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Revisiting India's Growth Transitions

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Abstract

This paper reconsiders two questions relating to India's economic growth: structural breaks in growth and the impact of equipment investment on aggregate economic growth. First, statistical tests of structural change show that economic growth in post-independence India has witnessed four structural breaks: in 1964-65, in 1978-79, in 1990-91, and in 2004-05. However, substantial growth accelerations, i.e. increase of more than 1.0% per annum in the growth rate of per capita real GDP, occurred only at two points: 1978-79 and 2004-05. Second, to analyze the impact of equipment investment on growth, I use an ARDL bounds testing methodology. I find a positive and statistically significant long run positive impact of private investment in equipment and machinery on the growth rate of real GDP.
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Keywords: India, economic growth, structural change, ARDL bounds testing.

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1 Introduction

India's growth transition, whereby it moved from a slow to a high growth path a few decades ago, has attracted lot of scholarly attention (Rodrik and Subramanian, 2005; Virmani, 2006; Basu and Maertens, 2007; Sen, 2007; Kotwal et al., 2011; Ghate and Wright, 2012; Kar and Sen, 2016). Two issues that have been discussed in this literature are the exact timing and the causes of the growth acceleration. An early set of contributions identified the structural break in economic growth in the early 1990s and understood the economic reforms - especially those relating to international trade - initiated in 1991 as the prime cause of the acceleration in growth (Panagariya, 2004). Later contributions have challenged that conclusion. Analytical narrative accounts argued that the cause of the growth transition was the change in attitude of the State towards capital in the early 1980s (Delong, 2003; Rodrik and Subramanian, 2005; Kohli, 2006). Statistical analyses of structural break corroborated this account by identifying the growth acceleration in the late 1970s (Balakrishnan and Parameswaran, 2007).

The formal analysis in Balakrishnan and Parameswaran (2007) used aggregate, and sectoral, data for the period 1950-51 to 2003-04 and found that the "growth rate of GDP shows only one shift, in 1978-79." Using a principal-components methods on a state-level data set, Ghate and Wright (2012) identified the single break in growth in the mid-1980s and ascribed it to the trade liberalization that began around that time but accelerated after 1991 (Panagariya, 2004). For a while, the literature seemed to have settled down on the consensus that there was a single break in economic growth and that it occurred sometime in the early to mid-1980s. The remaining debate was about the causes of the growth acceleration, with one strand emphasising change in attitudes of the State (Rodrik and Subramanian, 2005) and another focusing on changes in economic policies, with different set of policies emphasized by different authors (Panagariya, 2004; Sen, 2007; Ghate and Wright, 2012).

Recent work has taken the discussion forward by identifying multiple breaks in, and correspondingly distinct regimes of, economic growth (Kar et al., 2013; Kar and Sen, 2016). For instance, (Kar and Sen, 2016) identify four growth regimes: a period of slow growth, 1950-92; growth acceleration during 1993-01; a further acceleration of growth from 2002 to 2010; and a period of slowdown starting in 2011. After identifying growth regimes, Kar and Sen (2016) offer a political economy account to explain the transition between regimes.

The first contribution of this paper is to revisit the analysis of structural breaks in the time series of aggregate output in India. Using four different measures of aggregate output for robustness, I find four structural breaks in India's post-independence growth record - 1964–655, 1978–79, 1990–91 and 2004–05 (or 2005–06) - and five growth regimes. While all the breaks are statistically significant, only the ones in 1978–79 and 2004–05 (or 2005–06) are economically significant in the sense that they lead to changes in average growth rate of per capital real GDP between regimes of more than 1.0% per annum. A simple sectoral decomposition analysis shows that the growth accelerations have been largely driven and sustained by growth in the tertiary sector. Taken together, the timing and sectoral dimension of growth accelerations raise questions about the narrative that economic reforms - initiated in the mid-1980s and accelerated in the early 1990s - contributed in a significant way to India's transition into a high growth economy.

The second contribution of this paper is to revisit the analysis of the impact of capital accumulation on economic growth in India. Using an updated data set used in Sen (2007), I take a re-look at the impact of investment in equipment and machinery by the private corporate sector on economic growth. The importance of private equipment investment in the Indian growth story has been analysed previously by Sen (2007). I extend the analysis in Sen (2007) by taking explicit account of the time series properties of the variables involved. This is important because, as I show below, some of the variables are stationary but others are difference stationary. In such a situation, if we do not take explicit account of trending behaviour, we might end up with spurious regressions (Granger and Newbold, 1987).

To take account of the combination of I(0) and I(1) variables in such an analysis, I use an ARDL bounds testing procedure. I find a long run relationship between different components of investment - private equipment investment, public equipment investment, investment in structures, and changes in stocks - and economic growth. In particular, I find a positive and statistically significant long run impact of private equipment investment on the growth rate of real GDP: an increase in private equipment investment by 1 percent of GDP has caused about 0.54 percentage points increase in the growth rate of real GDP in the long run. This analysis suggests that the growth acceleration in the Indian economy has been partly driven by the steady increase in private equipment investment. Hence, India's growth story is, at least in important respects and in the long run, a story of (private equipment) investment-driven growth.

The rest of the paper is organized as follows: section 2 discusses the data used for the analysis; section 3 presents the structural break analysis; section 4 investigates the relationship between private equipment investment and economic growth; and section 5 concludes the paper with some thoughts about future research. Appendix A presents detailed information about data sources and variable definitions.

2 Data: Variables and Descriptive Analysis

The primary source of data for the analysis in this paper are various issues of the *National Account Statistics* (NAS), which is an annual publication of the Ministry of Statistics and Programme Implementation of the Government of India. The NAS provides information on aggregate and sectoral output, components of aggregate demand, price indices, savings and investment, and aspects of government revenue and expenditure for the Indian economy. The data from the NAS is also tabulated in the *Handbook of Statistics on Indian Economy* (HSIE), an annual publication of the Reserve Bank of India, and the *Economic Survey* (ES), an annual publication of the Ministry of Finance, Government of India.

From various issues of the NAS, HSIE and the ES, I collect annual data on real GDP, real GDP per capita, real GDP at factor cost, real GDP at factor cost per capita, various components of gross fixed capital formation, and sectoral gross value added by the primary, secondary and tertiary sectors for the period from 1950 to 2018.[1] Summary statistics for all the variables used for the analysis in this paper can be found in Table 1, and time series plots of some key variables can be found in Figure 1. The time series plots highlight one important fact: most variables display trending behaviour. One will need to explicitly take this fact into account in any analysis.[2]

[Table 1 about here]

We can motivate the two questions investigated in this paper by referring to Figure 1. The first question I investigate in this paper relates to regimes of growth acceleration in the Indian economy.[3] From the bottom panel of Figure 1, we can see that, despite lot of fluctuations, there is a distinct upward trend in the time series of real GDP growth rate from around the early 1980s. Moreover, the variance of the growth rate series also seems to have fallen since the early 1980s. In the next section, I will present results from a more rigorous test for structural break in the log real GDP series, where we will identify structural breaks in economic growth and the corresponding growth regimes.

[Figure 1 about here]

The second question I investigate in this paper relates to the importance of capital accumulation in triggering and sustaining growth. In particular, I look at a specific type of

[1] Data on most variables are available for financial years. To save space, I will use the following notation throughout this paper: a calendar year, like 1950, will be used to refer to the corresponding financial year, 1950–51. For instance, 1960 will refer to 1960–61; and 2018 will refer to 2018–19, etc.

[2] Further details about the variables are available in Appendix A.

[3] The annual growth rate of real GDP is computed as the first difference of log real GDP; the same method is used to compute annual growth rates of all variables.

capital accumulation: investment in equipment and machinery. From Figure 1, we see that both public and private (corporate sector) investment in equipment and machinery has increased over time. There is an important difference in the two: public equipment investment rose till the mid-1980s, and declined subsequently; private equipment investment kept rising, with fluctuations, all the way to the end of our sample period. Hence, from the figure it seems both that equipment investment might be positively correlated with growth - since both have rising trends over the sample period - and that private equipment investment might have had a larger role to play in sustaining the upward trend of economic growth than public equipment investment. In section 4, I will investigate this question in detail.

3 Structural Breaks in Economic Growth

The first question that I wish to investigate is whether we can identify structural breaks in the time series of aggregate output (like real GDP). The traditional method of identifying a structural break in a linear regression model, when the break date is known, is to conduct a Chow test for difference in the regression coefficients in the two periods identified by the known break date (Chow, 1960). In many cases, the date of the break is not known by the researcher and needs to be estimated with other parameters in the model. Andrews (1993) extended the standard method to the case of an unknown structural break, and Bai and Perron (1998) extended the analysis further to the case of multiple unknown breaks. Bai and Perron (2003) offered an efficient algorithm to implement the method outlined in Bai and Perron (1998). In this paper, I use Bai and Perron (1998, 2003) to identify possible structural breaks in the time series of the growth rate of aggregate output in India.

3.1 Conceptual Framework

Since we are interested in identifying breaks in economic *growth*, we implement the Bai-Perron method by running regressions of the following form,

$$\log(y_t) = \alpha + \beta t + u_t, \tag{1}$$

where y_t is some measure of aggregate output, and β is the exponential growth rate in y_t after accounting for random disturbances captured by u_t. The methodology of Bai and Perron (2003) is implemented by estimating the model in (1) on $m+1$ segments (or regimes) of the sample that come from m breaks, and then choosing the value of m that maximizes the sum of squared residuals. To be more precise, let $(T_1, \ldots, T_m)$ denote a partition of the sample years, $1, 2, \ldots, T$, into $m+1$ segments, with the convention that $T_0 = 0$ and $T_{m+1} = T$. For the j-th segment, the regression is given by

$$\log(y_t) = \alpha_j + \beta_j t + u_t, \quad t = T_{j-1}+1, \ldots, T_j \tag{2}$$

and the sum of squared residuals is given by

$$SSR_j(T_1, \ldots, T_m) = \sum_{t=T_{j-1}+1}^{T_j} \left\{ y_t - \hat{\alpha}_j - \hat{\beta}_j t \right\}^2.$$

Then the estimated break points $\left(\hat{T}_1, \ldots, \hat{T}_m\right)$ are such that

$$\left(\hat{T}_1, \ldots, \hat{T}_m\right) = \underset{T_1,\ldots,T_m}{\arg\min}\, S(T_1, \ldots, T_m)$$

where the minimization is carried out over all partitions $(T_1, \ldots, T_m)$ such that $T_j - T_{j-1} > q$ (for some given q), and $S(T_1, \ldots, T_m)$ is the sum of squared residuals added up for all the

$m+1$ segments, i.e.

$$S\left(T_1,\ldots,T_m\right)=\sum_{j=1}^{m+1} SSR_j\left(T_1,\ldots,T_m\right)=\sum_{j=1}^{m+1}\sum_{t=T_{j-1}+1}^{T_j}\left\{y_t-\hat{\alpha}_j-\hat{\beta}_j t\right\}^2.$$

3.2 Results of Structural Break Tests

Using the Bai-Perron methodology, I conduct structural break tests on four different measures of output: log real GDP at market prices, log real GDP at market prices per capita, log real GDP at factor cost, and log real GDP at factor cost per capita.[4] To implement the structural break test with multiple unknown breaks, I impose the restriction that each segment identified by the structural break test must be at least 15% of the total smaple size, i.e. each segment must have at least 10 years (because the length of the time series used for the analysis is 69). This implies, because the sample size of my data set is 69, that there can be at most 6 regimes and 5 breaks. The results of these structural break tests are summarized in Table 2, Table 3 and in Figure 2. In Table 2, I present details of the structural break test for all the measures of aggregate output; in Table 3, I present estimates of average exponential growth rates for the distinct growth regimes identified by the structural break test, and in Figure 2, I present the same information in a graphical form.

[Table 2 about here]

In the top panel in Table 2, we have information on the break dates and the corresponding value of residual sum of squares (RSS) and Bayesian information criteria (BIC) for all possible configurations of structural breaks in the linear regression of log real GDP on a linear time trend (and a constant). For instance, when the linear regression of log real GDP on a linear time trend (and a constant) admits of one structural break, the date of the break is 1989,

[4] For definitions and sources of variables, see Appendix A. Sructural break tests were conducted with the `strucchange` package in R (Zeileis et al., 2002).

and the corresponding values of the RSS and BIC are 1.417 and -59.614, respectively. From the results in the top panel, we see that the value of RSS and BIC are minimized for four structural breaks, where the value of RSS and BIC are 0.019 and -306.603, respectively. This gives us the main finding from structural change analysis: there were *four structural breaks* in the growth rate of output in India between 1950 and 2018. This implies that there were *five distinct growth regimes* in India between 1950 and 2018. The breaks occurred in 1964, 1978, 1990, and 2004, so that the five growth regimes were: 1950–64 ,1965–78, 1979–90, 1991–04, and 2005–18. The identification of four breaks and five regimes is consistent across all the four measures of aggregate output.[5]

In Table 3, I present estimates of average exponential growth rates for the distinct growth regimes identified by the structural break test. From the results in Table 3, we see the following pattern for the five growth regimes identified by the structural break test: the second regime was marked by growth *deceleration*, i.e. the average growth rate in the second regime was significantly lower than in the first regime; the other three regimes were marked by growth *acceleration*, i.e. average growth rate in a regime was significantly higher than the previous regime. This pattern can be seen in all the panels in Table 3 and is visually highlighted by the step-wise manner in which the red line - which is a plot of average exponential growth rates in different regimes - in Figure 2 moves over the sample period.[6]

[Table 3 about here]

Using the results in the top panel in Table 3, we see that real GDP grew at 4.08% per annum in the period 1950–64, but fell to 3.68% per annum over the next regime (1965–78). In the next three regimes, growth accelerated continuously from 5.36%, to 5.86% and finally to 7.11%. The implications of these different growth regimes, in terms of average standards of

[5]There is a slight difference for the per capita real GDP at factor cost. For this series, the last break occurred in 2005, instead of 2004.

[6]There has been a deceleration in growth in the Indian economy since 2016. This is not detected by the structural break tests because of inadequate data points after the start of the recent deceleration.

living, are better illustrated by looking at growth rates of *per capita* real GDP (second panel in Table 3).[7] In the first regime, 1950–64, per capita real GDP grew at 2.09% per annum. The relatively high growth rate of real GDP, at 4.08% per annum, was partly nullified by the high growth rate of population. The deceleration is brought home starkly in the second regime, 1965–78, when per capita real GDP grew at a meagre 1.43% per annum. Growth picked up in the next two regimes, with per capita real GDP growing at 3.22% and 3.99% per annum, respectively. There was a major acceleration in the last regime, 2005–18, when per capita real GDP grew at 5.80% per annum.

Two features of the growth regimes are worth highlighting. First, other than the period from the mid-1960s to the late 1970s, economic growth has been continuously rising in India. Thus, only the period from the mid-1960s to the late-1970s is an anomaly in terms of economic growth; all other periods identified by the structural break tests saw an acceleration of economic growth in a stepwise and continuous manner. Second, the major growth accelerations occurred only twice over the whole post-independence period, in the late 1970s and in the mid-2000s. While all growth accelerations are statistically significant, they might not be economically significant. To identify an episode of growth acceleration, let us use the following rule of thumb: growth accelerations can be considered to be major if the change in average growth rate of per capita real GDP between regimes is more than 1 percentage points.

Using this rule of thumb for the results in the second panel in Table 3, we can see that there are only two major growth accelerations, the first in 1978–79 and the second in 2004–05. This is because the average growth rate of per capita real GDP in 1979–90 was 1.79% higher than in the previous period of 1965–78; again, average growth rate of per capita real GDP in 2005–18 was 1.81% higher than in the previous growth regime, 1991–04. But the change

[7] Living standard depends not only on per capita GDP but also on its distribution among the population. In this paper I abstract from distributional issues and focus only on average living standard.

in the average annual growth rate of per capita GDP between the third and fourth regimes, i.e. between the periods and 1979–90 and 1991–04, was only 0.76%. Hence, the analysis in this paper amends the well known finding that Indian economic growth has witnessed only one major growth acceleration (Balakrishnan and Parameswaran, 2007). In fact, if we use the sample from 1950 to 2018, then we see that the Indian economy has witnessed not one but two major growth accelerations.

[Figure 2 about here]

3.3 The Sectoral Dimension

Let us now turn to investigating the sectoral dimension of growth accelerations. To see which sectors played important roles in the transitions to the various growth regimes identified by the structural break test, I carry out a simple decomposition analysis for each growth regime. If y denotes aggregate output and y_i denotes output of sector i, then $y = \sum_i y_i$. Let $s_i = (y_i/y)$ denote the share of the i-th sector in aggregate output, and let g_y and g_{y_i} denote the growth rates of aggregate output and the output of the i-th sector, respectively. Then, we have $g_y = \sum_i s_i g_{y_i}$, so that the contribution of the i-th sector to growth of aggregate output is given by

$$c_i = \frac{s_i g_{y_i}}{g_y} = \frac{s_i g_{y_i}}{\sum_i s_i g_{y_i}}. \tag{3}$$

In Table 4, I present results of estimating contributions to growth of real GDP at factor cost, using the formula in (3), by the primary, secondary and tertiary sectors for each of the five growth regimes identified by the structural break test in the previous section. The *primary sector* includes agriculture and allied activities; the *secondary sector* includes mining & quarrying, manufacturing, and electricity, gas, water supply & other utilities; the *tertiary sector* includes construction, trade, hotels, communication, transportation, and services related to broadcasting, finance, insurance and real estate, and public administration, defense and other services.

[In Table 4 about here]

In the first growth regime, 1950–64, real GDP-FC grew at 3.87% per annum. The secondary sector grew at a respectable 6.49% per annum, even though its contribution to growth of aggregate output was only 21.97% because of its relatively small size. Due to its large share, agriculture and allied activities contributed 31.84% to aggregate growth; and the tertiary sector made the largest contribution to aggregate growth at 45.53%. The second growth regime, 1965–78, was one of slower growth. Real GDP-FC grew at 3.7% per annum, with the secondary sector witnessing the major deceleration (with average annual growth rate falling by 2 percentage points to 4.5% per annum). A mild acceleration in the primary sector prevented an even slower overall growth from materializing.

In the third growth regime, 1979–90, average annual growth rate of real GDP-FC accelerated to 5.2% per annum, with growth accelerations witnessed by all the three sectors. The main contribution to the acceleration in real GDP-FC came from the tertiary sector, which grew at 6.14% per annum, and increased its contribution to the growth rate of real GDP-FC from 46.7% in the previous regime to 55.25% in the current one. The contribution of the primary sector fell sharply, and the contribution of the secondary sector rose marginally - by 2 percentage points.

The transitions from the third to the fourth and from the fourth to the fifth regimes mirror the pattern observed during the transition from the second to the third growth regime. The major acceleration is witnessed in the tertiary sector and its contribution to the growth rates of real GDP-FC rise even further. In the fourth regime, 1991–05, the tertiary sector grew at 7.55% per annum; in the fifth regime, 2006–18, it grew at 8.17% per annum. Mirroring the rise of the tertiary sector has been the decline of the primary sector. On the other hand, the secondary sector, which had contributed around 20% to the growth of real GDP-FC in all regimes saw its contribution decline to 18.41% in the fifth regime.

The main conclusion that emerges from this sectoral analysis is that growth accelerations have been sustained by growth in the tertiary sector; the primary sector has had no role and the secondary sector only a minor role in the growth accelerations. In fact, among the two major growth accelerations - one in 1979 and another in 2006 - the secondary sector has played a minor role in the first and no role at all in the second. In the transition of the late-1970s, the contribution of the secondary sector rose by 2 percentage points, but its contribution declined by about 1.6 percentage points in the transition of 2006. In contrast, the contribution of the tertiary sector increased in both transitions - by close to 10 percentage points in the late-1970s and by about 7 percentage points in the mid-2000s. An important implication of this analysis is that we need to re-think the commonly accepted conclusion that policy changes like trade liberalization that were initiated in the 1980s, and accelerated in the early 1990s, played a major role in India's growth transitions (Panagariya, 2004; Sen, 2007; Ghate and Wright, 2012). The timing and sectoral dimension of the transition raise questions about this narrative.

4 Growth and Private Equipment Investment

4.1 Conceptual Framework

What are the causes of the growth accelerations that we have identified for India? A classical perspective would point to capital accumulation as an important determinant of economic growth (Kaldor, 1961; Foley et al., 2019). Careful empirical analysis has identified a specific component of capital accumulation as playing the most important role: investment in equipment and machinery (Delong and Summers, 1991, 1993). Conceptually, this component of investment can play an important role in growth because of the potential it has for generating and sustaining external economies. Investment in equipment and machinery is coterminous with investment in research and development, which has the potential to contribute to the growth in productivity far beyond the original domain in which the investment might have been made.

To investigate the possible relationship of capital accumulation and economic growth I posit the following model:

$$GWTH_t = c_0 + c_1 t + \beta_1 PVEQI_t + \beta_2 PBEQI_t + \beta_3 STRI_t + \beta_4 CHST_t + \varepsilon_t, \tag{4}$$

where $t = 1950, 1951, \ldots, 2018$, indexes years, $GWTH_t$ is the annual growth rate of real GDP, the regressors are the various components of aggregate investment, c_0 is an intercept, $c_1 t$ is a linear deterministic trend, and ε_t captures factors that impact economic growth other than investment. Apart from the the intercept and the linear trend, the regressors are: $PVEI_t$, which refers to private investment in equipment and machinery; $PBEI_t$, which denotes public investment in equipment and machinery; $STRI_t$, which refers to total (private + public) investment in structures; and $CHST_t$, which refers to the change in stocks. Together these components make up aggregate investment, and are expected to drive growth, i.e. total investment is the sum of private equipment investment, public equipment investment, investment in structures (by private and public sectors), and change in stocks. Our primary interest is in estimating the impact of equipment investment - both private (corporate) and public - on economic growth.

One immediate concern with the growth equation in (4) is omitted variables. Economic theory and empirical analysis suggests that there are many other determinants of the growth rate of real GDP, like human capital, quality of institutions, etc., that have been left out of the model. These omitted variables are all clubbed together into the error term. Since components of investment might be correlated with these omitted factors, estimation of the model with OLS will give rise to biased estimates. One option is to use instrumental variables

(Sen, 2007). But the use of OLS or even IV is likely to give unreliable estimates if trending behaviour of some of the variables are not explicitly taken into account. That is why I use a different approach - the ARDL bounds testing approach - that treats all the variables as potentially endogenous in a VAR framework. In this framework, problems of residual serial correlation and endogeneity are addressed simultaneously by appropriate choice of the orders of an extended ARDL model (Pesaran and Shin, 1999).

4.2 Unit Root Tests

The primary challenge in estimating the model in (4) arises from the time series properties of the variables. To emphasize this, in Table 5, I present results of augmented Dickey-Fuller (ADF) unit root tests, for both levels and first difference of variables appearing in (4). In the ADF unit root tests, the null hypothesis is that the variable is unit root nonstationary and the alternative is that the variable is stationary. When the test statistic is large in magnitude and negative in sign, it leads to a rejection of the null against the alternative hypothesis.[8]

[Table 5 about here]

For the ADF test on the levels of the variables, we see from Table 5 that we can reject the null of unit root nonstationarity unambiguously for only two variables: the growth rate of real GDP (test statistic is -6.85) and the change in stocks (test statistic is -4.08). For all other variables, the value of the test statistic is larger than the 5% critical value of -3.45. Hence, we cannot reject the null of unit root nonstationarity for these variables. Turning to the ADF test on the *first difference* of the variables, we see from Table 5, that the test statistic for all variables is smaller than the 5% critical value. Hence, we can reject the null of unit root nonstationarity for the first difference of all variables. From the results of the unit root tests reported in Table 5, we can draw two conclusions: (1) there is a mix of I(1)

[8]Unit root tests were conducted with the function `ur.df()` from the `urca` package in R (Pfaff, 2008).

and I(0) variables: the growth rate of real GDP and the change in stocks is I(0), and all other variables are I(1); (2) the first difference of all variables is stationary, so that no variable is I(2).

4.3 ARDL Bounds Testing Methodology

In the growth equation in (4), there is a mixture of stationary and I(1) variables. The dependent variable, growth rate of real GDP, and one regressor, change in stocks, are stationary; but three regressors are I(1): private equipment investment, public equipment investment, and investment in structures. Hence estimating the model by OLS, or even instrumental variables, as was done in Sen (2007), runs the danger of ending up with spurious regressions (Granger and Newbold, 1987). But all variables are not I(1), and so cointegration analysis cannot be applied as well. One way to deal with the mixture of I(0) and I(1) variables is to use the bounds testing procedure developed by Pesaran et al. (2001). Hence, I will use this methodology - the Pesaran-Shin-Smith (PSS, henceforth) methodology - to identify a possible long run, i.e. levels, relationship among the variables appearing in the model in (4).[9]

To fix ideas, let y_t denote the scalar growth rate of real GDP, i.e. $y_t = GWTH_t$, let $\boldsymbol{x_t}$ denote the vector whose elements are different components of investment,

$$\boldsymbol{x_t'} = (PVEQI_t, PBEQI_t, STI_t, CHST_t)$$

and let $\boldsymbol{z_t} = (y_t, \boldsymbol{x_t'})'$. We assume that the dynamic interactions among the five variables in $\boldsymbol{z_t}$ are captured by a stable VAR(p) process,

$$\boldsymbol{\Phi}\left(\boldsymbol{L}\right)\left(\boldsymbol{z_t} - \boldsymbol{\mu} - \boldsymbol{\gamma t}\right) = \boldsymbol{\varepsilon_t},$$

[9]For some examples of the use of the ARDL bounds testing procedure, see Atkins and Coe (2002); Narayan (2005); Rushdi et al. (2012).

where the vector lag polynomial, $\boldsymbol{\Phi}\left(\boldsymbol{L}\right)$, has no explosive roots, $\boldsymbol{\mu}$ and $\boldsymbol{\gamma t}$ denote the intercept and deterministic trend terms, and the error term, $\boldsymbol{\varepsilon_t}$ is distributed as a multivariate normal random variable with no serial correlation across periods. The VAR(p) process can be re-written, with suitable algebraic manipulations, in error correction form as follows:

$$\boldsymbol{\Delta z_t = a_0 + a_1 t + \Pi z_{t-1} + \sum_{i=1}^{p} \Gamma_i \Delta z_{t-1} + \varepsilon_t}. \tag{5}$$

An important assumption of the bounds testing procedure is that the vector process, $\boldsymbol{x_t}$, is *long-run forcing* for the scalar process y_t (Pesaran et al., 2001, pp. 293). This is implemented with zero restrictions on certain elements of the long run multiplier matrix, $\boldsymbol{\Pi}$, that ensures the absence of feedback of y_{t-1} on $\boldsymbol{\Delta x_t}$, i.e. the error correction model (ECM) for $\boldsymbol{\Delta x_t}$ excludes the lagged level of y_t. In our case, this assumption would mean that lagged $GWTH_t$ must not enter into the ECM for the right-hand side variables in (4). I do not test this assumption directly but rather use it as an underlying maintained assumption. It is important to note that this assumption is less restrictive than it looks at first sight. First, the ECM for the right-hand side variables in (4) can include lagged changes in $GWTH$. Thus, components of investment can be impacted by lagged changes in the growth rate, even though the lagged growth rate itself is ruled out. Second, the assumption does not rule out Granger-causality of $GWTH$ on the components of investment.

The focus of the bounds testing procedure is to investigate the possibility of a *single* long run level relationship between the scalar y_t and the vector $\boldsymbol{x_t}$. Hence, we look at the error correction equation for the first element of the above system in (5), i.e. Δy_t. Under the assumption that $\boldsymbol{x_t}$, is long-run forcing for y_t, the ECM for y_t can be written as

$$\Delta y_t = c_0 + c_1 t + \pi_0 y_{t-1} + \boldsymbol{\pi x_{t-1}} + \sum_{i=1}^{p-1} \boldsymbol{\psi_i' \Delta z_{t-i}} + \boldsymbol{\omega' \Delta x_t} + u_t \tag{6}$$

where the coefficient vectors, $\boldsymbol{\pi}, \boldsymbol{\psi_i}, \boldsymbol{\omega}$ are conformable to the relevant vectors they multiply. The model in (6) is an extended ARDL model that was analyzed in Pesaran and Shin (1999). The assumption that $\boldsymbol{x_t}$, is long-run forcing for y_t ensures that the parameters of (6) can be consistently estimated with OLS (Pesaran et al., 2001, pp. 308). In the extended ARDL framework, potential problems of endogeneity and residual serial correlation are simultaneously addressed by choice of an appropriate lag order, where different variables can have different lag orders for capturing the short run dynamics (Pesaran and Shin, 1999).

The PSS bounds testing procedure tests the null hypothesis that there is no level relationship between y_t and the vector, $\boldsymbol{x_t}$. Using (6), this can be implemented with a Wald or F test of the following joint null hypothesis $H_0 : \pi_0 = 0; \boldsymbol{\pi} = \boldsymbol{0'}$ is tested against the alternative hypothesis that $H_1 : \pi_0 \neq; \boldsymbol{\pi} \neq \boldsymbol{0'}$. Note that the null hypothesis rules out levels of the variables on the right hand side of (6), because, under the null, $\pi_0 = 0$, and $\boldsymbol{\pi} = \boldsymbol{0'}$, so that y_{t-1} and $\boldsymbol{x_{t-1}}$ drop out from the extended ARDL model. Hence, the null hypothesis implies that there is no levels relationship among the variables.

The key novelty of the PSS procedure is that we can test the absence of a level relationship between y_t and the vector $\boldsymbol{x_t}$ irrespective of whether elements of $\boldsymbol{x_t}$ are stationary or difference-stationary. Under the null hypotheses, the Wald or F-statistic for testing the joint null hypothesis has a non-standard distribution. PSS provides bounds for critical values of the test statistics and a method to test for a single long run relationship without having to determine whether the variables are I(0) or I(1): if the test statistic is larger than the upper bound, we are able to reject the null; if the magnitude of the test statistic is smaller than the lower bound then we cannot reject the null; and if the test statistic lies between the lower and upper bound, the test is inconclusive.

4.4 Results from the ARDL Bounds Testing Procedure

In Table 6, I report results of applying the PSS bounds testing procedure for two specifications of the extended ARDL model in (6). In the first specification, I allow for an unrestricted intercept but rule out a deterministic trend (case 3 in the terminology of Pesaran et al. (2001)); in the second specification, I allow for an unrestricted intercept and an unrestricted linear deterministic trend (case 5 in the terminology of Pesaran et al. (2001)). In both specifications, appropriate lag orders of the ARDL model are chosen with the AIC assuming maximum orders of the autoregression and short run effects of 3 each. For both specifications, we have the following: the chosen autoregressive order is 3 and the chosen lag orders for the short run responses are 3, 2, 2, and 2 for $PVEQI, PBEQI, STI$ and $CHST$, respectively.[10]

For the first specification (unrestricted intercept, no deterministic linear trend), we see from Table 6 that the value of the F-statistic is 6.61. The bounds for the 10% critical value is $(2.552, 3.648)$; the bound for the 5% critical value is $(3.022, 4.256)$; and the bounds for the 1% critical value is $(4.098, 5.57)$. Since the magnitude of the test statistic is larger than the upper bound for the 1% critical value, we can confidently reject the null hypothesis. We arrive at a similar conclusion if we use the second specification (unrestricted intercept, unrestricted deterministic linear trend). In this case, the value of the F-statistic is 6.52, and this is larger in magnitude than the upper bound for the 1% critical value. Hence the PSS bounds testing procedure allows us to conclude that there is a long run level relationship among the variables appearing in the growth equation, irrespective of whether we allow for a linear deterministic trend and irrespective of whether the variables are I(0) or I(1).

The bottom panel of Table 6 presents results of diagnostic tests that are important in ensuring validity of the bounds testing procedure. Two crucial assumptions for the validity

[10] The ARDL bounds testing procedure was conducted with the `ardlBounds()` function from the `dLagM` package in R (Demirhan, 2019).

of the bounds testing procedure relate to properties of the error term: the error term should not have serial correlation and it should be normally distributed. We can confirm from Table 6 that both these assumptions are satisfied. From the results of the Box-Ljung test, we see that the residuals have no serial correlations (the null hypothesis is that there is no serial correlation and the p-value of the test is larger than 0.05 for both specifications); and from the results of the Shapiro-Wilk test, we see that the residuals are normally distributed (the null hypothesis is that the residual are normally distributed and the p-value of the test is larger than 0.05 for both specifications).

An additional important assumption implicit in the bounds testing methodology is that there are no I(2) variables in the model in (4). This assumption can be seen to have been satisfied from the unit root test results in Table 5. This is because the first difference of all variables are stationary - so that the variable itself is at most I(1). Hence, diagnostic test results in Table 6 and unit root tests in Table 5 show that the critical assumptions that make the PSS bounds testing procedure valid are satisfied in our case.

4.5 Long Run Level Relationship

From the parameter estimates of the extended ARDL model that underlies the PSS bounds testing procedure, we can compute the levels relationship. To see this, note that, under the alternative hypothesis, the following levels relationship is implied by the ARDL model in (6):

$$c_0 + c_1 t + \pi_0 y_{t-1} + \boldsymbol{\pi x_{t-1}} + u_{t-1} = 0,$$

where u_{t-1} is a zero mean stationary random variable (Pesaran et al., 2001, pp. 294–95). Explicitly writing out the variables represented by y and $\boldsymbol{x}$, the long run level relationship for period t becomes

$$c_0 + c_1 t + \pi_0 GWTH_t + \pi_1 PVEQI_t + \pi_2 PBEQI_t + \pi_3 STI_t + \pi_4 CHST_t + u_t = 0.$$

This can be re-written to give us the estimated version of the growth equation we had set up in (4):

$$\begin{aligned} GWTH_t = &- \left(\frac{c_0}{\pi_0}\right) - \left(\frac{c_1}{\pi_0}\right) t - \left(\frac{\pi_1}{\pi_0}\right) PVEI_t \\ &- \left(\frac{\pi_2}{\pi_0}\right) PBEI_{t-1} - \left(\frac{\pi_3}{\pi_0}\right) STI_{t-1} - \left(\frac{\pi_4}{\pi_0}\right) CHST_{t-1} + v_t, \end{aligned} \tag{7}$$

where v_t is a zero mean stationary random variable. Once we have the estimates of $c_0, \pi_1, \ldots, \pi_5$ and the associated covariance matrix, we can estimate the *long run multipliers* in (7) by the relevant ratios and their standard errors with the delta method. For instance, the long run multiplier of $PVEQI_t$ on $GWTH_t$ is given by $(-\pi_1/\pi_0)$, and so on. It is important to emphasize that these are *long-run* multipliers. The short run dynamics are captured by the coefficients on the first difference of variables (which we do not discuss in this paper).[11]

[Table 7 about here]

Estimates of all the parameters of the ARDL models, for both specifications, are presented in Table 7. Using these estimates, I compute the long run relationship between growth and the components of investment appearing in (7). Estimates of and standard errors for the long run multipliers, for both specifications of the model, are presented in Table 8. My interest is primarily in the long run relationship. So, I will not comment on the underlying

[11] Pesaran et al. (2001, pp. 294–95) discuss two types of non-degenerate long run relationships. In the first type, the dependent variable is I(0), and the relationship is understood as a "conditional long-run level relationship". In the second type, the dependent variable is I(1), and the relationship is understood as cointegration. In our analysis, the dependent variable, $GWTH_t$, is I(0). Hence, what we uncover is a long run relationship of the first type between the growth rate of real GDP and the different components of investment.

parameters in Table 7. Recall that the first specification has an unrestricted intercept but no trend, and the second specification has an unrestricted intercept and an unrestricted trend. Both specifications give qualitatively similar results of the long run relationship. Hence I will restrict my comments to the first specification, i.e. the specification without a linear deterministic trend.

[Table 8 about here]

The results for for the first specification in Table 8 show that the long run multiplier of private equipment investment on the growth rate of real GDP is 0.54 (which is statistically significant at 1% level). Thus, every percentage point increase in private equipment investment, as a share of GDP, translates into 0.54 percentage points increase in the growth rate of real GDP *in the long run*. All the other components of investment, including public investment in equipment and machinery, have positive but statistically insignificant effects on economic growth in the long run.

It is also interesting that the impact of private equipment investment on growth has increased over the decades. For instance, in the period 1950–64, average private equipment investment was 1.26 percent of GDP and the average growth rate of GDP (as can be seen from panel A in Table 3) was 4.076 percent per annum. Hence, using the long run relationship estimated above, private equipment investment would predict about $17\%(= (0.54 * 1.26)/4.076)$ of the average growth over this period. If we carry out this same computation for all the regimes in Table 3, private equipment investment predicts an increasing portion of growth: from the first period onwards, it predicts 17%, 18%, 28%, 50% and 58% of economic growth, respectively. This suggests that the role of private equipment investment in sustaining long run economic growth has become more important over time.

5 Conclusion

In this paper I have investigated two issues related to economic growth in India: structural break in economic growth (and corresponding regimes of growth) and the impact of capital accumulation on growth. Using the Bai-Perron methodology on four different measures of aggregate output (real GDP, real GDP per capita, real GDP at factor cost, real GDP at factor cost per capita), for the period 1950-51 to 2018-19, I find that economic growth in India has witnessed four breaks. These occurred in 1964-65, in 1978-79, in 1990-91, and in 2004-05 (or 2005–06 for real GDP at factor cost). This implies that there have been five distinct growth regimes in post-independence India, i.e. for the period 1950-51 to 2018-19.

The average annual growth rates show an interesting pattern over the regimes. While the second regime was one of deceleration in growth (compared to the first regime), the next three have witnessed growth accelerations, i.e. the average annual growth rate has increased over the previous regime. However, substantial growth accelerations, i.e. increase of more than 1.0% per annum in the growth rate of per capita real GDP, occurred only at two points: in 1978-79 and in 2004-05 (or 2005–06 for real GDP at factor cost). Thus, the analysis in this paper amends the well-known finding about one structural break in the economic growth in India in the late 1970s. There is not one but two structural breaks - in the sense of major growth accelerations - in post-independence India, the first in the late 1970s (as the previous literature has found) and the second in the mid-2000s (which is a new finding).

It is also worth highlighting that contrary to popular belief, there is no *major* break in economic growth in the early 1990s. While there is a statistically significant change in average growth rate of real GDP in the early 1990s, the magnitude of the break is relatively small, especially compared to the breaks in the late 1970s and the mid-2000s. Turning to the sectoral dimension of growth we see that growth accelerations are predominantly driven by the tertiary sector, as I have demonstrated in section 3.3. Thus, both the timing and sectoral dimensions of growth accelerations raise questions about the narrative that economic reforms of the early-1990s were a major contributor of moving the Indian economy onto a high growth path.

Turning to the determinants of growth, I have re-examined the role of investment in equipment and machinery in generating and sustaining economic growth. Using a ARDL bounds testing procedure - since growth and different components of investment are a mixture of I(0) and I(1) variables - I find a long run relationship between the growth rate of real GDP and different components of investment - private equipment investment, public equipment investment, total investment in structures, and change in stocks. This means that India's growth accelerations have been partly driven by the steady step-up of private investment in equipment and machinery. India's growth story, from a long run perspective, is one that is driven by investment by the private corporate sector in equipment and machinery.

We can quantify this aspect of growth with the long run multiplier of private equipment investment on growth. From the long run relationship identified by the bounds testing procedure, I find the estimate of the long run multiplier of private equipment on the growth of real GDP to be 0.54. Thus, an increase in private equipment investment by 1 percent of GDP increases the growth rate of real GDP by 0.54 percentage points in the long run. This analysis might also offer insights into India's recent growth slowdown from a long run perspective: private equipment investment peaked in 2007 and has declined since then. This might be behind the deceleration in long run growth - which has been brought to the fore by a string of policy missteps and the pursuit of a politics of disenfranchisement by the current government (Basu, 2019).

The next logical step for this analysis would be to investigate the determinants of private equipment investment. Sen (2007) provides an initial analysis in this direction. But the analysis in Sen (2007) might be misleading because it does not take explicit account of difference stationary variables - including private equipment investment. Hence, the results are likely to suffer from problems of spurious regression (Granger and Newbold, 1987). Therefore, a future direction of research would be to estimate an investment function, along the lines of Sen (2007), using a mtehod - like cointegration analysis - that can explicitly uncover long run relationships among stochastically trending variables.

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Table 1: Summary Statistics for Covariates[a]

	N	Min	Mean	Max	St. Dev.
Log Real GDP	69	12.59	14.05	16.02	0.99
Log Per Capita Real GDP	69	9.01	9.78	11.14	0.60
Log Real GDP at Factor Cost	69	7.94	9.37	11.33	0.99
Log Per Capita Real GDP at Factor Cost	69	4.36	5.09	6.46	0.60
Growth Rate of Real GDP (%)	68	−5.38	5.04	10.03	2.89
Private Equipment Investment (% of GDP)	68	0.41	3.58	9.95	2.61
Public Equipment Investment (% of GDP)	68	0.62	2.96	5.63	1.25
Investment in Structures (% of GDP)	68	2.09	5.65	9.69	1.59
Change in Stocks (% of GDP)	68	−1.06	1.45	4.04	1.05

[a] Summary statistics for variables relating to the Indian economy over the period, 1950–2018. For definitions of variables and sources, see Appendix A.

Table 2: Results of Structural Break Tests for Log Real GDP[a]

	Number of Breaks					
	0	1	2	3	4	5
A. Real GDP						
Break Years				1964	1964	1959
Break Years						1971
Break Years			1978	1978	1978	1982
Break Years		1989			1990	1994
Break Years			2003	2003	2004	2004
RSS	1.417	0.084	0.028	0.024	0.019	0.022
BIC	-59.614	-242.057	-304.076	-304.370	-306.603	-284.849
B. Per Capita Real GDP						
Break Years				1964	1964	1959
Break Years						1971
Break Years			1978	1978	1978	1982
Break Years		1991			1990	1994
Break Years			2002	2002	2004	2004
RSS	1.996	0.106	0.034	0.025	0.019	0.022
BIC	-35.945	-225.483	-290.790	-299.768	-306.798	-284.447
C. Real GDP-FC						
Break Years					1964	1959
Break Years						1971
Break Years		1988	1983	1978	1978	1982
Break Years				1990	1990	1994
Break Years			2004	2005	2005	2005
RSS	1.584	0.079	0.030	0.023	0.019	0.022
BIC	-51.889	-246.310	-299.330	-304.804	-304.943	-282.183
D. Per Capita Real GDP-FC						
Break Years					1964	1959
Break Years						1971
Break Years			1984	1978	1978	1982
Break Years		1991		1990	1990	1994
Break Years			2004	2004	2004	2004
RSS	2.189	0.101	0.036	0.026	0.019	0.022
BIC	-29.570	-229.065	-288.544	-296.346	-304.810	-282.224

[a] This table reports the details of the structural break tests for a regression of log output on a constant and a linear time trend, as shown in (1), for the period 1950 to 2018. Four different measures of output has been used. RSS refers to residual sum of squares and BIC refers to Bayesian Information Criterion.

Table 3: Average Growth Rates Across Distinct Growth Regimes Identified by Tests for Structural Breaks[a]

	Intercept		Time Trend	
	Coef	Std Err	Coef	Std Err
A. Real GDP				
1950 - 1964	-66.902	1.682	4.076	0.086
1965 - 1978	-59.161	3.385	3.680	0.172
1979 - 1990	-92.402	2.150	5.357	0.108
1991 - 2004	-102.362	1.657	5.856	0.083
2005 - 2018	-127.442	1.677	7.109	0.083
B. Per Capita Real GDP				
1950 - 1964	-31.700	1.599	2.087	0.082
1965 - 1978	-18.857	3.451	1.431	0.175
1979 - 1990	-54.370	2.196	3.223	0.111
1991 - 2004	-69.568	1.648	3.985	0.082
2005 - 2018	-105.883	1.605	5.799	0.080
C. Real GDP-FC				
1950 - 1964	-67.541	1.841	3.870	0.094
1965 - 1978	-64.319	3.182	3.704	0.161
1979 - 1990	-93.773	2.632	5.189	0.133
1991 - 2005	-110.698	1.557	6.038	0.078
2006 - 2018	-129.172	1.751	6.963	0.087
D. Per Capita Real GDP-FC				
1950 - 1964	-32.339	1.765	1.881	0.090
1965 - 1978	-24.015	3.250	1.455	0.165
1979 - 1990	-55.741	2.673	3.055	0.135
1991 - 2004	-76.219	1.383	4.083	0.069
2005 - 2018	-110.040	1.853	5.773	0.092

[a] This table reports the average exponential growth rates for four different measures of output in distinct growth regimes identified by structural break tests reported in Table 2. GDP refers to gross domestic product at market prices; GDP-FC refers to gross domestic product at factor costs. The coefficient on the time trend and its standard error has been multiplied by 100 so that it can be interpreted as the growth rate in percentage points. For definitions of variables and sources, see Online Appendix A.

Table 4: Sectoral Growth Rates, Shares and Contributions to the Growth of Real GDP at Factor Cost (GDP-FC)[a]

	Primary Sector	Secondary Sector	Tertiary Sector
1950–64:			
Average Growth Rate (%)	2.51	6.49	4.84
Share of GDP-FC	0.50	0.13	0.37
Contrib (%) to Growth of GDP-FC	31.84	21.97	45.53
1965–78:			
Average Growth Rate (%)	2.94	4.50	4.00
Share of GDP-FC	0.40	0.17	0.43
Contrib (%) to Growth of GDP-FC	32.16	20.96	46.70
1979–90:			
Average Growth Rate (%)	3.44	6.19	6.14
Share of GDP-FC	0.33	0.20	0.47
Contrib (%) to Growth of GDP-FC	21.53	22.96	55.25
1991–05:			
Average Growth Rate (%)	2.70	5.89	7.55
Share of GDP-FC	0.24	0.21	0.55
Contrib (%) to Growth of GDP-FC	10.59	20.04	68.79
2006–18:			
Average Growth Rate (%)	3.13	6.66	8.17
Share of GDP-FC	0.13	0.20	0.66
Contrib (%) to Growth of GDP-FC	5.88	18.41	75.66

[a] This table reports the sectoral contributions to growth. The *primary sector* includes agriculture and allied activities; the *secondary sector* includes mining & quarrying, manufacturing, and electricity, gas, water supply & other utilities; the *tertiary sector* includes construction, trade, hotels, communication, transportation, and services related to broadcasting, finance, insurance and real estate, and public administration, defense and other services. Source: author's calculations.

Table 5: ADF Tests for Presence of Unit Roots in the Levels and First Differences of Variables[a]

	Level	First Difference
Growth Rate of Real GDP	-6.85	-10.78
Private Equipment Investment	-3.08	-4.89
Public Equipment Investment	-1.49	-5.87
Investment in Structures	-3.12	-5.18
Change in Stocks	-4.08	-9.87
Memo:		
1% critical value	-4.04	-3.51
5% critical value	-3.45	-2.89
10% critical value	-3.15	-2.58

[a] This table reports the test statistic for the augmented Dickey-Fuller (ADF) tests on the levels and first difference of variables. The ADF regression for the levels of variables includes a linear time trend; the ADF regression for the first difference includes a drift, but no linear time trend. Optimal lag lengths are chosen with AIC. The null hypotheses for the ADF test is that the variable is unit root nonstationary.

Table 6: Results of the ARDL Bounds Testing Procedure[a]

	Specification 1 (Unrestricted Intercept, No Trend)		**Specification 2** (Unrestricted Intercept, Unrestricted Trend)	
	Lower Bound	Upper Bound	Lower Bound	Upper Bound
10% Critical Value	2.552	3.648	3.182	4.258
5% Critical Value	3.022	4.256	3.720	4.904
1% Critical Value	4.098	5.570	4.922	6.328
F-statistic	6.61		6.517	
Memo: Diagnostics for the Bounds Testing Procedure				
Breusch-Godfrey Test	0.149		0.165	
Ljung-Box Test	0.593		0.591	
Breusch-Pagan Test	0.053		0.044	
Shapiro-Wilk Test	0.671		0.583	
Ramsey RESET test	0.785		0.806	

[a] This table reports the F-test for the ARDL bounds testing procedure discussed in section 4.3. In the Breusch-Godfrey test, the null hyothesis is that there is no serial correlation of order 1 in the residuals; in the Box-Ljung test, the null hypothesis is that there is no serial correlation in the residuals; in the Studentized Breusch-Pagan test, the null hypothesis is that the residuals are homoskedastic; in the Shapiro-Wilk test, the null hypothesis is that the residuals are normally distributed; in the Ramsey RESET test for specification error, the null hypothesis is that the linear model is correctly specified.

Table 7: Parameter Estimates of the ARDL Model[a]

	(1)	(2)
Growth Rate of Real GDP, 1-Lag	−1.771***	−1.787***
	(0.306)	(0.312)
Pvt Eqpmt Investment, 1-Lag	0.951**	1.093**
	(0.392)	(0.481)
Pub Eqpmt Investment, 1-Lag	−0.105	−0.052
	(0.310)	(0.316)
Investment in Structures, 1-Lag	0.188	0.265
	(0.607)	(0.676)
Change in Stocks, 1-Lag	0.014	−0.018
	(0.584)	(0.619)
First Diff of Pvt Eqpmt Investment	0.929**	1.002**
	(0.454)	(0.489)
First Diff of Pvt Eqpmt Investment, 1-Lag	−0.289	−0.371
	(0.456)	(0.450)
First Diff of Pvt Eqpmt Investment, 2-Lag	−0.691	−0.817
	(0.480)	(0.588)
First Diff of Pub Eqpmt Investment	−1.195	−1.155
	(0.961)	(0.992)
First Diff of Pub Eqpmt Investment, 1-Lag	0.911	0.854
	(1.242)	(1.183)
First Diff of Investment in Structures	0.590	0.683
	(0.683)	(0.698)
First Diff of Investment in Structures, 1-Lag	0.062	0.048
	(0.855)	(0.875)
First Diff of Change in Stocks	−0.042	−0.069
	(0.378)	(0.394)
First Diff of Change in Stocks, 1-Lag	−0.366	−0.383
	(0.312)	(0.311)
Linear Time Trend		−0.024
		(0.048)
First Diff of Growth Rate of Real GDP, 1-Lag	0.515**	0.526**
	(0.207)	(0.211)
First Diff of Growth Rate of Real GDP, 2-Lag	0.224*	0.232**
	(0.115)	(0.114)
Constant	4.621**	4.459*
	(2.200)	(2.324)

[a] Parameter estimates of ARDL models. Specification (1) uses unrestricted intercept but no trend; specification (2) allows for both unrestricted intercept and trend. Heteroskedasticity and autocorrelation consistent (HAC) standard errors appear in parentheses below estimates. Significance levels: *** 1 percent level; ** 5 percent; * 10 percent.

Table 8: Long-Run Level Relationship Derived from the ARDL Model used in the Bounds Testing Procedure[a]

	Specification 1 (Unrestricted Intercept, No Trend)		**Specification 2** (Unrestricted Intercept, Unrestricted Trend)	
	Estimate	Std Err	Estimate	Std Err
Pvt Equipment Investment	2.609	1.08	2.496	1.165
Pub Equipment Investment	0.537	0.178	0.612	0.215
Investment in Structures	-0.059	0.174	-0.029	0.177
Change in Stocks	0.106	0.347	0.149	0.384
Intercept	0.008	0.329	-0.01	0.347
Trend			-0.014	0.026
Observations	64		64	

[a] This table reports parameters of the long-run level relationship in (7). The dependent variable in the long run levels relationship is the growth rate of real GDP. These estimates have been computed from underlying estimates reported in Table 7. Standard errors computed by the delta method using HAC covariance matrix.

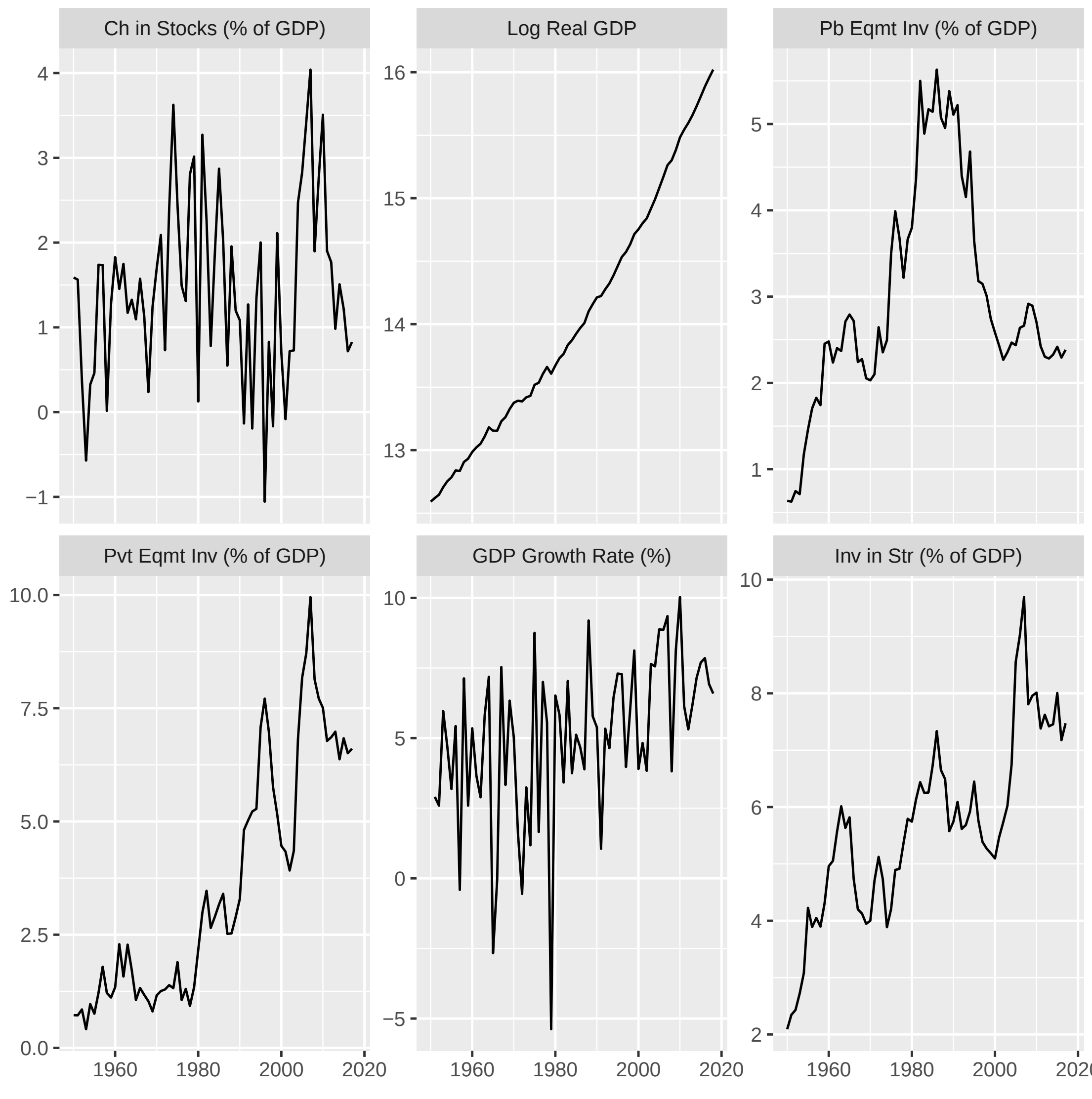

Figure 1: *Time series plots of key variables used for the analysis in this paper. For summary statistics of these variables, see Table 1; for sources and definitions, see Appendix A.*

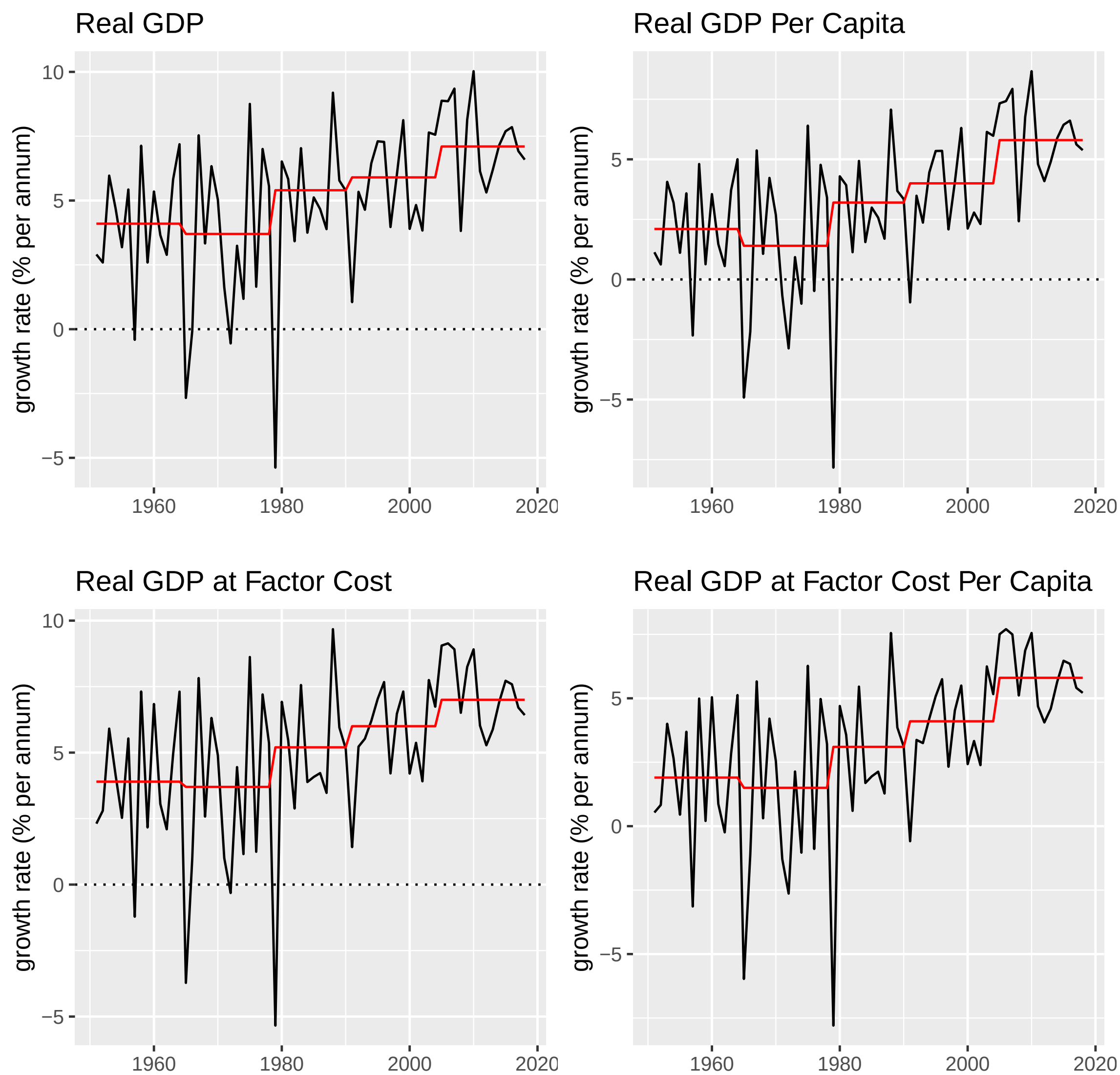

Figure 2: *Growth regimes in the Indian economy. The black line is the time series of annual growth rate of the series. The red line is the average exponential growth of the series in distinct growth regimes identified by structural break tests. For details of structural break tests, see section 3.*

A Data: Variable Definitions and Sources

In this appendix, I provide details about all the variables used for the analysis in this paper.

- Real GDP (rupees crore): This variable is the gross domestic product at market prices valued at constant (2004–05) prices. The data on this variable is from two sources. For the years, 1950–51 to 1960–61, the data are from Table 1.6 and 1.7 in the Statistical Appendix of *The Economic Survey of India 2018-19*; the data from 1961–62 to 2011–12 are from Table 4 of the *Handbook of Statistics on Indian Economy, 2016-17*; and the data from 2012–13 onwards are from Table 4 of the *Handbook of Statistics on Indian Economy, 2018-19*. The data on GDP are computed with 2004–05 as the base year till 2011–12; from 2012–13, GDP computation uses 2011–12 as the base year. To create a consistent series with 2004–05 as the base year, I have used growth rates of the 2011–12 series recursively to forward-extend the 2004–05 series.

- Population (crore): The time series of population is generated by dividing nominal net national income with per capita nominal net national income. Data on nominal net national income and per capita nominal net national income are taken from Table 1.1 in the Statistical Appendix of *The Economic Survey 2018-19*.

- Real GDP per capita (rupees): This is the ratio of real GDP and the population, computed in the previous steps.

- Real GDP at Factor Cost (rupees crore): This variable measures the gross domestic product at factor cost in constant (2004-05) prices till the year 2011-12, and gross value added at basic prices (GVABP) after that. The GVABP series is in 2011-12 prices, and has been rebased at 2004-05 prices (as explained in the first point above). The data on this variable are from Table 3 and 3A of various issues of the *Handbook of Statistics on Indian Economy*.

- Real GDP at Factor Cost per capita (rupees): This is the ratio of Real GDP at Factor Cost and the population.

- Capital formation data are from the following sources:
  - National Accounts Statistics - Back Series 2011[12]. For current price series, Statement 11; for constant (2004-05) price series, Statement 12. This data goes from 1950-51 to 2004-05.
  - National Accounts Statistics 2014[13]. For current and constant (2004-05) price series, Statement 19. This data goes from 2004-05 to 2012-13.
  - National Accounts Statistics 2019[14]. For current and constant (2011-12) prices, Statement 1.11. This data goes from 2012-13 to 2017-18.

[12] See http://mospi.nic.in/publication/national-accounts-statistics-back-series-2011
[13] See http://mospi.nic.in/publication/national-accounts-statistics-2014
[14] See http://mospi.nic.in/publication/national-accounts-statistics-2019

- Private investment in equipment and machinery (% of GDP): This is the ratio of gross fixed capital formation in equipment in the private corporate sector in current prices and the nominal GDP. Data on the former variable are from various issues of the *National Account Statistics*, as explained in the previous point. Data on nominal GDP are from Table 4 of various issues of the *Handbook of Statistics on Indian Economy*.

- Public investment in equipment and machinery (% of GDP): This is the ratio of gross fixed capital formation in equipment in the public sector in current prices and the nominal GDP. Data on the former variable are from various issues of the *National Account Statistics*, and data on nominal GDP are from Table 4 of various issues of the *Handbook of Statistics on Indian Economy*.

- Investment in structures (% of GDP): This is the ratio of gross fixed capital formation in structures in the private *and* public sector in current prices and nominal GDP. Data on the former variables are from various issues of the *National Account Statistics*, and data on nominal GDP are from Table 4 of various issues of the *Handbook of Statistics on Indian Economy*.

- Change in stocks (% of GDP): This is the ratio of change in stocks in current prices and the nominal GDP. Data on the former variable are from various issues of the *National Account Statistics*, and data on nominal GDP are from Table 4 of various issues of the *Handbook of Statistics on Indian Economy*.