion and recession phases across specific cycles. A higher value of the coefficient indicates greater diversity across cycles.

$$CV_D^{Expansion} = \frac{\sqrt{\frac{1}{K}\sum_{i=1}^{K}(D_i^{Expansion} - \bar{D}^{Expansion})^2}}{\frac{1}{K}\sum_{i=1}^{K} D_i^{Expansion}}$$

Table 1 Dates of turning points in GDP

This table shows the chronology of turning points using GDP as the reference series. The first period of recession is from 1999 Q4 to 2003 Q1. The period of expansion starts in 2003 Q1 and continues till 2007 Q2. This is followed by a period of recession from 2007 Q2 to 2009 Q3. This is followed by a period of expansion from 2009 Q3 to 2011 Q2, followed by a period of recession from 2011 Q2 to 2012 Q4.

Phase	Start	End	Duration	Amplitude
Recession	1999-Q4	2003-Q1	13	3.3
Expansion	2003-Q1	2007-Q2	17	2.5
Recession	2007-Q2	2009-Q3	9	2.3
Expansion	2009-Q3	2011-Q2	7	1.3
Recession	2011-Q2	2012-Q4	6	0.9

Table 2 Summary statistics of GDP growth cycles

This table shows the summary statistics of growth cycle turning points. It shows the average duration and amplitude of expansion and recessions. The average amplitude of expansion is seen to be 2.5% while the average amplitude of recession is 2.2%. The average duration of expansion is seen to be 12 quarters while the average duration of recession is seen to be 9.3 quarters. The table also shows the coefficient of variation (CV) in duration and amplitude across expansions and recessions. We find that diversity in durations of expansions and recessions is similar. The diversity in duration of expansion is seen to be 0.34 while the diversity in duration of recession is 0.31. Turning to the diversity in amplitude, we find that the amplitude of recession is more diverse at 0.45. The diversity in amplitude of expansion is 0.38. This implies that some episodes of recession are more severe than the others across specific cycles.

Exp/Rec	Average amplitude (in per cent)	Average duration (in quarters)	Measure of diversity in duration (CV_D)	Measure of diversity in amplitude (CV_A)
Expansion	2.5	12.0	0.34	0.38
Recession	2.2	9.3	0.31	0.45

Table 3 Changing nature of Indian business cycle: Evidence from the literature

This table presents a comparison of the average duration of expansion and recession reported in the literature. It provides evidence of change in the nature of business cycle turning points. We find that the average duration of expansion is 12 quarters and the average duration of recession is 9 quarters. This is in contrast to the relatively shorter duration reported in the literature ((Mohanty *et al.*, 2003; Dua and Banerji, 2012))

	Reference time period of expansion	Average duration of recession	Average duration
Mohanty (2003)	1970-2001	4 quarters	5 quarters
Dua and Banerji (2012)	1960-2010	5 quarters	6 quarters
Our findings	1996-2014	12 quarters	9 quarters

$$CV_D^{Recession} = \frac{\sqrt{\frac{1}{K}\sum_{i=1}^{K}(D_i^{Recession} - \bar{D}^{Recession})^2}}{\frac{1}{K}\sum_{i=1}^{K} D_i^{Recession}}$$

Where:
$D_i^{Expansion}$ is the duration of the expansionary phase of specific cycle i.
$\bar{D}^{Expansion}$ is the average duration of expansionary phases

$$CV_A^{Expansion} = \frac{\sqrt{\frac{1}{K}\sum_{i=1}^{K}(A_i^{Expansion} - \bar{A}^{Expansion})^2}}{\frac{1}{K}\sum_{i=1}^{K} A_i^{Expansion}}$$

$$CV_A^{Recession} = \frac{\sqrt{\frac{1}{K}\sum_{i=1}^{K}(A_i^{Recession} - \bar{A}^{Recession})^2}}{\frac{1}{K}\sum_{i=1}^{K} A_i^{Recession}}$$

Where:
$A_i^{Expansion}$ is the amplitude of the expansionary phase of specific cycle i.
$\bar{A}^{Expansion}$ is the average amplitude of expansionary phases.

Table 2 shows that the diversity in duration of recessions and expansions are similar (both are equally diverse) whereas we see greater diversity in the amplitude of recessions when compared to expansions. This implies that some recessions are more severe relative to the others across different cycles.

We compare our findings on average duration of phases with the findings reported in earlier literature. The average duration of phases is found be longer than the duration reported by the earlier literature (Mohanty *et al.*, 2003; Rand and Tarp, 2002; Dua and Banerji, 2012) (See Table 3). Mohanty *et al.* (2003) applies the growth cycle approach to IIP and identifies 13 growth cycles during the period 1970-71 to 2001-02. The authors find that the average duration of expansion is 4 quarters. Recessions are characterised by relatively longer duration of 5 quarters. Dua and Banerji (2012) using the growth rate cycle approach for the period 1960-2010 find that the average

Table 4 Change in U.S business cycles over time

This table reports the average duration of recession (peak to trough), expansion (trough to peak) and cycle (peak to peak and trough to trough) for the U.S over three distinct time periods. If we compare the period 1854-1919 and 1919-1945, we find that recessions (peak to trough) have become shorter and expansions have become longer in 1919-1945. Consequently the cycles have become longer in 1919-1945 as compared to 1845-1919.

Cycles	Peak to trough	Trough to peak	Trough to trough	Peak to peak
1854-1919 (16 cycles)	21.6	26.6	48.2	48.9
1919-1945 (6 cycles)	18.2	35.0	53.2	53.0
1945-2009 (11 cycles)	11.1	58.4	69.5	68.5

duration of speed-up is 5 quarters and average duration of slowdown is 6 quarters. One plausible explanation for relatively shorter durations of phases in earlier studies could be that these studies cover the pre-1991 period. In the pre-19991 period, the fluctuations were driven by short-lived weather and oil price shocks. Inventory-investment fluctuations which is central to a conventional business cycle did not play a prominent role.[8]

3.2 Characteristics of turning points: Have the cycles changed over time?

Do the characteristics of business cycles change over time? Table 4 shows the changing nature of U.S business cycles over time. Comparing two distinct periods–1854-1919 and 1945-2009, we find that recessions (from peak to trough) have become shorter and cycles (from trough to trough; or from peak to peak) have become longer.

In recent decades, a number of emerging economies have undergone structural transformation and reforms aimed at greater market orientation. There is an emerging strand of literature that studies the changes in business cycle facts in response to these changes (Kim *et al.*, 2003; Alp *et al.*, 2012; Ghate *et al.*, 2013). A key finding of this literature is that, emerging economy cycles have changed in the post-1991 period. Alp *et al.* (2012) compare business cycle properties of the Turkish economy between the pre and post 2001 period. The authors find that the post 2001 period is associated with a significant decline in the volatility of GDP, consumption and investment. In a broader

[8]We cannot compare the findings on coefficient of variation as this statistic is not reported in earlier studies.

Table 5 Average duration in quarters: Evidence from pre and post IIP

This table presents a comparison of the average duration of expansion, recession and overall cycle between the pre and post reform period. We find that the average duration of expansion has increased and the average duration of recession has reduced. As a result the average duration of cycle has increased.

Reference time period	Average duration of expansion	Average duration of recession	Average duration of cycle
1971-1990	5.2	6.7	11.9
1992-2014	5.9	6.3	12.2

study Kim *et al.* (2003) analyse the cyclical features of seven Asian countries[9] spanning the period 1960-1996. Since most of these countries experienced structural transformation, the authors compare the business cycle characteristics between two sub-periods (1960-1984) and (1984-1996) to understand whether business cycle characteristics change in response to structural transformation and policy reforms. A key finding emerging from the analysis is that the amplitude of economic fluctuations in Asian economies seems to be dampening over time. The decrease in amplitude of economic fluctuations is explained by a shift in sectoral composition away from agriculture.

For India, Ghate *et al.* (2013) present a comparison of the business cycle stylised facts for the pre and post-1991 period. The authors find that post-1991 Indian business cycle stylised facts resemble that of an economy in transition. While the volatility of macroeconomic variables in the post-reform period in India is high and similar to emerging market economies, in terms of correlation and persistence, the Indian business cycle looks similar to advanced economies, and less like emerging market economies.

Studies find that business cycle stylised facts change over time. In this section we formally explore whether the duration of business cycle has changed over time. This analysis cannot be performed using GDP since the quarterly series is available only from 1996. In order to gain intuition into the changing nature of cycles, we use IIP for which we have a longer time series. We analyse the series in two phases: pre-reform phase from 1971-1990 and post-reform phase from 1992-2015. We follow the same approach. We adjust the series for seasonality and apply the CF filter to extract the cyclical component. The NBER business cycle periodicity of 2-8 years is used to extract the cyclical component. To the standardised cyclical component of pre and post-reform IIP, we apply the dating algorithm by Bry and Boschan (1971).

[9]The authors study: Indonesia, Korea, Malaysia, The Philippines, Singapore, Taiwan, and Thailand

Table 6 Have the phases of cycles become more diverse over time?

This table shows the coefficient of variation in duration and amplitude of expansion and recession identified using the cyclical component of IIP. The table shows that in terms of both duration and amplitude, the phases of expansion and recessions have become more diverse in the post-reform period. Here CV_D and CV_A refer to the coefficient of variation in duration and amplitude respectively.

Phase	CV_D		CV_A	
	Expansion	Recession	Expansion	Recession
1971-1990	0.28	0.32	0.61	0.59
1992-2014	0.43	0.46	0.74	0.71

Table 5 shows the average duration of expansions and recessions in the two sub-periods. Table shows that while expansions have become longer, recessions have become shorter in the post-reform period. As an outcome, cycles have become longer. This analysis shows over time the duration of cycles have changed.

Table 6 reports the coefficient of variation in duration and amplitude of phases across different cycles in the pre and post-1991 period. Table shows that in the post-reform period both expansions and recessions have become diverse in terms of duration and amplitude. Some episodes of recession are relatively more deeper and severe relative to others in the post-reform period. Similarly there is considerable variation in the duration of expansion and recession across specific cycles in the post-reform period. Some are short-lived while others are relatively more persistent. This dimension of change is hidden if we limit our analysis to comparing average duration and amplitude of phases in pre and post-1991 period. Our analysis points to interesting features about the Indian business cycles. While the average cycle has become longer in the post-reform period, episodes of expansion and recession are relatively more diverse in the post-reform period.

What could explain the increase in the average duration of cycle in the post-reform period? One possible reason could be the changing nature of shocks that affect the economy. In the pre-reform period, good and times were determined by monsoon. A good year was one with good monsoon and vice-versa. These changes played out over a short time-frame. Output fluctuations in the pre-reform period reflected a series of uncorrelated monsoon shocks (Shah, 2008). In the post-reform period, agricultural shocks matter less. This is evident from the decline in the volatility of aggregate GDP in the post-reform period as shown by Ghate *et al.* (2013). Further, the authors show that the cyclical components of key macroeconomic variables have become more

persistent in the post-reform period. As an example, the authors show that the persistence of output for India is higher than the developing economies average figure. The persistence is even higher when non-agricultural GDP is taken as the aggregate measure of business cycle activity. Price levels are also significantly persistent. Persistence in key series point is a reflection of a more stable business cycle.

Further, the decline in the average duration of recession shows the interplay of macro-stabilisation measures. With the onset of the 2008 crisis, the Central Government announced a series of fiscal stimulus packages in the form of additional plan spending and cut in duties to fuel growth (Kumar and Soumya, 2010). This manifested in an increase in the fiscal-deficit to GDP ratio from 2.5% in 2007-08 to 6% in 2008-09 and further to 6.46% in 2009-10. This was also a period of monetary expansion characterised by easing of the monetary policy instruments.[10] The 2011-12 recessionary period also witnessed an increase in deficit from 4.8% to 5.73%. The fiscal-monetary stimulus cushioned the slowdown in growth and prevented a much sharper fall in GDP growth during the identified periods of slowdown.

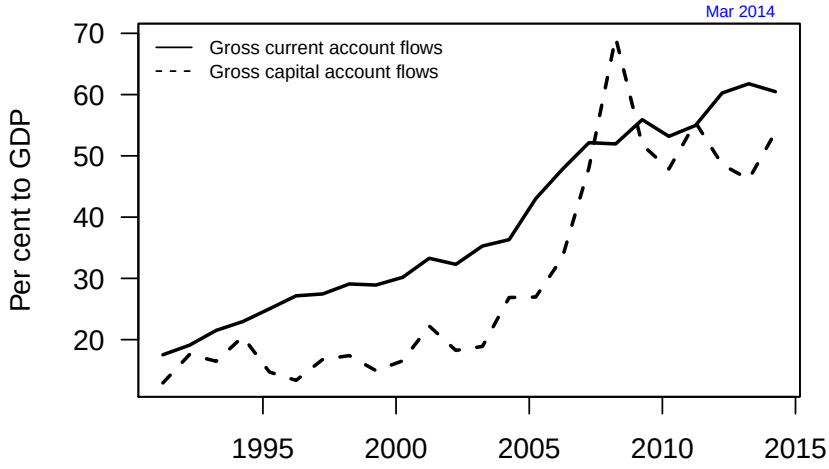
However the individual phases of business cycles have become more diverse in the post-reform period. This could be attributed to two defining features of the Indian economy in the post-reform period:

1. Investment-inventory fluctuations: In the post-reform period, fluctuations in the economy are driven by fluctuations in investment and inventory. In the pre-reform period, a prominent source of investment was government investment in the form of plan expenditure, which did not show any cyclical fluctuations. In the present environment with eased controls on capacity creation and dismantling of trade barriers, private sector investment as a share of GDP has shown a significant rise. The dramatic changes in private corporate sector investment leads to sharp upswings and downswings in GDP (Shah, 2008). The greater correlation between the cyclical components of investment and GDP in the post-reform period also indicate that investment fluctuations drive output fluctuations in the post-reform period (Ghate *et al.*, 2013).

2. Current and capital account integration: Another potential source of diversity in business cycles in the post-reform period could be the sharp increase in India's integration on both current and capital account (See Figure 3). Figure shows a sharp surge in capital flows post

[10]From October 2008 to April 2009, the repo rate was reduced 6 times by a total of 425 basis points. CRR was also eased during this period.

Figure 3 Gross flows on current and capital account (As per cent to GDP)



2000. This coincided with a period of business cycle expansion in the U.S. [11] Emerging economies experience a sharp surge in net capital flows when the U.S is in expansion than when it is in recession (Reinhart *et al.*, 2001). Sharp surge in flows has implications for business cycle volatility in emerging economies. A significant strand of literature has analysed the association between greater trade and financial openness and business cycle volatility. These show differential impact of trade and financial openness on business cycles through impact on consumption and investment (Razin and Rose, 1992; Buch *et al.*, 2005)

We present a description of the characteristics of the business cycle turning points in the post-reform period. Using seasonally adjusted quarterly GDP from 1996Q2 to 2014 Q3 we identify three episodes of recession: 1999Q4 to 2003Q1, 2007Q2 to 2009Q3 and 2011Q2 to 2012Q4. The average duration of expansion is seen to be 12 quarters while the average duration of recession is seen to be 9.3 quarters. We also report coefficient of variation: a measure of diversity of amplitude and duration of expansion and recession across specific cycles. We find that while the duration of both expansion and recession are equally diverse, recessions have a more diverse amplitude as compared to expansions. We offer evidence of change in the characteristics of turning points over time using IIP. In addition to reporting evidence of change in the average duration and amplitude of expansion and recession, we also show change in the diversity of amplitude and duration of expansion and recession

[11]The NBER Business Cycle Dating Committee identified November 2001 to December 2007 as the period of business cycle expansion in the U.S.

Table 7 Dates of turning points in GDP using HP filter

This table shows the business cycle chronology using HP filter. Broadly similar periods of recession (2000 Q1–2003 Q1, 2007 Q4–2008 Q4 and 2011 Q1–2014 Q1) are identified using the cyclical component extracted through the HP filter. In addition, some high frequency cycles are also extracted through the application of the HP filter.

Phase	Start	End	Duration	Amplitude
Recession	2000-Q1	2003-Q1	12	4.3
Expansion	2003-Q1	2004-Q1	4	0.9
Recession	2004-Q1	2004-Q4	3	0.1
Expansion	2004-Q4	2007-Q4	12	2.7
Recession	2007-Q4	2008-Q4	4	2.1
Expansion	2008-Q4	2009-Q3	3	1.6
Recession	2009-Q3	2010-Q1	2	1.5
Expansion	2010-Q1	2011-Q1	4	2.0
Recession	2011-Q1	2014-Q1	12	2.9

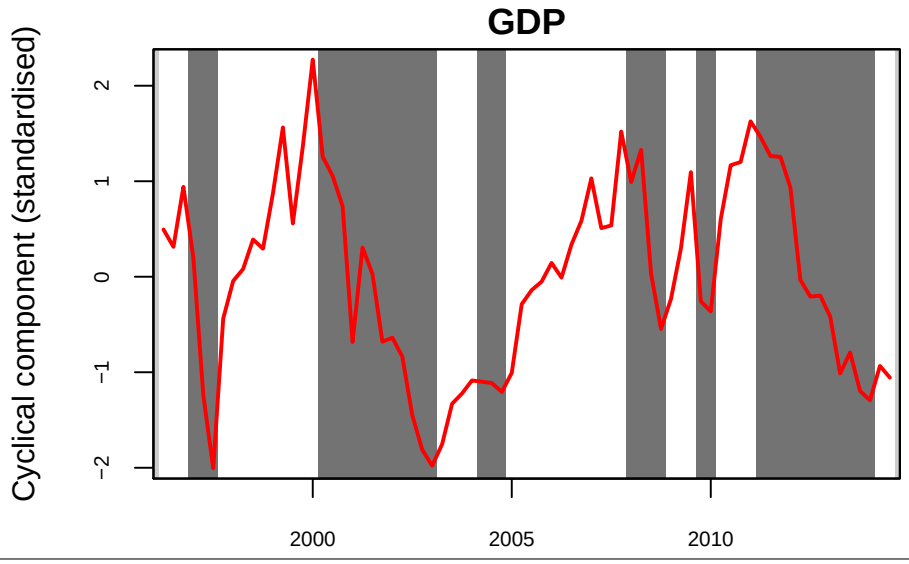
over time.

4 Robustness of these results

In this section we present robustness checks to examine the sensitivity of our findings on business cycle chronology to the choice of the filter and to the choice of the reference variable. We perform two sets of robustness checks. First, we check the sensitivity of our results to the detrending procedures. To do this, we use the Hodrick-Prescott filter in place of the CF filter to extract the cyclical component. We perform this check to test if cyclical components derived from different detrending procedures yield similar turning points. We also check the robustness of our findings with the Hamilton's cycle extraction technique. Second, we check the robustness of our findings to the choice of reference series. We use IIP, non-agricultural, non Government GDP and firms' net sales index as a proxy for analysing business cycle chronology to test the if the chronology of turning points are sensitive to the choice of the reference series.

Figure 4 Dates of turning points in GDP using HP filter

This figure shows the turning points in the cyclical component of GDP. Here the cyclical component is extracted using the HP filter using the conventional smoothing parameter of 1600.



4.1 Robustness check I: Using different detrending procedures

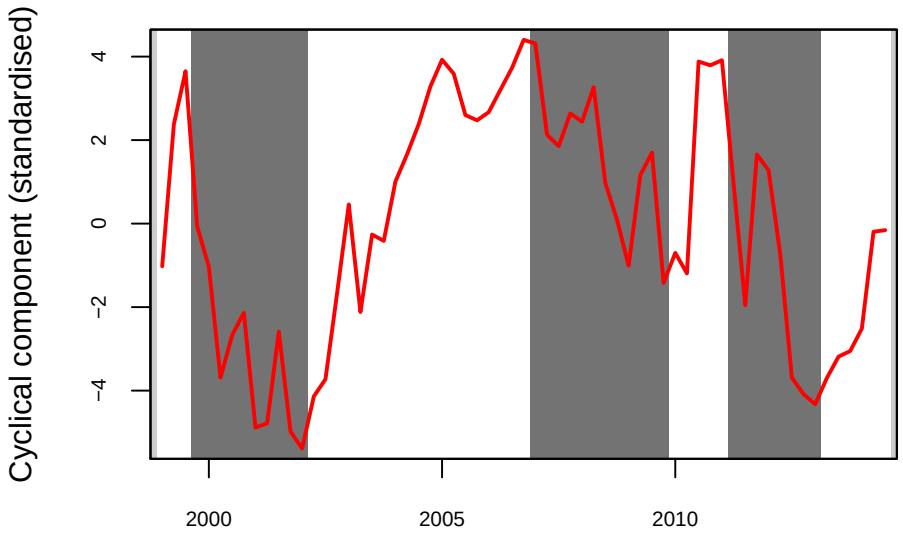
In this section we report the sensitivity of our findings to the choice of filter to detrend the series. Figure 4 and Table 7 shows the turning points in the cyclical component of GDP extracted using the H-P filter. As discussed earlier the choice of the smoothing parameter is crucial for the application of the H-P filter. With quarterly data, the smoothing parameter is set priori to 1600. We test the robustness of our findings with the default value of the smoothing parameter (λ). With this value of smoothing parameter, the H-P filter defines the cyclical component as fluctuations with a period less than 8 years.[12]

It is noteworthy that broadly similar periods of recession (2000 Q1–2003 Q1, 2007 Q4–2008 Q4 and 2011 Q1–2014 Q1) are identified using the cyclical component extracted through the Hodrick-Prescott filter. A comparison of Table 1 and Table 7 shows that the application of H-P filter to extract cyclical component yields more number of cycles. This is attributed to the property

[12]OECD (2016) also use the HP filter but they modify the default smoothing parameter to align it to the frequency domain sphere.

Figure 5 Dates of turning points in GDP using Hamilton filter

This figure shows the turning points in the cyclical component of GDP. Here the cyclical component is extracted using the Hamilton method of extracting the cyclical component.



of HP filter. The reason is that the HP filter puts weight on high frequencies whereas the two band pass filters do not put any weight on these frequencies. As an outcome some high frequency cycles are also extracted through the application of HP filter. A visual inspection of the cyclical component extracted through the CF and HP filter also shows that the CF filter extracts smoother cycles compared to the HP (See Figures 2 and 4).

Figure 5 and Table 8 show the turning points in the cyclical component of GDP extracted using the Hamilton filter. Three episodes of recession are identified: 1999Q3–2002Q1, 2006Q4–2009Q4 and 2011Q1–2013Q1. The second and the third phase of recession identified using the cycle extracted through the Hamilton filter broadly concur with the phases of recession identified using our baseline CF filter.

4.2 Robustness check II: Using other reference series

We turn to examine the turning points using some additional series that could be considered as proxy indicators to study the business cycle chronology. We use IIP, GDP excluding agriculture and government and Firms' net sales index as reference series to analyse the business chronology. We exclude

Table 8 Dates of turning points in GDP using Hamilton filter

This table shows the business cycle chronology using the Hamilton filter. The three periods of recession identified using the baseline CF filter are broadly identified using the Hamilton filter as well.

Phase	Start	End	Duration	Amplitude
Recession	1999-Q3	2002-Q1	10	9
Expansion	2002-Q1	2006-Q4	19	9.8
Recession	2006-Q4	2009-Q4	12	5.8
Expansion	2009-Q4	2011-Q1	5	5.3
Recession	2011-Q1	2013-Q1	8	8.2

agriculture since agriculture is affected by strong seasonal fluctuations which depend on the outcome of the monsoon. In contrast, the government sector is affected by significant short run volatility due to the dynamics of public sector outlays. GDP excluding agriculture and excluding government focuses on the output of individuals, small firms and large firms and is closely related to business cycles.

Next, we use a measure of output utilising firm data. We construct an index of firms net sales. For the construction of the firms' net sales index we focus on all listed firms observed in the CMIE Prowess database other than finance and oil companies. We exclude finance companies since they follow very different accounting concepts. We also exclude oil companies since their balance-sheets experience large changes owing to government's decisions about administered prices. These fluctuations are not an indication of underlying business cycle conditions. For the rest of the firms we construct an index of their net sales. This is done as follows: For each pair of quarters, we construct a panel of firms observed in both quarters, and work out the percentage change in the sum of net sales across all the firms. These percentage changes are used to construct a net sales index.

Following our baseline methodology we use the CF filter to extract the cyclical component and then apply the Bry-Boschan algorithm. Tables 9, 10 and 11 show the phases of expansion and recession in IIP, GDP excluding agriculture and excluding government and Firms' net sales respectively. The periods of recession identified using the three series are broadly in conformity with the periods of recession identified in the GDP series. IIP as a reference series yields 2000-Q2 to 2003-Q3, 2007-Q4 to 2009-Q2 and 2011-Q1 to 2013-Q4 as periods of recession. These are broadly similar to the three periods of recession identified using GDP as the reference series. GDP excluding agriculture and government yields the three periods of recession: 2000-Q1 to

Table 9 Dates of turning points in IIP

This table shows the business cycle chronology using IIP as the reference series. The periods of recession: 2000-Q2 to 2003-Q3, 2007-Q4 to 2009-Q2 and 2011-Q1 to 2013-Q4 are broadly similar to the three periods of recession identified using GDP as the reference series.

Phase	Start	End	Duration	Amplitude
Recession	2000-Q2	2003-Q3	13	2.2
Expansion	2003-Q3	2004-Q4	5	1.3
Recession	2004-Q4	2006-Q1	5	1.5
Expansion	2006-Q1	2007-Q4	7	3.8
Recession	2007-Q4	2009-Q2	6	5.3
Expansion	2009-Q2	2011-Q1	7	3.5
Recession	2011-Q1	2013-Q4	11	1.6

Table 10 Dates of turning points in GDP (excluding agriculture and Government.)

This table shows the chronology of business cycle turning points using GDP excluding agriculture and Government as the reference series. The periods of recession: 2000-Q1 to 2003-Q1, 2007-Q2 to 2009-Q3 and 2011-Q2 to 2012-Q4 are almost identical to the recessions identified using GDP as the reference series.

Phase	Start	End	Duration	Amplitude
Recession	2000-Q1	2003-Q1	12	2.7
Expansion	2003-Q1	2004-Q2	5	0.6
Recession	2004-Q2	2005-Q1	3	0.2
Expansion	2005-Q1	2007-Q2	9	2.2
Recession	2007-Q2	2009-Q3	9	3.3
Expansion	2009-Q3	2011-Q2	7	1.8
Recession	2011-Q2	2012-Q4	6	0.7

2003-Q1, 2007-Q2 to 2009-Q3 and 2011-Q2 to 2012-Q4. These are almost identical to the recessions identified using GDP as the reference series. Firms net sales index yields 2000-Q2 to 2002-Q4, 2007-Q4 to 2009-Q3 and 2011-Q2 to 2013-Q4. These are broadly in conformity with the recession periods identified using GDP as the reference series.

On the whole, the robustness checks show that the chronology of recession is broadly robust to the choice of the detrending procedure and to the choice of the reference series. Our findings on the three phases of recession are broadly robust to the choice of the filter and to the choice of the reference series. With H-P filter, we do get some additional short cycles. These are attributed to the property of the filter.

Table 11 Dates of turning points in Firms' net sales

This table shows the chronology of business cycle turning points using firms' net sales as the reference series. The periods of recession 2000-Q2 to 2002-Q4, 2007-Q4 to 2009-Q3 and 2011-Q2 to 2013-Q4 are broadly in conformity with the recession periods identified using GDP.

Phase	Start	End	Duration	Amplitude
Recession	2000-Q2	2002-Q4	10	2.7
Expansion	2002-Q4	2004-Q3	7	1.9
Recession	2004-Q3	2005-Q4	5	0.9
Expansion	2005-Q4	2007-Q4	8	1.2
Recession	2007-Q4	2009-Q3	7	3.2
Expansion	2009-Q3	2011-Q2	7	3.8
Recession	2011-Q2	2013-Q4	10	3.1

5 Conclusion

India has become a more market-oriented economy. This has brought fresh impulses upon academic and policy work in macroeconomics. In both dimensions, certain pillars of measurement are required in order to embark on the analysis. The first pillar concerns the procedures of seasonal adjustment. This was undertaken in our previous work (Bhattacharya *et al.*, 2016). The second pillar of measurement concerns the dates of turning points of the business cycle. This work has been done in this paper.

Prior to this work, the OECD dates were the best source of dates for the Indian business cycle. However, the OECD work uses a somewhat unusual double-HP filtering. We move close to mainstream macro-economics with the CF filter and Hamilton's recent work. The OECD uses the Index of Industrial Production. However, business cycle fluctuations should be viewed through GDP data, which we employ. We undertake robustness checks at every step of the way, and release the full source code, so as to contribute a robust building block to this emerging literature.

A Indian business cycles

The nature of Indian business cycles has changed over time. In the pre-reform years, good times and bad times were primarily determined by weather. Good times were characterised by good monsoons and vice-versa. Another determinant of bad times was the oil price shock. Business cycles in the

Table 12 Sectoral share (Expressed as a % to GDP)

This table shows the sectoral composition of GDP. The table shows that the share of agriculture has declined from 51.4% in 1951 to 13.9% in 2013. The share of services has increased from 29.6% to 59.9% during the same period.

	Agriculture	Industry	Services
1951	51.4	16.7	29.63
1981	35.7	26.23	37.49
1992	28.5	26.7	44.05
2013	13.9	26.12	59.9

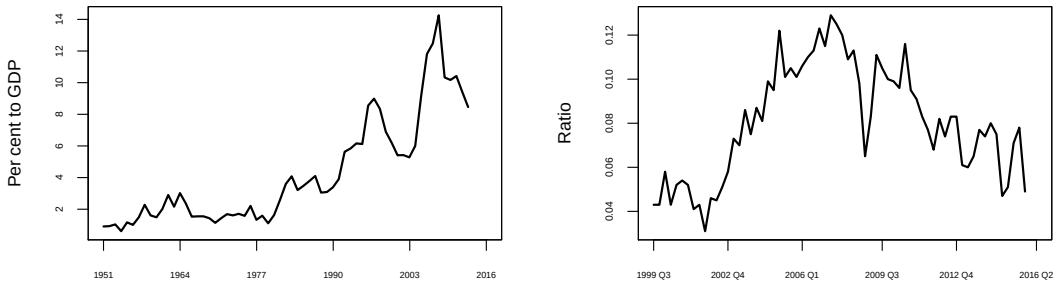
conventional sense involving an interplay of investment and inventory did not exist. In addition, the high share of public sector in investments meant a high degree of stability in investment demand.

In the following years, all this changed (Ghate *et al.*, 2013; Shah and Patnaik, 2010). The share of agriculture has declined and the share of services has increased (See Table 12). The impact of agriculture on the supply of raw material and food price on the one hand, and demand for non agricultural products on the other was much stronger when the economy was a closed economy with a large agriculture sector. Decline in the share of agriculture implies that monsoon shocks matter less for the economy.

Further, there has been a significant change in the environment in which firms operate. In the pre-reform period, the economy was characterised by controls on capacity creation and barriers to trade with limited role for private investment. One prominent source of investment was government investment in the form of plan expenditure, which did not exhibit any cyclical fluctuations. In the post-reform period with eased controls on capacity creation and dismantling of trade barriers, private sector investment as a share of GDP has shown a significant rise. With reduced barriers, competition has increased. Profits are uncertain, and expectations about profit drive investment decisions, as is the case with firms in market economies. After 1991, India has seen a sharp increase in private corporate sector investment as a share of GDP. However this share has shown sharp upswings and downswings. The first plot in Figure 6 shows the time series of private corporate gross fixed capital formation (GFCF) expressed as a percent to GDP. In the mid-1990s, private corporate GFCF rose from 5% of GDP in 1991-1992 to 9% of GDP. This fell dramatically in the business cycle downturn of 2000-03 and hovered around 5% of GDP. It again surged to 12-14% of GDP in the period 2005-07

Figure 6 Private corporate gross fixed capital formation and net profit margin of firms

The figure on the left shows the private corporate gross fixed capital formation expressed as a percent to GDP. The share shows sharp upswings and downswings. In the mid-1990s, private corporate GFCF rose from 5% of GDP in 1991-1992 to 9% of GDP. This fell in the business cycle downturn of 2000-03 and hovered around 5% of GDP. The ratio rose in the upswing of 2005-07 before moderating in the recent period.
The figure on the right shows fluctuations in the net margin of firms. The fluctuations indicate the emergence of conventional business cycles.



before moderating in the recent years. Investment-inventory fluctuations are today central to understanding the emergence of business cycles in India. This is also reflected in the performance of firms. The second plot in Figure 6 shows the quarterly net profit margin of non-financial firms. The series exhibits business cycle fluctuations as opposed to short-lived shocks associated with monsoons (Shah, 2008).

B Business cycle turning points identified in the literature

Table 13 shows the dates of troughs and peaks identified in the literature on Indian business cycle.

C Detrending techniques

Cycle extraction is a crucial step in the growth cycle approach. The class of band-pass filters translate the series in a frequency domain framework. In the frequency domain, we can treat the series as a construction of sine waves

Table 13 Trough and peak dates in literature

This table captures the dates of troughs and peaks identified in the literature on Indian business cycle using different approaches to business cycle measurement.

Trough	**Peak**
Mall (1999), growth cycle approach	
	1951-52
1953-54	1956-57
1959-60	1964-65
1967-68	1969-70
1974-75	1978-79
1980-81	1989-90
1992-93	1995-96
Patnaik and Sharma (2002), classical approach	
	1956-57
1957-58	1963-64
1965-66	1978-79
1979-80	1990-91
1991-92	
Mohanty (2003), growth cycle	
1971 November	1972 December
1973 October	1974 July
1976 January	1976 August
1978 March	1979 March
1980 September	1982 May
1983 September	1984 September
1986 December	1987 July
1988 April	1989 January
1989 November	1990 September
1993 March	1993 November
1994 September	1995 May
1995 December	1996 August
1998 March	2000 November
2001 September	
Chitre (2004), growth cycle	
	January 1952
November 1953	June 1956
June 1958	March 1961
February -1962	March-1965
January - 1968	April-1970
November - 1970	February - 1972
January - 1975	November - 1976
October - 1977	May - 1978
April - 1980	
Dua and Banerji (2012), classical approach	
	November 1964
November 1965	April 1966
April 1967	June 1972
May 1973 November	1973
February 1975	April 1979
March 1980 March	1991
September 1991	May 1996
November 1996	
OECD (2016), growth cycle	
1997 October	1999 December
2003 January	2007 September
2009 March	2010 December
2013 April	

of different wave length. The trend part of the series is comprised by the low frequency (high wave length) sine waves, whereas the noise is formed by a set of high frequency sine waves (OECD, 2016).

Once we have the series in the frequency domain, we can single out the cycles we are interested in, and eliminate the components whose wave length is too long (trend) or too short (noise). The category of band-pass filters help in extracting cycles of a chosen frequency (Christiano and Fitzgerald, 2003; Baxter and King, 1999). The de-trending methods need to be aligned with the chosen business cycle frequency or periodicity.

The cyclical component in Christiano-Fitzgerald filter is calculated as follows:

$c_t = B_0 y_t + B_1 y_{t+1} + ... + B_{T-1-t} y_{T-1} + B^{\sim}_{T-t} y_T + B_1 y_{t-1} + ... + B_{t-2} y_2 + B^{\sim}_{t-1} y_1$

where $B_j = \frac{sin(jb) - sin(ja)}{\pi j}$, $j \geq 1$, and $B_0 = \frac{b-a}{\pi}$, $a = \frac{2\pi}{p_u}$, $b = \frac{2\pi}{p_l}$

$$\tilde{B}_k = -\frac{1}{2} B_0 - \sum_{i=1}^{k-1} B_j$$

Where the parameters p_u and p_l are the cut-off cycle length and c_t is the cyclical component.

We use the asymmetric CF filter. Asymmetric filter varies with time. The alternative methodology is through the application of symmetric filters. Symmetric approximation assumes no phase-shifts in the resulting filtered series. However symmetric approximation requires pruning of series. Depending on the extent of pruning a certain number of observations at the end of the series cannot be filtered. Baxter-King filter: another filter in the class of band-pass filters is a symmetric filter (Baxter and King, 1999).

Hodrick-Prescott filter:

$y_t = \tau_t + c_t$

$min_{\tau_t} \sum_t (y_t - \tau_t)^2 + \lambda * sum_t (\tau_{t+1} - 2 * \tau_t + \tau_{t-1})^2$

The initial y_t series is decomposed into λ_t the trend component and c_t - the cyclical component, with the objective being to minimise the distance between the trend and the original series and, at the same time to minimise the curvature of the trend series. The trade-off between the two goals is captured by the λ parameter.

It is possible to transform the Hodrick-Prescott filter into frequency domain. The literature uses 1600 as the value of λ for quarterly series but it is possible

to align the λ parameter with the goal of filtering out cycles in a certain frequency range depending upon our definition of business cycle with the help of the transformation into the frequency domain (Pedersen, 2001).

D Algorithm for detection of turning points

The Bry-Boschan (BB) and Harding Pagan (H-P) algorithms find the turning points as follows:

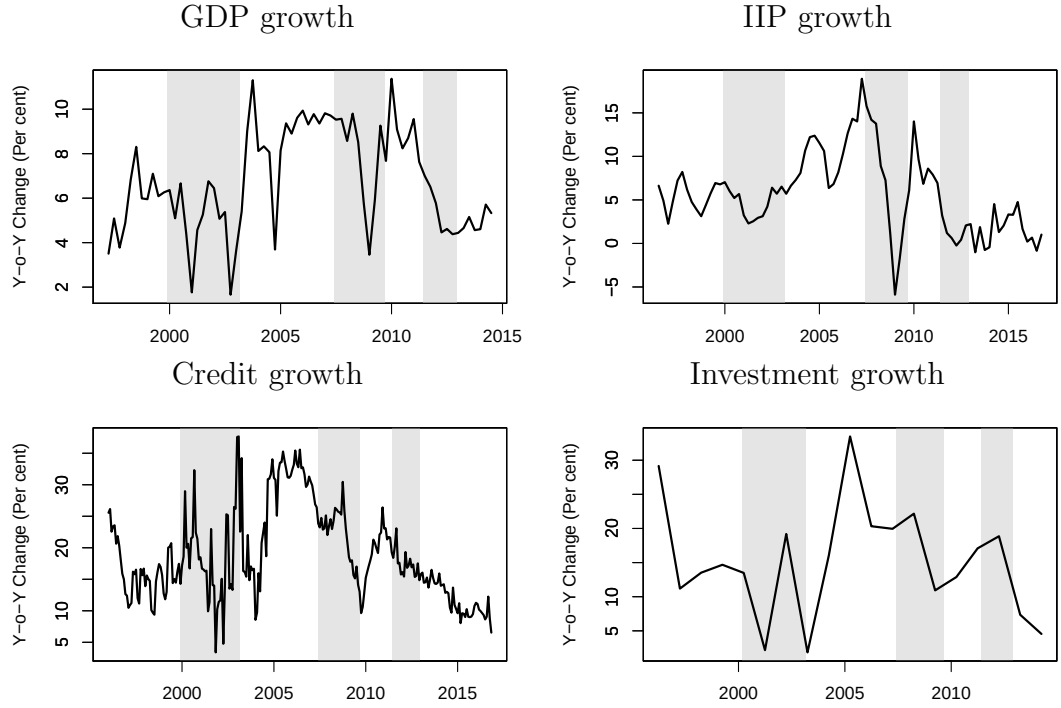
- The data is smoothed after outlier adjustment by constructing short-term moving averages.
- The preliminary set of turning points are selected for the smoothed series subject to the criterion described later.
- In the next stage, turning points in the raw series is identified taking results from smoothed series as the reference.

The identification of turning point dates is done subject to the following rules:

- The first rule states that the peaks and troughs must alternate.
- The second step involves the identification of local minima (troughs) and local maxima (peaks) in a single time series, or in y_t after a log transformation.
- Peaks are found where y_s is larger than k values of y_t in both directions.
- Troughs are identified where y_s is smaller than k values of y_t in both the directions.
- Bry and Boschan (1971) suggested the value of k as 5 for monthly frequency which Harding and Pagan (2002) transformed to 2 for quarterly series.
- Censoring rules are put in place for minimum duration of phase (from peak to trough or trough to peak) and for a complete cycle (from peak to peak or from trough to trough).
- Harding and Pagan identify minimum duration of a phase to be 2 quarters and the minimum duration of a complete cycle to be 5 quarters.
- For monthly data, the minimum duration is 5 months and 15 months for phase and cycle respectively.

Figure 7 Slowdown in macro-economic variables during the identified periods of recession

This figure shows the growth patterns in key macro-economic variables during the identified periods of recession. The figure shows that the year-on-year growth in GDP, IIP, non-food credit and investment shows considerable decline during the shaded periods of recession.



- The identification of turning points is avoided at extreme points.

The dating algorithm does not define double-dip recession. Two periods of contraction can be either two separate recessions or parts of the same recession. The determination in the algorithm is based on the duration and strength of the upturn after the initial trough.

E Description of recessions and expansions

Figure 7 shows the performance of key macroeconomic variables during the three identified periods of recession. The shaded portions show the period of recession identified in the cyclical component of GDP. The first figure in the first row shows the year-on-year change in GDP growth. The year-on-year

Table 14 Growth rate in GDP and its sectors

This table shows the growth rate in GDP and its sectors in the nineties. The table shows a pick-up in growth rate during the initial post-crisis years from 1992-1996. Since 1997 a broad-based moderation is seen in growth rates for overall GDP, agriculture and industrial GDP.

Year	GDP	Agriculture	Industry	Services
1991-92	1.43	-1.95	0.34	4.69
1992-93	5.36	6.65	3.22	5.69
1993-94	5.68	3.32	5.5	7.38
1994-95	6.39	4.72	9.16	5.84
1995-96	7.29	-0.7	11.29	10.11
1996-97	7.97	9.92	6.39	7.53
1997-98	4.3	-2.55	4.01	8.93
1998-99	6.68	6.32	4.15	8.28
1999-00	7.59	2.67	5.96	11.19

growth shows sharp moderation during the three shaded periods of recession from 1999 Q4 to 2003 Q1, from 2007 Q2 to 2009 Q3 and from 2011 Q2 to 2012 Q4. The second figure in the first row shows the year-on-year growth in IIP. The growth in IIP also shows a decline during the shaded periods of recession. Similar trend is seen in credit growth and investment growth. Both the series show considerable decline during the shaded periods of recession. The above analysis shows that the trends in standard indicators conform to the chronology of recession.

A brief description of the macro-economic conditions during the periods of expansion and recession is presented below. To set the context, we begin by giving a brief overview of the macroeconomic conditions in the nineties.

The decade of nineties : The decade of nineties saw far reaching changes in economic policy. The Balance of Payments crisis in the early nineties triggered wide ranging reforms towards a market oriented economy. These led to a spurt in economic growth in the first half of the nineties.Some of the key reforms introduced in the early nineties were:

1. Devaluation and transition to a market determined exchange rate.
2. Phased reduction of peak custom duties.
3. Policies to encourage foreign direct and portfolio investment.
4. Abolition of industrial licensing
5. Gradual liberalisation of interest rates
6. Setting up of Securities and Exchange Board of India (SEBI) as capital market regulator and decontrol of Government over capital issues

Figure 8 Industrial production and exports in the nineties

This figure shows the year-on-year growth in industrial production and exports in the nineties. The first figure shows the growth in IIP and the second figure captures the growth in exports. The growth in both these variables witnessed a surge in the initial years of the nineties before moderating from 1996-97 onwards.

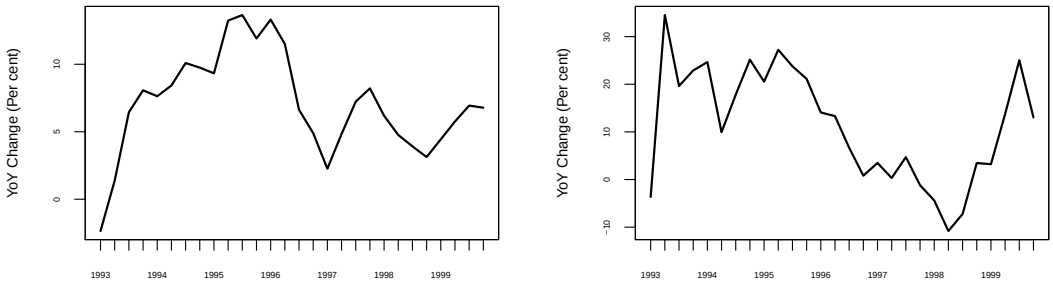


Table 15 External debt indicators in the nineties

This table shows the key external debt indicators in the nineties. One of the outcome of the reform measures introduced in the nineties was the improvement in the external debt indicators.

Year	External debt to GDP (%)	Ratio of short-term debt debt to total debt	Ratio of foreign exchange reserves to total debt	Ratio of short-term debt to foreign exchange reserves
1991-92	38.7	8.3	10.8	76.7
1992-93	37.5	7.0	10.9	64.5
1993-94	33.8	3.9	20.8	18.8
1994-95	30.8	4.3	25.4	16.9
1995-96	27.0	5.4	23.1	23.2
1996-97	24.6	7.2	28.3	25.5
1997-98	24.3	5.4	31.4	17.2
1998-99	23.6	4.4	33.5	13.2
1999-00	22.0	4.0	38.7	10.3

Source: India's external debt: A status report 2014-15

Against the backdrop of these reforms the external and real sector witnessed a sharp turnround. Table 14 shows a spurt in growth in GDP and its components in the initial post crisis years. Figure 8 shows a sharp growth in industrial production and exports during the initial years of the nineties. The initial post crisis years saw a sharp growth in IIP with growth peaking at 13.7% in mid 1995. Export growth surged to 20% in 1993-94. The external debt indicators also witnessed an improvement (Table 15). The external debt stock to GDP ratio improved from 38.7% in 1991-92 to 30.8% in 1994-95 and further to 22% in 1999-00. The ratio of short-term debt to total debt declined from 8.3% in 1991-92 to 4.3% in 1994-95 to 4% in 1999-00. Ratio of foreign exchange reserves to total debt and the ratio of short-term debt to foreign exchange reserves also witness an improvement in the nineties.

Aggregate savings and investments were also buoyant during the first half of the

Table 16 Key macro-economic conditions in 2000-03

This table shows the growth rate in GDP, gross fixed investment as a ratio to GDP and savings as a ratio to GDP during 2000-03 period. We see a moderation in GDP growth rate. Broadly, the savings rate exceeded the investment rate in this period.

	1999-2000	2000-01	2001-02	2002-03
Annual GDP growth rate	7.6	4.3	5.5	4.0
Gross fixed investment (% to GDP)	24.1	22.8	25.1	23.7
Savings (% to GDP)	25.7	23.8	24.9	25.93

nineties. Gross domestic savings as a percent to GDP rose from 21.3 in 1991-92 to 24.15% in 1997-98. Similarly gross domestic capital formation rose from 22.5% in 1991-92 to reach a peak of 26.1% in 1995-96 before slowing down to 22% in 1996-97.

From 1997 onwards we see a deceleration in India's growth story (Acharya, 2012). GDP growth moderated to 4.3% in 1997-98 from 8% in 1996-97. Agriculture and industrial growth also slowed down in 1997-98. The growth in manufacturing fell sharply to less than 1% in 1997-98 from 9.5% in the previous year. Figure 8 shows a slump in industrial production and exports in 1997. The moderation in growth from 1997-98 onwards could be attributed to the investment boom of the previous years. The investment boom of the previous three years had built up large capacities, which discouraged further expansion. Another reason could be the advent of coalition governance had dampened business confidence.

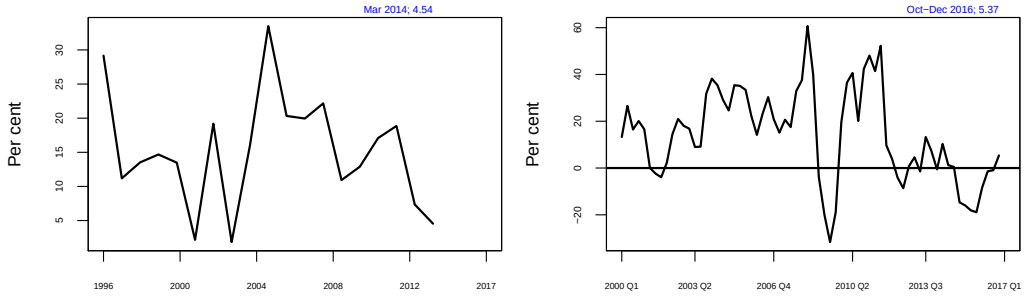
The subsequent paragraphs present an overview of the phases of expansion and recession from 1999 onwards.

End 1999 to 2003Q1 recession : Table 16 shows the performance of key macro-economic indicators during the period 2000-03. GDP growth slowed down from 7.6% in 1999-2000 to 4.3% in 2000-01. The ratio of gross fixed investment to GDP was lower than the ratio of savings to GDP. With low private investment demand, foreign investment was sought to improve the investment climate. However in the aftermath of the Asian financial crisis, FDI inflows did not gain momentum. The bursting of the dot-com bubble, and the brief decline in software export growth after the "Y2K" problem also contributed to the slowdown (Nagaraj, 2013). On the whole, the macro-economic conditions were largely benign. But conditions began to look positive from 2003 onwards. The upswing from 2003 onwards was driven by a boom in investment and a revival of foreign capital inflows that had dried up after the Asian financial crisis.

2003-mid2007 expansion : The economy witnessed an upswing in the cycle, primarily led by high credit growth during this period when firms borrowed and initiated a number of projects. What triggered this boom? From 2001 to 2004, RBI engaged in sterilised intervention. In early 2004, it ran out of bonds. This period was marked by currency trading that was not backed by sterilisation. Without sterilisation dollar purchases resulted in injection of rupee in the economy. The economy became flush with funds, interest rates went down. This kicked off a bank credit boom from 2004 to 2007. The third graph of Figure 7 shows a surge in credit growth between 2004

Figure 9 Slowdown in investment and exports in 2008-09

This figure shows the slowdown in investment and exports growth during the 2008-09 period. The first growth the year-on-year growth in investment and the second graph shows the year-on-year growth in exports.



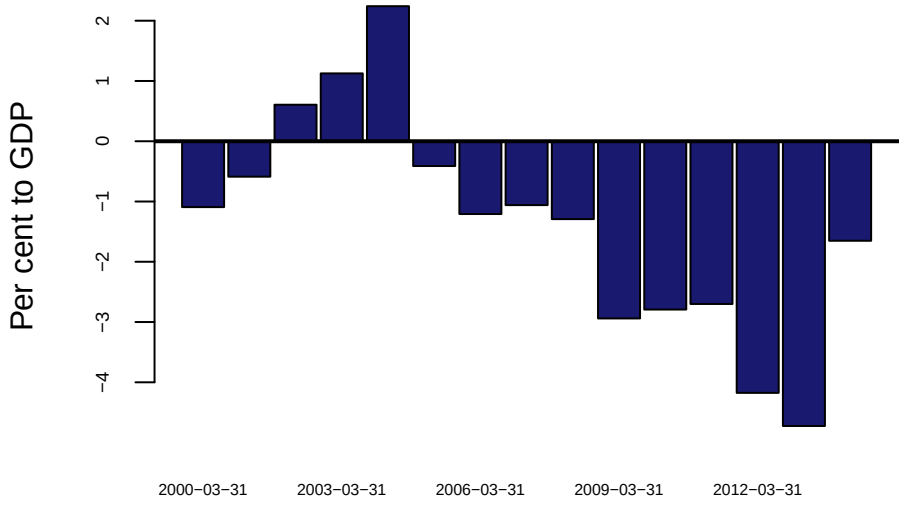
to 2007. The credit growth reached a peak of 40% during this period. GDP growth remained strong at 8-10% during this period.

Mid 2007 to mid 2009 recession : Global financial crisis affected India through trade and financial linkages. Export growth saw a sharp deceleration in this period (Patnaik and Shah, 2010; Patnaik and Pundit, 2014). This could have been the result of greater synchronisation of domestic cycles with global cycles (Jayaram *et al.*, 2009). The immediate transmission of the financial crisis to India was through a slowdown of credit flows which was reflected in the spiking of overnight call money rates that rose to nearly 20 per cent in October and early November 2008. Investment growth also slowed down in 2008-09 (See the first graph of Figure 9).

Mid 2009 to mid 2011 expansion : We saw a business cycle upswing in 2009. GDP growth recovered to 8.6% in 2009-10 from 6.72% in 2008-09. The growth further strengthened to 8.9% in 2010-11. The upswing was an outcome of a coordinated monetary and fiscal policy stimulus package announced in 2008-09. The Fiscal Responsibility and Budget Management (FRBM) Act, 2003, according to which, the government is required to follow fiscal prudence to reduce its deficits to a target rate, was suspended in 2009 in order to accommodate the stimulus policies. On the monetary side, the Reserve Bank of India introduced measures, such as rate cuts, to boost liquidity and ease credit in order to boost investment. The rate cut cycle began in October 2008 and continued till March 2010. Guidelines for External Commercial Borrowing were also liberalised to ease firms' access to external finance (Patnaik and Pundit, 2014).

Mid 2011 to 2012 recession : Since 2011, again, we saw a business cycle slowdown. GDP growth plummeted to 6.7% in 2011-12 and further to 4.47% in 2012-13. This was a culmination of a number of factors. The macroeconomic policy stimulus intended to cushion the fallout of crisis culminated in high inflation and current account pressures. The quality of the fiscal stimulus, which focused on tax cuts and increased revenue expenditure, added to demand pressures, resulting in high inflation. The efficacy of monetary policy to deal with inflation was blunted by persistent rise in food prices (Bhattacharya and Sen Gupta, 2015).

Figure 10 Surge in current account deficit as a ratio to GDP during 2011-12



Inability to achieve fiscal consolidation coupled with surging current account deficit contributed to slowdown in the economy. The fiscal deficit as a ratio to GDP rose from 4.8 in the year ending March 2011 to 5.73 percent in the year ending March 2012. The current account as a percent to GDP also rose beyond comfort levels to 4.17% for the year ending March 2012. High domestic inflation and negative real interest rates on deposits encouraged gold imports thus adding to CAD pressures.

F Data sources

Table 17 Data sources

Variables	Sources
GDP Base year: 2004-05	Central Statistical Organisation
IIP	Central Statistical Organisation
GDP (Excluding Agriculture and Government)	CSO, Authors' calculations
Firms Net Sales Index	CMIE Prowess and Authors' calculations
Non-food credit	RBI
Gross fixed capital formation (Investment)	CSO
Gross domestic savings	CSO
Exports	Ministry of Commerce & Industry
Current account deficit	RBI
Fiscal deficit	Ministry of Finance

References

Acharya S (2012). "India: Crisis, reforms and growth in the nineties." *Working Papers 139*, Stanford Center for International Development. URL http://scid.stanford.edu/publications/india-crisis-reforms-and-growth-nineties.

Aguiar M, Gopinath G (2004). "Emerging Market Business Cycles: The Cycle is the Trend." *NBER Working Papers 10734*, National Bureau of Economic Research, Inc. URL http://ideas.repec.org/p/nbr/nberwo/10734.html.

Alp H, Baskaya Y, Kilinc M, Yuksel C (2011). "Estimating Optimal Hodrick-Prescott Filter Smoothing Parameter for Turkey." *Iktisat Isletme ve Finans*, **26**(306), 09–23. URL http://EconPapers.repec.org/RePEc:iif:iifjrn:v:26:y:2011:i:306:p:09-23.

Alp H, Baskaya YS, Kilinc M, Yuksel C (2012). "Stylized Facts for Business Cycles in Turkey." *Working Papers 1202*, Research and Monetary Policy Department, Central Bank of the Republic of Turkey. URL https://ideas.repec.org/p/tcb/wpaper/1202.html.

Baxter M, King R (1999). "Measuring business cycles: approximate band-pass filters for economic time series." *Review of Economics and Statistics*, **81**(4), 575–593. ISSN 0034-6535.

Bhattacharya R, Pandey R, Patnaik I, Shah A (2016). "Seasonal adjustment of Indian macroeconomic time-series." *Working Papers 16/160*, National Institute of Public Finance and Policy. URL https://ideas.repec.org/p/npf/wpaper/16-160.html.

Bhattacharya R, Sen Gupta A (2015). "Food Inflation in India: Causes and Consequences." *Working Papers 15/151*, National Institute of Public Finance and Policy. URL https://ideas.repec.org/p/npf/wpaper/15-151.html.

Bjornland H (2000). "Detrending methods and stylized facts of business cycles in Norway- an international comparison." *Empirical Economics*.

Boschan C, Banerji A (1990). "A reassessment of composite indexes." In "Analysing business cycles," M.E Sharpe, New York.

Bry G, Boschan C (1971). *Cyclical Analysis of Time Series: Selected Procedures and Computer Programs*. National Bureau of Economic Research. URL http://www.nber.org/chapters/c2145.

Buch CM, Doepke J, Pierdzioch C (2005). "Financial openness and business cycle volatility." *Journal of International Money and Finance*, **24**(5), 744 – 765. ISSN 0261-5606. URL //www.sciencedirect.com/science/article/pii/S0261560605000392.

Burns A, Mitchell W (1938). "Statistical indicators of cyclical revivals." *NBER Bulletin*, **69**.

Burns AF, Mitchell WC (1946). *Measuring Business Cycles*. National Bureau of Economic Research.

Burnside C (1998). "Detrending and business cycle facts: A comment." *Journal of Monetary Economics*.

Calderon C, Fuentes R (2006). "Characterising business cycle fluctuations in emerging economies." *Central bank of Chile working papers*.

Canova F (1998). "Detrending and business cycle facts." *Journal of Monetary Economics*.

Chauvet M (1998). "An Econometric Characterization of Business Cycle Dynamics with Factor Structure and Regime Switching." *International Economic Review*, **39**(4), 969–96. URL `http://EconPapers.repec.org/RePEc:ier:iecrev:v:39:y:1998:i:4:p:969-96`.

Chauvet M, Hamilton JD (2006). "Dating business cycle turning points." *Contributions to Economic Analysis*, **276**, 1–54.

Chauvet M, Piger J (2008). "A Comparison of the Real-Time Performance of Business Cycle Dating Methods." *Journal of Business & Economic Statistics*, **26**(1), 42–49. ISSN 07350015. URL `http://www.jstor.org/stable/27638960`.

Chitre V (1982). *Growth Cycles in the Indian Economy*. Artha vijnana reprint series. Gokhale Institute of Politics & Economics. URL `https://books.google.co.in/books?id=o-SwAAAAIAAJ`.

Chitre V (2001). "Indicators of Business Recessions and Revivals in India: 1951-1982." *Indian Economic Review*, **36**(1), 79–105. URL `http://ideas.repec.org/a/dse/indecr/v36y2001i1p79-105.html`.

Chitre VS (2004). "Indicators of business recessions and revivals in India 1951 - 82."

Christiano L, Fitzgerald T (2003). "The band pass filter." *V International Economic Review*, **44**(2), 435–465.

Christoffersen PF (2000). "Dating the Turning Points of Nordic Business Cycles." *EPRU Working Paper Series 00-13*, Economic Policy Research Unit (EPRU), University of Copenhagen. Department of Economics. URL `https://ideas.repec.org/p/kud/epruwp/00-13.html`.

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

Dua P, Banerji A (2000). "An Index of Coincident Economic Indicators for the Indian Economy." *Working papers 73*, Centre for Development Economics, Delhi School of Economics. URL http://ideas.repec.org/p/cde/cdewps/73.html.

Dua P, Banerji A (2001a). "An Indicator Approach to Business and Growth Rate Cycles: The Case of India." *Indian Economic Review*, **36**(1), 55–78. URL http://ideas.repec.org/a/dse/indecr/v36y2001i1p55-78.html.

Dua P, Banerji A (2001b). "A Leading Index for the Indian Economy." *Working papers 90*, Centre for Development Economics, Delhi School of Economics. URL http://ideas.repec.org/p/cde/cdewps/90.html.

Dua P, Banerji A (2006). "Business Cycles in India." *Working Paper 146*, Centre for Development Economics Department of Economics, Delhi School of Economics. URL http://www.cdedse.org/pdf/work146.pdf.

Dua P, Banerji A (2012). "Business And Growth Rate Cycles In India." *Working papers 210*, Centre for Development Economics, Delhi School of Economics. URL https://ideas.repec.org/p/cde/cdewps/210.html.

Dua P, Kumawat L (2005). "Modelling and Forecasting Seasonality in Indian Macroeconomic Time Series." *Working papers 136*, Centre for Development Economics, Delhi School of Economics. URL http://ideas.repec.org/p/cde/cdewps/136.html.

Dubois E, Michaux E (2008). "Grocer 1.3: An Econometrics toolbox for Scilab." URL http://dubois.ensae.net/grocer.html.

Ghate C, Pandey R, Patnaik I (2013). "Has India emerged? Business cycle stylized facts from a transitioning economy." *Structural Change and Economic Dynamics*, **24**(C), 157–172. URL https://ideas.repec.org/a/eee/streco/v24y2013icp157-172.html.

Hall VB, McDermott CJ (2009). "The New Zealand Business Cycle." *Econometric Theory*, **25**(4), 1050–1069. ISSN 02664666, 14694360. URL http://www.jstor.org/stable/20532482.

Hamilton J (2016). "Why You Should Never Use the Hodrick-Prescott Filter." *University of California, Working Paper*.

Hamilton JD (1989). "A New Approach to the Economic Analysis of Nonstationary Time Series and the Business Cycle." *Econometrica*, **57**(2), 357–384. ISSN 00129682, 14680262. URL http://www.jstor.org/stable/1912559.

Harding D, Pagan A (1999). "Knowing the Cycle." *Melbourne Institute Working Paper Series wp1999n12*, Melbourne Institute of Applied Economic and Social Research, The University of Melbourne. URL http://ideas.repec.org/p/iae/iaewps/wp1999n12.html.

Harding D, Pagan A (2002). "Dissecting the cycle: a methodological investigation* 1." *Journal of monetary economics*, **49**(2), 365–381. ISSN 0304-3932.

Harding D, Pagan A (2003). "A comparison of two business cycle dating methods." *Journal of Economic Dynamics and Control*, **27**(9), 1681–1690. URL http://ideas.repec.org/a/eee/dyncon/v27y2003i9p1681-1690.html.

Harding D, Pagan A (2006). "Synchronization of cycles." *Journal of Econometrics*, **132**(1), 59–79. URL http://ideas.repec.org/a/eee/econom/v132y2006i1p59-79.html.

Harvey AC, Jaeger A (1993). "Detrending, Stylized Facts and the Business Cycle." *Journal of Applied Econometrics*, **8**(3), 231–47. URL http://ideas.repec.org/a/jae/japmet/v8y1993i3p231-47.html.

Hatekar N (1994). "Historical behaviour of business cycles in India: Some stylised facts for 1951-1985." *Indian School of Political Economy¡ Poona¿: Journal of Indian School of Political Economy*, **6**(4), 684–706.

Hodrick RJ, Prescott EC (1997). "Postwar U.S. Business Cycles: An Empirical Investigation." *Journal of Money, Credit and Banking*, **29**(1), 1–16. URL http://ideas.repec.org/a/mcb/jmoncb/v29y1997i1p1-16.html.

Jayaram S, Patnaik I, Shah A (2009). "Examining the Decoupling Hypothesis for India." *Economic and Political Weekly*, **44**(44), 109–116. ISSN 00129976, 23498846. URL http://www.jstor.org/stable/25663740.

Joshi H (1997). "Growth cycles in India : an empirical investigation."

Kim SH, Kose MA, Plummer MG (2003). "Dynamics of Business Cycles in Asia: Differences and Similarities." *Review of Development Economics*, **7**(3), 462–477. URL https://ideas.repec.org/a/bla/rdevec/v7y2003i3p462-477.html.

Klein PA, Moore GH (1985). "Developing Growth Cycle Chronologies for Market-Oriented Countries." In "Monitoring Growth Cycles in Market-Oriented Countries: Developing and Using International Economic Indicators," NBER Chapters, pp. 29–69. National Bureau of Economic Research, Inc. URL https://ideas.repec.org/h/nbr/nberch/4165.html.

Kumar R, Soumya A (2010). "Fiscal Policy Issues for India after the Global Financial Crisis (2008-2010)." *ADBI Working Papers 249*, Asian Development Bank Institute. URL http://EconPapers.repec.org/RePEc:ris:adbiwp:0249.

Layton AP, Banerji A (2001). "Dating the Indian Business Cycle: Is Output All That Counts?" *Indian Economic Review*, **36**(1), 231–240. URL http://ideas.repec.org/a/dse/indecr/v36y2001i1p231-240.html.

Mall O (1999). "Composite Index of Leading Indicators for Business Cycles in India." *RBI Occasional Papers*, **20**(3), 373– 414.

Mintz I (1974). "Dating United States Growth Cycle." *Technical report*, NBER.

Mohan R, Kapur M (2015). "Pressing the Indian Growth Accelerator: Policy Imperatives." *IMF Working Papers 15/53*, International Monetary Fund. URL https://ideas.repec.org/p/imf/imfwpa/15-53.html.

Mohanty J, Singh B, Jain R (2003). "Business cycles and leading indicators of industrial activity in India." *Mpra paper*, University Library of Munich, Germany. URL http://EconPapers.repec.org/RePEc:pra:mprapa:12149.

Nagaraj R (2013). "India's Dream Run, 2003-08." *Economic and Political Weekly*, **48**(20).

Nandi A (2010). "India's cosine curve: A business cycle approach of analysing growth, 2007 onwards." *Corporate Economic Cell, Aditya Birla Management Corporation*.

Nilsson R, Gyomai G (2011). "Cycle Extraction: A Comparison of the Phase-Average Trend Method, the Hodrick-Prescott and Christiano-Fitzgerald Filters." *OECD Statistics Working Papers 2011/4*, OECD Publishing. URL https://ideas.repec.org/p/oec/stdaaa/2011-4-en.html.

OECD (2016). "OECD Composite Leading Indicators: Turning Points of Reference Series and Component Series." *Technical report*, OECD. URL http://www.oecd.org/std/leading-indicators/CLI-components-and-turning-points.pdf.

Panagariya A (2008). *India: The emerging giant*. Oxford University Press.

Patnaik I, Pundit M (2014). "Is India's Long-Term Trend Growth Declining?" *ADB Economics Working Paper Series 424*, Asian Development Bank. URL http://EconPapers.repec.org/RePEc:ris:adbewp:0424.

Patnaik I, Shah A (2010). "Why India choked when Lehman broke." *Finance Working Papers 22974*, East Asian Bureau of Economic Research. URL https://ideas.repec.org/p/eab/financ/22974.html.

Patnaik I, Sharma R (2002). "Business cycles in the Indian economy." *MARGIN-NEW DELHI-*, **35**, 71–80. ISSN 0025-2921.

Pedersen TM (2001). "The Hodrick Prescott filter, the Slutzky effect, and the distortionary e!ect of filters ." *Journal of Economic Dynamics & Control*, **25**, 1081–1101.

Plessis SD (2006). "Business Cycles in Emerging market Economies: A New View of the Stylised Facts." *Working Papers 02/2006*, Stellenbosch University, Department of Economics. URL https://ideas.repec.org/p/sza/wpaper/wpapers16.html.

Rand J, Tarp F (2002). "Business Cycles in Developing Countries: Are They Different?" *World Development*, **30**(12), 2071–2088.

Razin A, Rose A (1992). "Business Cycle Volatility and Openness: An Exploratory Cross-Section Analysis." *NBER Working Papers 4208*, National Bureau of Economic Research, Inc. URL https://ideas.repec.org/p/nbr/nberwo/4208.html.

Reinhart C, Calvo G, Fernandez Arias E, Talvi E (2001). "The Growth-Interest Rate Cycle in the United States and its Consequences for Emerging Markets." *MPRA Paper 9075*, University Library of Munich, Germany. URL https://ideas.repec.org/p/pra/mprapa/9075.html.

Romer CD (1999). "Changes in Business Cycles: Evidence and Explanations." *Journal of Economic Perspectives*, **13**(2), 23–44. URL https://ideas.repec.org/a/aea/jecper/v13y1999i2p23-44.html.

Shah A (2008). "New issues in macroeconomic policy." *Business Standard India*, pp. 26–54.

Shah A, Patnaik I (2010). "Stabilising the Indian business cycle." *Working papers*, National Institute of Public Finance and Policy. URL http://EconPapers.repec.org/RePEc:npf:wpaper:10/67.

Stock J, Watson M (1999). "Business cycle fluctuations in us macroeconomic time series." In JB Taylor, M Woodford (eds.), "Handbook of Macroeconomics," volume 1, Part A, chapter 01, pp. 3–64. Elsevier, 1 edition. URL http://EconPapers.repec.org/RePEc:eee:macchp:1-01.