Examining the Decoupling Hypothesis for India

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Working Paper No. 2009-61

June 2009

National Institute of Public Finance and Policy
New Delhi
http://www.nipfp.org.in

Examining the decoupling hypothesis for India

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June 19, 2009

Abstract

This paper examines the decoupling hypothesis for India. We analyse business cycle synchronisation between India and a set of industrial economies, particularly the United States, over the period 1992 to 2008. The evidence suggests that the Indian business cycle exhibits increasing co-movement with business cycles in industrial economies over this period. Indian business cycle synchronisation is stronger with industrial countries as a whole as opposed to the co-movement found with the US.

JEL Codes: E32, F15, F41.

Keywords: Business cycles, synchronisation, decoupling, trade, dynamic correlation.

*This paper was written under the aegis of the SPF Financial and Monetary Policy Reform Project at the National Institute of Public Finance and Policy, New Delhi. We gratefully acknowledge help from Matthieu Stigler, Giovanni Veronese, Eric Dubois, Charles Adams, Radhika Pandey and Rudrani Bhattacharya. The paper has been implemented using open source software: R, Scilab, grocer and x12arima. All code is available on request from `shruthi@caa.columbia.edu`.

Contents

1 Introduction

India has seen greater integration with the world economy through trade in goods and services, and through financial integration, over the past two decades. Has this integration been accompanied by business cycle synchronisation with the rest of the world? Or is India in a period of high economic growth which is decoupled from the rest of the world?

The literature on developed countries suggests that increasing trade intensity leads to business cycle synchronisation, but there is no consensus, either in the theory or in the evidence, on what might come about with developing economies. This has given rise to the debate about a possible 'decoupling' of the business cycle in emerging markets, especially in India and China, from that found in developed countries. The apparent divergence in the performance of different regions of the world economy in 2008 brought the theme of decoupling to the forefront of debates on the international economy [Kohn, 2008].

The early literature, which focused on developed countries, found ample evidence that increasing trade intensity leads to increased business cycle synchronisation [Frankel and Rose, 1998]. More recent work on emerging markets shows mixed results, with Agenor et al. [2000] and Calderon et al. [2007] finding an increase in output correlations over time and Fidrmuc et al. [2008] finding evidence of decoupling. Chan and Khong [2007] find that Asia-Pacific economies tend to be more correlated with Japan than the US. Studies such as Kose et al. [2003] find that increased trade and financial liberalisation adds to contagion of macroeconomic and trade shocks. The findings of Kose et al. [2008] seem to suggest evidence in favour of decoupling between industrial countries and emerging economies.

Disagreements in the empirical literature arise from the differences in countries and time periods studied, alternative detrending techniques and business cycle 'identification' procedures, accounting for production asymmetries and the impact of inter-industry trade (specialisation and divergence) versus that of intra-industry trade (common shocks and convergence) on the business cycle [Kose and Yi, 2001, Frankel and Rose, 1998, Krugman, 1993]. Cycle interactions between different economies also pose challenges, with shocks precipitating and dissipating via feedback loops across various countries. Data availability, changes in the policy environment and structural breaks in trend growth are some more of the accepted difficulties of estimating business cycle synchronisation in emerging markets.

While anecdotal evidence for India suggests increased linkages with the world, the systematic evidence on this is limited. India is part of the sample of countries studied by Agenor et al. [2000] and Fidrmuc et al. [2008]. The

latter paper examines the case of India and China and finds evidence in favour of decoupling. Similarly, Akın and Kose [2008] find that countries of the Emerging South (that includes India and China) have decoupled with industrial countries over time.

Another dimension of exploration lies in linkages with the US as opposed to other industrial countries. The US has strong trade and financial links with India.[1] In addition, Indian monetary policy has often consisted of a *de facto* pegged exchange rate, which generates a channel for transmission of US monetary policy into the Indian economy [Patnaik, 2007]. Hence, it is useful to measure the extent to which the Indian business cycle is synchronised with the US, as opposed to synchronisation with a broader set of industrial countries.

In this paper, we use output and trade data on India and the rest of the world to investigate three questions:

1. How has the Indian business cycle behaved during world expansions and recessions?

2. Has there been a change in business cycle synchronisation over time between India and the rest of the world?

3. Does India have particularly strong linkages with the US, or is the co-movement stronger with a broad set of industrial countries?

It can be seen that these questions are only of correlation and not causation. In the context that there is no consensus in the literature on the impact of increasing trade and financial liberalisation on business cycle integration, establishing or rejecting the synchronisation hypothesis is in itself an important element in the debate. The sharp increase in economic integration between India and the rest of the world across 1992-2008 suggests that business cycle synchronisation could have changed over this period, necessitating its separate measurement.

We construct a data set consisting of measures of industrial production for India and advanced economies and a coincident indicator for the US business cycle. In addition to exploratory data analysis, we use the Harding-Pagan index of concordance to measure the extent of synchronisation.

Our results show that the Indian business cycle is linked to business cycle conditions in the US and the rest of the world with statistical and economic significance. We find that there is a significant increase in this synchronisation over the period 1992-2008. Finally, we find that the Indian business

[1]Exports to the US accounted for 13 percent of India's exports in 2007, and has long been India's biggest trade partner.

cycle is more synchronised with a composite of all advanced countries, rather than just the United States.

This paper contributes to the literature on decoupling that focuses on the changes in the pattern of co-movements between industrial and developing countries. It complements the multi-country empirical research in the field by studying the case of India in detail.

The remainder of this paper is divided into the following sections. Section 2 discusses what economic theory and existing evidence tells us abut business cycle synchronisation for developing countries. Section 3 deals with methodological issues such as business cycle identification and detrending, and also discusses our dataset and its limitations. Section 4 presents preliminary findings based on graphical analysis. Section 5 describes the Harding-Pagan index of concordance and discusses our main results. Section 6 presents sensitivity analyses of the results. Section 7 concludes and suggests areas for further research.

2 Business cycle synchonisation

There is no consensus in the theoretical literature on the impact of increasing trade and financial liberalisation on business cycle integration. Some theoretical arguments predict decoupling while others predict synchronisation. An empirical literature has sprung up, aiming to resolve this debate.

2.1 The theory

There are many channels through which synchronisation might come about. The first is the demand channel, which emphasises that demand shocks in one economy lead to income shocks in its trading partners. Thus, as intra-industry trade grows, output correlations increase leading to business cycle convergence [Frankel and Rose, 1998].

The second argument emphasises financial market linkages and 'contagion'. As financial integration increases, capital flows in different countries are synchronized through various channels of financial contagion including herd behavior and information asymmetry. Region-based investment decisions and positively correlated capital shocks also lead to synchronisation[Kose et al., 2003].

The third channel through which co-movement comes about between two countries is monetary policy. Significant *de facto* openness on the capital account is now found in almost all large countries. Under these conditions, when a country chooses to engage in exchange rate pegging, whether *de*

facto or *de jure*, it loses autonomy of monetary policy. As an example, countries in the Middle East have adopted US monetary policy through the use of currency boards. This induces co-movement. In the Indian case, there is evidence of periods of *de facto* exchange rate pegging to the US dollar [Patnaik, 2007], and of the consequent loss of monetary policy autonomy [Patnaik, 2005].

Commodity price movement, such as the price of oil, and remittances from industrial countries to developing countries constitute other channels through which business cycles are transmitted.

However, Krugman [1993] argues that inter-industry international trade leads to specialisation. As specialisation increases, business cycles diverge due to sector-specific shocks. Similarly, increased financial integration also promotes product specialisation, as firms use portfolio diversification to insure against country-specific shocks. This can increase business cycle asymmetry.

2.2 The empirical evidence

The early literature focusing on developed countries found significant evidence that increasing trade integration led to increased business cycle synchronisation. Frankel and Rose [1998] estimated an instrumental variable regression model to test if bilateral trade intensity explains cyclical output correlations in the industrial world. Shin and Wang [2003] test a similar model, also controlling for intra-industry trade. Both studies show that increasing trade intensity led to increased business cycle synchronisation.

The literature on emerging markets has mixed results. Agenor et al. [2000] and [Rana, 2008] present stylised facts to show that output correlations with developed countries have increased over time. Calderon et al. [2007] present similar results, but find that controlling for production structure asymmetries between countries yields lower output correlations. Chan and Khong [2007] find that Asia-Pacific economies tend to be more correlated with Japan than the US, and this synchronisation between Asia-Pacific economies is also confirmed by Kumakura [2006] and Moneta and Ruffer [2009].

Some studies find evidence of decoupling. Kose et al. [2003] find that increased trade and financial liberalisation adds to contagion of macroeconomic and trade shocks but the effect for developing countries is weak. Fidrmuc et al. [2008] conduct cross-spectral analysis between quarterly GDP of the OECD countries and emerging markets such as India and China. They estimate dynamic correlations, and find that over the sample period 1996-2006 there is little coherence, in business cycle frequencies, of India and China with OECD. Kose et al. [2008] find that while there is no strong evidence

in support of worldwide convergence of business cycles, there is evidence of inter-group convergence within industrial countries and within emerging economies. This seems to suggest decoupling between industrial countries and emerging economies.

2.3 Business cycles in India

The existing empirical literature in India in the field of business cycle analysis deals with the problems of dating the cycle, and examining leading, coincident and lagging indicators [RBI, 2006, Patnaik and Sharma, 2002, Dua and Banerji, 2006, Chitre, 2001]. These studies find evidence of market-oriented cycles post-1991 and also that some indicators of world output are relevant as leading indicators of Indian cycles [RBI, 2006, Mall, 1999].[2] Some of the studies on international business cycle synchronisation include India as one of many countries in a multi-country dataset [Kose and Yi, 2001, Agenor et al., 2000, Calderon et al., 2007]. This limits their ability to obtain greater detail on India. However, studies like Fidrmuc et al. [2008] and Akın and Kose [2008] which are closer to studying business cycle synchronisation of India and China as a group, or as part of the smaller group, with the industrial world find some evidence in favour of decoupling.

3 The data set and definitons

3.1 Identifying the business cycle

We follow the NBER approach and study the trend-cyclical component of seasonally adjusted data. However, in order to address the "classical expansion" faced by emerging markets where all measures of output have been on a steady increase over the past decade or so, we modify this approach to study cyclical fluctuations in annualised point-on-point growth rates of output. Effectively, we are studying growth rate cycles.

This approach is based on the premise that shocks to both the trend component and the cyclical component of output are relevant to business cycle analysis. It has the advantages of not modifying data properties via detrending, and lowering the impact of possible structural breaks on the results. This is especially relevant to emerging economies, where recent work on trend-cycle integration in developing countries suggest a stochastic data

[2]Most of these studies look at growth cycles, i.e. deviations of output from a designated "trend growth".

generating process for the trend component of output [Aguiar and Gopinath, 2007].

An alternative method to identify the business cycle component of an output series is to detrend it using a time or frequency domain filter.[3] However, detrending can induce spurious cycles and is vulnerable to filter-sensitivity [Canova, 1998, Harvey and Jaeger, 1993]. Over the past two decades, India has seen several economic and institutional changes, including in its exchange rate regime, monetary policy framework, financial regulatory framework and trade policy structure. India has globalised rapidly and witnessed rapid economic growth. Given this institutional environment, the case for trend-cycle interaction is strengthened.

3.2 Data

The literature on business cycles in India uses monthly data for industrial production as a proxy for output, for two reasons. First, structural changes in the Indian economy over the last two decades have caused monsoon-related cycles in the period 1950-1991 to morph into growth/growth rate cycles in the 1990's [Patnaik and Sharma, 2002]. This makes studying investment-inventory cycles relevant only after 1991. Second, any meaningful analysis of cyclical fluctuations require data of quarterly or monthly frequency. This is not easily available in India. Since quarterly GDP data is available only from 1996, the use of either annual or quarterly GDP data is inadequate. Data for employment, retail sales and income are not available on a monthly or even quarterly basis.

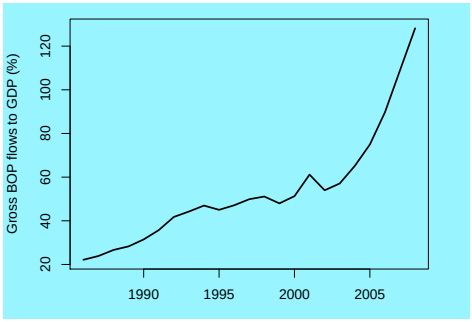
The dataset that we create runs from August 1992 till December 2008. Monthly data for the Indian Index of Industrial Production (IIP) is obtained from the Business Beacon database published by the Centre for Monitoring Indian Economy (CMIE). We source data on merchandise exports, GDP, gross flows on the current and capital account, corporate profits after tax, and corporate revenue growth from the same database.

We use the Conference Board coincident indicator for the United States. It is a composite of the Index of Industrial Production, non-farm payroll employment, personal disposable income excluding transfers and retail manufacturing and sales.[4] We source the US Index of Industrial Production from the website of the Federal Reserve Bank.

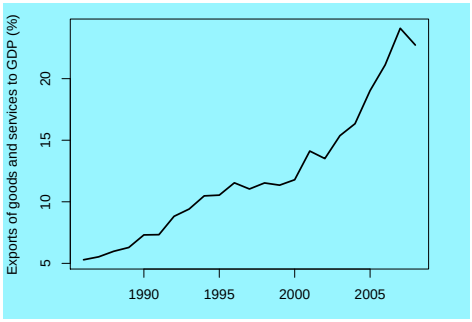
[3]Commonly used filters include the Hodrick-Prescott filter, the Baxter-King filter and the Christiano-Fitzgerald filter.

[4]This indicator is available from The Conference Board's website at `http://www.conference-board.org/economics/bci/`.

Figure 1 Increased integration with the the rest of the world



Gross BOP flows to GDP



Goods & Services exports to GDP

The Advanced Economies Index of Industrial Production (AEIIP) is a weighted index of non-seasonally adjusted industrial production for 22 countries classified as "industrial" by the International Monetary Fund. The value added in industry in the year 2000 (expressed in US dollars) is used as a weighting factor for each country.[5] This data is sourced from the IMF-IFS. Similary, the data for world trade used in the sensitivity analysis is obtained from the IMF-IFS.

4 Exploratory analysis

In this section, we present graphical evidence of India's trade and financial integration with the world economy and examine how Indian macroeconomic variables behaved during world expansions and recessions. We examine evidence of change in business cycle synchronisation across the period 1992-2008.

Industrial production indices are measures of quantity and thus represent real variables. We seasonally adjust the data using X-12 ARIMA.[6] Following Frankel and Rose [1998], who break their sample into four equal parts to examine the increase in integration, the sample period is cut across into three roughly equal sub-samples. The break-points chosen are August 1997 and August 2003.

4.1 Increased integration

There has been a sharp increase in India's integration with the world economy on both trade and financial flows, as shown in Figure 1, which shows graphs

[5]Bases are harmonised to 2000=100 using chain-linking via ratio-splicing.

[6]Model specifications were verified using the HEGY seasonal unit root tests and residual diagnostics.

Table 1 Ratios of trade and gross BOP flows to GDP in India

Sub-Sample	Trade to GDP (%)	Gross BOP Flows to GDP (%)
1992-1997	20.44	45.83
1997-2003	23.28	53.77
2003-2008	34.26	93.94

for the growth of gross flows on the BOP to GDP, and the exports of goods and services to GDP. Table 1 shows averages of these values for three periods of interest.

In the context that there is no consensus in the literature on the impact of increasing trade and financial liberalisation on business cycle integration, establishing or rejecting the synchronisation hypothesis is an important element in the debate. The sharp increase in economic integration suggests that business cycle synchronisation could have changed over these periods, thus necessitating separate measurement of business cycle synchronisation.

Table 2 Correlations of weekly returns on the CMIE Cospi stock market index against global stock market indexes

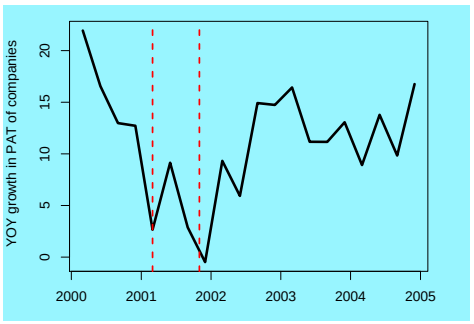
	UK FTSE-100	Japan Nikkei-225	US S&P 500
1992-1997	-0.008	-0.038	-0.023
1997-2003	0.184	0.168	0.167
2003-2008	0.463	0.390	0.339
Full period	0.192	0.149	0.150

Table 2 shows correlations of the CMIE Cospi stock market index, which depicts the total returns on the broad market in India, against three major international indexes: the US S&P 500 index, the Japanese Nikkei 225 index and the UK FTSE-100 index. With all these three indexes, across the three sub-periods, correlations have gone up. This suggests increasing synchronisation with the world economy. In the latest period, the correlation against the UK FTSE-100 (0.463) and the Japanese Nikkei 225 (0.39) exceeds the correlation with the US S&P 500 index.

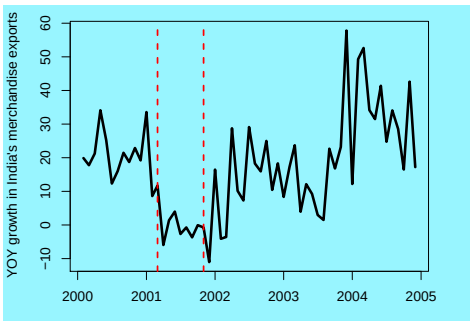
4.2 Preliminary evidence

To look at some preliminary evidence about whether business cycles in India have been "coupled" or "decoupled" with those in industrial countries, we look back towards the last US business cycle as defined by the NBER (starting in March 2001 and ending in November 2001). Figure 2 shows data for

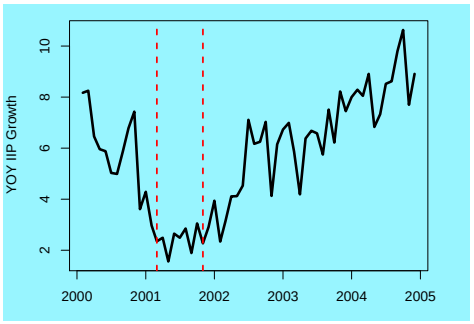
Figure 2 Increased integration with the the rest of the world



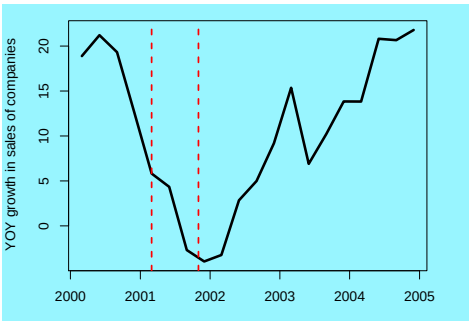
(a) Corporate profit after tax



(b) Merchandise exports



(c) Industrial Production



(d) Corporate revenue growth

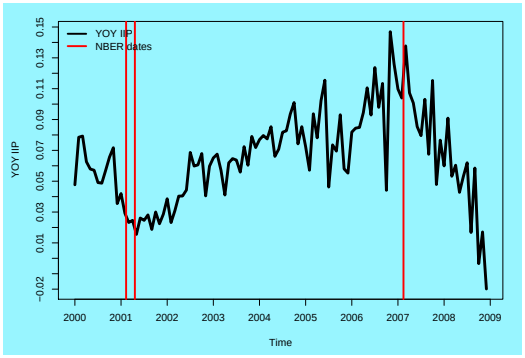
India during that period. This shows that the growth of exports, industrial production, corporate revenues and corporate profits all fell to very low levels.

Since the above analysis is limited to one business cycle downturn in the US, it only presents anecdotal evidence of greater synchronisation. However, graphs for a longer sample period (See Figure 3) also suggest similar behaviour. Industrial production in India across business cycle peaks and troughs over the period 1995-2008 show increased integration. Point-on-point growth rates between the US coincident indicator and Indian IIP, as well as those between industrial production in advanced economies and in India suggest the same, especially in the sample period 2003-2008.

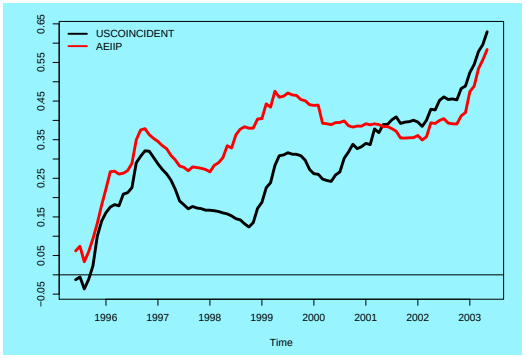
Finally, we present two sets of correlations between Indian IIP and the two variables representing world output. The first is cross-correlations, which are the simplest and most commonly used method to analyse co-movements between series. The second is rolling correlations across an eight year window (See Figure 4(b)) with Indian IIP and the US coincident indicator and Adv. Ec. IIP.

Despite their static nature, cross-correlations provide two sources of in-

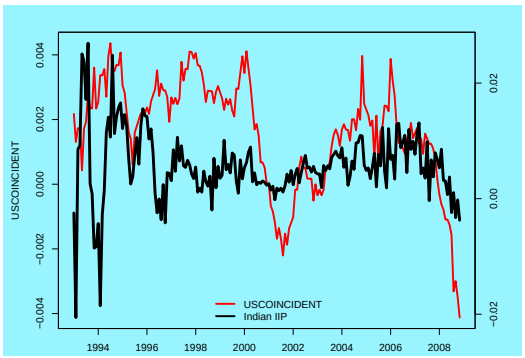
Figure 3 Increased integration with the the rest of the world: Further evidence



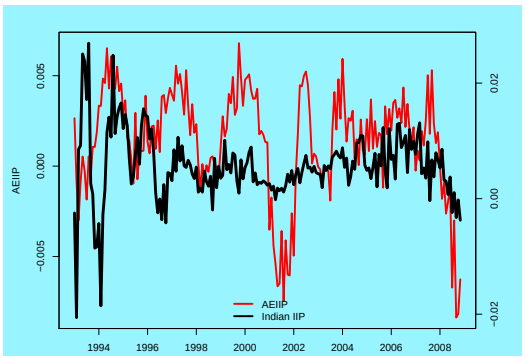
(a) Indian IIP and US recessions



(b) Rolling correlations with Indian IIP



(c) US coincident indicator & Indian IIP



(d) Advanced economies IIP & Indian IIP

sight into co-movements. The level of the correlation indicated the strength of co-movements. The nature of pro/counter cyclicality of the variable is indicated by the sign - a positive sign indicates pro-cyclicality while a negative sign indicates counter-cyclicality. A value of zero indicates that the variable is acyclical. It can be seen that as we move across samples, the correlations switch signs from negative to positive. They also increase considerably in magnitude and statistical significance, with all correlations in Sample 3 (2003-2008) being significant at 1%. Confidence intervals at 95% are calculated using sample covariances.

Similarly, the rolling correlations can also be seen to be increasing with time, starting from a negative value in the mid 1990's to above 0.5 post-2005. This is the case for both the US coincident indicator and the Adv. Ec. IIP.

Overall, the preliminary analysis suggests that business cycles in the rest of the world show co-movement and that the correlation between growth rates of IIP in India and the industrial economies (particularly the US) has

Table 3 Cross-correlations with Indian IIP

Variables	t-4	t-3	t-2	t-1	t	t+1	t+2	t+3	t+4
Period 1: 1992-1997									
US Coincident Ind.	-0.02	-0.15	-0.08	-0.07	-0.04	0.02	0.00	0.09	-0.07
Adv. Ec. IIP	0.15	0.13	-0.01	-0.01	0.01	-0.06	-0.13	-0.30*	-0.26
Period 2: 1997-2003									
US Coincident Ind.	0.07	0.14	0.20	0.25*	0.26*	0.30**	0.29**	0.29**	0.30**
Adv. Ec. IIP	0.16	0.27*	0.35***	0.46***	0.48***	0.46***	0.52***	0.49***	0.47***
Period 3: 2003-2008									
US Coincident Ind.	0.37***	0.47***	0.44***	0.54***	0.56***	0.56***	0.44***	0.38***	0.35***
Adv. Ec. IIP	0.36***	0.31**	0.50***	0.45***	0.55***	0.41***	0.45***	0.36***	0.33***
Full Period: 1992-2008									
US Coincident Ind.	0.14	0.15*	0.17*	0.19**	0.20**	0.22**	0.18**	0.19**	0.15*
Adv. Ec. IIP	0.20**	0.20**	0.21**	0.21**	0.24***	0.19**	0.18**	0.10	0.10

been increasing over time. Section 5 now turns to a more formal analysis of this preliminary finding.

5 Empirical analysis

5.1 Methodology

There are a variety of formal methods in the literature to study business cycle synchronisation, the most popular being dynamic correlations, spectral analysis and Harding-Pagan's index of concordance [Simone, 2003, Fidrmuc et al., 2008, Chan and Khong, 2007].

We use the index of concordance as developed by [Harding and Pagan, 2006] as a means to test increasing business cycle synchronisation across our three sample periods. The Harding-Pagan index of concordance measures the proportion of the time that two variables are in the same state. Assuming two variables x and y over N time periods, the index of concordance between them would be:

$$\hat{I_{xy}} = \frac{\#[S_{xt} = 1, S_{yt} = 1] + \#[S_{xt} = 0, S_{yt} = 0]}{N} \tag{1}$$

The value of the HP index ranges between 0-1. An index value of close to 1 would indicate perfect procyclicality while an index value of 0 would indicate perfect counter-cyclicality. However, given the markov-transition probability structure of recessions ($Pr(S_{t+1} = 0, S_t = 0) \gg Pr(S_{t+1} = 0, S_t = 1)$), there is extensive serial correlation in the S_t series [Harding and Pagan, 2006]. Also, since the data duration is very short, the chances of a prolonged expansion or recession in one of the series skewing the value of the index are non-zero.

To correct for these flaws, [Harding and Pagan, 2006] demonstrate that the following relationship holds between the correlation coefficient $\hat{\rho_{xy}}$ be-

Table 4 Harding-Pagan Index of concordance with Indian IIP

Variable	$\hat{I_{xy}}$	$\rho_{\hat{S_x S_y}}$	t statistic	p value
Period 1: 1992-1997				
US Coincident Ind.	0.536	-0.136	-0.800	0.427
Adv. Ec. IIP	0.500	-0.333	-2.629	0.011**
Period 2: 1997-2003				
US Coincident Ind.	0.767	0.356	1.544	0.127
Adv. Ec. IIP	0.781	0.526	2.720	0.008**
Period 3: 2003-2008				
US Coincident Ind.	0.781	0.501	6.438	0.000***
Adv. Ec. IIP	0.984	0.965	43.497	0.000***
Full period: 1992-2008				
US Coincident Ind.	0.639	0.254	2.178	0.031**
Adv. Ec. IIP	0.743	0.476	3.569	0.000***

tween S_x and S_y and $\hat{I_{xy}}$, which implies that the properties of $\rho_{\hat{xy}}$ are symmetric to that of $\hat{I_{xy}}$

$$\hat{I_{xy}} = 1 + 2\rho_{\hat{xy}}\sigma_{\hat{S_x}}\sigma_{\hat{S_y}} + 2\mu_{\hat{S_x}}\mu_{\hat{S_y}} - \mu_{\hat{S_x}} - \mu_{\hat{S_y}} \tag{2}$$

To estimate the correlation coefficient ρ_{xy}, we use the following OLS estimation:

$$\frac{S_{yt}}{\sigma_{\hat{S}_{x_t}}\sigma_{\hat{S}_{y_t}}} = A + \rho_{xy}\frac{S_{xt}}{\sigma_{\hat{S}_{x_t}}\sigma_{\hat{S}_{y_t}}} + \epsilon_t \tag{3}$$

where $\sigma_{\hat{S}_{y_t}}$ denotes the sample standard deviation of S_{y_t}. Given that ϵ_t inherits the serial correlation in S_t, we report p-values for the Heteroskedasticity-Autocorrelation (HAC) corrected t-statistics for $\rho_{\hat{xy}}$.[7]

5.2 Main results

The results of the Harding-Pagan analysis on the data and three sub-samples are reported in Table 4. We report the index of concordance and the cross-correlations of the state variables as two measures of concordance. Newey West HAC t-statistics and p-values reported are for the estimated correlation coefficient, but can be extrapolated to the index of concordance [Harding and Pagan, 2006]. The results support the early exploratory analysis: there is business cycle synchronisation between India and the rest of the world, and that synchronisation has increased over time.

[7]We use the Harding-Pagan turning points algorithm as implemented in the software GROCER [Dubois and Michaux, 2008].

For the full sample (1992-2008) the index of concordance suggests that Indian and US business cycles are in the same phase for 63.9% of the sample period, while cycles of industrial production in India and advanced economies are in the same phase for 74.3% of the sample. Both are statistically significant at a 95% confidence interval, and the value for the US is lower. This indicates business cycle synchronisation.

The most recent sample (2003-2008) shows stronger synchronisation. The index rose to 0.781 with the US coincident indicator, and 0.984 against advanced countries.

In Period 1 (1992-1997), both the US coincident indicator and IIP for advanced economies were *negatively* correlated with Indian industrial production, suggesting that the Indian business cycle was weakly counter-cyclical to the world during this time.

This was a high volatility period due to structural adjustment to reforms and revival from the balance-of-payments crisis of 1991. Hence, it can be viewed as a "transition period" in the Indian economy, a possible explanatory factor for this result.

Also, across all samples, it can be seen that the Adv. Ec. IIP is more strongly correlated with Indian IIP, suggesting that the Indian synchronisation with industrial economies as a whole is stronger than the synchronisation with the US. In fact, for the last period 2003-2008, the the index of concordance against Adv. Ec. IIP is as high as 0.984, and it has a t statistic of 43.5.

Our results support Calderon et al. [2007], who test for the impact of increasing trade intensity on business cycle synchronisation and find increased correlations for countries that have closer trade ties. They are also similar to those of Rana [2008] who also finds increased synchronisation between East Asian economies and the rest of the world in the time period that the East Asia liberalised trade and financial policy. However, they contrast sharply with Fidrmuc et al. [2008] who find evidence of Chinese and Indian decoupling from the OECD countries using spectral analysis.

In the following sections, we test the sensitivity of these results through a series of alternative estimation procedures.

6 Sensitivity tests

We present the robustness of our main results to four sets of sensitivity tests:

1. The first is the redefinition of sample periods. While we show evidence of synchronisation across time, we believe that there is no clear "begin" or "end" date for this synchronisation, rather that it is a slowly evolving

Table 5 Sensitivity analysis 1: Harding Pagan analysis with changed sub-samples

Variable	$\hat{I_{xy}}$	$\rho_{\hat{S_x}\hat{S_y}}$	t statistic	p value
Period 1: 1992-1997				
US Coincident Ind.	0.597	-0.075	-0.451	0.654
Adv. Ec. IIP	0.565	-0.277	-2.444	0.017**
Period 2: 1997-2003				
US Coincident Ind.	0.636	0.196	0.941	0.35
Adv. Ec. IIP	0.779	0.534	3.136	0.002***
Period 3: 2003-2008				
US Coincident Ind.	0.453	0.277	2.325	0.024**
Adv. Ec. IIP	0.396	0.212	2.244	0.029**
Full Period: 1992-2008				
US Coincident Ind.	0.639	0.254	2.178	0.031**
Adv. Ec. IIP	0.743	0.476	3.569	0.000***

phenomenon that reflects changes in the underlying structural composition of the Indian economy with respect to the rest of the world. For the analysis we change the sub-sample period dates, changing the break points to Feb-1998 and Jun-2004.

2. The second sensitivity test is done by changing the method used for analysis by detrending the data, rather than conducting growth rate cycle analysis. We have so far conducted all analysis on the trend-cyclical component of output. We now detrend the data using the Hodrick-Prescott (HP) filter, which is widely used in business cycle literature.

3. The third test is to utilise another methodology that is widely used for measuring co-movement: spectral analysis [Fidrmuc et al., 2008, Calderon et al., 2007].

4. Finally, we verify that the key results hold across redefininition of some key variables.

6.1 Redefining sample periods

Table 5 presents the results of the Harding-Pagan analysis for the changed sample periods. The key results hold. One difference is the value of the index of concordance for Adv. Ec. IIP in Sample 3 - it seems to have fallen considerably although it remains statistically significant at 5%.

Table 6 Sensitivity analysis 2: Harding-Pagan analysis with HP-filtered IIP series

Variable	$\hat{I_{xy}}$	$\rho_{\hat{S_x}\hat{S_y}}$	t statistic	p value
Period 1: 1992-1997				
US Coincident Ind.	0.41	0.116	0.843	0.402
Adv. Ec. IIP	0.328	-0.186	-0.766	0.447
Period 2: 1997-2003				
US Coincident Ind.	0.904	0.758	12.618	0.000***
Adv. Ec. IIP	0.507	0.218	1.762	0.082*
Period 3: 2003-2008				
US Coincident Ind.	0.954	0.776	6.445	0.000***
Adv. Ec. IIP	0.862	0.243	1.775	0.081*
Full Period: 1992-2008				
US Coincident Ind.	0.629	0.242	1.672	0.096*
Adv. Ec. IIP	0.599	0.238	1.595	0.112

6.2 Detrending

The Hodrick-Prescott filter is a time-domain filter that renders the resulting cyclical component stationary.[8]. We use the Hodrick-Prescott filter with a smoothing parameter of 14400 since the data is of a monthly frequency in order to decompose the series into trend and cycle. Our empirical strategy is then repeated using the detrended data.

Table 6 reports these results. While these results cannot be directly contrasted with our main findings (this analysis tests for growth cycle synchronisation, while our main results test for growth rate cycle synchronisation), they still examine broadly the same question of synchronisation in the context of integration.[9]

We see that the synchronisation of business cycles in the most recent sample (2003-2008) is robust to the HP filter. However, there are two notable differences in the results obtained. First, the world variable Adv. Ec. IIP is not significantly synchronised with Indian IIP across the total sample 1992-2008. Second, the HP filter finds that there is no statistically significant synchronisation in the period 1992-1997. This agrees with evidence of negative synchronisation in this period.

[8]Criticisms of the HP filter include spurious cycles, phase shifts in the variables and a high level of sensitivity of results [Canova, 1998, Harvey and Jaeger, 1993].

[9]See Harding and Pagan [2002] for an overview of the differences between growth and growth rate cycles.

Table 7 Sensitivity analysis 3: Harding-Pagan analysis, redefining key variables

Variable	$\hat{I_{xy}}$	$\rho_{\hat{S_x}\hat{S_y}}$	t statistic	p value
Period 1: 1992-1997				
USIIP	0.375	-0.064	-0.266	0.791
WORLDTRADE	0.536	-0.299	-2.570	0.013**
Period 2: 1997-2003				
USIIP	0.781	0.548	2.966	0.004***
WORLDTRADE	0.795	0.509	2.893	0.005***
Period 3: 2003-2008				
USIIP	0.429	0.123	0.913	0.365
WORLDTRADE	0.841	0.698	7.282	0.000***
Full Period: 1992-2008				
USIIP	0.516	0.048	0.353	0.724
WORLDTRADE	0.705	0.397	3.014	0.003***

6.3 Dynamic correlations

We now examine spectral analysis as a methodology for checking co-movement. It is widely used in the literature [Fidrmuc et al., 2008, Calderon et al., 2007] and the results confirm our key findings. Spectral coherence (also called dynamic correlation) for each world variable with respect to Indian IIP has substantially increased over the period 1992-2008, over growth rate cycle frequencies. Appendix A.2 reports our findings and methodology in greater detail.

6.4 Redefining key variables

For the final sensitivity test, we redefine our measure of US business cycles from the US coincident indicator to the Index of Industrial Production in the US. In a similar vein, we use a measure of total world trade (exports plus imports), as a proxy for Adv. Ec. IIP[10]. The results are reported in Table 7.

It can be seen that all results hold with respect to the variable measuring world trade, but there is a fall in the statistical significance of USIIP both in the total sample and in the third period (2003-2008).

[10]Export and import data is sourced from the IMF-IFS, and expressed in USD billion. US IIP is sourced from the St. Louis Federal Reserve Database (FRED). Both variables are adjusted for seasonal fluctuations.

7 Conclusion

In this paper, we find that the Indian business cycle is synchronised with that of the US and other industrial economies. We also find that this synchronisation has increased across time in the period 1992-2008, i.e. the period that saw a significiant rise in India's trade and capital flows. Finally, the linkages of the Indian economy are stronger when measured against a broad set of industrial countries as opposed to just the US.

This paper contributes to the evolving empirical evidence on the question of whether emerging market economies such as India are decoupled with industrial economies or not. As there is no consensus in the literature, and business cycles in India have emerged as an important part of the debate, the paper is an important contribution as it strongly supports the evidence that business cycles in India are coupled with those in industrial countries and that this coupling has been increasing with India's greater globalisation.

This paper focused on establishing business cycle synchronisation. It did not attempt to study the transmission mechanism and causal relationships through which business cycle synchronisation takes place. In a similar vein, it did not control for intervening countries, such as other emerging markets that may help precipitate or dissipate the impacts of shocks, thereby strengthening or weakening co-movements between India and the advanced economies. Finally, it analysed only output fluctuations between two countries to study co-movement of cycles. Future research would need to analyse other countries and other variables as well as study the transmission mechanism of co-movements.

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A Appendix

A.1 Data sources

Data descriptions and sources are listed below.

Table 8 Variable definitions

Variable	Source	Unit	Frequency	Time period
Indian IIP	CMIE BB	Index (1993=100)	Monthly	1992-2008
Gross BOP flows to GDP: India	CMIE BB	Percentage growth	Quarterly	1985-2008
Indian exports to GDP	CMIE BB	Percentage	Quarterly	1985-2008
CMIE COSPI Index	CMIE BB	Index	Weekly	1992-2008
Indian corporate profit after tax	CMIE Prowess	Percentage growth	Quarterly	2000-2005
Indian merchandise exports	CMIE BB	Percentage growth	Quarterly	2000-2005
Indian corporate revenue growth	CMIE Prowess	Percentage growth	Quarterly	2000-2005
US coincident indicator	Conference Board	Index (2004=100)	Monthly	1992-2008
Advanced economies IIP	IMF-IFS	Index (1999=100)	Monthly	1992-2008
US S&P 500	Yahoo Finance	Index	Weekly	1992-2008
UK FTSE-100 Index	Yahoo Finance	Index	Weekly	1992-2008
Japan Nikkei-225	Yahoo Finance	Index	Weekly	1992-2008
US IIP	FRED Database	Index (1999=100)	Monthly	1992-2008
World trade	IMF-IFS	USD Billion	Monthly	1992-2008

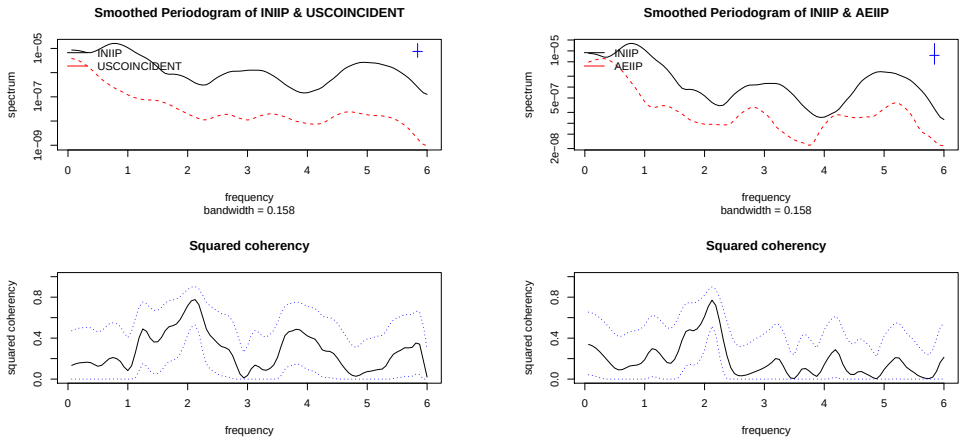
A.2 Spectral analysis

Spectral analysis provides a frequency domain complement to cross-correlation analysis, with the advantages of being able to decompose comovements into those at short, medium and long term frequencies. However, as we are studying growth rate cycles, we must keep in mind that differencing is an asymmetric frequency operation and may lead to the introduction of high frequency components [Iacobucci, 2003]. Moreover, since our data duration is short (197 observations across 16 years of monthly data), spectral estimations may be biased. In spite of these limitations, a frequency domain perspective does provide further insight into business cycle comovements. First, we present cross-spectral periodograms (See Figure A.2). Periodograms are estimated via a Discrete Fast Fourier Transformation, and then smoothed with a modified Daniell filter to generate the periodogram with scaled densities.

Second, we report spectral coherence, a frequency domain analogue to the correlation coefficient. It is calculated as per Equation 4 where $S_1(k)$ is the spectral periodogram of Variable 1 at frequency k, $S_2(k)$ is that of variable 2 and $S_{12}(k)$ is their cross-spectrum. Based on growth rate cycle periodicities (roughly between 12-24 months), low frequencies are identified as those with 0.5 or less cycles per year, mid-range as those between 1 to 0.5 cycles per year and high greater than 1 cycle per year.

$$\hat{K}_{12}(k) = \frac{\hat{S}_{12}(k)}{\sqrt{\hat{S}_1(k)\hat{S}_2(k)}} \tag{4}$$

Figure 4 Cross-spectral analysis between Indian IIP and world variables



(e) Indian IIP & US coincident indicator

(f) Indian IIP & Adv. Ec. IIP

Table 9 Spectral coherence with Indian IIP

Variable	Coherence		
	Low freq	Mid freq	High freq
Period 1: 1992-1997			
US coincident indicator	0.07	0.04	0.04
Adv. Ec. IIP	0.03	0.02	0.06
Period 2: 1997-2003			
US coincident indicator	0.08	0.18	0.15
Adv. Ec. IIP	0.05	0.64	0.35
Period 3: 2003-2008			
US coincident indicator	0.10	0.69	0.51
Adv. Ec. IIP	0.26	0.68	0.42
Full Period: 1992-2008			
US coincident indicator	0.02	0.12	0.08
Adv. Ec. IIP	0.21	0.11	0.19

It can be seen that both sets of results indicate business cycle synchronisation, and the mean coherence estimates over the three sub-samples indicate that this synchronisation has been increasing over time. Following RBI [2006], we consider a coherence of greater that 0.30 as an indication of significant comovement. It can be seen that the coherence at the mid-range frequencies over the period 2003-2008 are 0.69 and 0.68 respectively, and that coherence across this range of frequencies has been increasing over the period 1992-2008.