Has India Emerged? Business Cycle Stylized Facts from a Transitioning Economy

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Abstract

This paper presents a comprehensive set of stylized facts for business cycles in India from 1950-2010. We show that most macroeconomic variables are less volatile in the post reform period, even though the volatility of macroeconomic variables is still high and similar to other emerging market economies. Consistent with other emerging market economies, relative consumption volatility has gone up in the post reform period. In terms of co-movement and persistence however, India looks similar to advanced economies, and less like other emerging market economies. We report evidence that these changes are driven primarily by structural changes caused by market oriented reforms, and not by "good luck."

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1 Introduction

This paper describes the changing nature of the Indian business cycle from 1950 - 2010.[1] Our focus is to compare India's business cycle in the pre 1991 economy, with the post 1991 Indian economy, after the large scale liberalization reforms of 1991. We show that after 1991, key macroeconomic variables are less volatile in the post reform period compared to the pre-reform period. However, the volatility of macroeconomic variables in the post-reform period in India is still high and similar to emerging market economies. Consistent with other emerging market economies, we also find that relative consumption volatility has gone up marginally in the post reform period. In contrast, in terms of co-movement and persistence, the Indian business cycle looks similar to advanced economies, and less like emerging market economies in the post reform period.

While our paper is the first exercise to comprehensively document - using both annual and quarterly data - an exhaustive set of stylized facts for the Indian business cycle in the pre and post reform period, we use the data to report evidence that these changes are driven primarily by structural changes caused by market oriented reforms, and not by "good luck." Thus, a shift from a command to a market economy, and sectoral shifts, have led to a better ability to absorb shocks.

In recent years, considerable research in the field of international business cycle has focused on documenting stylized features of business cycles and developing dynamic stochastic general equilibrium models - both of the RBC and New Keynesian type - to explain them. Traditionally, studies in this area of research have primarily dealt with documenting business cycle features of major developed economies (Kydland and Prescott, 1990; Backus and Kehoe, 1992; Stock and Watson, 1999; King and Rebelo, 1999). There has also been a growing interest in understanding the business cycle features of developing and emerging market economies (Agenor *et al.*, 2000; Rand and Tarp, 2002; Male, 2010) and comparing them with those of developed economies (Neumeyer and Perri, 2005; Aguiar and Gopinath, 2007). A small literature looks at the change in the nature of business cycles. Kim *et al.* (2003), for instance, examine the nature of business cycles in emerging Asian economies after trade liberalization and financial development. In a more recent paper Alp *et al.* (2012) examine the changes in the Turkish business

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[1]In the Indian convention, this means 1950-51 to 2009-2010. Both annual and quarterly data are in 2004-2005 base year prices. The quarterly data goes from the second quarter (Q2) of 1999, to Q2 2010.

cycle after financial sector reform in 2001.

While most developing countries exhibit more macroeconomic volatility than developed economies (see (Hnatkovska and Loayza, 2004)), the equilibrium business cycle literature does not suggest a clear relationship between stages of development and volatility. While specific features of development such as financial integration and trade openness affect volatility, theoretical predictions from stylized quantitative general equilibrium models and country specific findings tend to conflict. For instance, when a country witnesses trade and financial integration with global markets, this provides countries with a way to smooth consumption (see (Razin and Rose, 1994)). However, higher trade integration may expose a commodity exporting or importing country to greater volatility due to changes in the terms of trade.[2] Similarly, greater financial integration may expose a developing country to booms and busts as capital flows to emerging markets are often pro-cyclical and tend to exacerbate business cycles (see (Kaminsky *et al.*, 2005)). This literature also does not address the question of *how* the nature of business cycles in emerging economies change when economies develop. In general - our reading of the literature is that the change in the nature of business cycles when economies adopt market oriented reforms has been largely untouched.

Using India as an interesting case study, our paper attempts to fill these gaps. In particular, we focus on whether a move towards market oriented reforms can cause a change in the nature of business cycles in a large developing economy. We define structural change as referring to the shift away from state domination towards a market economy. This definition is consistent with a core attribute of structural change in which economic reform is used to increase the role of the market economy (Ishikawa, 1987). India provides an interesting example as the nature of cycles have changed after India liberalised its economy. After the 1991 reforms, India moved away from a planned, closed economy characterized by controls on capacity creation and high import duties to a market determined industrializing open economy. Since the mid 1990s, financial repression has steadily declined. Trade lib-

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[2]To the extent that increasing international financial integration allows countries to better smooth consumption through international risk sharing, an increase in consumption volatility is a puzzle. We show later that our findings for India are consistent with the large literature on the apparent disconnect between the theoretical predictions of the financial liberalization process, and country specific findings. For instance,Ang (2011) finds that financial liberalization magnifies consumption growth volatility in India. Kose *et al.* (2009) find no evidence of international risk sharing in an emerging market subsample that includes India. See also (Broner and Ventura, 2010).

eralization has also been substantial since 1991.[3] Our claim is that market oriented reforms led to structural changes which changed the properties of the Indian business cycle. Our paper therefore builds upon the existing literature by investigating the *change* in the nature of Indian business cycle in response to structural changes induced by changes in the policy environment.

We compare the properties of Indian business cycle over two periods: 1950-1991 for the pre-liberalization period and 1992-2010 for the post-liberalization period. GDP, private consumption, total gross fixed capital formation, consumer prices, exports, imports, government expenditure, M1, M3, reserve money, inflation, and the nominal exchange rate, are the key variables analyzed. The emerging business cycle literature reports strong counter-cyclicality of net exports and highly volatile and counter cyclical interest rates. We also report the business cycle properties of these variables for India, though our results differ. We follow the standard procedure in the international business cycle literature and decompose each time series into secular and cyclical components. Several methods are available for implementing this type of trend-cycle decomposition. We adopt the commonly used Hodrick-Prescott filter to derive the cyclical components and then check the robustness of our results with the Baxter-King filter, quarterly data, and different subsamples. The cyclical components are then used to study the business cycle characteristics relating to volatility, co-movement and persistence.

Our main finding is that after the liberalization of the Indian economy in 1991, the properties of the Indian business cycle resemble an economy closer in some ways to advanced economies. Specifically, we find that key macroeconomic variables in our dataset are less volatile in the post reform period compared to the pre-reform period. The reduction in volatility resembles that of advanced economies (Kydland and Prescott, 1990; Backus and Kehoe, 1992; Stock and Watson, 1999; King and Rebelo, 1999) and other Asian economies (see Kim *et al.* (2003)) that have experienced structural transformation. We argue that these changes are driven primarily by structural changes caused by market oriented reforms, and not by "good luck".

However, we find that the *level of* volatility of macroeconomic variables in the post-reform period is still high and comparable to emerging market economies. In terms of emerging markets, this is consistent with the findings of (Male, 2010; Neumeyer and Perri, 2005; Alper, 2002) that report higher output volatility for developing and emerging market economies. In addition, consumption – is more volatile than output in the post-reform period. This is similar to the findings of Kim *et al.* (2003) who report higher relative

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[3]See (Gangopadhyay and Shanthi, 2012) and (Ghate and Wright, 2012).

consumption volatility for most of the Asian economies in the second period.

In contrast, in terms of co-movement and persistence, the Indian business cycle looks similar to advanced economies. There is an increase in the co-movement of investment with respect to output. Imports have become more pro-cyclical in the post reform period. Net exports show a transition from being a-cyclical in the pre-reform period to counter-cyclical in the post reform period. There is also higher persistence for all the key macroeconomic variables in the post reform period. India thus looks more similar to advanced economies, and less like emerging market economies, when we look at the co-movement and persistence of key macroeconomic variables. A key feature that distinguishes emerging economies from developed economies is the pro-cyclicality of monetary policy. Consistent with this literature, we report evidence of pro-cyclical monetary policy in the post-reform period using a variety of indicators.

The remainder of the paper is structured as follows. Section 2 outlines the main features of emerging economies business cycle with an overview of the sources of shocks in these economies. Section 3 outlines the data sources and the variables included in the study. Section 4 provides empirical evidence on the causes behind the changing nature of the Indian business cycle comparing the pre and post reform periods. Section 5 presents results on sensitivity tests. Section 6 concludes. Appendix A lists the sources and definitions of variables used in this study. Appendix B details the methodology employed to compute the Indian business cycle stylized facts. Appendix C details the procedure through which TFP has been calculated.

2 Business Cycles in Emerging Market Economies

One of the main features that distinguishes emerging economies business cycles from advanced economies is their higher volatility. Current account balances, output growth, interest rates, and exchange rate tend to exhibit larger, and more frequent changes (Calderón and Fuentes, 2006). In particular, consumption in emerging market economies is typically more volatile than output; real interest rates are highly volatile and counter-cyclical, and net exports are strongly counter-cyclical. We reproduce Table 1 from the seminal work on emerging market business cycles by Aguiar and Gopinath (2007) to locate the position of Indian business cycle vis-a-vis other developed

and developing economies.[4] The analysis in Aguiar and Gopinath (2007) covers 13 developed and 13 emerging economies based on a quarterly dataset.[5]

Table 1 Business cycle statistics for developed and emerging economies using quarterly data

	Developed economies			Emerging economies		
	Std dev.	Rel std. dev.	Cont. cor.	Std dev.	Rel. std. dev.	Cont. cor.
Real GDP	1.34	1.00	1.00	2.74	1.00	1.00
Private Consumption		0.94	0.66		1.45	0.72
Investment		3.41	0.67		3.91	0.77
Trade balance		1.02	-0.17		3.22	-0.51

Source: Aguiar and Gopinath, 2007.

Table 1 shows that the business cycle characteristics of developed and emerging economies differ on some important dimensions. Emerging economies, on an average have higher output volatility compared with the developed economies: Table 1 shows an average volatility of 1.34 for developed economies and 2.74 for emerging economies. Consumption – relative to output – also tends to be more volatile than output in emerging economies: the average relative volatility of consumption is 1.45 for emerging economies and 0.94 for developed economies. Relative investment volatility is comparatively higher for emerging economies at 3.91, compared to 3.41 for developed economies. Thus, the findings in Table 1 are broadly consistent with the findings of other papers on the business cycle stylized facts of developing economies.

To study these features, the small open economy RBC model has been widely used (Aguiar and Gopinath, 2007; Neumeyer and Perri, 2005; Uribe and Yue, 2006; Garcia-Cicco *et al.*, 2010). Aguiar and Gopinath (2007) for instance allow for permanent and transitory changes to productivity. In their view, emerging markets are characterized by a large number of regime shifts, which are modeled as changes in trend productivity growth. A shock to the growth rate implies a boost to current output, but an even larger boost to future output. Consumption responds more than income, reducing savings

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[4]We refer to this paper as it provides average figures for business cycle characteristics for developed and developing economies.

[5]Australia, Austria, Belgium, Canada, Denmark, Finland, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden and Switzerland comprise the sample of developed economies while Argentina, Brazil, Ecuador, Israel, Korea, Malaysia, Mexico, Peru, Philippines, Slovak Republic, South Africa, Thailand and Turkey comprise the set of emerging economies.

and generating a current account deficit. If growth shocks dominate transitory income shocks, the economy resembles a typical emerging market with its volatile consumption process and counter-cyclical current account. By contrast, developed economies typically face stable economic and political regime changes. Hence, a developed economy characterized by relatively stable growth process will be dominated by standard, transitory productivity shocks. Such a shock will generate an incentive to save that will offset any increase in investment, resulting in limited cyclicality of the current account.[6].

The small open economy RBC model approach to studying emerging market business cycles is not without criticism. For instance, Calderón and Fuentes (2006) suggest that because the sources of shocks in Aguiar and Gopinath (2007) remain a black box, it is not clear whether these are being driven by changes in economic reforms, or other market frictions. Indeed, Chari *et al.* (2007) show that a variety of frictions can be represented in reduced form as Solow residuals. Garcia-Cicco *et al.* (2010) show that when estimated over a long sample, the Aguiar and Gopinath (2007) RBC model driven by permanent and transitory shocks does a poor job in explaining observed business cycles in Argentina and Mexico, along a number of dimensions. These findings of Garcia-Cicco *et al.* (2010) suggest that the RBC model driven by productivity shocks may not provide an adequate explanation of business cycles in emerging economies.

Other papers in the literature, such as Neumeyer and Perri (2005) emphasize the interaction between foreign interest rate shocks and domestic financial frictions that drive business cycle fluctuations in emerging market economies. Firms in their model demand working capital to finance their wage bill making labour demand sensitive to interest rate fluctuations. An increase in the emerging market economy's interest rate leads to a rise in labour costs. Since labour supply is insensitive to interest rate shocks, a lower demand for labour leads to lower levels of employment and output in equilibrium. Uribe and Yue (2006) find that both country interest rates drive output fluctuations in emerging market economies as well as the other way around. Kose *et al.* (2003) analyse the importance of domestic and external factors as causing cycles. Calvo (1998) argues that the idea of sudden stops are an important determinant of large cycles in emerging markets.

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[6]However, counter-cyclical net exports is also reported for developed economies by Stock and Watson (1999); Rand and Tarp (2002)

2.1 Relevance of the RBC approach to India

The two issues that arise in the modelling of business cycles in India are the relevance of the small open economy assumption and the appropriateness of the equilibrium business cycle approach in studying fluctuations in emerging market economies. With respect to the first, the assumption of openness is based on both the openness for FDI flows and for other capital flows in the economy. As a country with large FDI flows, it is seen that India is one of the more open emerging economies. Figure 1 plots the FDI to nominal GDP ratio for select emerging market economies.[7] The graph shows that before the onset of the global financial crisis of 2008, India's FDI as a percentage of GDP is amongst the largest.[8]

Figure 1 Measures of openness
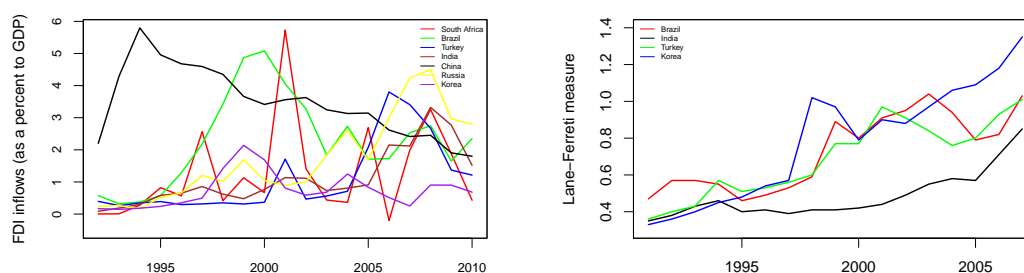
The second graph of Figure 1 plots the Lane and Milesi-Ferretti (Lane and Milesi-Ferretti, 2007) measure of financial openness, which is a widely used measure of *de facto* financial integration. The Lane and Milesi-Ferretti measure measures the stock of all external assets and liabilities of a country expressed as a ratio of GDP. As the graph shows that, India's value in this measure lies in a similar range to other emerging economies like Turkey and Brazil.

Further, since India's share of total exports, as per latest figures of 2010, was only 1.5 % and its share of total imports was 2.12 %, these miniscule shares

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[7]The countries are South Africa, Brazil, China, Russia, Turkey, and Korea.

[8]The data have been obtained from UNCTAD `http://unctadstat.unctad.org/Tableviewer/tableView.aspx`

support the small open economy assumption.[9] In the DSGE literature, India has also been treated as a small open economy. See (Batini *et al.*, 2010).

Finally, while we do not report these results here, we have also compared India's business cycle properties with another large and similarly sized emerging economy: Brazil.[10] We find that the main properties of business cycles in Brazil are similar to the stylized facts for India and for the (small open) emerging economy averages reported in Table 1.

The second issue concerns the relevance of the *equilibrium* approach to understanding business cycles in a developing economy such as India, and in particular, its usefulness in studying India's experience in the Asian financial crisis of 1997, and the Great Recession of 2008.[11] Our view is that the small open economy RBC model appears as a reasonable first approximation to thinking about business cycles in India.[12] Future work can use the findings of this paper to assess the extent to which DSGE models, starting with the simplest RBC model through to New-Keynesian models with labour markets and financial frictions introduced in stages, can explain business cycle fluctuations in India. Both closed and open economy models can be examined.

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[9]See Table 1.6 and Table 1.7 in `http://www.wto.org/english/res_e/statis_e/its2011_e/its11_world_trade_dev_e.htm`.

[10]These are available from the authors on request. We do not report stylized facts for China because of the lack of availability of quarterly macroeconomic data for a comparable time period.

[11]The Asian financial crisis in 1997 left India largely unaffected, as it was still not fully integrated with world markets. In 2008, however, India's experience with the financial crisis was exacerbated by the unprecedented world inflation in crude oil, food, and primary products which happened in the months prior to the crisis. One of the main differences between the Indian financial crisis in 2008 (vis-a-vis those of other countries) is that the chain of causation was more from the real sector to the financial sector, rather than the other way around. See (Gangopadhyay and Shanthi, 2012).

[12]There is now a large literature that uses the stochastic small open economy neoclassical model to study several features of emerging market business cycles, as well as the sudden contractions in output that were seen during the Asian crisis of (1997). Otsu (2008) quantitatively accounts for the sudden recession and rapid recovery in Korea during the Korean crisis of 1997. Otsu (2010) applies the business cycle accounting method a la (Chari *et al.*, 2007) to assess the recession patterns in emerging economies like Thailand during the 1997 Asian financial crisis. Tiryaki (2012) calibrates the real business cycle model in (Neumeyer and Perri, 2005) to study the quantitative effects of interest rates on the Turkish business cycle. Boz *et al.* (2009) use a real business cycle model of a small open economy which embeds a Mortensen-Pissarides type of search matching friction to understand consumption variability and countercyclical current accounts in emerging market economies. Arellano (2008) shows that combining non-contingent one period government debt with a strategic default decision by the government permits a standard RBC model to generate several features of the data in emerging markets.

Comparisons with a representative developed economy, say the US, can then be made. Proceeding in this way, one will be able to assess the relative importance of various frictions in driving aggregate fluctuations in India.

3   The Dataset

The business cycles examined in the literature are typically known as growth cycles, extending from the work of (Lucas, 1977) where the business cycle component of a variable is defined as its deviation from trend.[13]

We follow this standard methodology in deriving the stylized facts for Indian business cycles. In Appendix B, we detail the statistical procedure used to extract the business cycle. In India, quarterly data for output and key macroeconomic variables is available only from June 1999. To understand the changing nature of Indian business cycles, we examine annual data. We then check the validity of our results with quarterly data. This is consistent with the literature on stylized facts (King and Rebelo, 1999; Stock and Watson, 1999; Male, 2010), that relies on quarterly data to study business cycle properties of macroeconomic variables. Following King and Rebelo (1999) we choose private consumption and investment as key variables. In addition, we analyze exports, imports, net exports, consumer prices (Consumer Price Index-Industrial Worker (CPI-IW))[14], government expenditure and a range of nominal variables such as the nominal exchange rate and different measures of the money supply. Data on hours worked is not available for India. We use GDP as a measure of aggregate activity in the economy.

For the annual analysis, we have a sample period covering 1950-2010. To study the transition of the economy, the data is analyzed in two periods: the pre-liberalization period from 1950-1991 and the post liberalization period from 1992 to 2009. The primary data source is the National Accounts Statistics of the Ministry of Statistics and Programme Implementation. The data for consumer prices is taken from the Labour Bureau, Ministry of Labour and Employment. The data for government expenditure is taken from the budget documents of the Government of India. GDP, private consumption,

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[13]Business cycles dating goes back to the early work by (Burns and Mitchell, 1946). The classical approach propounded by (Burns and Mitchell, 1946) defines business cycles as sequences of expansions and contractions in the *levels* of either total output or employment. In 1990, (Kydland and Prescott, 1990) established the first set of stylized facts for business cycles in other developed economies, based on their research of US business cycle.

[14]In most countries the headline inflation number is consumer prices, in India it is wholesale prices. We follow the literature on stylized facts in using consumer prices.

gross fixed capital formation, exports and imports are expressed at constant prices with base 2004.[15] Government expenditure is expressed in real terms by deflating it with the GDP deflator. Following Agenor *et al.* (2000) and Neumeyer and Perri (2005) net exports is divided by real GDP to control for scale effects. We source the data from the Business Beacon database produced by the Centre for Monitoring Indian Economy (CMIE), who source it from the primary data sources mentioned above. All variables and their sources are described in detail in the Appendix.

The variables analyzed are first log transformed. The cyclical components of these variables are then obtained from the Hodrick-Prescott filter, as is standard in the literature (King and Rebelo, 1999; Agenor *et al.*, 2000; Neumeyer and Perri, 2005).[16] The cyclical components are then used to derive the business cycle properties of the variables in terms of their volatility, co-movement and persistence. For the sensitivity analysis, we test the robustness of our results by using the band-pass filter of Baxter-King (Agenor *et al.*, 2000). As a further check, we also use quarterly data to verify the validity of our results.

4   The Indian Business Cycle

Table 2, which constitutes the main finding of this paper shows the changing nature of the Indian business cycle from 1950 - 2010.

The main features can be summarized as follows:

- *Volatility of key macroeconomic variables has fallen*: High macroeconomic volatility is considered both a source as well as reflection of underdevelopment (Loayza *et al.*, 2007). Aggregate GDP has seen a decline in volatility from 2.13 in the pre-reform period to 1.78 in the

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[15]For their analysis of investment, King and Rebelo (1999) use only the fixed investment component of gross domestic private investment. The other components of gross domestic private investment are residential and non-residential investment. The volatility of gross domestic private investment in the US is higher than the component of fixed investment as residential investment is highly volatile. We take gross fixed capital formation as a proxy for investment since unlike the US, we do not have data on the categories of gross investment.

[16]Much of the literature following Nelson and Plosser (1982), supports the view that it is impossible to distinguish large stationary auto-regressive roots from unit auto-regressive roots, and that there might be non-linear trends. With a near unit root, linear de-trending will lead to spurious cycles. See (Stock and Watson, 1999).

Table 2 Business cycle statistics for the Indian economy using annual data: Pre and post reform period

	Pre-reform period (1950-1991)				Post-reform period (1992-2010)			
	Std. dev.	Rel. std. dev.	Cont. cor.	First ord. auto corr.	Std. dev.	Rel. std. dev.	Cont. cor.	First ord. auto corr.
Real GDP	2.13	1.00	1.00	0.045	1.78	1.00	1.00	0.716
Non-agri GDP	1.69	1.00	1.00	0.553	1.81	1.00	1.00	0.735
Pvt. Cons.	1.82	0.85	0.69	0.026	1.87	1.05	0.89	0.578
Investment	5.26	2.46	0.22	0.511	5.10	2.85	0.77	0.593
CPI	5.69	2.66	0.07	0.511	3.49	1.95	0.29	0.624
Exports	7.14	3.34	0.07	0.205	7.71	4.31	0.33	0.226
Imports	11.23	5.26	-0.19	0.204	9.61	5.38	0.70	0.470
Govt expenditure	6.88	3.22	-0.35	0.230	4.60	2.58	-0.26	0.474
Net exports	0.9	0.4	0.24	0.245	1.1	0.65	-0.69	0.504
Nominal exchange rate	6.74	3.15	0.10	0.632	5.35	3.00	-0.48	0.492
M1 (Narrow Money)	3.43	1.57	-0.03	0.413	3.27	1.83	0.54	0.546
M3 (Broad Money)	2.12	0.97	-0.01	0.593	2.64	1.47	0.65	0.710
Reserve Money	3.02	1.38	0.06	0.42	4.85	2.71	0.70	0.542
CPI Inflation	5.78	2.48	-0.29	0.228	2.94	1.64	0.55	0.378

post-reform period. This is consistent, in particular, with the experience of other major Asian economies (Kim *et al.*, 2003). This is due to a decline in volatility in the agricultural component of GDP.[17] The volatility of non-agriculture GDP however has gone up in the post reform period. The volatility of investment has declined from 5.26 in the pre-reform period to 5.10 in the post-reform period. Consumer prices, imports, government expenditure and nominal exchange rate have also become less volatile in the post-reform period. Inflation has also become less volatile - akin to the Great Moderation – experienced in the US. While government expenditures are less volatile in the post reform period, they are still more volatile than output.[18] However, the fall in volatility is not common to all the macroeconomic variables that we consider. For instance, exports has seen a marginal increase in volatility from 7.14 to 7.71 respectively in the post-reform period.

- *Increased consumption volatility*: Private consumption has seen an increase in volatility from 1.82 to 1.87 in the post-reform period, with an increase in relative volatility from .85 to 1.05. While the increase in consumption volatility is similar to other emerging Asian economies ex-

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[17]The volatility of the agricultural GDP has fallen to half from 4.26 in the pre-reform period to 2.56 in the post-reform period.

[18]In advanced economies, government expenditures are *less* volatile than output.

periencing structural change (see Kim *et al.* (2003)), the increase in the *relative* standard deviation of consumption in the post reform period in India is largely driven by the larger and more pronounced reduction in the volatility of real GDP.[19]

- *Increased pro-cyclicality of investment with output*: A significant feature of modern capitalist economies is that investment is highly pro-cyclical vis-a-vis the aggregate business cycle. Table 2 reports a significant increase in contemporaneous correlation of investment with output from 0.22 in the pre-reform period to 0.60 in the post reform period.

- *Increased pro-cyclicality of imports with output*: Imports have become pro-cyclical in the post-reform period. The external sector policies in the pre-reform period were based on protectionism and import licensing. This is reflected in a negative correlation of imports with output in the pre-reform period. The policy thinking underwent a major change in post 1991 period. Tariff barriers were reduced and non-tariff barriers were dismantled in the mid 1990s. The demand for raw material imports increased substantially with easing of capacity controls on industries. This resulted in imports fluctuating with changes in aggregate business activity. Table 2 shows an increase in the contemporaneous correlation of imports from an insignificant -0.19 in pre-reform period to 0.70 in post-reform period. The pro-cyclical nature of imports is again a feature similar to those for advanced open economies.

- *Counter-cyclical nature of net exports*: Since imports are significantly pro-cyclical and exports are not highly correlated with GDP, on balance this leaves us with a counter-cyclical nature of net exports. Table 2 shows a transition from a-cyclicality in net exports to counter-cyclical net exports.

- *Counter-cyclicality of nominal exchange rate*: The nominal exchange rate has turned counter-cyclical in the post-reform period. From an a-cyclical relation in the pre-reform period, the post-reform period shows that the exchange rate goes up in bad times and moves down in good times. This is indicative of the presence of a flexible exchange rate regime in the post-91 period.

- *Pro-Cyclicality of monetary policy*: A key feature that distinguishes emerging market economies from developed economies is the pro-cyclicality

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[19]We show later that while the increase in the *relative* standard deviation of consumption also obtains when we use the Baxter-King filter (Section 5.3), the *absolute* volatility of private consumption declines in the post reform period.

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of monetary policy. Table 2 shows a clear pro-cyclical monetary policy in the post-reform period. Pro-cyclical capital flows with a "managed" exchange rate has induced a pro-cyclical monetary policy response in the post reform period. The contemporaneous correlation of both money supply variables, M1 and M3, with aggregate output has changed from negative values in the pre reform period to positive values after the reform as seen in Table 2.

- *Persistence* As mentioned before, persistence indicates the inertia in business cycles. It also captures the length of observed fluctuations. Real GDP exhibits weak persistence in the pre-reform period, although there is higher persistence in pre-reform non-agricultural GDP. In the post-reform period, the persistence of real GDP increases substantially, which provides more leeway for predicting the course of business cycles. In general, all variables reveal low persistence in the pre-reform period, with higher persistence in the post-reform period.

4.1 Comparison with other economies experiencing structural change

A careful look at Table 2 shows that though the level of volatility of key macroeconomic variables has declined, it is still high and similar to emerging market economies. For example, the volatility of real GDP declines from 2.13 to 1.78 in the pre to post reform period. These numbers are closer to the volatility statistics reported by Kim *et al.* (2003) for Asian economies before and after the structural transformation respectively.[20] The volatility numbers are also comparable to those reported by Alper (2002) for Mexico and Turkey but much higher than the numbers reported for the U.S. An interesting finding is that the relative volatility of consumption has gone up in the post-reform period, again similar to the findings reported by Kim *et al.* (2003). While the absolute volatility of trade variables has marginally declined, the relative volatility is still high. This is consistent with the findings of Kim *et al.* (2003) who report reduced but still higher relative volatility of trade variables as compared to those of the G-7 countries.

In contrast, the Indian business cycle is similar to the developed economies on co-movement and persistence of macroeconomic variables. Table 2 shows

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[20]The paper compares the business cycle stylized facts of seven Asian economies for the period 1960-1984 and 1984-1996. The mean volatility declines from 3.00 in the first sub-period to 2.00 in the second sub-period.

that the contemporaneous correlation of investment with output increases from 0.22 in the pre-reform period to 0.77 in the post-reform period. While the post-reform correlation figure is higher than the number reported by Kim *et al.* (2003) for Asian economies for their second period, it is similar to the numbers reported by Male (2010) for developed economies. Similarly, the correlation of imports with output increases in the post-reform period. The figure reported in Table 2 is much higher than the corresponding average correlation figures reported by Kim *et al.* (2003). Another feature on which the Indian business cycle resembles that of an advanced economy is the persistence of macroeconomic variables. As an example, the persistence of output reported in Table 2 is greater than the average persistence figures reported for Asian economies by Kim *et al.* (2003) and for developing economies by Male (2010).

4.2   Structural Change or the Good Luck Hypothesis

In this section, we list several key factors that account for the changing nature of the Indian business cycle. Three broad properties about the pre and post reform Indian business cycle emerge from Table 2. First, compared to the pre reform period, the volatility of main macroeconomic variables are much smaller in the post reform period. Second, while the volatility of the main macroeconomic variables decreases in the post reform period, they are still higher than developed countries, but with a similar comparable magnitude to other emerging market economies. However, the degree of persistence and contemporaneous correlation with output are similar to developed countries. And third, there has been a marginal rise in relative consumption volatility in the post-reform period. Finally, we address whether changes in the Indian business cycle from 1950 - 2010 were driven by "good luck" - a reduction in the variance of exogenous shocks - or structural changes caused by market oriented reforms, or better policies. If changes in the nature of the Indian business cycle were driven by structural changes, an important question is what features of India's structural transformation are responsible for changes in the nature of the Indian business cycle.

Figure 2 The story of India's transition
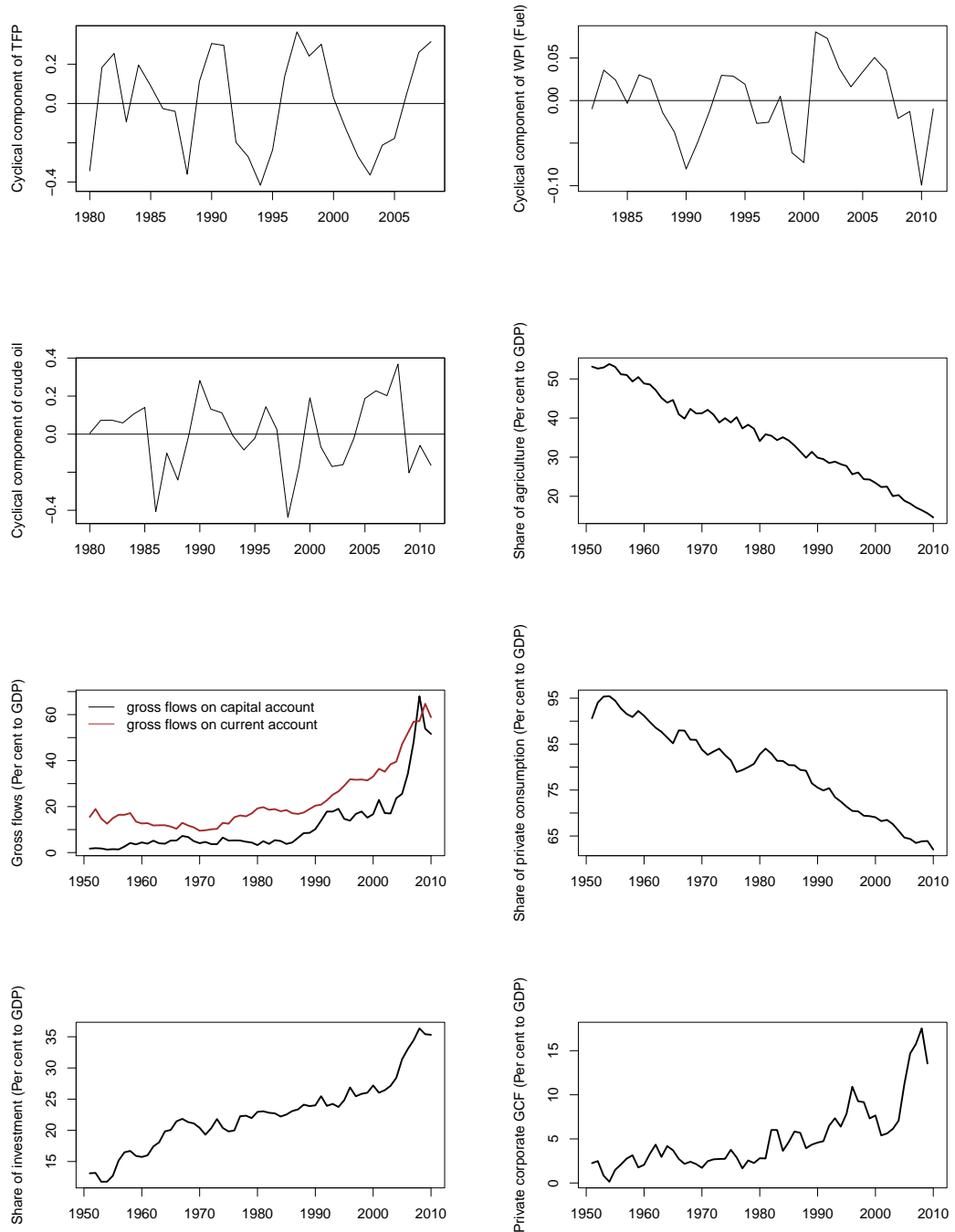
1. Evidence against the Good Luck Hypothesis.

     The variance of exogenous shocks: The good luck hypothesis, the reduction in volatility caused by less frequent and/or smaller exogenous shocks, is typically attributed as a potential cause of a decline in volatility of aggregate economies. Two of the main candidates for exogenous shocks used in the literature are oil shocks and productivity shocks.

     The first plot of Figure 2 shows the cyclical component of TFP from 1980-2010.[21] The standard deviation increases from .21 to .27 in the post reform period. The second graph plots the cyclical component of WPI (fuel)[22]. The standard deviation increases from 2.29 in 1982 - 1991, to 4.83 from 1992 - 2011. The first graph (second row) plots the cyclical component of the Brent crude oil price. The standard deviation marginally increases from 19.49 (1980-1990) to 19.73 (1992-2011). The evidence therefore doesn't support the good luck hypothesis as the cause of the changing pattern of Indian business cycles in the post reform period.

     Better Policies: Better policy is typically viewed as an improvement in the performance of fiscal and monetary policy. As noted in Section 4, government expenditures are less volatile in the post reform period, even though they are still more volatile than output. With respect to monetary policy, the definition of "better policies" typically refer to adherence to policy rules. Levine (2012) however finds that the evidence supporting that monetary policy by the RBI can be captured by a Taylor Rule, with the interest rate as the policy instrument, is weak. Further, as discussed in Section 4, Table 2 shows a clear pro-cyclical monetary policy in the post-reform period. Indeed, a key feature that distinguishes emerging market economies from developed economies is the pro-cyclicality of monetary policy.

2. Key factors explaining explaining the decline in the volatility of main macroeconomic variables:

     Declining Share of Agriculture: Figure 2 shows a consistently declining share of agriculture since 1950s. Table 3 shows the changing

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[21]Appendix C details how TFP has been calculated. Our TFP calculations are from 1980 onwards because of the lack of reliable data for years before.

[22]The data for WPI (fuel) is sourced from the website of the Office of the Economic Adviser to the Government of India, Ministry of Commerce and Industry available at `http://eaindustry.nic.in/`.

composition of Indian GDP, the decline in the share of agriculture has been matched with a rise in the share of services. The fact that monsoon shocks matter less is evident from the declining share of agriculture in Indian GDP.[23]

Table 3 Changing composition of GDP

	Agriculture	Industry	Services
1951	53.15	16.5	30.2
1992	28.8	27.4	44
2009	14.6	28.4	57

3. Key factors explaining other properties of the Indian Business Cycle:

Current and Capital Account Integration: While volatility has fallen in several business cycle indicators in the post reform period, aggregate volatility still remains high as in other emerging and developing economies who have experienced structural changes. One source of volatility is that while the transformation of the Indian economy to a more open economy in the post reform period has been accompanied by high growth, there has also been a sharp increase in India's integration on both trade and financial flows. Figure 2 also shows the evolution of current and capital account flows expressed as a percent to GDP. In the pre-reform period the flows on current and capital account were around 20% of GDP. The conducive policy environment has resulted in both current and capital account flows to GDP ratio rising to around 60% each in 2009. In the Indian case the period of higher current and capital account openness has seen a lower volatility of aggregate output.[24]

Investment-Inventory Fluctuations: From a purely monsoon driven economy, fluctuations in the economy are now driven primarily by fluctuations in inventory and investment. The share of investment in GDP has increased from 13% in 1950-51 to 35% in 2009-10. In the pre-reform period, the Indian economy was characterized by controls on capacity

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[23]See (Shah, 2008; Patnaik and Sharma, 2002).

[24]Another source of volatility is when productivity shocks get amplified by frictions as in Aghion *et al.* (2004). Here, excess output volatility results because of capacity under-utilization. Aghion *et al.* (2010) show however that there is not much evidence that investment responds more to productivity shocks in economies with less good capital markets. On the other hand, Aghion *et al.* (2010) paper also finds that the fraction of long term investment in total investment is more pro-cyclical in economies with less good capital markets. If long run investment enhances productivity, then the reform story made explicit in this paper acquires salience.

creation and barriers to trade. In such a scenario, conventional business cycles characterized by an interplay of inventories and investment did not exist. One 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 increase has been particularly prominent since 2004-05. Figure 2 shows the time series of private corporate gross capital formation expressed as a percent to GDP. In recent years we can see the emergence of the behavior found in the conventional business cycle. In the investment boom of the mid-1990s, private corporate GCF rose from 5% of GDP in 1990-91 to 11% of GDP in 1995-96. This then fell dramatically in the business cycle downturn to 5.39% in 2001-02, and has since recovered to 17.6% in 2007-08. The recent recession has led to its fall to 13.5% in 2009-10.[25]

4. Key factors behind the increase in relative consumption volatility.

A puzzle: Can the increase in relative consumption volatility be explained by transitory or permanent productivity shocks, a shift towards market oriented reforms, or is this simply a reflection of the disconnect between theoretical findings on the role of financial liberalization and country specific findings? As shown in Table 2, consumption volatility has increased. Aguiar and Gopinath (2007) suggest that consumption volatility is high because of permanent productivity shocks, i.e., consumption volatility is driven by shocks to income that are larger or more persistent than they should be. This leads to a larger Solow residual, which is consistent with the increase in volatility of exogenous shocks documented in Figure 2. To the extent that increasing international financial integration allows countries to better smooth consumption through international risk sharing, an increase in consumption volatility is a puzzle.[26] As noted before, our findings are consistent with the large literature on the apparent disconnect between the theoretical

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[25]The fifth plot shows the of Figure 2 show the behavior of the consumption-output ratio from 1950-2010. The graphs show that while the share of private consumption has declined, there is a gradual and consistent increase in the share of investment in GDP.

[26]In the pre-reform period India was sheltered from external competition through high import duties and other barriers to trade. The capital account was also subject to strict regulations on inflows and outflows. Since the adoption of market oriented reforms, the restrictions on current and capital account have been eased. This has resulted in India being globally financially integrated.

predictions of the financial liberalization process, and country specific
findings.

In sum, several factors have been responsible for the changing nature of the
Indian business cycle in the pre and post reform period. We have reported
new evidence on the variance of exogenous shocks and related this to the
lack of evidence for the good luck hypothesis. We have also described other
changes such as the conduct of monetary policy, India's increased current and
capital account openness, structural transformation, rising relative consumption volatility, and changing patterns of investment-GDP and consumption-GDP ratios, that help explain the changing nature of the Indian business cycle.

5 Robustness Checks

In this section we perform a variety of robustness checks to test the validity
of our results.

5.1 Robustness of Correlation Results

Following Ambler *et al.* (2004), we investigate whether our contemporaneous
correlation measures are mere statistical noise or are robust to procedures
for testing the statistically significant difference in correlation.[27]

Table 4 shows the difference in contemporaneous correlation with the the

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[27]The procedure for testing the statistically significant difference in correlation involves
the following steps:

- Let r_1 be the correlation between the two variables for the first group with n_1
  subjects.

- let r_2 be the correlation for the second group with n_2 subjects.

- To test $H0$ of equal correlations we convert r_1 and r_2 via Fisher's variance stabilizing
  transformation
  $z = 1/2 * ln[(1 + r)/(1 - r)]$ and then calculate the difference:
  $z_f = (z_1 - z_2)/\sqrt{(1/(n_1 - 3) + 1/(n_2 - 3))}$

- The difference is approximately standard normal distribution.

- If the absolute value of the difference is greater than 1.96 (assuming 95% confidence
  interval) then we can reject the null of equal correlations.

associated p-values. The application of the test shows that the difference in contemporaneous correlation between the pre and post-reform period is statistically significant for investment, imports, net exports and the nominal exchange rate, as well as for both narrow and broad definitions of money, and CPI inflation. The changes in the volatility of these variables are key in demonstrating the change in the nature of business cycles from the pre reform to the post reform period.[28]

Table 4 Test of significance of differences in contemporaneous correlation with output

Variables	Difference in correlation (z)	P-value
Private Consumption	-1.92	0.054
Investment	-2.61	0.0089*
CPI	-0.77	0.44
Exports	-0.88	0.37
Imports	-3.49	0.0004*
Government expenditure	-1.15	0.25
Nominal exchange rate	2.08	0.037*
Net exports	3.63	0.000278*
Narrow Money (M1)	-2.11	0.03*
Broad Money (M3)	-2.61	0.0088*
Reserve Money	-2.65	0.0079*
CPI Inflation	-2.87	0.0004*

For private consumption, CPI, exports and government expenditure, the test results are not significant. This implies that the nature of correlation of these variables with output does not change between the pre and post reform period.

5.2 Using Quarterly Data

In this section we present India's business cycle statistics with quarterly data to check whether the estimates are consistent with results for the post-reform period in the annual data. Our quarterly data analysis starts from 1999 Q2, when quarterly GDP becomes available. Figure 3 shows the de-trended path of the key variables with output proxied by GDP. The cyclical component

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[28]As an example, these results imply that the difference in the cyclical relation between, say, investment and output, is statistically significant between the pre and post reform period.

of the GDP series is placed in each panel of the figure to gauge the relative volatility and co-movement of each series in question with the reference series.

Business cycle stylized facts for key variables are provided in Table 5.

Volatility: Table 5 shows private consumption as more volatile than output. This is similar to the finding for other developing economies. In general, consumption is 40 percent more volatile than income in developing economies. Conversely, in developed economies the ratio is sightly less than one on average (Aguiar and Gopinath, 2007). Table 5 reports the relative volatility of private consumption for India as 1.31.

Prices are also more volatile than output. Again, this is consistent with the findings for developing economies. In Latin American countries, prices are six times more volatile than output (Male, 2010). The relative volatility of price level for India is 1.09

Exports and imports exhibit significant volatility. Higher export and import volatility can also be seen for developed economies, though the extent of volatility is lower (Kim *et al.*, 2003). For India, the relative volatility of exports and imports are 7.40 and 7.52 respectively. Net exports are also found to be more volatile than output.

Consistent with the business cycle facts for developing economies, government expenditure is more volatile than output. The relative volatility of government expenditure is 5.53. Thus on volatility, our business cycle features resemble those of developing and emerging market economies.

Co-Movement: Table 5 shows investment as significantly pro-cyclical. The contemporaneous correlation of investment with output is 0.69. The strong correlation between investment and output for India provides evidence for a growing resemblance between India and advanced economies business cycles. This is consistent with the results from annual data.

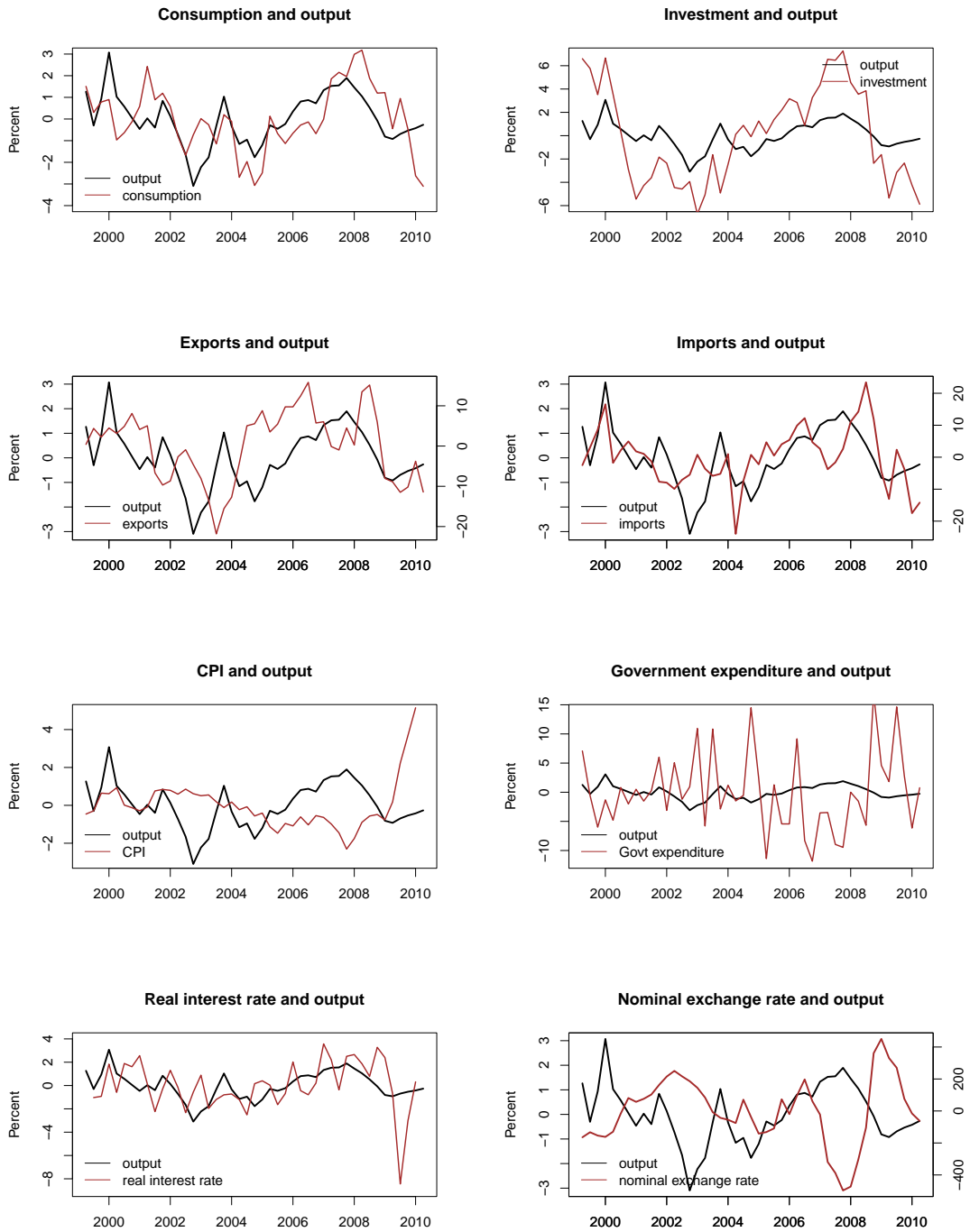**Figure 3** Detrended path of key variables with GDP

Table 5 Business cycle stylized facts using quarterly data (1999 Q2-2010 Q2)

	Std. dev.	Rel. std. dev.	Cont. corr.	First ord. auto corr.
Real GDP	1.18	1.00	1.00	0.73
Private Consumption	1.54	1.31	0.51	0.67
Investment	4.08	3.43	0.69	0.80
CPI	1.30	1.09	-0.29	0.70
Exports	8.79	7.40	0.31	0.77
Imports	8.93	7.52	0.45	0.54
Govt expenditure	6.69	5.53	-0.35	0.005
Net exports	1.24	1.04	-0.15	0.45
Real interest rate	2.11	1.77	0.38	0.372
Nominal exchange rate	4.61	3.88	-0.54	0.82
M1 (Narrow Money)	3.13	2.64	0.5	0.105
M3 (Broad Money)	1.79	1.50	0.06	0.40
Reserve Money	4.53	3.82	0.47	0.50
CPI Inflation	0.88	0.74	0.05	0.66

Table 5 shows imports as pro-cyclical, while exports as mildly pro-cyclical. Again, this feature indicates resemblance between Indian and advanced economies business cycle facts.

For fiscal policy to play a stabilizing role in an economy, government expenditure should be counter-cyclical. A significant difference between the annual and quarterly data analysis pertains to the correlation of government expenditure with output. For the annual analysis, the relation is counter-cyclical, though not significant. With the quarterly analysis, which pertains to recent data, we report a significant counter-cyclical relation between government expenditure and output. The correlation coefficient is -0.35. Crucially, this is similar to the findings for developed economies. Also consistent with the results of the annual post-reform period, nominal exchange rate is found to be counter-cyclical. Both narrow money (M1) and reserve money are found to be pro-cyclical.

Persistence Using quarterly data, Table 5 shows persistent output fluctuations for the Indian business cycle. The magnitude of persistence is comparable to those of developed economies. Male (2010) finds the average persistence for developed economies to be 0.84 and for developing economies to be 0.59. The persistence of output for India is higher than the developing economies average figure. The persistence is even higher at 0.84 if non-agricultural GDP is taken as the aggregate measure of business cycle

activity.[29] Price levels are also significantly persistent. Other variables in Table 5 are also found to be significantly persistent (with the exception of government expenditure and real interest rate).

In summary, the results of the quarterly data analysis broadly confirm the findings of the post-reform period using annual data. The findings support the view that the Indian economy has witnessed a change in the nature of business cycles after it adopted market oriented reforms and moved away from a command economy. While on volatility, the business cycle features resemble those of developing economies, the correlation and persistence results show growing similarity with the advanced economies business cycle.

5.3 The Baxter-King Filter with Annual Data

As another sensitivity measure, we check the robustness of our annual results to the choice of the de-trending technique. Following Stock and Watson (1999); Agenor *et al.* (2000) we use the Baxter-King to derive the business cycle properties of our macroeconomic variables. The Baxter-King filter belongs to the category of band-pass filters that extract data corresponding to the chosen frequency components. We are interested in extracting the business cycle components. In line with the NBER definition, the business cycle periodicity is defined as those ranging between 8 to 32 quarters.

Table 6 reports our findings for the Indian business cycle with the cyclical components derived from the Baxter-King filter. The results are broadly consistent with those corresponding to the Hodrick-Prescott filter. Output volatility shows a decline in the post-reform period. We find that the measures of contemporaneous correlation with output are broadly the same. Investment becomes pro-cyclical in the post-reform period. Since exports are a-cyclical and imports are pro-cyclical, net exports are found to be counter-cyclical. Similar to the Hodrick-Prescott filter, the nominal exchange rate becomes counter-cyclical in the post-reform period. Monetary policy is also found to be pro-cyclical in the post reform period.

There are some notable differences in the results related to volatility. This arises due to differences in the properties of the two filters. While the Baxter-King filter belongs to the category of band-pass filters that remove slow moving components and high frequency noise, the Hodrick-Prescott filter is an approximation to a high-pass filter that removes the trend but passes high frequency components in the cyclical part. The Baxter-King filter therefore

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[29]These results are available from the authors on request.

tends to underestimate the cyclical component (Rand and Tarp, 2002)[30]. As an example, in contrast to the findings of the Hodrick-Prescott filter, the absolute volatility of private consumption declines in the post-reform period, when the Baxter-King filter is used to de-trend the variables.[31]

There are also notable differences with respect to persistence compared to the HP filter. Persistence in the pre-reform period for almost all the variables is low. Real GDP, consumption, and exports have negative persistence. In the post reform period, persistence rises, but the variables are less persistent compared to when the HP filter is used to extract cycles.

Table 6 Business cycle statistics for the Indian economy using annual data: Pre and post reform period (with Baxter-King filter)

	Pre-reform period (1950-1991)				Post-reform period (1992-2010)			
	Std. dev.	Rel. std. dev.	Cont. cor.	First ord. auto corr.	Std. dev.	Rel. std. dev.	Cont. cor.	First ord. auto corr.
Real GDP	1.94	1.00	1.00	-0.171	0.95	1.00	1.00	0.234
Non-agri GDP	1.09	1.00	1.00	0.249	0.89	1.00	1.00	0.550
Pvt. Cons.	1.59	0.81	0.86	-0.308	1.05	1.10	0.84	-0.041
Investment	3.49	1.79	0.22	0.325	3.12	3.26	0.60	0.243
CPI	4.29	2.20	0.28	0.297	1.51	1.58	0.28	0.189
Exports	5.99	3.07	-0.03	-0.133	6.08	6.35	0.36	0.180
Imports	8.76	4.49	-0.06	0.037	6.15	6.42	0.47	0.215
Govt expenditure	6.39	3.10	-0.17	0.010	3.73	3.90	-0.44	0.358
Net exports	0.68	0.34	0.08	0.013	0.81	0.84	-0.26	0.029
Nominal Exchange Rate	4.34	2.23	0.05	0.312	2.17	2.27	-0.17	0.124
M1 (Narrow Money)	2.47	1.23	-0.10	-0.08	1.42	1.48	0.43	0.49
M3 (Broad Money)	1.40	0.70	0.02	0.265	1.44	1.51	0.31	0.515
Reserve Money	2.43	1.21	0.02	0.2	2.33	2.47	0.40	0.08
CPI Inflation	5.78	2.65	-0.21	0.228	2.94	3.07	0.43	0.378

5.4 Redefining the Sample Period

To examine whether our results could be arising from differences in the sample sizes of the pre and post reform period, we now check if our findings hold when the two sample periods are roughly the same. For this we shorten the

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[30]For a detailed comparison of the filtering procedure of Hodrick-Prescott and Baxter-King, refer to Baxter and King (1999)

[31]While we do not report these results here, the statistical testing procedure shows that the difference in correlations is close to the cut-off value of 1.96, even though it is not as strong as with the Hodrick-Prescott filter.

(annual) pre reform period to the same length as the post reform period of twenty years.

Table 7 Business cycle statistics for the Indian economy using annual data: Pre reform period (1971-1991)

	Pre-reform period (1971-1991)			
	Std. dev.	Rel. std. dev.	Cont. cor.	First order auto corr.
Real GDP	2.24	1.00	1.00	-0.008
Pvt. Cons.	1.94	0.86	0.69	-0.03
Investment	3.55	1.57	0.50	0.41
CPI	5.96	2.64	-0.16	0.481
Exports	6.00	2.66	0.10	0.501
Imports	8.71	3.87	-0.10	0.312
Govt expenditure	5.62	2.62	0.50	0.245
Net exports	0.8	0.3	0.12	0.279
Nominal exchange rate	5.54	2.46	0.40	0.564
M1 (Narrow money)	3.86	1.67	-0.133	0.233
M3 (Broad money)	1.80	0.78	0.25	0.515
Reserve money	4.15	1.79	0.11	0.458
CPI Inflation	5.96	2.58	-0.43	0.212

Table 7 reports business cycle facts when the pre-reform period is defined as starting from 1971. The broad stylized facts remain the same. On correlation, our results remain the same as reported in Table 2. Investment and imports become highly pro-cyclical, while net exports and nominal exchange rate turn counter-cyclical in the post-reform period. On volatility, we get a mixed picture. While aggregate GDP is highly volatile at 2.24 in the pre-reform period, it falls to 1.78 in the post-reform period (see Table 2). Other variables, with the exception of investment, exports, imports and net exports also show a fall in volatility from the pre to post reform period.

6 Conclusion and Future Work

Documenting business cycle stylized facts forms the foundation of quantitative general equilibrium models either in the RBC or the New Keynesian DSGE tradition. Such a study assumes greater relevance in the context of an economy like India which has undergone significant change since 1991. The industrial sector has been freed from capacity controls, import duties have been reduced and a reasonably conducive environment towards the global

economy has evolved over the last few years. The novel aspect of this paper is to present a comprehensive set of stylized facts governing an economy in transition. We locate facts about Indian business cycles in the context of other industrial economies, as well as other emerging and developing countries.

The paper's main contribution is to highlight the difference in the properties of the Indian business cycle stylized facts over the two periods, and suggest reasons for these changes. Our main finding is that after the liberalization of the Indian economy in 1991, key macroeconomic variables are less volatile in the post reform period compared to the pre-reform period. However, relative consumption volatility has increased in the post reform period, and the volatility of several macroeconomic variables in the post-reform period in India is still high and similar to emerging market economies. In contrast, in terms of co-movement and persistence, India looks more similar to advanced economies, and less like emerging market economies. The changing pattern of India's business cycle suggests that there are links between development stages and macro cycles, an area for future research.

Future work can use the findings of this paper to assess the extent to which DSGE models, starting with the simplest RBC model through to New-Keynesian models with labour markets and financial frictions introduced in stages, can explain business cycle fluctuations in India. Both closed and open economy models can be examined. Comparisons with a representative developed economy, say the US, can then be made. Proceeding in this way, one will be able to assess the relative importance of various frictions in driving aggregate fluctuations in India. Another avenue for future work relates to Lucas (1987), which pointed out that the welfare gains from eliminating business cycle fluctuations in the standard RBC model are small, and dwarfed by the gains from increased growth. While adding New Keynesian frictions significantly increases the gains from stabilization policy, they still remain small compared to the welfare gains from increased growth. However, there is relatively little work introducing long-run growth into DSGE models, and exploring the relationship between volatility and endogenous growth. This takes particular importance for India which has moved to a higher growth path in recent years, with the attendant decline in macroeconomic volatility, as documented in this paper.

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A Data Definition and Sources

Variable	Definition	Source
Gross domestic product	GDP is a measure of the volume of all goods and services produced by an economy during a given period of time. GDP is expressed at 2004-05 prices and chained backwards to 1999-2000 prices. The variable is expressed at factor cost	National Accounts Statistics
Private consumption	The Private final consumption expenditure is defined as the expenditure incurred by the resident households on final consumption of goods and services, whether made within or outside economic territory. The variable is expressed at 2004-05 prices and chained backwards to 1999-2000 prices	National Accounts Statistics
Gross fixed capital formation	Gross fixed capital formation refers to the aggregate of gross additions to fixed assets and increase in inventories. The variable is expressed at 2004-05 prices and chained backwards till 1999-2000 prices	National Accounts Statistics
Exports	Exports of goods and services, rebased at 1999-2000 prices.	National Accounts Statistics
Imports	Imports of goods and services, rebased at 1999-2000 prices.	National Accounts Statistics.
Net exports	Exports - Imports divided by GDP at constant prices	
Consumer prices	Consumer Price Index for Industrial Workers measured at 2001 prices	Labour Bureau, Ministry of Labour and Employment.
Government expenditure	Total expenditure of the Central Government on revenue and capital accounts	Budget documents, Government of India
Real interest rate	91-day treasury bill rate on the secondary market deflated by CPI inflation	Reserve Bank of India
Nominal exchange rate	Nominal rupee-dollar exchange rate	Reserve Bank of India.
M1 (Narrow money)	Currency with the public plus demand deposits and "other deposits" with the RBI	Reserve Bank of India
M3 (Broad money)	Narrow money plus time deposits	Reserve Bank of India
M0 (Reserve Money)	Currency in circulation "other deposits" with RBI Bankers' deposits with RBI	Reserve Bank of India

B   Statistical Methodology

In choosing the technique to derive the cyclical component, the literature on stylized facts mainly relies on either the Hodrick-Prescott filter (King and Rebelo, 1999; Male, 2010) or the band-pass filter proposed by Baxter and King (Stock and Watson, 1999). We use the Hodrick-Prescott filter (Hodrick and Prescott, 1997) to de-trend the series and then check the robustness of our results with the Baxter-King filter (Baxter and King, 1999).[32]

For annual data analysis, the log transformed series is passed through a filter to extract the cyclical (stationary) and trend (non-stationary) component. In case of quarterly data, the variables are adjusted for seasonal fluctuations using the X-12-ARIMA seasonal adjustment program. Once adjusted for seasonality, the series are transformed to log terms and then filtered to extract the cyclical and trend component.

The Hodrick-Prescott method involves defining a cyclical output y_t^c as current output y_t less a measure of trend output y_t^g with trend output being a weighted average of past, current and future observations:

$$y_t^c = y_t - y_t^g = y_t - \sum_{J=-j}^{J} a_j y_{t-j}$$

After de-trending the series to obtain the cyclical components, we can then determine the properties of the business cycle. In the subsequent analysis, all references to the variables refer to their cyclical component. The cyclical component of the variable is used to derive the volatility, co-movements and persistence of variables.

Our definition of these terms is standard in the literature. Volatility is a measure of aggregate fluctuations in the variable of interest. It is measured by the standard deviation of the variable. Relative volatility is the ratio of volatility of the variable of interest and the variable used as a measure of aggregate business cycle activity. A relative volatility of more than one implies that the variable has greater cyclical amplitude than the aggregate business cycle.

Contemporaneous co-movements with output series indicate the cyclicality of key macroeconomic variables. In particular, the degree of co-movement of a variable

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[32]A large literature exists on the choice of the de-trending procedure to extract the business cycle component of the relevant time series (Canova, 1998; Burnside, 1998; Bjornland, 2000). Canova (1998) argues that the application of different de-trending procedures extract different types of information from the data. This results in business cycle properties differing widely across de-trending methods. However, commenting on (Canova, 1998), Burnside (1998) shows through spectral analysis, that the business cycle properties of variables are robust to the choice of the filtering methods if the definition of business cycle fluctuations are uniform across all the de-trending methods.

of interest y_t with the measure of aggregate business cycle x_t is measured by the magnitude of correlation coefficient $\rho(j)$ where j refers to leads and lags (Agenor *et al.*, 2000). The variable is considered to be pro-cyclical if the contemporaneous coefficient $\rho(0)$ is positive, a-cyclical if the contemporaneous coefficient $\rho(0)$ is zero and counter-cyclical if the contemporaneous coefficient $\rho(0)$ is negative.

Finally, persistence indicates the inertia in business cycles. It also captures the length of observed fluctuations. This is measured by the first order auto-correlation coefficient. A high coefficient implies a persistent, long economic fluctuation. Positive coefficients indicate that high values follow high values, or low values follow low values. Negative coefficients indicate reversals from high to lower values, or vice-versa.

C   Estimation of Aggregate TFP for India

The methodology for calculating TFP is as follows. The series for sectoral GDP and net capital stock is rebased at 2004-05 prices to arrive at a longer time series. We use the distribution of labour force (per 1000 households, male/female, rural/urban) as reported for each sector in the NSSO's quinquennial Employment Unemployment Survey as well as in the annual surveys based on a thin sample to generate a time series of the distribution of sectoral employment. Using the sectoral distribution of labour force and the total labour force data published by the World Bank, we obtain sectoral employment series. We then compute the sectoral TFP series for India using sectoral real GDP, net fixed capital stock and employment data. Given the availability of employment data, our measure of TFP series spans 1980-2009.

Using the sectoral shares (w_s^j) of capital, labour and land in agriculture, industry and services from Verma (2008), we then measure the sectoral TFP series as

$$\log(A_t^s) = \log(Y_t^s) - \sum w_s^j \log(X_t^{sj}), \quad \sum_{j=1}^{n_s} w_s^j = 1, \tag{1}$$

where n_s is the number of inputs used in sector s. Here s denotes major sectors constituting the economy namely, agriculture, industry and services, Y represents real GDP and X^j denotes factors of production in the respective sector. For example when, $s = \text{agriculture}, j = \text{land}, \text{physical capital}, \text{labour}$. When $s = \text{industry}, \text{services}, j = \text{physical capital}, \text{labour}$.

Finally, aggregate TFP is measured as a weighted average of the sectoral TFPs as following:

$$\log(A_t) = \sum_s \log(A_t^s), \quad s = \text{Agriculture}, \text{Industry}, \text{Services} \tag{2}$$