# Analyzing the Structural Change and Growth Relationship in India: State-level Evidence

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**Abstract**

This paper examines the link between structural change and growth in India. It constructs indices of structural change, and performs a panel data analysis using data for India's 16 major states. It finds that there is one-way positive impact from structural change to growth for the period 2000-2006. This finding emerges only if one assumes that the disturbances are heteroskedastic, contemporaneously cross-sectionally correlated and autocorrelated of type AR(1).

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## 1. Introduction

Classical development economics emphasized the link between structural change and economic growth. Growth was seen as driven by industrialization, and by the re-allocation of labor from lower-productivity activities or sectors (e.g., traditional agriculture) to higher-productivity employment in areas such as manufacturing. Pioneering twentieth century growth theories (e.g., Young, 1928; Verdoorn, 1949; Kaldor, 1957) tried to provide analytical underpinnings for the growth process, while influential empirical work tried to establish empirical regularities across developing countries in the patterns of structural change associated with economic growth (e.g., Chenery, 1960). Recent surveys of cross-country experience (e.g., United Nations, 2006) have re-emphasized the importance of structural change:

> Diverging patterns of growth among developing countries are also visible in differences in terms of structural change. An examination of the patterns of structural change over the past four decades indicate that the fast-growing East and South Asian economies were clearly characterized by dynamic transformations. Economies with relatively little structural change lagged behind, particularly those in sub-Saharan Africa. (United Nations, 2006, p. 49)[1]

In the context of the structural change-growth relationship, there has been relatively little analysis of the basic nature of this connection for the case of one of the recent decades' fastest growing economies, namely India. This is not to say that the growth process in India has been neglected. Several questions have been asked of the data, including identifying the patterns and drivers of growth, and the timing of India's recent growth acceleration. There has been some related discussion of structural change, but no focused econometric analysis, with the exception of Cortuk and Singh (2011), which explicitly tackles the connection between structural change and growth in India.

[1] Similarly, McMillan and Rodrik (2011) conclude that "the bulk of the difference between Asia's recent growth, on the one hand, and Latin America's and Africa's, on the other, can be explained by the variation in the contribution of structural change to overall labor productivity." However, the McMillan-Rodrik measure of structural change is quite different than what we use here. In particular, it uses sectoral productivity levels to weight changes in employment shares of sectors, and hence it associates structural change with productivity increases in the definition. Recently, Hasan, Lamba and Sen Gupta (2013) have applied the McMillan-Rodrik method to state-level Indian data, finding that the positive contribution of structural change to growth holds for India as well. A qualitative discussion of the literature on structural change and growth that connects it to the Indian experience is Papola (2006). A somewhat different, more qualitative approach to the concept of structural change in economic development is that of the "new structural economics," championed by Justin Lin (e.g., Lin, 2011).

This paper extends the analysis of the structural change-growth relationship in India by examining data from India's major states, which cover over 90 percent of the country's population. Previous work by the authors was with data at the national level. Hence, the current paper also provides some insights into differences in the growth process across India's states. The remainder of the paper is structured as follows. In Section 2, we discuss related literature on India's growth process. Section 3 describes the data and methodology. Section 4 describes and interprets our empirical findings. Section 5 is a summary conclusion, together with suggestions for future research.

## 2. Related Literature

While there has been relatively little rigorous, specific empirical analysis of the structural change-growth relationship for India, overall there has been a rich, multi-stranded literature on the growth process. One important issue has been that of identifying the drivers of India's growth. On this question, for example, Sen (2007) finds that private investment, among other factors, played an important role in accelerating growth in India. In another strand of the literature, many analyses have examined unusual patterns in India's growth, particularly services intensity (e.g., Singh, 2006) and skill intensity (e.g., Kochhar et al., 2006), and empirically documented these patterns, with their associated concerns about sustainability (and hence an implicit concern with growth drivers as well).

By far the largest strand of literature on India's growth process has been with trying to identify when its (substantial) growth acceleration began. The main candidates have been the period around 1980, and the period around 1988. A difference of a few years, in this case, has potentially important implications for inferences about the drivers of the growth process. In particular, much of this debate is focused on the role of economic policy reforms (particularly those introduced in 1991-92) in accelerating growth. Panagariya (2008), in particular, reviews and evaluates the evidence and the debate, making his own case for 1988 as an important break year in terms of the time series of Indian growth rates. Using new data and novel techniques of analysis, Ghate and Wright (2012) more recently reach a similar conclusion, namely, that India's growth rate accelerated in the late 1980s.

Studies of the timing of India's growth acceleration also can analyze of drivers of growth, including various aspects of structural change. In particular, analyses such as Wallack (2003), Virmani (2006), and Balakrishnan and Parameswaran (2007), examine the behavior of growth at the sectoral level, particularly for manufacturing, but also for certain sub-sectors of services. More directly for the issue of structural change, Mazumdar (2010) charts the behavior of sectoral shares in India's GDP, and informally discusses some observed patterns and possible implications for inferences about the role of economic policy reform in explaining these patterns. Several authors (e.g., Srinivasan, 2003; Wallack, 2003; Bosworth, Collins and Virmani, 2007) note that India's growth rate acceleration benefited from a shift in activity from slower-growing to faster-growing sectors.

However, none of the papers discussed so far explicitly measure structural change or directly examine its empirical link to India's growth rate. This was the innovation of Cortuk and Singh (2011). Using standard definitions of structural change indices, they examine the connection between measures of structural change and growth for India, for the period 1951-2007. They find that there is a structural break in the two time series considered jointly, and this break occurs in 1988. Furthermore, there is a one-way causal relationship between structural change and growth (the former Granger causes the latter), but only for the 1988-2007 period. Hence, this analysis provides more objective empirical support for previous informal assertions in the literature.[2]

A considerable amount of research on India's growth has focused on state-level data. The main question asked by these studies is whether India's states have been converging over time in terms of per capita incomes. The question of convergence comes from the standard neoclassical growth model, and in practice is often posed in terms of conditional convergence – with a variety of economic and political variables being used to capture varying initial conditions for growth. Given differences in the state of states, time period and conditioning variables used in different studies, it is perhaps unsurprising that different conclusions are reached. On the whole, however, it seems

[2] The literature often focuses more on the impact of policy reforms on growth, which is a different, and perhaps empirically more challenging, relationship. Analyses of the timing of India's growth acceleration do not directly trace a causal relationship from policy reform to faster growth, but find significance in the coincidence of the two events. Investigations at the plant or firm level, tracing increases in productivity growth (e.g., Bollard, Klenow and Sharma, 2013; Geng, 2010), are also pertinent, particularly when they identify differences across types of firms (exporting firms in the case, of Geng, 2010).

that the preponderance of evidence is for some degree of divergence, indicating that regional inequality in India has been increasing.[3]

Ghate and Wright (2012) also examine state-level data, and their analysis and conclusions are worth summarizing here for later comparison with our own results. They do not estimate convergence regressions, but examine the time series of per capita income for 16 states over the period 1960-2003 (hence, a longer period than most convergence studies). Eyeballing the data suggests that a subset of nine states "diverges" from the others from 1985 onward, in the sense of moving to a higher growth path.[4] These diverging states are Andhra Pradesh, Gujarat, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Rajasthan, Tamil Nadu and West Bengal. The seven remaining states are Assam, Bihar, Haryana, Jammu & Kashmir, Orissa, Punjab and Uttar Pradesh. Note that the two groups had essentially equal per capita incomes up to 1985, controverting suggestions that it was richer states that benefited from India's growth acceleration. Therefore, the Ghate-Wright data does not provide straightforward implications for convergence or divergence among the entire group of states. The grouping of states obtained by Ghate and Wright will be of interest for comparison with our results.

## 3. Data and Methodology

### *Data*

We start by describing our variables that reflect the main characteristics of the Indian economy, namely growth rates and structural change indices. Per capita net state domestic product data and implied growth rates for 16 major states are calculated with data that were obtained from *Reserve Bank of India's* website (http://www.rbi.org.in/scripts/PublicationsView.aspx?id=13593). The data cover the period from 2000-2006, where the years are fiscal years, running from April 1 to March 31 of the next year.[5] Thus we have six years of data, and 96 observations. The 16 states in our

[3] The simplest and starkest statement of this increasing inequality was Ahluwalia (2002), though he did not directly use a convergence regression framework. A recent survey of state-level convergence studies for India can be found in Singh et al. (2010). This survey also examines alternative approaches to measuring changes in regional inequality. The empirical work in Singh et al. (2010) itself is focused on analyzing the issue of convergence using sub-state data, using both NSS region data (there are 78 regions versus 28 states) and district level data.

[4] These states diverge from the others, but converge toward US per capita income levels, which serve as the benchmark for the Ghate-Wright analysis.

[5] More detail regarding the sectoral classification of the data is given in the Appendix A. Note that the years covered in our study overlap with Ghate and Wright's period, but extend beyond it by three years.

data are listed in Table 1. It is important to note the differences from the set of states used by Ghate and Wright, for example. We have used only general category states, omitting Assam and Jammu and Kashmir: this makes sense to us, since there are substantial differences in the economic conditions of the special category states, especially Jammu and Kashmir. At the same time, our newer data allows us to break out the new states of Chhattisgarh and Jharkhand, which were carved out respectively from Madhya Pradesh and Bihar.

**Table 1: List of States in Sample**

| | | | |
|---|---|---|---|
| Andhra Pradesh | Haryana | Madhya Pradesh | Rajasthan |
| Bihar | Jharkhand | Maharashtra | Tamil Nadu |
| Chhattisgarh | Karnataka | Orissa | Uttar Pradesh |
| Gujarat | Kerala | Punjab | West Bengal |

Similarly, Table 2 shows summary statistics of these states with regard to their per capita state domestic product and growth rates.

Regarding the structural change variable, we use the same indices as in Cortuk and Singh (2011). The first index for measuring the structural change is the Norm of Absolute Values (NAV) calculated as shown below, following Dietrich (2009) [6]:

(1) $$NAV = 0.5\sum_{i=1}^{n} | x_{it} - x_{is} |$$

For computation of this index, first the differences of the sector shares $x_i$ between two points in time, $s$ and $t$, are calculated. Then the absolute amounts of these differences are summed up and divided by two (since each change is counted twice). In implementing this calculation for the Indian case, sectoral shares are calculated for two levels of disaggregation of the GDP data. In the first disaggregation, there are three main sectors, namely agriculture, industry and services. In the

[6] This is also called the Michaely-Index (Michaely, 1962) or Stoikov-Index (Stoikov, 1966).

second disaggregation, there are 13 subsectors. Table 3 shows these subsectors and their shares for each state.[7]

**Table 2: Per Capita State Domestic Product and Growth Rates of States, 2000-06**

| State | Per Capita State Domestic Product (Rs.) | | | Growth Rate | | |
|---|---|---|---|---|---|---|
| | Average | Median | Std. Deviation | Average | Median | Std. Deviation |
| **Andhra Pradesh** | 18,148.7 | 17,486.0 | 2,012.9 | 6.83 | 8.07 | 2.46 |
| **Bihar** | 6,371.4 | 6,554.0 | 397.2 | 7.71 | 12.65 | 11.57 |
| **Chhattisgarh** | 12,682.9 | 12,202.0 | 1,455.9 | 6.44 | 6.31 | 8.56 |
| **Gujarat** | 20,717.1 | 19,509.0 | 3,051.3 | 7.35 | 8.13 | 7.05 |
| **Haryana** | 27,517.6 | 26,726.0 | 3,532.1 | 9.28 | 8.88 | 2.91 |
| **Jharkhand** | 11,362.1 | 11,173.0 | 1,172.0 | 5.21 | 6.89 | 9.09 |
| **Karnataka** | 18,623.9 | 18,115.0 | 1,687.9 | 5.38 | 5.36 | 4.29 |
| **Kerala** | 22,490.3 | 21,942.0 | 2,869.9 | 7.33 | 7.19 | 2.93 |
| **Madhya Pradesh** | 11,799.7 | 11,870.0 | 614.3 | 2.72 | 4.34 | 6.94 |
| **Maharashtra** | 24,393.3 | 23,447.0 | 2,487.4 | 6.13 | 7.72 | 4.56 |
| **Orissa** | 11,613.0 | 10,701.0 | 1,501.2 | 7.02 | 6.11 | 6.45 |
| **Punjab** | 26,718.7 | 25,992.0 | 1,117.5 | 4.13 | 3.97 | 2.25 |
| **Rajasthan** | 14,067.7 | 13,933.0 | 1,350.5 | 5.65 | 6.22 | 14.02 |
| **Tamil Nadu** | 21,200.1 | 20,319.0 | 2,264.3 | 6.57 | 6.23 | 5.71 |
| **Uttar Pradesh** | 10,035.3 | 9,806.0 | 417.0 | 4.28 | 5.01 | 2.00 |
| **West Bengal** | 17,839.6 | 17,567.0 | 1,584.0 | 5.87 | 5.88 | 1.93 |

[7] Hence, we report only the latter results here – the more aggregate results are qualitatively the same.

**Table 3: Sectoral Shares in State Domestic Product (Percent)**

| State | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Andhra Pradesh | 24.98 | 0.92 | 2.39 | 2.94 | 9.99 | 1.42 | 6.72 | 8.10 | 14.59 | 5.03 | 8.22 | 4.37 | 10.31 |
| Bihar | 30.83 | 1.80 | 1.51 | 0.16 | 5.08 | 0.54 | 5.82 | 6.43 | 19.99 | 4.08 | 2.35 | 6.37 | 15.04 |
| Chhattisgarh | 20.53 | 2.04 | 1.23 | 13.46 | 12.85 | 2.17 | 4.95 | 6.41 | 12.66 | 2.97 | 5.86 | 4.04 | 10.82 |
| Gujarat | 17.69 | 0.31 | 0.98 | 2.17 | 24.70 | 1.97 | 6.06 | 6.09 | 16.93 | 6.90 | 5.78 | 3.74 | 6.69 |
| Haryana | 26.81 | 0.68 | 0.12 | 0.27 | 17.61 | 0.55 | 8.42 | 7.97 | 16.54 | 3.78 | 7.86 | 2.55 | 6.84 |
| Jharkhand | 15.95 | 1.74 | 0.30 | 10.80 | 19.49 | 1.19 | 8.22 | 8.66 | 11.44 | 2.58 | 4.48 | 4.69 | 10.44 |
| Karnataka | 21.70 | 1.50 | 0.49 | 0.77 | 12.76 | 1.59 | 8.65 | 6.74 | 13.77 | 7.24 | 12.24 | 4.07 | 8.49 |
| Kerala | 15.14 | 1.66 | 1.78 | 0.39 | 7.77 | 1.21 | 12.67 | 9.71 | 22.81 | 5.81 | 7.74 | 4.24 | 9.04 |
| Madhya Pradesh | 25.90 | 1.81 | 0.23 | 3.32 | 8.60 | 1.97 | 7.64 | 6.92 | 17.09 | 4.56 | 6.53 | 4.20 | 11.24 |
| Maharashtra | 14.94 | 0.62 | 0.32 | 0.76 | 16.85 | 1.83 | 5.34 | 7.03 | 16.67 | 13.57 | 10.59 | 4.12 | 7.35 |
| Orissa | 24.98 | 2.52 | 1.41 | 5.50 | 8.69 | 1.45 | 6.29 | 8.36 | 11.55 | 4.08 | 5.89 | 5.00 | 14.27 |
| Punjab | 36.73 | 0.31 | 0.31 | 0.02 | 12.87 | 1.89 | 5.83 | 5.98 | 13.78 | 5.25 | 3.44 | 4.46 | 9.11 |
| Rajasthan | 29.49 | 1.74 | 0.07 | 2.34 | 9.17 | 2.21 | 11.19 | 6.05 | 14.95 | 3.96 | 5.99 | 3.95 | 8.90 |
| Tamil Nadu | 13.21 | 0.43 | 1.24 | 0.48 | 16.89 | 1.20 | 8.52 | 9.64 | 18.10 | 8.18 | 6.96 | 4.73 | 10.43 |
| Uttar Pradesh | 32.58 | 0.95 | 0.39 | 0.93 | 10.21 | 3.06 | 7.03 | 7.94 | 13.42 | 4.22 | 5.61 | 5.09 | 8.57 |
| West Bengal | 24.54 | 0.85 | 3.11 | 1.13 | 8.60 | 1.09 | 6.06 | 7.97 | 16.27 | 6.78 | 8.83 | 4.61 | 10.15 |

(1) Agriculture
(2) Forestry
(3) Fishing
(4) Mining
(5) Manufacturing
(6) Electric and Gas
(7) Construction
(8) Transportation, Storage
(9) Trade, Hotels and Restaurant
(10) Banking & Insurance
(11) Real Estate & Business service
(12) Public Administration
(13) Other Services

The second index is the modified Lilien index (MLI). The Lilien (1982) index originally measured the standard deviation of the sectoral growth rates of employment from period *s* to period *t*. Stamer (1999) modified this index in order to fulfill the characteristics of a metric. The MLI is constructed as follows:

(2) $$MLI = \sqrt{x_{it} . x_{is} \left( \ln \frac{x_{it}}{x_{is}} \right)^2}$$ where $x_{is} > 0$ and $x_{it} > 0$.

**Table 4: Structural Change Indices**

| State | NAV Index | | | MLI Index | | |
|---|---|---|---|---|---|---|
| | Average | Median | Std. Deviation | Average | Median | Std. Deviation |
| **Andhra Pradesh** | 0.0206 | 0.0186 | 0.0085 | 0.0183 | 0.0190 | 0.0104 |
| **Bihar** | 0.0562 | 0.0572 | 0.0112 | 0.0497 | 0.0505 | 0.0170 |
| **Chhattisgarh** | 0.0639 | 0.0654 | 0.0218 | 0.0597 | 0.0674 | 0.0210 |
| **Gujarat** | 0.0348 | 0.0342 | 0.0118 | 0.0368 | 0.0419 | 0.0113 |
| **Haryana** | 0.0189 | 0.0205 | 0.0060 | 0.0202 | 0.0229 | 0.0071 |
| **Jharkhand** | 0.0532 | 0.0462 | 0.0298 | 0.0575 | 0.0452 | 0.0399 |
| **Karnataka** | 0.0287 | 0.0312 | 0.0070 | 0.0330 | 0.0334 | 0.0084 |
| **Kerala** | 0.0176 | 0.0157 | 0.0065 | 0.0176 | 0.0153 | 0.0068 |
| **Madhya Pradesh** | 0.0339 | 0.0360 | 0.0175 | 0.0403 | 0.0414 | 0.0238 |
| **Maharashtra** | 0.0144 | 0.0154 | 0.0078 | 0.0144 | 0.0127 | 0.0090 |
| **Orissa** | 0.0359 | 0.0331 | 0.0108 | 0.0371 | 0.0365 | 0.0147 |
| **Punjab** | 0.0134 | 0.0141 | 0.0027 | 0.0134 | 0.0137 | 0.0030 |
| **Rajasthan** | 0.0430 | 0.0357 | 0.0291 | 0.0523 | 0.0480 | 0.0400 |
| **Tamil Nadu** | 0.0174 | 0.0172 | 0.0101 | 0.0177 | 0.0174 | 0.0127 |
| **Uttar Pradesh** | 0.0155 | 0.0156 | 0.0062 | 0.0153 | 0.0134 | 0.0085 |
| **West Bengal** | 0.0142 | 0.0132 | 0.0031 | 0.0149 | 0.0145 | 0.0027 |

The use of two indices allows us to check the robustness of our analysis with respect to the structural change measure. We constructed two annual series of structural change for each of the 16 Indian states, one for each index. The two indices (NAV and MLI) of structural change for the 16 states are displayed in Table 4. We report the mean, median and standard deviation for each index for each state, calculated for the six-year sample period. The two indices are quite similar in their magnitudes and patterns, and yield similar empirical results in the regression analysis. Hence, we will focus on the NAV index and present results for that case only: the robustness of the results with respect to the MLI index is discussed briefly later in the paper.

***Empirical Methodology***

We start our analysis by running two fixed effect regressions by assuming no heteroskedasticity, no autocorrelation and no cross sectional dependence among disturbances. In the first regression, growth is regressed on lagged growth, the structural change index and per capita net state domestic product (SDP). In the second regression, the structural change index is regressed on lagged structural change index, growth and per capita net SDP.

As a next step, we replicate the same regressions allowing the disturbances to be heteroskedastic and autocorrelated of type AR(1). Finally, we rerun the regressions by allowing disturbances first to be both heteroskedastic and AR(1) autocorrelated and secondly to be simultaneously heteroskedastic, autocorrelated and cross-sectionally correlated.

## 4. Empirical Findings

***Preliminary Data Analysis***

We begin by presenting some average relationships between the three variables of interest: growth rates, SDP per capita, and the structural change index.

Figure 1 plots average growth rates for the six year period against SDP per capita. There is a slight positive relationship, indicative of the phenomenon of divergence found in other studies and discussed earlier in this paper. In the figure, observations for the diverging group of states identified by Ghate and Wright are colored in orange – we include Chhatisgarh along with Madhya Pradesh in this group, for a total of 10 states. There is a clear and striking difference between the performance of these two states (as also for Bihar and Jharkhand). From the figure, it does not appear obvious that the relationship found by Ghate and Wright has persisted, since Bihar (though without Jharkhand), Haryana and Odisha are all above the regression line.

**Figure 1: SDP per capita and growth rates**

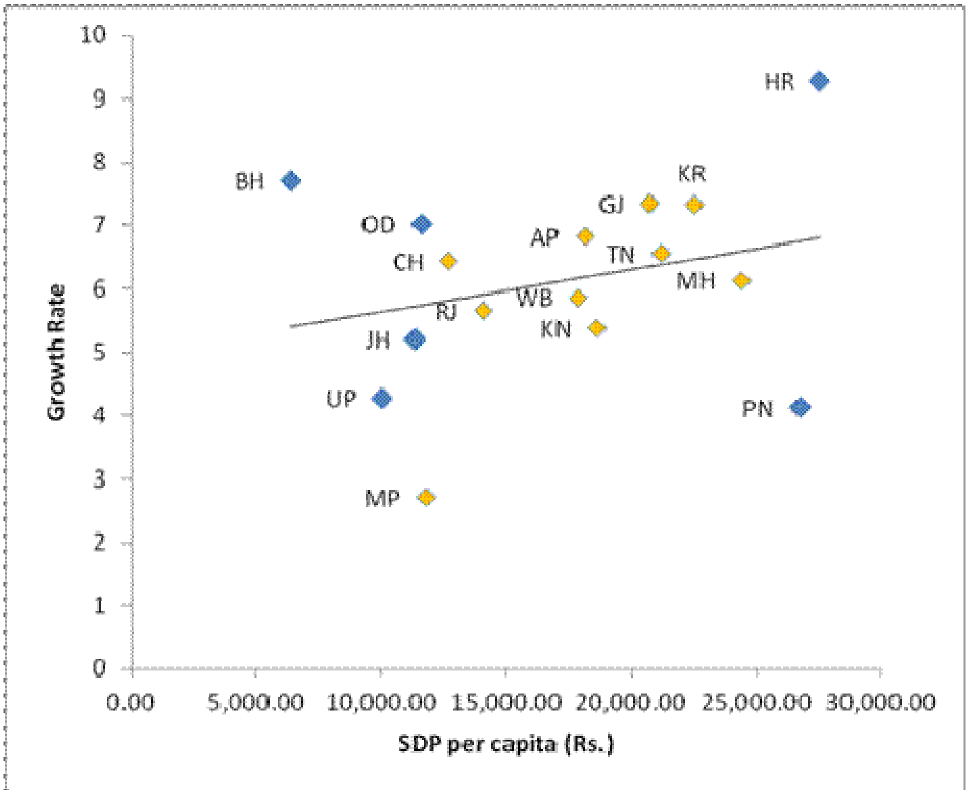
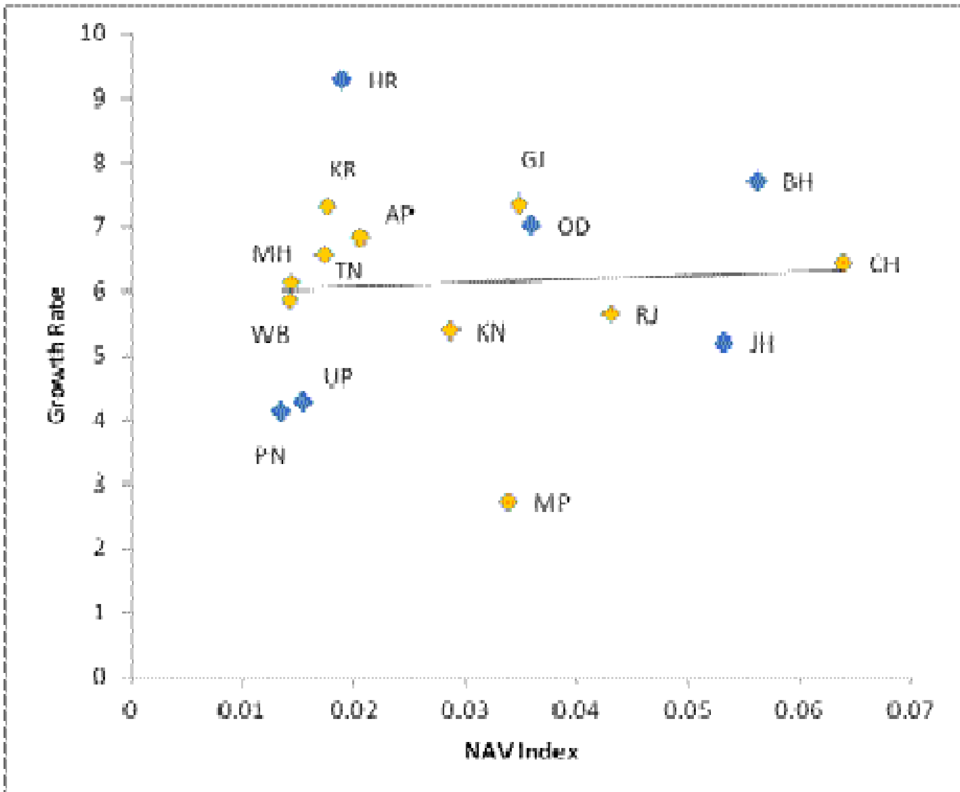



Figure 2 offers a similar plot, but with the NAV structural change index on the horizontal axis. Now the regression line is somewhat flatter, though still with a positive slope, indicating a weak positive relationship between structural change and growth over this period. Again, there is no obvious dichotomy between the two groups of states identified by Ghate and Wright.[8]

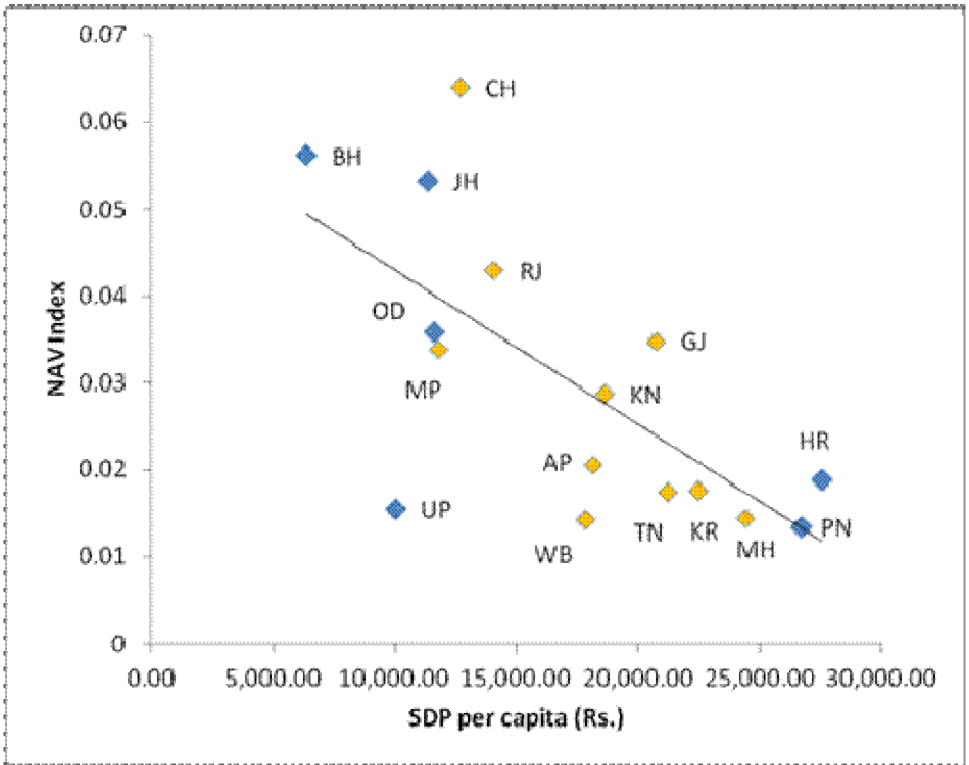
[8] It is worth emphasizing that we do not claim to controvert their results, since our coverage in terms of states and years is different, but we introduce structural change as an additional causal factor in the growth process.

**Figure 2: Structural change and growth rates**




Finally, Figure 3 shows a clear negative relationship between per capita SDP and structural change. India's richer states have seen less structural change over this period. One striking feature of all three plots is that Uttar Pradesh is a substantial negative outlier in all three regressions. In this final figure, the difference between Haryana and Punjab is not very great, whereas its higher growth rate put Haryana far from Punjab in the first two figures. The recent experience of Haryana is an interesting departure from the Ghate-Wright analysis, but it may simply reflect its proximity to the national capital and the mushrooming of Gurgaon as an outsourcing destination. In any case, the plots merely serve as exploratory analysis as a prelude to the formal regression analysis.

**Figure 3: Per capita SDP and structural change**




***Regression Analysis***

Table 5 displays the main empirical findings of the two regressions, in which growth and NAV (the structural change index) are the dependent variables respectively. The first section of this table presents our findings from the regressions with disturbances assumed to be homoskedastic, uncorrelated and cross-sectionally independent. Accordingly, in the regression where growth is the dependent variable, it indicates that the lagged value of the structural change index of NAV is not significant. On the other hand, the other two variables, namely lagged growth and lagged per capita net state domestic product are significant having opposite signs in the regression. More specifically, lagged per capita SDP has a positive sign (consistent with Figure 1 and the idea of divergence) whereas lagged growth has a negative one. The latter result is indicative of a higher growth year in any state being followed by a lower growth year. Using the same structural change index, but with national level data, Cortuk and Singh (2011) found the sign of lagged growth positive for 1951-1988 and negative for 1988-2007. Thus, the result found here with state-level data is consistent with the national-level result for the 1988-2007 period.

**Table 5: Regression Results**

| | | GROWTH | | NAV INDEX | |
|---|---|---|---|---|---|
| | **Variable** | **Coefficient** | **t stat** | **Coefficient** | **t stat** |
| **Cross sectionally Independent Disturbances without Heteroskedasticity and Autocorrelation** | Growth(-1) | -0.5468 | -5.74 | 0.0001 | 0.55 |
| | NAV(-1) | 39.97 | 0.91 | 0.2086 | 1.89 |
| | Per Capita SDP(-1) | 0.0012 | 3.64 | -2.65e-06 | -3.04 |
| | Constant | -13.16 | -2.12 | 0.0687 | 4.39 |
| **Heteroskedastic Disturbances** | Growth(-1) | -0.5468 | -4.47 | 0.0001 | 0.52 |
| | NAV(-1) | 39.97 | 0.67 | 0.2086 | 1.38 |
| | Per Capita SDP(-1) | 0.0012 | 4.77 | -2.65e-06 | -3.73 |
| | Constant | -13.16 | -2.45 | 0.0687 | 5.13 |
| **AR(1) Autocorrelated Disturbances** | Growth(-1) | -0.7352 | -7.53 | 0.0003 | 1.34 |
| | NAV(-1) | 59.27 | 1.12 | -0.008 | -0.06 |
| | Per Capita SDP(-1) | 0.001 | 2.20 | -3.36e-06 | -2.65 |
| | Constant | -7.17 | -1.03 | 0.0866 | 4.81 |
| **Heteroskedastic and AR(1) Autocorrelated Disturbances** | Growth(-1) | -0.5468 | -4.12 | 0.0001 | 0.83 |
| | NAV(-1) | 39.97 | 0.52 | 0.2086 | 2.52 |
| | Per Capita SDP(-1) | 0.0012 | 4.15 | -2.65e-06 | -3.20 |
| | Constant | -13.16 | -2.11 | 0.0687 | 4.8 |
| **Heteroskedastic, AR(1) Autocorrelated and Cross-Sectionally Correlated Disturbances** | Growth(-1) | -0.3587 | -4.20 | 0.00006 | 0.31 |
| | NAV(-1) | 71.28 | 2.79 | 0.5966 | 8.04 |
| | Per Capita SDP(-1) | 0.0003 | 5.18 | -5.43e-07 | -3.37 |
| | Constant | 0.591 | 0.4 | 0.0192 | 4.15 |

As regards to the second regression of the first pair, where NAV is the dependent variable, the only significant variable is lagged per capita SDP, which has a negative sign, consistent with the time-averaged relationship seen in Figure 3. The other variables in the regression, lagged growth and the lagged NAV index are insignificant, though the latter is positive and close to significant.

The next two pairs of regressions in Table 5 repeat the previous regressions, but with heteroskedastic and AR(1) autocorrelated disturbances respectively. There are no improvements in the significance levels of the variables even if disturbances are considered as either heteroskedastic or autocorrelated of type AR(1). Nor is there any major change in the signs of coefficients or loss of significance as a result of these alternative assumptions on the error structure.

In the fourth pair of regressions, we simultaneously allow for disturbances that are both heteroskedastic and autocorrelated of type AR(1). With this change, lagged NAV becomes a significant variable (with a positive coefficient) at the 95% confidence level in the second regression of the fourth pair, which seeks to explain structural change. This result is consistent with structural change being a cumulative process. The other significant relationships found in the previous three sets of regressions remain quite robust to the changes in specification of the error structure.

In the final set of regressions, we allow the disturbances to simultaneously be heteroskedastic, AR(1) autocorrelated, and also cross-sectionally correlated. This last assumption captures the possibility of shocks that simultaneously affect the different states in the cross-section, and complements the idea of serial correlation in the time dimension. As in the previous set of regressions, structural change is positively affected by its lagged value: in fact, the estimated magnitude of the effect goes up substantially. Most strikingly, in the growth regression of this final set, the structural change index also becomes significant and positive (together with lagged growth, which remains negative in its impact on growth, and lagged per capita SDP, which remains positive). This last result is also consistent with Cortuk and Singh (2011) emphasizing the same relation with the longer time series data of India as a whole.

Taken together, the last pair of regression equations provides useful evidence that structural change plays a positive role in the growth process: it directly affects future growth, and is itself a cumulative process.[9] This last point is evidenced by the positive coefficient of lagged structural change on structural change. Notably, the processes of growth and structural change behave quite differently. High growth in one period tends to be associated with lower growth in the next period, which is the opposite of the relationship between structural change from one period to the next. Also, the initial level of per capita SDP has opposite effects on growth and structural change in the following period, being associated with higher growth but less structural change. Most importantly, structural change in one period is associated with higher growth in the following period, but growth does not appear to lead to structural change in the same manner.

That the causality between growth and structural change is asymmetric is not surprising, perhaps, given that they measure different types of change in economic activity. Also, unlike growth, structural change is more of a finite process, since, beyond a point, growth does not translate into structural change measured at the current level of aggregation, but with much subtler processes of change such as quality upgrading, process innovation and so on. A final point to note is that is that allowing for cross-sectional correlation is crucial to the results, and uncovering the growth-structural-change relationship depends on allowing for unobservable factors, as well as effects that persist over time.

### *Robustness: MLI Index as a Structural Change Measure*

To check robustness, we employed the MLI index instead of the NAV index under the various assumptions about the disturbance terms for the two regressions described earlier, and we obtained similar results. Accordingly, neither (lagged) growth nor (lagged) MLI has significant effects in explaining the other variable in the initial specifications. However, when disturbances are modeled as heteroskedastic, AR(1) autocorrelated and cross-sectionally correlated, the lagged structural change index of MLI becomes significant in the growth regression. Furthermore, this is not the case with the lagged value of growth in the structural change regression. All the results for the MLI index are in line with the results for the NAV index, and we can conclude that our results are completely robust to using the alternative structural change index.

[9] We would argue that this is a stronger result than that of Hasan, Lamba and Sen Gupta (2013), since our index of structural change does not use productivity weights. Of course our results are broadly consistent in that we also find that structural change positively affects growth.

## 5. Conclusions

Our results show that structural change of the Indian economy is significant in explaining the growth of the economy for the period of 2000 to 2006 but not vice versa – growth does not seem to lead to structural change. However, this result emerges only if the specification of the disturbance terms is carefully done. In particular, we need to allow for heteroskedastic, autocorrelated of type AR(1) and cross-sectionally correlated error terms. Otherwise, both (lagged) growth and (lagged) structural change indices have insignificant effects explaining each other in the regressions. Our main result in this paper is consistent with the study of Cortuk and Singh (2011), which used the same structural change indices, but employing a time series analysis with national-level data. The advantage of our approach to understanding the growth-structural-change relationship is that it uses a quantifiable measure, rather than the more qualitative approach of, for example, Lin (2011). Our results complement those of Hasan, Lamba and Sen Gupta (2013), which use a measure of structural change that gives more weight to sectoral shifts into high productivity sectors). Extending the data set can provide an avenue for further research. Our work takes an approach that is different from, but also complements, more common studies of Indian economic growth, which look at structural breaks in the growth process, or convergence/divergence across India's states.

**APPENDIX A: Data**

Net state domestic product data have three main sectors and thirteen subsectors shown below:

- Agriculture and allied activities,
    - Agriculture
    - Forestry & Logging
    - Fishing
    - 
- Industry
    - Mining and Quarrying
    - Manufacturing
    - Electric, Gas and Water Supply
- Services
    - Construction
    - Transport, Storage & Communication
    - Trade, Hotels, Restaurants
    - Banking& Insurance
    - Real Estate, Ownership of Dwelling and Business Services
    - Public Administration
    - Other Services

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