Volatility, Persistence and Synchronisation in State Business Cycles

Working Paper · November 2017

DOI: 10.13140/RG.2.2.13478.83525

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Volatility, Persistence and Synchronisation in State Business Cycles (1960-2014)

Abstract[1]

This paper studies Indian state business cycles in the period 1960-2014. The Hodrick-Prescott filter is applied on log-linearised Annual Net State Domestic Product (at Constant Factor Prices) to obtain estimates of state cycles. These were consequently analysed. After liberalisation in 1991, state business cycles were less volatile and more serially correlated. Across time, average volatility has fallen and first order auto-correlation has risen. In the post reform period, some states were less synchronised, with the national cycle, but average synchronisation of all states has been increasing over time. The largest Indian states were even more synchronised. Robustness checks show that these results always hold at larger values of the smoothening parameter and at different sizes of the rolling window. However the finding that volatility has fallen, holds even at smaller values of the smoothening parameter.

Introduction

This paper seeks to study Indian state business cycles across a long horizon. It documents the volatility, persistence and synchronisation in Indian state cycles, as they change in the post-reform period. To show this, I use spliced Net State Domestic Product (At Constant Factor Prices) from 1960-61 to 2015-16 for 21 post-bifurcation Indian states. Four parent and four daughter states were merged to obtain a long time series. The Hodrick-Prescott (HP) filter was applied on 17 pre-bifurcation states to obtain the cycles. The robustness checks are offered with alternate of the smoothening parameter.

The first finding is that state cycles are less volatile in the post-reform period. This finding is robust to alternate values of the smoothening parameter. Second, state cycles are more serially correlated in the post-reform period. This findings is not robust to the smaller value of the smoothening parameter but holds at the higher value. Third, individually some states are more synchronised in the post reform period, while others are not. But average synchronisation of state cycles (with the national cycle), as computed using rolling windows, was low in the 1970s and 1980s, but had increased in the post reform period. The findings were not robust to smaller values of the smoothening parameter but were robust to the larger value and to alternate sizes of the rolling window. Provided that the window was large enough to capture a full cycle.

The definition of the business cycle is taken from Lucas (1977). Advanced economy macro aggregates display cyclical deviations from trend, that can be captured by low order autoregressive stochastic processes [endnote1]. Working exclusively on Indian data, Ghate et. al (2013) found the Indian business cycle looking similar to that of advanced economies in the post reform period. National output was less volatile and more serially correlated, typically observed in advanced economies. Since these changes took place despite any reduction in the nature of shocks, the authors concluded that it was due to “good policy” and not “good luck”. But whether these results extend to the state-level was left unclear. This paper helps extend some of these findings to the state level.

Research on Indian states’ output has been so far on estimating convergence and divergence in terms of growth rates. Most studies reject absolute convergence (Kalra & Sodsriwiboon, 2010) while some find evidence of conditional convergence (Ghosh 2008, 2010, 2012). Some find that convergence occurs within exclusive clubs (Bandhyopadhyay 2011). The impact of economic liberalisation on states

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has also been studied in terms of long term growth trends, not in terms of business cycles. To my knowledge only Behara et. al, 2017 analyses state business cycles but that study is limited to data after 2011. This paper tries to fill this empirical gap, by presenting stylized facts on volatility and persistence over a long time horizon.

This paper also touches on an untouched issue: synchronisation of state cycles. The question of synchronisation has been traditionally motivated in the context of the European Union and the United States. Synchronisation of regional cycles has been traditionally studied in the context of the European and the United States (Haan et al 2008, Magrini et. al 2013, Duran et. al 2017). There is empirical evidence to suggest that different groups of countries in the EU can find themselves on the opposite ends of the business cycle. Synchronisation is thus very relevant for monetary and fiscal policy, as evident from the studies on Europe and the US.

There is little a-priori reason why this should not apply to India. If the business cycles of Indian states diverge considerably, then stabilisation policy will prove difficult. States in downswing would require easing, while those in upswing, tightening. The findings of this paper would thus be of particular interest to state finance ministers; states that are out of sync with the national cycle are not in the best position to reap the dividends of national-level stabilisation policies.

The results of any analysis hinge on the sharpness of the instrument. The instrument in this case is the HP filter. This filter breaks any time series into a trend component and a cyclical component, based on certain assumptions (Kydland & Prescott 1990, Harvey & Jagger 1991). Despite heavy criticism (Hamilton 2017) it remains very popular in academia and policy circles due to its coherence with theoretical predictions and ease of computation. The main point of controversy is the value of the smoothening parameter. While there is a established conventional value, some scholars have suggested other values (Correia et al. 1992, Ravn & Uhlig 2002). Therefore the first robustness check was to use these alternate values of the smoothening parameter, and see whether the results hold. The second robustness check was to change the size of the rolling window when computing average volatility, persistence and correlation/synchronisation. The second check was conducted but not reported due to paucity of space.

The next section elaborates the “Data and Methodology”; this is critical to the interpretation of the results. The next section titled “Volatility and Persistence” is concerned with the volatility and persistence of state cycles. The penultimate section is titled “Synchronisation of State Cycles”. After which the paper summarises and concludes.

Data and Methodology

A Long Time Series

The data for State Net Domestic Product at Constant Prices was obtained from the EPW-Times series portal. The data was originally generated at the respective State Department of Statistics and Information, and then compiled by the Central Statistics Organisation (CSO). While there are estimates prior to 1960-61, these are marred by numerous missing values.

The 1960-61 series published by the CSO put together the first comparable and continuous series on 15 states (Bihar, Delhi, Gujarat, Haryana, Himachal Pradesh, Jammu & Kashmir, Karnataka, Kerala, Maharashtra, Manipur, Punjab, Rajasthan, Tamil Nadu, Tripura, West Bengal). The data for Himachal begins from 1967-68, after it was created from Punjab. The data for Punjab and Haryana for 1961-62 to 1964-65 is missing as these states underwent bifurcation in 1966. The 1970-71 series added new states (Arunachal Pradesh, Assam, Goa, Orissa, Puducherry). It also backdates the series for Andhra Pradesh, Uttar Pradesh and Madhya Pradesh up till 1960-61. The 1980-81 series included Andaman & Nicobar Islands, Meghalaya, Nagaland and Sikkim. The 1993-94 series split Mizoram from Assam, and the Union Territory of Chandigarh from Punjab and Haryana. It also split the series for Chattisgarh from Madhya Pradesh, Jharkhand from Bihar and Uttarakhand from Uttar Pradesh. The 1999-2000 series left states intact, but the 2004-05 series split Telangana from Andhra Pradesh. I measure state output by using Net State Domestic Product at Factor Cost (at Constant Prices) because Gross estimates are not available for states prior to 1980-81 Base Year.

For National Output, I took the spliced estimate of Net Domestic Product at Factor Cost (at Constant Prices) from 1950-51 to 2013-14 (Base Year 2004-05), from Centre for Monitoring Indian Economy (CMIE). National output data thus ranges from 1950-51 to 2013-14.

The splicing methodology involved two basic principles. First, I assume that newer series contain superior information than older series. For any overlapping estimates for levels or growth rates, only data from the newer series is considered. Second, I applied a pure form of splicing where only the growth rate was preserved. The final analysis was conducted on levels and not first differences.

As is practiced I omit the data for Union Territories and all North Eastern states except Assam. These regions are too small to be of any relevance to the question at hand and often their behaviour is too erratic. To keep series as long as possible I merge daughter and parent states; Andhra Pradesh with Telangana, Chattisgarh with Madhya Pradesh, Jharkhand with Bihar and Uttarakhand with Uttar Pradesh.

The Hodrick-Prescott Filter

Let us assume that actual output has a trend and a cyclical component,

$$Y_t = T_t + C_t$$

where T(t) is the trend and C(t) is the cyclical component or output gap. The trend is assumed to be a smooth process that is integrated of order two. This implies that,

$$T_{t+1} - T_t = T_t - T_{t-1} + E_t$$

Thus growth in trend is a random walk and E_t is white noise. The critical assumption is the link between C_t and E_t. The variance of E_t is not expected to be zero, as potential growth can be affected by shocks. The smoothening parameter "λ" sets the variance of E_t with respect to the variance of C_t.

$$\lambda = V(C_t)/V(E_t)$$

Applying the HP filter is thus equivalent to splitting the series into a trend whose growth follows a random walk and a cyclical component that is about λ^(1/2) times as volatile as the growth of the trend component. The justification for this comes from economic theory which tells us that potential growth can be affected by shocks, but also that cyclical deviations from trend are short-lived and recurrent. I take λ to be 100 as is the convention for annual series. But there are two other values of the smoothening parameter than are commonly suggested in the literature. One is 6.25 (Ravn & Uhlig 2002) and the other is 400 (Correia et al. 1992). I take λ to be 100 for my main results, but offer robustness checks with the other values.

Rolling Windows

Rolling windows have been employed to study how the volatility, persistence and synchronisation of Indian states changes over time. Volatility is measure by standard deviation, persistence by first-order autocorrelation and synchronisation by cross-correlation (with the national cycle. The next paragraph contains a detail of the procedure for calculating average volatility. Replacing standard deviation with first-order autocorrelation and cross-correlation will give us average persistence and synchronisation.

First the rolling standard deviation are obtained for every state business cycle using fixed-size rolling windows. Second, we find the average standard deviation across all states and this value is assigned to the date at the middle of the rolling window. Third, this procedure is repeated till we obtain an index of average volatility in all states over a long period of time.

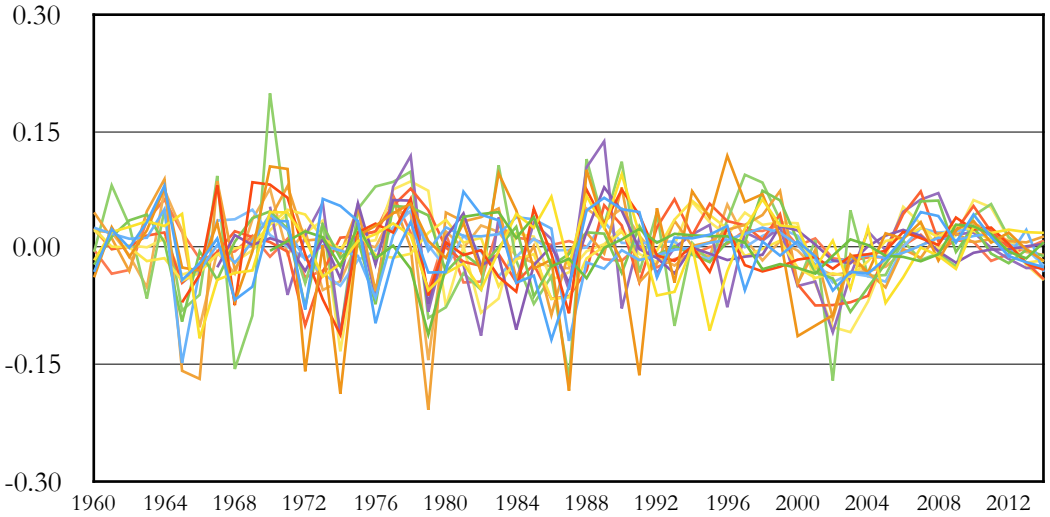
The size of the rolling window should be large enough to capture an entire business cycle. For this paper, the rolling window used was 11 years. But for the robustness check, I used 9, 13 and 15 years. The size of the rolling windows never affected the main results. What held at 11 years did not change with 9, 13 or 15 years. Also, because all series were not of uniform length only data from 1970 to 2014 was used in this exercise.

Section 1: Volatility and Persistence

Transitioning Together

Charts 1 captures the evolution of Indian state business cycles. Prior to 1991, states show large cyclical fluctuations that are quickly reversed. The inability of economy in the pre-reform period (1960-1991) to deal with supply shocks has been documented before (Goyal 2013). Chart 1 shows that famines (1964) and oil shocks (1974, 1979) made strong dents in nearly all states. In the 1980s the cycles seem to diverge; when some climb above trend, others have gone below it. Chart 1 shows that the fundamental character of cycles has changed in the post-reform period. One, overall volatility has fallen. Two, cycles are more persistent. Three, the cycles also seem to be more synchronised. Consider the boom period of 2003-2008; prolonged expansions were uniformly felt across all states. Visual comparison can always be deceptive, and so a statistical study is necessary.

Chart 1: HP Filtered 17 State Business Cycles



Volatility Statistics

The volatility of state cycles can be approximated by their standard deviation. Table 1 presents the volatility statistics for state cycles. State cycles are more volatile than the national cycle. For instance, Rajasthan's output is about four times as volatile as the national output. After 1991, we see that this situation improves and volatility falls. Ghate et al (2013) found that volatility had come down at the national level. These results can be extended to the state level. After 1991, in absolute terms volatility falls for all but two states. States like Rajasthan, Haryana and Himachal Pradesh have seen volatility fall to a third of what it was. Volatility in Odisha, Andhra Pradesh, Assam, Madhya Pradesh, Uttar Pradesh, Haryana and West Bengal has also been cut by half. However, there are the important exceptions of Tamil Nadu and Maharashtra. The reduction in volatility in the two periods is statistically significant for 10 states. The rest are statistically not any less volatile than before.

In order to observe how average volatility has changed across time, we apply rolling standard deviation (11 years window) to the cycles, to obtain a measure of volatility for each state at a given point in time (corresponding to the centre of the window). Next we average across all states to obtain a composite index of volatility for all states at a given point in time (at the centre of the window). This index is plotted in Chart 2. The results show that volatility has been falling consistently since the 70s, and market reforms have strengthened this process. There is also a sharp decline in volatility towards the end of the high growth phase of 2003-2008.

Robustness checks show that similar findings are obtained with the smaller and larger value of the smoothening parameter. Volatility has not increased in a statistically significant way in any state. It has decreased in 12 states at the 5% level for λ=6.25 and for 7 states for λ=400. Chart 2 shows that average volatility is seen to be declining for λ=6.25 and λ=400. Additionally it was also found but not reported here, that the reduction in average volatility is robust to the size of the window.

Table 1: Volatility Statistics (Standard Deviation)

				Robustness Check					
				λ=6.25			λ=400		
Variable	Before 1991	After 1991	P-Value	Before 1991	After 1991	P-Value	Before 1991	After 1991	P-Value
IND	2.42%	2.13%	0.65	2.14%	1.15%	0.01*	2.51%	2.36%	0.77
AP	5.30%	2.90%	0.00*	4.39%	2.18%	0.01*	5.51%	3.33%	0.00*
ASS	3.55%	1.80%	0.05**	2.70%	1.16%	0.02*	3.84%	2.54%	0.26
BIH	4.34%	4.14%	0.95	3.35%	3.12%	0.94	5.12%	5.04%	0.88
GUJ	7.84%	5.60%	0.25	7.04%	3.54%	0.01*	8.05%	6.40%	0.48
HAR	5.90%	2.07%	0.00*	4.85%	1.39%	0.00*	6.22%	2.81%	0.00*
HIM	4.34%	1.53%	0.00*	3.64%	1.25%	0.00*	4.62%	1.66%	0.00*
JK	4.33%	1.56%	0.02*	3.59%	0.97%	0.01*	4.86%	1.71%	0.01*
KAR	3.93%	3.75%	0.49	3.49%	2.38%	0.05**	4.05%	4.01%	0.55
KER	2.76%	2.64%	0.84	1.70%	1.25%	0.07**	3.85%	3.03%	0.44
MP	7.21%	3.43%	0.02*	6.46%	2.41%	0.00*	7.42%	4.50%	0.17
MAHA	3.83%	4.60%	0.23	2.71%	2.31%	0.46	4.39%	5.51%	0.18
ODI	7.26%	4.27%	0.01*	6.65%	2.94%	0.00*	7.44%	5.07%	0.04*
PUN	2.69%	2.27%	0.60	1.77%	1.21%	0.14	2.87%	2.78%	0.92
RAJ	8.76%	5.80%	0.01*	7.91%	4.78%	0.01*	9.11%	6.33%	0.01*
TN	4.55%	4.87%	0.43	3.73%	2.75%	0.54	4.92%	5.72%	0.33
UP	4.71%	2.22%	0.01*	4.25%	1.44%	0.00*	5.01%	3.06%	0.09**
WB	2.87%	1.44%	0.01*	2.36%	0.88%	0.00*	3.00%	1.66%	0.04*

The P-Values are given for the Levene's test for robust equality of variance with the regular mean. * represents statistical significance at the 5% level. ** represents statistical significance at the 10% level.

Persistence & Auto-Correlation

To measure persistence is to measure autocorrelations. The first auto-correlation function for each state are presented in Table 2. For most states first order auto-correlations are significant after 1991. After 1991 the first order autocorrelation has gone up for all states but one. The outlier being Bihar. Prior to the reforms, most states except for Kerala, Maharashtra, Tamil Nadu, Punjab and Assam did not show any statistically significant persistence. Many large states like Gujarat and Karnataka even showed a negative autocorrelation. This situation has been drastically reversed in the post-reform period. These findings show persistent state business cycles (in a statistically significant way) in the post reform period in Assam, Himachal Pradesh, Gujarat, Karnataka, Kerala, Maharashtra, Punjab, Tamil Nadu, Uttar Pradesh and West Bengal. Chart 3 tells us that average persistence was fairly low until liberalisation and has been rising consistently in the post-reform period.

Table 2: Auto-Correlation Function

Variable	First Order Auto-Correlation		λ=6.25		λ=400	
	Before 1991	After 1991	Before 1991	After 1991	Before 1991	After 1991
IND	0.04	0.59*	-0.10	0.24	0.10	0.66*
AP	0.17	0.32	-0.05	-0.20	0.22	0.48*
ASS	0.33	0.61*	0.04	0.29	0.41**	0.75*
BIH	0.26	0.21	-0.09	-0.34	0.46*	0.41**
GUJ	-0.11	0.47*	-0.27	0.00	-0.05	0.58*
HAR	0.04	0.38	-0.24	-0.37	0.10	0.65*
HIM	-0.01	0.46*	-0.32	0.23	0.10	0.52*
JK	0.05	0.28	-0.25	-0.34	0.22	0.36**
KAR	-0.04	0.60*	-0.21	0.32	0.02	0.63*
KER	0.53*	0.72*	0.00	0.30	0.75*	0.76*
MP	-0.09	0.22	-0.26	-0.39*	-0.04	0.51*
MAHA	0.47*	0.65*	0.08	0.06	0.57*	0.73*
ODI	-0.27	0.38	-0.42*	-0.12	-0.22	0.55*
PUN	0.45*	0.66*	0.17	0.28	0.49*	0.75*
RAJ	-0.10	-0.03	-0.27	-0.31	-0.03	0.12
TN	0.17	0.68*	-0.10	0.38*	0.27	0.75*
UP	-0.06	0.52*	-0.20	-0.04	0.04	0.72*
WB	0.22	0.48*	-0.03	0.00	0.27	0.56*

Barletts Test, * signifies significance at 5% ** at 10%.

Robustness checks show that similar findings are obtained with the larger value of the smoothening parameter. For λ=6.25 the results show contrary findings for Andhra Pradesh, Haryana, Madhya Pradesh, Uttar Pradesh and West Bengal. With λ=6.25, the rolling windows technique does not show a very large increase in average persistence. With λ=400, the results continue to hold and the rolling windows technique shows an even higher level of persistence.

Chart 3: Average Rolling First Order Auto-Correlation (11 Year Window)

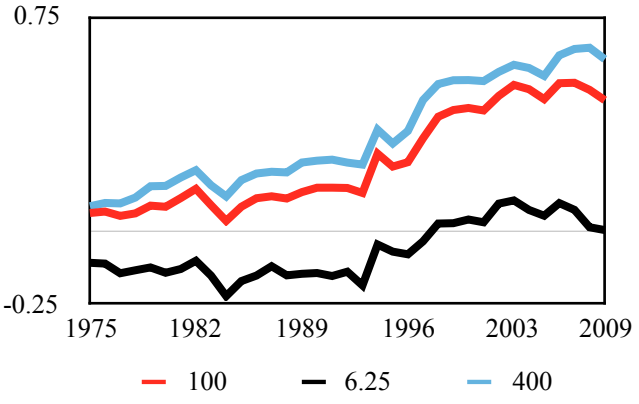
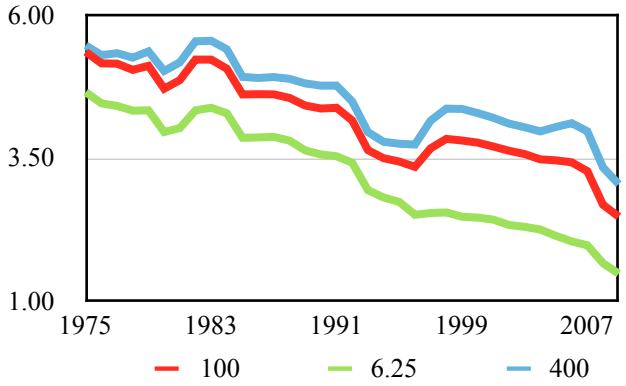


Chart 2: Average Rolling Standard Deviation (11 Year Window)



Section 2: Synchronisation

Cross Correlations

We can study synchronisation through the correlation of state cycles with the national cycle. In Table 4 we present the overall cross correlations of state cycles with the national cycle. We find that synchronisation has increased in the Southern states, Maharashtra, Punjab, Uttar Pradesh, West Bengal and Jammu Kashmir. It has fallen in the other Northern States, Gujarat and Assam. The change in correlation is not significant in either direction at the 95% level, but it is at lower levels. The findings are therefore quite mixed. The Z-scores reported in Table 4 are for the null of equal correlation in the pre and post reform period. Positive Z-scores indicate a rise in correlation in the post reform period, if greater than 1.96 then the result is statistically significant at the 95% level.

Table 4: Synchronisation with National Output

Variable	HP Filter Cross Correlations			Robustness Check	
				λ=6.25	λ=400
	Before 1991	After 1991	Z-Score	Z-Score	Z-Score
TN	0.43	0.75	1.79**	0.84	1.87**
AP	0.39	0.70	1.55	0.67	1.88**
KER	0.13	0.51	1.44	1.07	2.18*
KAR	0.39	0.67	1.35	-0.01	1.50
PUN	0.56	0.77	1.25	0.51	1.11
MAHA	0.49	0.66	0.89	0.17	1.48
JK	0.47	0.56	0.41	-2.00*	1.73**
WB	0.49	0.57	0.38	-0.12	-0.17
UP	0.74	0.78	0.25	-0.40	-0.19
ASS	0.26	0.17	-0.30	-1.22	0.01
MP	0.65	0.55	-0.53	-1.13	-0.19
HAR	0.68	0.54	-0.73	-0.61	-0.88
ODI	0.64	0.45	-0.86	-1.74**	-0.65
GUJ	0.62	0.42	-0.94	-2.28*	-0.62
RAJ	0.68	0.45	-1.16	-2.71*	-2.20*
BIH	0.57	0.15	-1.67**	-2.43*	-1.63
HIM	0.66	0.23	-1.79**	-1.26	-1.96*

Z-Scores are for the null of equal correlation in the pre and post reform period. These are obtained using Fisher's variance stabilising transformation, as detailed in Ghate (2013). * indicates significance at 5% level, ** indicates significance at 10% level.

Robustness checks show that similar findings are obtained with the larger value of the smoothening parameter. For λ=6.25 the results show inconsistent findings. For example, in case of Jammu and Kashmir this inconsistency is quite large. However with λ=400, the results hold well.

Average Synchronisation

To take a closer look, the average cross correlation of all states cycle with the national cycle was computed using rolling windows. From the graph it appears that synchronisation was falling the pre-reform period, and took a turn in the post reform period. A narrower focus on the largest 5 Indian states would also be of interest for policy-makers. The largest 5 states by the average proportion of state output to national output as measured over 1960 to 2014 are: Maharashtra, Tamil Nadu, Uttar Pradesh, Karnataka and Gujarat. These five states have contributed, on average, to about half of national output ever since 1960. In these states after liberalisation, cross correlation with national output has risen in all states except Gujarat, and this has made them far more synchronised in comparison with other states. The average rolling cross correlation for these 5 alone is given in Chart 5. This tells us that their level of synchronisation with national output is quite high. It even moves close to the 0.9 mark in the last decade. Such a result was expected, given that these states contribute to a large proportion of output.

Chart 4: Average Rolling Cross Correlation 11 Year Window (All States)

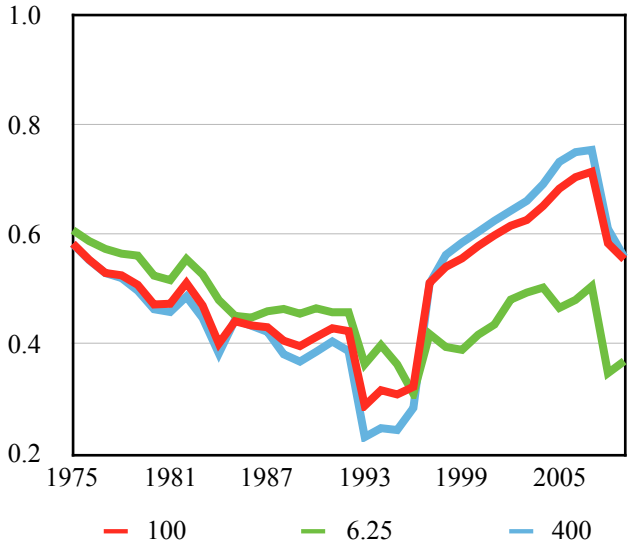
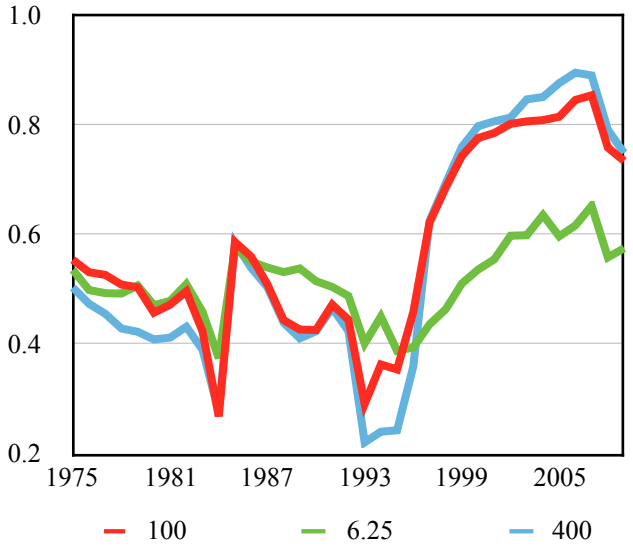


Chart 5: Average Rolling Cross Correlation 11 Year Window (Largest 5)



How do Indian states do in comparison to member states of the European Union and the U.S. States? A recent estimation of 18 European Countries in the period 1997:1 to 2013:3 gives an average cross correlation of 0.68 with aggregate European eurozone cycle, with high dispersion among members (Hasan 2017). In the context of the United States, the monthly coincident index for 1979:7 upto 2010:10 shows that average cross correlation between state cycles and national cycle is higher than 0.75, and crosses 0.9 at the onset of the financial crisis. It should be remembered that these studies are not strictly comparable, because they use different indicators and time periods.

Robustness checks show that similar findings are obtained with the larger value of the smoothening parameter. For λ=6.25 the results show inconsistent findings. With λ=6.25, the rolling windows technique does not show any rise in average synchronisation. With λ=400, the results continue to hold and the rolling windows technique shows an even higher level of persistence.

Conclusion

This paper conducted a preliminary investigation into Indian state business cycles across the period 1960-2014. This paper found that: (1) State level volatility is much larger than national level volatility. However, volatility in state cycles has been fallen across the pre and post reform period. This finding is highly robust. (2) The persistence in state cycles has, in the post-reform period, increased for

most states. This findings is not robust to the small values of the HP-filter. (3) While some states are more synchronised than others in the post-reform period, the index of average synchronisation is shown to be rising in the post-reform period. This finding is not robust to small values of the HP-filter. (4) With respect to the largest 5 states, synchronisation has not only increased in the post-reform period but it has also increased consistently over time, and is fairly high (close to 0.9). The evidence for (1) is stronger than for (2), (3) and (4).

Although establishing causality is notoriously difficult, but the evidence does suggest that reforms have changed the nature of Indian state business cycle. Reforms have not contributed to any increase in volatility, and they may have increased the persistence and synchronisation in state cycles. It may be safe to say that the Indian business cycle is looking more like that of advanced economies.

Also Indian states are not at similar levels of synchronisation, with respect to the national cycle. Common policies may thus have differentiated effects. But since the largest of Indian states are fairly synchronised with the national cycle, the magnitude of this problem may be smaller than suspected.

End Notes

1. Strictly speaking, the modern business cycles is not a “cycle”. The modern definition considers cycle to be low order autoregressive or moving average “irregular” processes. However the *classical* definition of the business cycle does in fact consider movements in output as a sinusoidal wave pattern in which “every recession contains the seeds of the next expansion”.

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