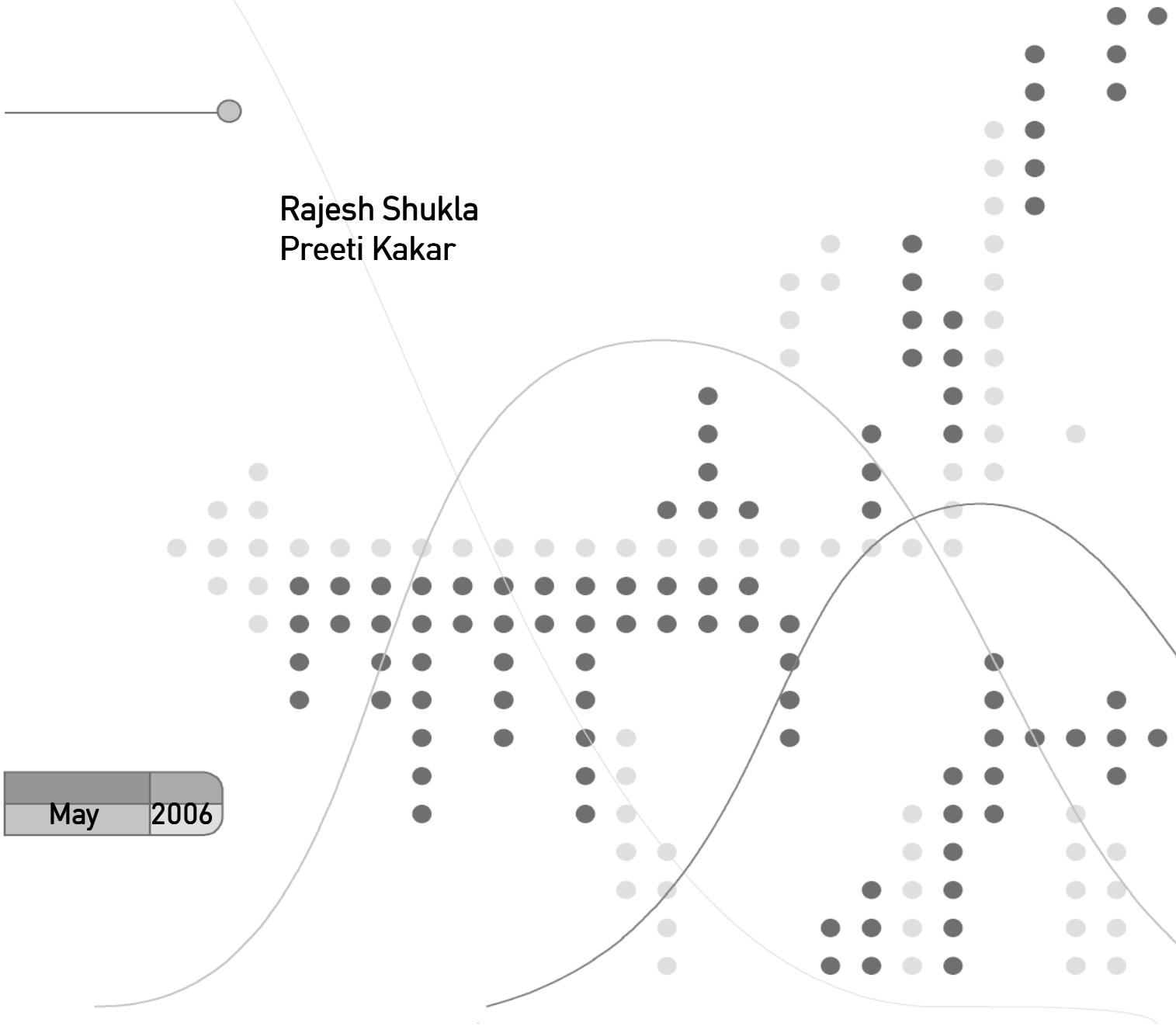
NCAER

NATIONAL COUNCIL OF APPLIED ECONOMIC RESEARCH

Working Paper

# Role of Science & Technology, Higher Education and Research in Regional Socio-Economic Development

Rajesh Shukla
Preeti Kakar



May 2006

# Contents

1. Introduction ..... 1
2. Concepts, Methodology and Construction of the Indices ..... 3
2.1 The Conceptual and Methodological Framework ..... 3
2.2 Constructing the Index: The statistical approach ..... 6
3. Discussion of Indicators ..... 7
3.1 Grouping of Indian States ..... 7
3.2 Discussion of Indicators ..... 8
4. The Indices and Benchmarking Results ..... 12
4.1 Economic Scores and Rankings ..... 12
4.2 S&T Scores and Rankings ..... 14
4.3 Welfare Scores and Rankings ..... 14
4.4 Intra-Group Comparisons ..... 15
5. Index Scores: Driving Factors ..... 16
6. S & T Index and Some Correlates ..... 17
7. Concluding Remarks ..... 19

## List of Tables and Figures

Figure 1: Conceptual Framework of Composite Index ..... 4
Figure 2: Ownership of Selected Goods and Services (% households own) (2004-05) ..... 10
Figure 3: Number of Research Institutes per million population (2004-05) ..... 11
Figure 4: Average Distance to Selected Public Facilities (km) (2004-05) ..... 11
Figure 5: Indices Scores by Group of States (2004-05) ..... 13

Table 1: Grouping of the States (2004-05) ..... 8
Table 2: Socio-economic Indicators ..... 9
Table 3: Health Indicators ..... 12
Table 4: Summary of Indices (2004-05) ..... 13
Table 5: Indices Scores and Rankings (2004-05) ..... 15
Table 7: Summary of the Contribution of Various Sub-Indices in all the Four Group of States (%) (2004-05) ..... 17
Table 8: Rank of Indices and Per Capita SDP - Indian States (2004-05) ..... 18
Table 9: Rank Correlation Coefficient of Three Major Indices- (2004-05) ..... 18

**Annexure 1: Summary of Indicators for Different Indices**

# Role of Science & Technology, Higher Education and Research in Regional Socio-Economic Development

**Rajesh Shukla and Preeti Kakar**

*This paper is an attempt to focus on the role of Science and Technology (S&T) on regional development of India by considering 21 Indian states. The Index approach using the Principal Component technique has been adopted. For analysing the impact, a set of three indices focussing on Current Economic Status, S & T and Welfare has been calculated. Further, using the S&T Index as the basis, the states have been classified into four major categories. Inter and intra-group comparisons are discussed.*

## 1. Introduction

Science and Technology (S&T) has been central to India's development efforts since the time of Independence. Jawaharlal Nehru, the first Prime Minister, was believed in the crucial importance of S&T for economic growth and social transformation. He helped lay a firm foundation of S&T education in the country[1]. Over the subsequent six decades, India's development planning proceeded by channeling substantial resources to S&T education, training and research. The country today has a vast S&T infrastructure comprising national laboratories and institutes, more than 200 universities and over 12,000 colleges. With its flagship nuclear and space programmes, high profile in information technology services and pharmaceuticals, Indian S&T has come a long way from its modest beginnings.

The issue of regional disparity has been a major concern for India's policy makers.[2] In any event, such glaring gaps are not healthy and are likely to impede the country's overall progress in S&T, and, by extension, the sustainability of economic and social wellbeing. Some states have achieved rapid S&T growth in recent years, while others have languished.

In this regard, the role of S&T is vital in achieving economic and social objectives. To act as an engine of development, S&T must take the lead to steady improvements in human conditions by expanding the range of people's choices, a notion that the concept of Human Development tries to capture. From this standpoint, the S&T performance of a country cannot be seen as the mere sum of its economic growth and export performance. Instead, it is a composite notion, reflecting how S&T relates to the range of choices available to people in a country at a particular point in time. The extent of such choice, in turn, relies much on the interplay among factors that determine S&T development outcomes.

Inter-state disparities, particularly in the context of their capacity to create and use technology for development, have persisted since Independence. The technological transformations that followed liberalisation and the emergence of the global marketplace have raised the stakes for all states to be able to create, adapt and use S&T innovations. But what is the role of S&T in the socio-economic context of regional development? Are states capable enough to reap such advantages? How does one measure such capabilities?

Measuring the role of S&T in sustainable development and its impact among other determinants is a complex exercise because of the paucity of data and non-existence of well-defined linkages. In recent years, there has been considerable growth in the use of well-conceptualised aggregates or composite indicators at various levels for the measurement of

regional diversity. Desai *et al* (2002) proposed a Composite Index of Technological Achievement (TAI), which reflected the level of technological progress and capacity of a country to participate in the network age. Like the Human Development Index, TAI is intended for use as a starting point towards overall assessment. It should be followed up with an examination of different indicators in greater detail. Another Index, the ICT Development Index of UNCTAD (2002), is used to evaluate the average achievement in a country based on three dimensions:

(a) 'Connectivity' is measured by the per capita consumption of telephone lines, mobile telephone subscribers, internet connections and personal computers
(b) 'Access' is measured by the number of estimated Internet users, the adult literacy rate, the cost per of local call and GDP per capita (PPP)
(c) 'Policy' is measured by the presence of Internet exchanges, the levels of competition in local loop telecom and the domestic long distance, and, the level of competition in the Internet Service Provider (ISP) market

The aim of this exercise is to examine whether scientific institutions and programmes of higher education and research have impacted various parts of the country uniformly. It analyses the impact of S&T for regional development and its relevance for fulfilling the much-desired objective. Thus, the current exercise is aimed at following research questions. How does one measure regional disparities? Is an index-based approach appropriate? What does an index tell us? How does the profile of the "more developed state" differ from that of the "less developed state"? What are the implications of the indices for planners, policy makers and academics?

To provide a more objective understanding, a set of three indices, focussing on Current Economic Status, S&T and Welfare has been calculated to determine the scientific, technological and socio-economic development of the states. This framework, by systematically accounting for the linkages of the determinants and their constituent elements, aims to serve as a monitoring mechanism of the states' economic, scientific and technological performance. It is also a diagnostic device to identify factors affecting such performance and a policy tool to help stimulate and promote national policies and measures with a view to keeping S&T focussed on development.

## 2. Concepts, Methodology and Construction of the Indices

### 2.1 The Conceptual and Methodological Framework

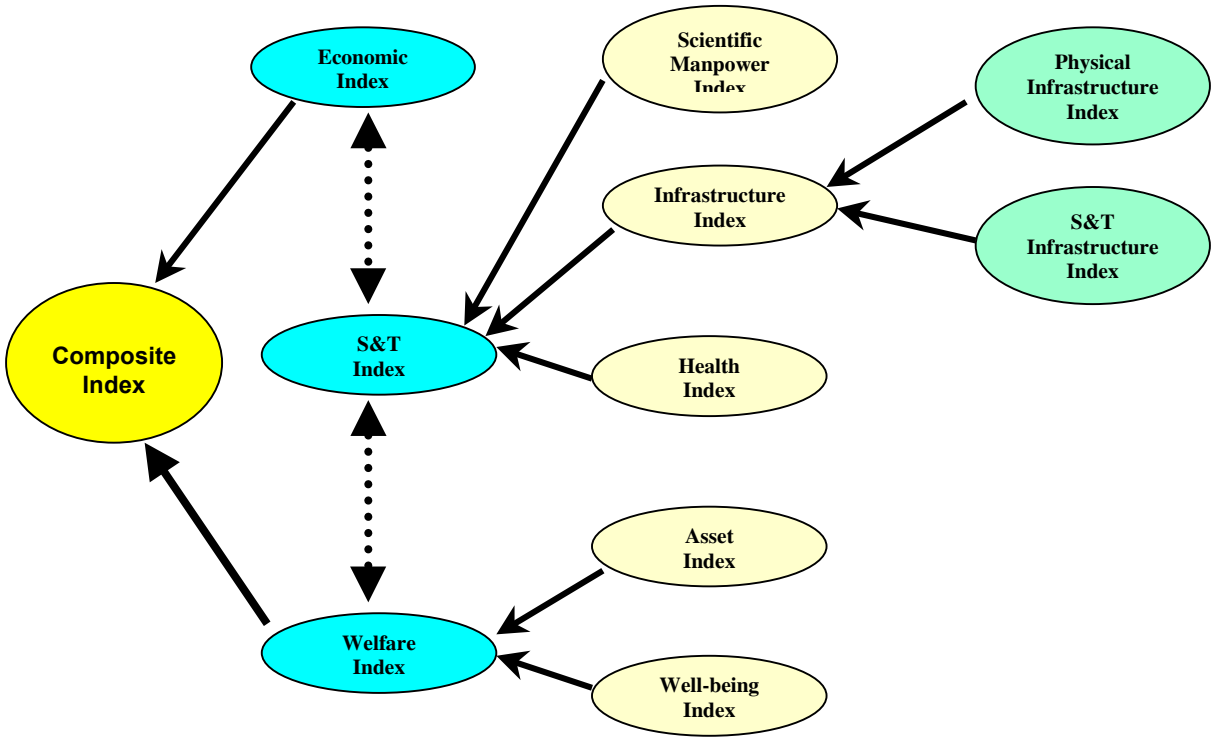
As indicated above, there are three major determinants or indices: Economic, S&T and Welfare. The relationships among these determinants, which themselves are composed of a number of sub-indices, are complex, mutually interacting and multi-directional, so that each of the components is both a cause of change in others and an outcome of the influences of the latter. **Fig.1** presents the conceptual framework of the indices. To get the detail of the indicators, which form these indices, see Annexure Table1.

The proposed Index is constructed on the basis of four socio-economic indicators, namely, per capita State Domestic Product (SDP), per capita debt burden as a percentage of Gross State Domestic Product (GSDP), per capita Foreign Direct Investment (FDI) and per capita employment in the organised sector. These indicators reflect the economic development of the states.

What factors go into the complex interplay of S&T development? This question was posed while selecting the indicators, as the objective was to construct an Index that focusses more on outcomes and achievements rather than efforts or inputs like number of scientists, R & D expenditure and policy environments. This is because the causal relationship between these inputs and outcomes are not well known. For example, does a larger number of scientists lead to greater output in technological advance? Do states that spend more on R & D achieve more?

So, a Composite Index of SA, reflecting the level of scientific progress and capacity of a state, is formed. It takes into consideration both the Output and Input of S&T progress. This Index is not a measure of which state is leading in technology development, but focusses on how well the state is participating in creating and using the technology.

**Figure 1: Conceptual Framework of Composite Index**




Thus the Composite Index of S&T comprises three sub-indices: Scientific Manpower, Health and Infrastructure.

(a) **Components of Scientific Manpower:** To capture the scientific capacity of Indian states, Scientific Manpower consists of 7 indicators: Number of graduates enrolled in proportion to total population (in per cent); share of science graduates to total (in per cent), skilled manpower as proportion of total manpower (in per cent); share of science stock to total stock of higher education (in per cent), HRSTE[3] per million workers, HRSTO[4] per million worker and HRSTC[5] per million worker.

(b) **Components of Health:** The Health of a particular state plays a major role in enhancing its economic growth. There are nine indicators to measure the health status of the people in the region: birth rate per 1,000 population, infant mortality rate, life expectancy at birth of female, population served per government hospital, population served per beds in the hospital, proportion of children immunised between 0-6 years, proportion of women immunised, per capita expenditure on health and proportion of households having access to safe drinking water.

(c) **Components of Infrastructure:** Availability of infrastructure is of paramount importance for the productive capacity of an economy. It is believed to be an essential element for growth and development. Without proper infrastructure

development, a state cannot achieve their full potential for development. Infrastructure is a Composite Index comprising two sub-indices, measuring the physical and S&T infrastructure capacity of Indian states. The Physical Index comprises 12 indicators: urban population ratio, the ratio of total area irrigated to grossed-cropped area, per capita electricity-installed capacity, per capita electricity generated, the proportion of cities and villages electrified in the state, surfaced road length per lakh population, distance to primary school , distance to college, distance to post office , distance to public telephone , distance to commercial banks and distance to medical store . The selected indicators reflect the overall physical infrastructure conditions of a state.

The S&T Infrastructure Index comprises nine indicators that measures the strength of a state's S&T infrastructure. This, in turn, reflects the state's technological progress. Recent breakthroughs, particularly in biotechnology, have led to transformations that are intertwined with economic globalisation leading to a historic shift from the industrial to network age. A new map of technology creation and diffusion is emerging. Better infrastructure facilities help in economic growth and the development process. To capture this dimension, we have included nine indicators: Industrial R&D units per lakh population, total research institutes per million population, research institutions in agriculture per million population, engineering research institutes per million population, medical science research institutions per million population, defence research institutions per million population, per capita infrastructure availability, distance to computer training centres and internet kiosks.

The Welfare Index evaluates the society's overall well-being and/ or standard of living. It comprises two sub-indices, namely, Asset and Wellbeing.

(a) **Components of Asset:** Asset comprises six indicators – TV set, computer, telephone, mobile phone, internet and cable. The proportion of each state's population that owns these durables are evaluated and the indicators reveal the overall affluence of the society

(b) **Components of well-being:** As the name suggests, this Index evaluates the overall wellbeing of society, which in turn reflects the wellbeing of the state as a whole. To measure the Wellbeing, we have included nine indicators: People below poverty line, literacy rate, per capita consumption expenditure (in Rs.), per capita expenditure on education, per capita expenditure on health per capita expenditure on telephone , per capita expenditure on mobile , per capita expenditure on internet and per capita expenditure on cable. By this analysis, the higher the value of the Index, the better the level of wellbeing of the region.

Thus, our Welfare Index is quite a comprehensive composite measurement to capture the quality of life of the people.

### 2.2 Constructing the Index: The statistical approach

Principal Component Analysis (PCA), is a multivariate statistical approach that transforms a set of correlated variables into a set of uncorrelated variables called components. These components are linear combinations of the original variables. PCA is used to reduce the dimensionality problems and to transform interdependent coordinates into significant and independent ones. Nagar and Basu (2002) presented more comprehensive presentation of this approach for development of social indicators. An application of this methodology is also provided in Klein and Ozmucur (2002/2003).

Principal Components (PC) are used as linear combinations of the variables selected to compose the social indicators. They have special statistical properties in terms of variances. The first PC is the linear combination, which accounts for the maximum variance of the original variables. The second PC accounts for the maximum variation of the remaining variations, and so on. Maximising variances helps maximise information involved among the set of variables, and, hence, it is most appropriate for weighting these variables for the development of the Index.

The main reason for employing PCA is that it makes it possible to define a synthetic measure that is able to capture interactions and interdependence between the selected set of indicators making up the three indices. These indicators are called Causal Variables, while the corresponding Index is the explained variable. While standard regression techniques require the explained/dependent variable to be observed, PCA treats the latter as a latent variable. Principal Component constitutes a canonical form and helps to understand both the individual contribution of each of the indicators to the Index and their aggregate contribution. An attractive feature of this methodology is that it permits calculation of statistical weights of the various components of the Index for the sample that thereby identifies what drive the results. A brief technical description of the methodology is presented below:

A Social Indicator is an Abstract Conceptual Variable and is supposed to be linearly dependent on a set of observable components plus a disturbance term.
Let indicator is

$$I = \alpha + \beta_1 X_1 + \ldots\ldots\ldots\ldots\ldots + \beta_n X_n + e \ldots\ldots\ldots\ldots\ldots (1)$$

where, $X_1, X_2, ...X_n$ is a set of components of the Index. The total variation in the Social Indicator is composed of two orthogonal parts: (a) variation due to set of proposed components, and (b) variation due to error.

Subtracting the minimum value of the particular component from its actual value and dividing it by the range, which is the difference between the maximum and minimum value of the selected components by following equation, individually normalise all components.

$$\frac{X_i - X_{\min}}{X_{\max} - X_{\min}}$$

When necessary, raw data have been transformed such that normalised values equal to unity corresponds to the best situation in the sample.

Correlation Matrix R is computed from standardised variables, followed by solving the determinant equation $|R - \lambda I|$=0 for $\lambda$ where R is an n x n matrix. This provides a $n^{th}$ degree polynomial equation in $\lambda$ and hence K roots. These roots are called Eigen Values of Correlation Matrix R. The $\lambda$ is arranged in descending order of magnitude, as $\lambda_1 > \lambda_2 > .... > \lambda_n$. Corresponding to each value of $\lambda$, the matrix equation $(R - \lambda I)\alpha = 0$ is solved for the n x1 Eigen Vectors $\alpha$ subject to the condition that $\alpha'\alpha = 1$ (normalisation condition.). The Index is estimated as weighted average of n principal components (P's), where the weights are the Eigen Values of the Correlation Matrix R, and it is known that

$$\lambda_1 = \text{var}(P_1), \lambda_2 = \text{var}(P_2) = ..... \lambda_{11} = \text{var}(P_n)$$

Thus, the Index is:

$$I = \frac{\lambda_1 P_1 + \lambda_2 P_2 + ..... + \lambda_{11} P_n}{\lambda + \lambda_2 + .....{}_1 + \lambda_n} ....(4)$$

Finally, the estimator of the Index is computed as the weighted average of the principal components.

## 3. Discussion of Indicators

### 3.1 Grouping of Indian States

In all, 21 states have been grouped according to the level of development of S&T, which is determined in the context of their Economic and Wellbeing status.

Delhi, Goa, Tamil Nadu, Kerala and Andhra Pradesh have emerged as the "most advanced", and are at the top-most rung with a score of >0.70. The "more advanced" states are a step below with scores ranging between 0.42 and 0.70. These include Maharashtra, Karnataka, Gujarat, Uttaranchal and Punjab. The third tier of "less advanced" states are those with S&T Index scores of between 0.16 and 0.42 including West Bengal, Assam, Haryana, Himachal Pradesh,Orissa and Uttar Pradesh. Finally, at the bottom of the S&T ladder are the "least advanced" states with scores of <0.16 – Chattisgarh, Bihar, Jharkhand, Madhya Pradesh and Rajasthan (Table 1).

**Table 1: Grouping of the States (2004-05)**

| Most advanced states (S&T index >0.70) | More advanced states (S&T index >0.42 & ≤ 0.70) | Less advanced states (S&T index >0.16 & ≤ 0.42) | Least advanced states (S&T index ≤ 0.16) |
|---|---|---|---|
| Delhi | Maharashtra | West Bengal | Chhattishgarh |
| Goa | Karnataka | Assam | Bihar |
| Tamil Nadu | Gujarat | Haryana | Madhya Pradesh |
| Kerala | Uttaranchal | Himachal Pradesh | Jharkhand |
| Andhra Pradesh | Punjab | Orissa | Rajasthan |
| | | Uttar Pradesh | |

### 3.2 Discussion of Indicators

#### 3.2 .1 Economic Development Indicators

The economic development and general welfare of the four groups of states are indicated in **Table 2**.

It is not surprising that the states that are classified as 'less' and 'least advanced' have bigger population than the 'more advanced' and 'most advanced' states. Further, the per capita state domestic product is much lower for 'less' and 'least advanced' states than those for the 'more' and 'most advanced' states indicating lower economic development. So while the 'most advanced' states have a per capita State Domestic Product of 27,509, for the 'least advanced' state it is less than half (12,275). The debt-burden of the 'least advanced' states is 49.5 compared to 34.9 for the 'most advanced' states. Per capita foreign direct investment is the highest for the 'more advanced' states at 1233 and 435 for the 'most advanced' states while that for the 'less advanced' and 'least advanced' states, the figures are 47 and 2 respectively.

### 3.2.2 Welfare Indicators

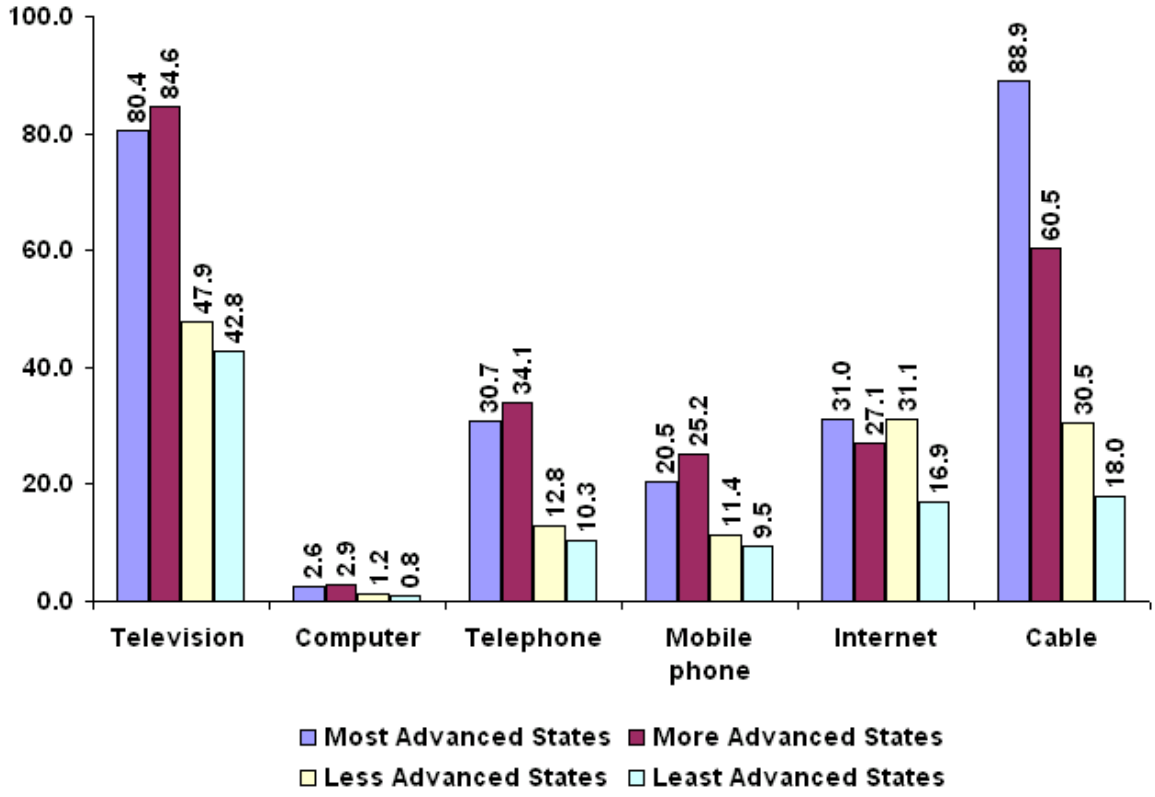
Factors such as poverty levels, literacy rate, per capita consumption expenditure, per capita expenditure on health, per capita expenditure on telephone, per capita expenditure on mobile, per capita expenditure on internet and per capita expenditure on cable indicate the welfare status of the states. Nearly twice the number of people in the bottom-two groups as compared to those in the top-two groups live below the poverty line. The literacy levels in the top two groups (at 82 per cent) is higher compared to the bottom two (74 and 68 per cent). The per capita expenditure on education are Rs 1,003 and Rs 933 respectively for the 'most advanced' and the 'more advanced' states while that for the 'less advanced' and 'least advanced' states it is Rs 588 and Rs 717 respectively. Similarly, the per capita health expenditure for the top two groups is higher (Rs 257 and Rs 207 respectively) than that for 'less' and 'least advanced' states (Rs 202 and Rs 188 respectively) (Table 2).

**Table 2: Socio-economic Indicators**

| Indicators | Most Advanced States | More Advanced States | Less Advanced States | Least Advanced States |
|---|---|---|---|---|
| Population (Million) (2004-05) | 190 | 238 | 350 | 246 |
| Per capita state domestic product (SDP) (2004-05) | 27,509 | 29,002 | 16,188 | 12,275 |
| Foreign direct investment (FDI)- Per capita (2004-05) | 435 | 1233 | 47 | 2 |
| Debt burden of state - percent of GSDP (2004-05) | 34.9 | 32.3 | 15.4 | 49.5 |
| People below poverty line (1999-00) | 16 | 20 | 30 | 34 |
| Literacy rate (2004-05) | 82.5 | 82.2 | 74.4 | 67.6 |
| Per capita consumption expenditure (in Rs.) (2004) | 862 | 835 | 658 | 540 |
| Per capita expenditure on education (Rs.) (2004-05) | 1,003 | 933 | 588 | 717 |
| Per capita expenditure on health (2004-05) | 257 | 207 | 202 | 188 |
| Urban population ratio (2004-05) | 0.39 | 0.41 | 0.21 | 0.20 |
| Irrigated area/gross cropped area (2004-05) | 0.44 | 0.33 | 0.53 | 0.37 |
| Per capita electricity installed capacity (2004-05) | 115 | 171 | 48 | 70 |

As has been discussed in the earlier section, the standards of living of a population – which adds up to its welfare status – are indicated by access to 'assets' such as TV sets, computers, telephones, internet and cable services, mobile phones, etc. While the top two groups of states have a higher penetration of television, telephones, mobile phones, internet and cable services, the corresponding penetration for the bottom two groups of states is much lower **(Fig. 2)**.

**Figure 2: Ownership of Selected Goods and Services (% households own) (2004-05)**




### 3.2.3 Composite S&T Index Indicators

Scientific manpower, health and infrastructure indicate the level of advancement in S&T of the states. The number of research institutes per million population is an indicator of the state's development in the area of S&T. It is evident that the states with better economic performance and higher welfare status are also the ones that have more research institutes across sectors such as agriculture, industry, engineering, medical science and defence **(Fig. 3)**.

Average distance to public facilities such as public phones, primary schools, colleges, computer training institutes and internet kiosks – which are considered essential to determine a states' overall status on the S&T arena – is much more in the 'less advanced' and 'least advanced' states than in the 'most' and 'more advanced' states (Fig. 4).

**Figure 3: Number of Research Institutes per million population (2004-05)**

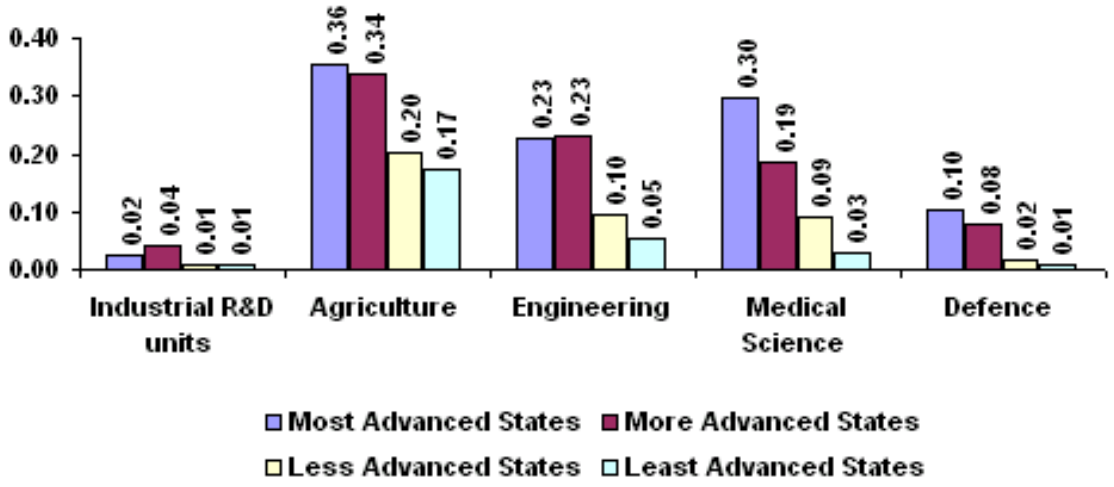
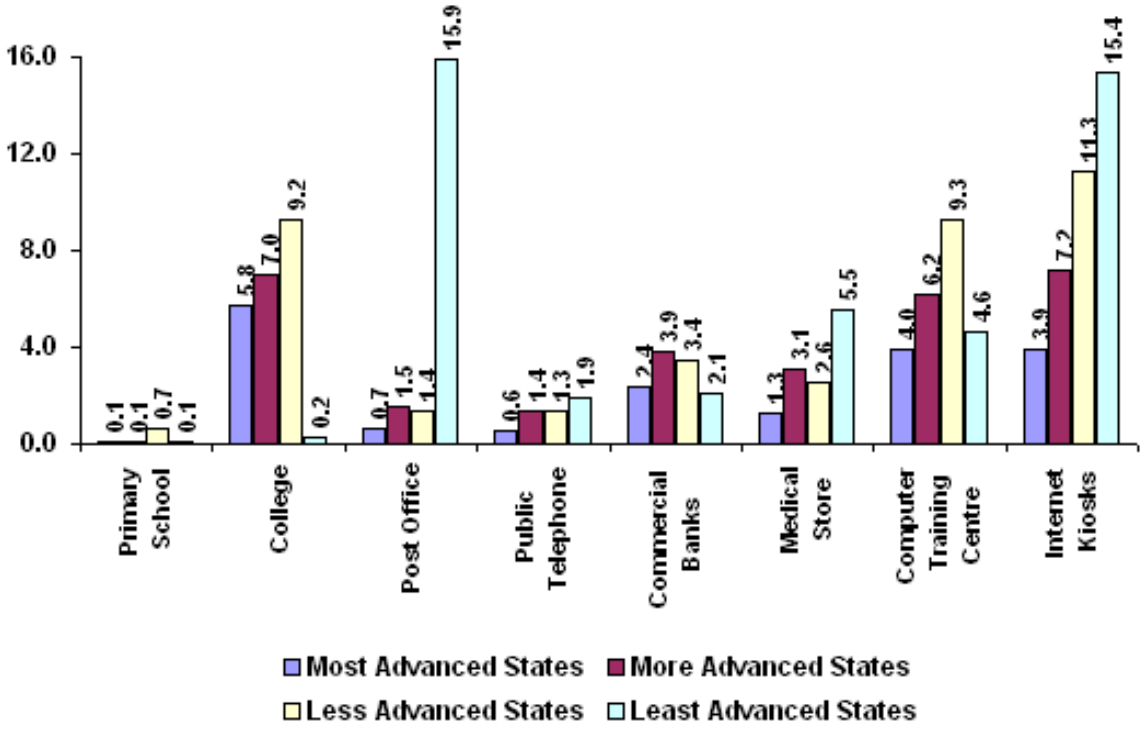



**Figure 4: Average Distance to Selected Public Facilities (km) (2004-05)**




Another key indicator s relevant in measuring a state's S&T development is the health status which is made up of components such as birth rate, infant mortality rate, female life expectancy rate and immunisation rate, etc. Table 3 provides a break-up of these sub-indices. As is to be expected, on each of these counts the 'less advanced and least advanced' states fare poorly as compared to those states in the top two categories. Take for instance, immunisation rates for children: while in the 'most advanced' and 'more advanced' states, it is 105 per cent and 81 per cent respectively, for the 'less advanced' and 'least advanced' states it is a dismal 40 per cent and 16 per cent respectively. Again, while in the

least advanced states, one government hospital bed on an average is available to approximately 3,944 people, in the 'most advanced' states, the number of people that one bed caters to is 955, thus indicating higher availability of hospital beds and services in the latter group.

**Table 3: Health Indicators**

| Indicators | Most Advanced States | More Advanced States | Less Advanced States | Least Advanced States |
|---|---|---|---|---|
| Birth rate per 1000 population (2004-05) | 17.9 | 20.6 | 26.2 | 28.7 |
| Infant mortality rate (%) (2004-05) | 38.8 | 48.9 | 65.5 | 66.8 |
| Life expectancy at birth – Female (2004-05) | 67.8 | 68.1 | 65.0 | 62.0 |
| Population served per govt. hospital (Lakh) (2002) | 0.96 | 0.70 | 1.82 | 4.48 |
| Population served per beds in the hospital (2002) | 955 | 1316 | 2354 | 3944 |
| Proportion of children immunised (%) (2004-05) | 105.3 | 80.7 | 40.0 | 16.0 |
| Proportion of women ANC in the state (%) (2004-05) | 100.7 | 91.4 | 61.7 | 59.1 |

### 3.3 Interpreting Index values

A higher Index score reflects higher performance and vice-versa. Index ranking provides an assessment of a state's performance *vis-à-vis* that of the entire country. Thus, Index ranking could be an indicator of change in the relative performance of the states over the years. The assumption, however, would be that the selected state sample is the same. Nevertheless, it would always be possible to refer to changes in Index values as an indicator of change in relative performance. Index values would then serve as a tool to track the progress of states in respect of its performance across states and over time.

## 4. The Indices and Benchmarking Results

### 4.1 Economic Scores and Rankings

Regional disparity is a major concern for policy makers in India, particularly since some of the states continue to lag behind others in terms of key human development and economic development indicators. This disparity is evident in the four groups of states in this research as well. The estimates and corresponding rankings of the Economic Index and its sub-indices is provided in Table 5. Table 4 provides a summary of all the indices in terms of the weighted scores[6] for all the four groups. It is clearly evident that there is a huge difference between the top and bottom groups across all indices (Fig.5). On the Economic Index, the 'more advanced' states lead with a score of 0.82 followed by 'most advanced' states with a

score of 0.55. The two bottom groups however fall way behind with scores of 0.18 ('less advanced') and 0.15 ('least advanced').

**Figure 5: Indices Scores by Group of States (2004-05)**

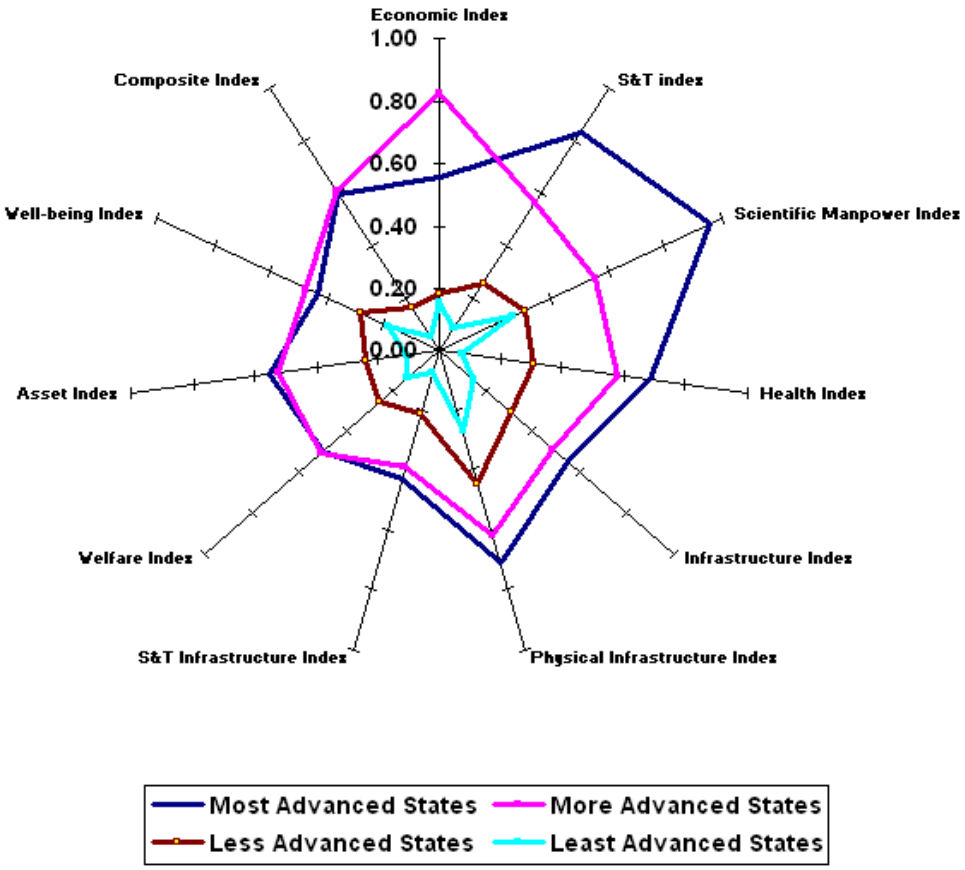



**Table 4: Summary of Indices (2004-05)**

| Index | | Most Advanced states | More Advanced states | Less Advanced states | Least Advanced states |
|---|---|---|---|---|---|
| 1 | Economic Index | 0.55 | 0.82 | 0.18 | 0.15 |
| 2 | S&T Index | 0.84 | 0.56 | 0.26 | 0.08 |
| 21 | Scientific Manpower Index | 0.96 | 0.55 | 0.30 | 0.26 |
| 22 | Health Index | 0.68 | 0.58 | 0.31 | 0.07 |
| 23 | Infrastructure Index | 0.54 | 0.48 | 0.30 | 0.14 |
| 231 | Physical Infrastructure Index | 0.71 | 0.61 | 0.44 | 0.27 |
| 232 | S&T Infrastructure Index | 0.43 | 0.39 | 0.21 | 0.08 |
| 3 | Welfare Index | 0.50 | 0.50 | 0.26 | 0.14 |
| 31 | Asset Index | 0.55 | 0.52 | 0.23 | 0.10 |
| 32 | Well-being Index | 0.43 | 0.47 | 0.28 | 0.18 |
| 4 | Composite Index | 0.59 | 0.61 | 0.16 | 0.05 |

### 4.2 S&T Scores and Rankings

This research is aimed at understanding how states differ in terms of their development in S&T. Does it follow that states that perform better in terms of economic and human development are also the ones to have a superior performance in S&T development? Or, are there inter-state differences, within each of the four groups of states, with respect to S&T growth?

The summary of indices (Table 4) reveals that the 'most advanced' states – Delhi, Goa, Tamil Nadu, Kerala, Andhra Pradesh – score a high 0.9 on the S&T Index compared to the 'more advanced' states which score 0.49, followed by the 'less advanced' states (0.28) and 'least advanced' states (0.10). For each of the sub-indices (Scientific Manpower, Health and Infrastructure), the scoring pattern is similar – with the 'most advanced' states recording the highest scores followed by the 'more advanced', 'less advanced' and 'least advanced' states.

Analysis of the Index scores also reveals that the differentials in the scores of the top two groups are quite high. This indicates that the 'more advanced' states still have some catching up to do with the top-most group in terms of developing its S&T. The bottom two groups have undoubtedly a lot of work to do in term of developing their S&T.

### 4.3 Welfare Scores and Rankings

The 'most advanced' states – with a score of 0.82 – are the best performers on the Welfare Index as well. The next group – the 'more advanced' states – while being closer to the top group when it comes to the Economic Index, however, does not fare as well on the Welfare Index. Their collective score of 0.54 is much lower. The 'less advanced' and 'least advanced' states – with scores of 0.30 and 0.10 respectively – are way down on the Welfare Index. The sub-indices – Asset Index and Well-Being Index – follow the overall-scoring pattern for this index.

**Table 5: Indices Scores and Rankings (2004-05)**

| | | Composite Index | | Economic Index | | S&T Index | | Welfare Index | |
|---|---|---|---|---|---|---|---|---|---|
| Grouping | States | Scores | Ranks | Scores | Ranks | Scores | Ranks | Scores | Ranks |
| Most Developed | Delhi | 1.00 | 1 | 1.00 | 1 | 1.00 | 1 | 1.00 | 1 |
| | Goa | 0.83 | 2 | 0.70 | 5 | 0.89 | 2 | 0.95 | 2 |
| | Tamil Nadu | 0.58 | 7 | 0.44 | 10 | 0.86 | 3 | 0.56 | 6 |
| | Kerala | 0.63 | 4 | 0.54 | 8 | 0.85 | 4 | 0.62 | 3 |
| | Andhra Pradesh | 0.51 | 8 | 0.57 | 7 | 0.78 | 5 | 0.30 | 14 |
| More Developed | Maharashtra | 0.66 | 3 | 0.94 | 2 | 0.62 | 6 | 0.46 | 10 |
| | Karnataka | 0.58 | 6 | 0.76 | 4 | 0.57 | 7 | 0.49 | 7 |
| | Gujarat | 0.63 | 5 | 0.84 | 3 | 0.52 | 8 | 0.58 | 5 |
| | Uttaranchal | 0.33 | 13 | 0.30 | 13 | 0.46 | 9 | 0.40 | 12 |
| | Punjab | 0.50 | 9 | 0.59 | 6 | 0.43 | 10 | 0.59 | 4 |
| Less Developed | West Bengal | 0.34 | 11 | 0.29 | 14 | 0.42 | 11 | 0.48 | 9 |
| | Assam | 0.36 | 10 | 0.48 | 9 | 0.34 | 12 | 0.40 | 13 |
| | Haryana | 0.33 | 12 | 0.40 | 11 | 0.34 | 13 | 0.42 | 11 |
| | Himachal Pradesh | 0.32 | 14 | 0.31 | 12 | 0.33 | 14 | 0.49 | 8 |
| | Orissa | 0.03 | 20 | 0.00 | 21 | 0.20 | 15 | 0.14 | 18 |
| | Uttar Pradesh | 0.06 | 19 | 0.13 | 19 | 0.17 | 16 | 0.12 | 19 |
| Least Developed | Chhattishgarh | 0.09 | 16 | 0.23 | 16 | 0.15 | 17 | 0.09 | 20 |
| | Bihar | 0.00 | 21 | 0.09 | 20 | 0.14 | 18 | 0.00 | 21 |
| | Madhya Pradesh | 0.06 | 17 | 0.17 | 17 | 0.08 | 19 | 0.16 | 17 |
| | Jharkhand | 0.12 | 15 | 0.29 | 15 | 0.00 | 20 | 0.25 | 16 |
| | Rajasthan | 0.06 | 18 | 0.13 | 18 | 0.00 | 21 | 0.28 | 15 |
| All-states | | 0.34 | | 0.41 | | 0.42 | | 0.34 | |

### 4.4 Intra-Group Comparisons

The 'most advanced' and 'more advanced' states perform much better across all indices – economic, welfare and S&T development. However, there are differences in Index rankings among the states within each group. For instance, Goa is ranked second for Welfare and S&T, but emerges at No. 5 on the Economic Development ranking (with a score of 0.70). Kerala, Tamil Nadu and Andhra Pradesh – in that order – are ranked third, fourth and fifth on the S&T Index. However, when it comes to the Welfare Ranking, Kerala is at No. 3, Punjab (which figures in the second category as a 'more advanced' state) is ranked fourth, and Gujarat is ranked fifth. The S&T Index ranking for Punjab and Gujarat respectively are No. 10 and No. 8. (Table 5).

The Index also reveals that it is not mandatory that if a state scores high on the Economic Index, its S&T Index would be of an equal ranking. Take the example of Maharashtra which ranks second in the Economic Index, but in terms of S&T ranking its rank is sixth. Though Goa is ranked 5th on the Economic Index, it is on top of the S&T Index ranking at No. 2.

The states that are at the bottom of the table – in terms of all three indices – have more or less similar rankings and scores for all indices. Consider Chattisgarh, which is ranked 16th

on the Economic Index, 17th on the S&T Index and 20th on the Welfare Index. Clearly, this indicates that there is more to S&T development than just overall economic well being.

## 5. Index Scores: Driving Factors

What drives the results presented above? To respond to this question, coefficients of each of the three dimensions of the S & T Index were obtained. These coefficients make it possible to work out the relative dominance and/or importance of the respective dimensions in determining the S & T scores. A straightforward rearrangement of the weighted dimensions of the S & T helps to express it as a weighted sum of the actual value of its 3 constituent dimensions. Hence,

S&T = 0.51*ScMI +0.38*health (HeI) + 0.41* InfI
where,

ScMI =Scientific Manpower, HeI= Health and InfI= Infrastructure

However, these coefficients should not be interpreted as partial regression coefficients since the left-hand side variable is not observable. For instance, it should not be interpreted as if along with an increase of the Health Index increases there is simultaneous S & T Index improvement by a figure that is proportional to the Health Coefficient. The above identity may be used to compute the share of each dimension in the S & T for each state and for the average S & T value for the sample as a whole.

**Table 6: Summary of the Contribution of the Sub-Indices (%) (2004-05)**

| Index | All-States |
|---|---|
| S&T index | |
| Scientific Manpower Index | 59.2 |
| Health Index | 28.6 |
| Infrastructure Index | 12.1 |
| Infrastructure Index | |
| Physical Infrastructure Index | 51.6 |
| S&T Infrastructure Index | 52.0 |
| Welfare Index | |
| Asset Index | 50.9 |
| Well-being Index | 49.1 |
| Composite Index | |
| Economic Index | 53.6 |
| S &T Index | 54.7 |
| Welfare Index | 48.0 |

Table 6 presents the share of each dimension in the average S & T score for the entire sample[7]. The contribution of Scientific Manpower (Sc MI) to S & T is the largest and explains almost 60 per cent of the S & T score. Contributions of other dimensions vary between 12

per cent and 30 per cent. Similarly contributions of asset and well being index was also calculated for the entire sample.

**Table 7: Summary of the Contribution of Various Sub-Indices in all the Four Group of States (%) (2004-05)**

| Index | Most Advanced States | More Advanced States | Less Advanced States | Least Advanced States |
|---|---|---|---|---|
| **S&T index** | | | | |
| Scientific Manpower Index | 52.0 | 46.4 | 58.7 | 67.1 |
| Health Index | 33.6 | 39.5 | 44.6 | 27.7 |
| Infrastructure Index | 29.9 | 40.8 | 47.3 | 5.2 |
| **Infrastructure Index** | | | | |
| Physical Infrastructure Index | 45.7 | 42.2 | 52.9 | 60.9 |
| S&T Infrastructure Index | 54.7 | 58.5 | 48.3 | 39.1 |
| **Welfare Index** | | | | |
| Asset Index | 59.6 | 52.7 | 43.4 | 48.9 |
| Well-being Index | 40.4 | 47.2 | 56.5 | 51.1 |
| **Composite Index** | | | | |
| Economic Index | 36.7 | 49.3 | 42.5 | 96.6 |
| S&T Index | 45.0 | 34.8 | 80.0 | 25.8 |
| Welfare Index | 31.9 | 33.0 | 67.6 | 84.9 |

Relative contribution of the various dimensions to the corresponding indices for all the four groups of states is presented in Table 7. It is evident that the contribution of Scientific Manpower Index is high for all the groups as compared to the other two sub-indices to the S&T index. The contribution of the Infrastructure Index is good for the top three groups, but it is very less (5.2 per cent only) in case of the least advanced group.

## 6. S & T Index and Some Correlates

In this section, we show the simple correlation of per capita SDP and the three main indices. One might wonder as to what extent the Index is in fact contributing to give an impetus to per capita SDP.

The simple rank correlation coefficient between the Economic Index and per capita SDP is 0.817 (coefficient is significant at 1 per cent level). Similarly, the correlation between S&T and SDP is 0.732 (coefficient is significant at 1 per cent level). This is good pointer that the Economic Index is well explaining the economic performance of the states (Table 8).

**Table 8: Rank of Indices and Per Capita SDP - Indian States (2004-05)**

| States | Economic index | S&T index | Welfare index | Composite index |
|---|---|---|---|---|
| Andhra Pradesh | 7(11) | 5(11) | 14(11) | 8(11) |
| Assam | 9(17) | 12(17) | 13(17) | 10(17) |
| Bihar | 20(21) | 18(21) | 21(21) | 21(21) |
| Chhattishgarh | 16(14) | 17(14) | 20(14) | 16(14) |
| Delhi | 1(2) | 1(2) | 1(2) | 1(2) |
| Goa | 5(1) | 2(1) | 2(1) | 2(1) |
| Gujarat | 3(6) | 8(6) | 5(6) | 5(6) |
| Haryana | 11(3) | 13(3) | 11(3) | 12(3) |
| Himachal Pradesh | 12(7) | 14(7) | 8(7) | 14(7) |
| Jharkhand | 15(19) | 20(19) | 16(19) | 15(19) |
| Karnataka | 4(10) | 7(10) | 7(10) | 6(10) |
| Kerala | 8(8) | 4(8) | 3(8) | 4(8) |
| Madhya Pradesh | 17(16) | 19(16) | 17(16) | 17(16) |
| Maharashtra | 2(4) | 6(4) | 10(4) | 3(4) |
| Orissa | 21(18) | 15(18) | 18(18) | 20(18) |
| Punjab | 6(5) | 10(5) | 4(5) | 9(5) |
| Rajasthan | 18(15) | 21(15) | 15(15) | 18(15) |
| Tamil nadu | 10(9) | 3(9) | 6(9) | 7(9) |
| Uttar Pradesh | 19(20) | 16(20) | 19(20) | 19(20) |
| Uttaranchal | 13(13) | 9(13) | 12(13) | 13(13) |
| West Bengal | 14(12) | 11(12) | 9(12) | 11(12) |
| Rank correlation | 0.817* | 0.732* | 0.851* | 0.818* |

**Note:** (…) rank of per capita SDP, * significant at 1% level. Rank 1 is the best performer and 21 is the worst.

Also, the grouping of the states done on the basis of the S&T Index scores is appropriate, as those states that have high per capita SDP make up the top two groups. An almost similar pattern is observed for the Welfare Index as well. The rank correlation coefficient for the Welfare Index is 0.85 (significant at 1% level).

**Table 9: Rank Correlation Coefficient of Three Major Indices- (2004-05)**

| Indices | Rank correlation coefficient |
|---|---|
| Economic & S&T Index | 0.82* |
| S&T & Welfare Index | 0.81* |
| Economic & Welfare Index | 0.82* |

* Significant at 1% level.

## 7. Concluding Remarks

This study's Conceptual Framework provides some basic information on regional disparities in terms of economic, scientific and technological and human development. The states that have been more successful in exploiting available resources and overcoming barriers to economic and technological development can provide crucial clues and directions towards better economic, human and S&T development.

Sustainable S&T development requires efforts in all three aspects of development – scientific, economic as well as human. While some states have achieved breakthroughs in adopting new techniques of development and adapting them to benefit their people, these lessons have not been put to use in the rest of the country. Therefore, there is still a tremendous amount of work to be done in the bottom-most rung of the S&T ladder in terms of developing appropriate environment, research institutions in the public as well as private sectors and adequate physical infrastructure.

## Notes

1. While delivering the convocation address at the Allahabad University in 1946, Nehru said, “It is science alone that can solve the problems of hunger and poverty, of insanitation and malnutrition, of illiteracy and obscurantism of superstition and deadening customs, of rigid traditions and blind beliefs, of vast resources going to waste of a rich country inhabited by starving millions.” The then leaders of science ably supported Nehru in his vision.
2. See Marjit et. al. (1996), Sachs et al (2002), Rao et al (1999) among many other studies.
3. Human resource in science & technology by education.
4. Human resource in science & technology by occupation.
5. Human resource in science & technology by occupation and education.
6. Since all the states have different populations, so weighted scores are calculated by taking population into consideration. For example, to calculate weighted score for most advanced states: economic score of each state is multiplied by its corresponding population and then the weighted average of all the states is taken.
7. For example, to calculate the average share of health index (He I), the current value of He I for each state is multiplied by the value of coefficient (i.e. 0.38) and divided by the state’s S & T current value. The average of states share of He I in S & T is then computed.

## References


1. Klein LR and Ozmucur S (2002/2003). The Estimation of China’s Economic Growth. Journal of Economic and Social Measurement, 62 (8), 187-202.
2. Meghnad Desai, S. Fukuda-Parr, C. Johansson, and F. Sagasti (2002): Measuring Technology Achievement of Nations and the Capacity to Participate in the Network Age. Journal of Human Development, Vol. 3, No. 1, 2002.
3. Nagar AL and Basu SR (2002) Weighting Socio-Economic Indicators of Human Development: A Latent Variable Approach, in Ullah A et al. (eds) Handbook of Applied Econometrics and Statistical Inference. Marcel Dekker, New York.
4. UNCTAD (2002): Trade and Development Report 2002, UNCTAD, New York and Geneva.

## Annexure 1: Summary of Indicators for Different Indexes

| Index | Indicators | Source |
|---|---|---|
| **Economic Index (4)** | Per capita state domestic product (SDP) | Economic Survey (2004-05) |
| | Debt burden of state – percent of GSDP* | Report of the Twelfth Finance Commission (2005-2010), November 2004, Govt. of India & Past Issues. |
| | Foreign direct investment (FDI)- Per capita | Lok Sabha Unstarred Question No. 182 dated 01.03.2005. |
| | Employment in organized sector* | Institute of Applied Manpower Research |
| **Physical Infrastructure Index (12)** | Urban population ratio | National Survey of Household Income and Expenditure (2004-05) |
| | Irrigated area/gross cropped area* | Ministry of Agriculture, Govt. of India. |
| | Per capita electricity installed* | Madhya Pradesh State Electricity Board. |
| | Per capita electricity generated* | Lok Sabha Question No.2702 dated 5.12.2002. |
| | Proportion electrified villages* | Rajya Sabha, Unstarred Question No. 67, Dated 07.07.2004. |
| | Surfaced road per lakh population* | Department of Road Transport & Highways, Govt. of India |
| | Distance to Primary School (Km) | National Survey of Household Income and Expenditure (2004-05) |
| | Distance to College (Km) | |
| | Distance to Post Office (Km) | |
| | Distance to public Telephone (Km) | |
| | Distance to Commercial Banks (Km) | |
| | Distance to Medical Store (Km) | |
| **S&T Infrastructure Index (9)** | Industrial R&D units per lakh population | Government of India |
| | Distance to Computer Training Centre (Km) | National Survey of Household Income and Expenditure (2004-05) |
| | Distance to Internet Kiosks (Km) | |
| | Per capita State Expenditure on infrastructure* | Twelfth Finance Commission Report |
| | Total Research Institutes per million population | Government of India |
| | Research Institutions in Agriculture & Related per million population | |
| | Research Institutions in Engineering per million population | |
| | Medical Science Research Institutions per million population | |
| | Defense Research Institutions per million population | |

| Index | Indicators | Source |
|---|---|---|
| **Health Index (9)** | Birth rate per 1000 population* | Sample Registration System (SRS) Bulletin, Volume 37, No. 2, October 2003, Registrar General, India. |
| | Infant mortality rate* | Rajya Sabha Starred Question No. 42, dated 04.03.2002 |
| | Life expectancy at birth – Female* | Family Welfare Programme in India, 2001 and Health Information of India 2002, Ministry of Health & Family Welfare, Govt. of India & Past Issues |
| | Population served per govt. hospital | Directorate of Health Services of States/UTs |
| | Population served per bed in the hospital | |
| | Proportion of children immunized* | National Family Health Survey (Part I & II) |
| | Proportion of women ANC* | |
| | Per capita expenditure on health | Planning Commission, Govt. of India. |
| | Proportion of the households having access to safe drinking water | National Survey of Household Income and Expenditure (2004-05) |
| **Asset Index (8)** | % of household own four wheeler | National Survey of Household Income and Expenditure (2004-05) |
| | % of household own two-wheeler | |
| | % of household own television | |
| | % of household own computer | |
| | % of household own telephone | |
| | % of household own mobile | |
| | % of household access to internet | |
| | % of household access to cable TV | |
| **Well-being Index (10)** | People below poverty line* | Tenth Five Year Plan 2002-07, Volume-III, Planning Commission, Govt. of India. |
| | Literacy rate | National Survey of Household Income and Expenditure (2004-05) |
| | Per capita consumption expenditure (Rs.) | National Sample Survey- 60$^{th}$ Consumption expenditure round |
| | Per capita expenditure on education (Rs.) * | Ministry of Human Resource Development |
| | Per capita expenditure on health (Rs.) * | Rajya Sabha Unstarred Question No. 756 dated 28.07.2003. |
| | Per capita expenditure on telephone (Rs.) | National Survey of Household Income and Expenditure (2004-05) |
| | Per capita expenditure on mobile (Rs.) | |
| | Per capita expenditure on internet (Rs.) | |
| | Per capita expenditure on cable (Rs.) | |

* Estimated figures for corresponding years were calculated by applying growth rate on the most recent data available.