Construction and Validation of 'Science Culture Index'

Results from Comparative Analysis of Engagement, Knowledge and Attitudes to Science: India and Europe

Working Paper No: 100

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Supported by

Royal Society, UK

London and Delhi
January 2009

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Rajesh Shukla[2] and Martin W Bauer[3]

Abstract

Countries world-wide routinely collate statistics on STS performance indicators such as R&D expenditure, science publications, citations and impact, high-tech employment, and penetration of high-tech goods. In parallel there have been several, but often isolated, attempts to define complementary 'public understanding of science (PUS)' indicators including concepts such as scientific literacy, public sentiment, interest, and attitudes. This has been somewhat successful, but also controversial. Thus, little progress has been achieved to explicitly combine STS performance indicators and PUS indicators in a composite index of 'science culture'. This exercise draws conceptual and methodological material used in the construction of such a composite index based on a combined data base of EU (32 countries) and India (23 States). On the basis of these 55 'state units' the theoretical basis, feasibility and validity of a globally portable index of science culture is demonstrated. Details of the analytical options considered and decisions made, particularly in regard to integration of two data sets, identifying and defining indicators, constructing composite indices and finally its validation has been discussed. The discussion inevitably involves a degree of EU-India specific analyses, however, the methodological issues and suggested solutions are of broader interest to researchers on the topic in other contexts.

[1] Authors are thankful to Royal Society (UK) for providing financial support under the 'UK-India Science Network Programme' to undertake this study. We also thank Ms. Asha Sharma, Ms. Preeti Kakar and Ms. Nitasha Monga of NCAER for providing necessary assistance in the analysis and preparation of the report. The views expressed here are of the authors and do not necessarily reflect those of their respective institutions.
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1. Introduction

Public understanding of science is increasingly recognised to play a role in R&D policy making, as it expresses the national aspirations with regard to science and technology. But hitherto there is a limited internationally comparative research to address this issue with a global outlook and required objectivity. Discussions of public understanding of science have been limited to national or regional data, and particular they have been limited to developed and industrialised countries. In this context, the current project was aimed to extend the analytic framework of public attitudes so that it is adequate to both developing (India and parts of new EU and EU candidate countries) as well as developed contexts (EU15) seeded by a grant from the Royal Society's UK-India Science Network programme in 2006.

Two world's largest and most elaborate datasets (Annexure 1), motivated under the agenda of assessing the 'public understanding of science' of the general public in Europe and India, provide the common basis for this endeavour.

a) The Indian survey was conducted in October/November 2004 (National Science Survey 2004 undertaken by NCAER under the leadership of Rajesh Shukla) covering all major Indian states (23) with a sample of over 30,000 face-to-face interviews, representative of the population in terms of age, gender and education, based on a sampling frame of 350,000 individuals. The survey was based on multi-level stratification covering states, districts and villages or urban blocks.

b) The European survey was conducted in January 2005 (Eurobarometer 63.1; Martin W. Bauer chaired the team designing the measurement instrument on behalf of DG Research) with a national sample of N=1000 through face-to-face interviews covering 32 countries. The survey covered EU25, EFTA and the candidate countries. The total sample size is 32,000, multi-stage stratified to be representative of the resident population in metropolitan, urban and rural areas in each country.

Separately and jointly these datasets constitute the most extensive and one of the best quality comparative datasets on public understanding of science of the general public to facilitate an attempt for comparative analysis of various indicators across 55 political units (considering that India has 23 states). One of the requirements for a science culture index is surely global relevance, and to demonstrate this relevance a widely differing contexts is a useful point of departure. The integrated dataset offers to construct and to model a "science culture index" across a range of contexts that span the Indian subcontinent and 'old' and 'new' Europe serve as 'extreme cases' to validate the resulted science culture index.

In this report we have attempted to argue the case, construct and show the potentials of a 'science culture index'. One of the key purposes of this exercise is to show how 'subjective' and 'objective' indicators of science could combine into a unified and useful index. This is a first step in that direction both in terms of scope and quality of data. We believe this collaborative research and analysis is likely to have significant global implications in the area of PUS research and development of 'science culture index'. This report is aimed towards following objectives.

- To situate indicators of 'public understanding' and traditional 'science indicators' within a wider concept of 'science culture' that combines both structural and symbolic elements of scientific activity.
- To construct a global index of 'science culture' that combines objective and subjective indicators.
- To make productive use of empirical PUS research, in particular by considering the non-linear relationship between literacy, attitudes and engagement for the construction of such an overall index. Non-linearity suggests the need of conditional transformations of indicator values for the model.
- To test the reliability and to validate and to benchmark the global index in a combined database of 55 state units across the wide range of contexts offered by a comparison of India and Europe.
- To re-open the discussion on the integration of 'public understanding' indicators into science indicators.

2. The need for cultural indicators of science

2.1. The science indicators context

The business of science indicators has come a long way, both in terms of methodological scrutiny as well as the level of institutionalisation. R&D expenditure, manpower, patents, high-tech balance of payments have become routine national statistics in many countries across the world, while statistics on publications and citations are provided by a private business with a world monopoly (initially Institute for Science Information of 1960, nowadays incorporated by Thompson Science). The construction of science indicators based on input, process and output measures moved on from early discussions of a 'science of science' (Price, 1963) and the foundation of journals like SCIENTOMETRICS in the late 1950s. Science indicators were the remit of a few national and international actors. After precursors in government agencies of the United States, Britain and Canada that reach back to the 1st world war, there came the initiatives of UNESCO (since 1960) endorsing the concept of 'science activities' (STA) and the NSF with its trend-setting annual 'science indicators' including a wide range of data (1st report of 1973) but limited analysis. The OECD pursued a narrow economist agenda, first with Frascati of 1963 to construct a database on R&D and manpower input, later added output data on hi-tech balance of payments (1990), on innovations in Oslo 1992, on human resources in Canberra 1995, and opening its remit with the more recent PISA programme on literacy attainment. The EC also made its most important contribution with innovation statistics in the 1990s (see Godin, 2005, 21ff) and also with a series of Eurobarometer surveys on attitudes.

Most of these efforts focus on input and output data collected for specific purposes. OECD standardizes and collates science statistics among industrial member countries. UNESCO attempts are wider both in coverage and concept, for example with its ‘World Science Reports’ (UN 2003) and subtle differences in emphasis. UNESCO’s notion of ‘science activity’ (STA) operates traditionally with a wider definition of relevant indicators. On the other hand it battles with lacunae in basic information in many regions of the world. Africa and the Arab world are found lacking basic statistical information in this area (Butler, 2006). Without concerning ourselves with the protracted political history of these diverse efforts which are excellently analysed by Godin (2005), now a days more reliable data on science indicators are available globally. However, there is clearly an economist bias in the tradition towards facts that are easily scaled on a monetary metric.

‘Subjective’ indicators of culture such as the **climate of opinion, belief, attitudes, interests, values, or the ‘semiophere’ of science** were never a formal part of these efforts towards science indicators, although efforts to measure the culture of science have an equally long and patchy history. The UNESCO, whose statistical efforts focused on ‘human resources’ from the beginning, operated with the concepts ‘science activity’ (STA) and ‘related science activities’ (RSA) including communication, education, product testing and improvement, which is a wider concept of ‘science’ than R&D and patenting. In the concepts, STA and RSA subjective indicators might have found their place more easily. Godin (2005, p75ff) reports that Canadian calculations showed that RSA captured 33% of government expenditure towards science, the remaining were made up by OECD defined industrial R&D. Since 1971, NSF in its report on scientific indicators considered “public attitudes” as an important issue along with other issues such as funding streams, education, PhDs, publications, patents, citations, and impacts. A similar approach was recently taken by FAPESP (2004) for the state of Sao Paulo in Brazil, and for the 1st India Science Report (Shukla, 2005). But in all these efforts the objective and the subjective world of science are neatly separated, relegated to different chapters with little reference to what goes on in other chapters.

In summary, there appears to be momentum in national and international efforts to put science indicators on a broader basis and also to consider subjective indicators as measures of intangibles assets. However, not much effort has been made to integrate objective and subjective indicators into a single model of science culture. Thus, it is our ambitious, if not daunting project to attempt this in this report.

2.2 Why the culture of science?

Does scientific culture really matters for the society? Since **culture is intangible that matters**, thus answer to this question is not straight-forward. The symbolic world is both a condition as well as a catalyst of activities. The 'subjective' side of human action, the dispositions, attitudes, imagination, moods and sentiments, are not epiphenomena of objective structures. They condition how people deal with the existing structures. This view seems to be taken-for-granted among historians who take the long-view. In their research, cultural comparisons feature prominently in explaining the path of technological developments both within the western world and between Western and other regions of the globe (e.g. Berg & Bruland, 1998). Human actions are doubly constraints, by external and internal conditions, and this seems obvious for science research and technological innovations. Since the 'objective world' is not a good proxy of the 'subjective world' in human affairs, and vice-versa, thus neither of the two should be ignored as both are complementary to each other. For world development both of them matter.

Erdal Inonu (2002) showed that **science production is poorly explained by economic facts** (i.e. GDP or GDP per capita in purchasing power parities). There are poor countries with rich science, and rich countries with poor science. Non-economic conditions need to be considered to understand a country's science production. The differential traditions of education and polity come into play, and, how these interact with people's representations of science, their imagination, attitude and motivations.

Take the field of democracy and development; similar concerns can be found. The process of democratisation across the world is not simply a matter of economic prosperity, the richer the more democratic. Research shows that one has to consider the citizen's motives, the 'emancipatory impetus' of autonomy and self-expression and its buttress in public conservations that mediates positively the relation between economy and democratisation (e.g. Welzel, 2006). By analogy, if science productivity is not explained by economic prowess only, the motivation and sentiment of citizens also play a role.

In this report, we will explore the hypothesis that the 'culture of science' is an independent driver of scientific society. There might be two versions of this hypothesis, a weaker and a stronger formulation, which take the following mathematical form for the sake of brevity.

Model Ia: Science Culture (SciCult)= STS + PUS = a*(STS) + b*(PUS) + error

Model Ia stipulates an additive function. Science culture is an additive function of objective structures (STS) and public understanding (PUS). Empirically their contribution is weighted and retains a residual of unexplained variance. But key fact is that, in extreme cases when PUS = 0, science culture will be fully explained by the structural variance (STS). Or in a dynamic model, if PUS does not change while STS does, or vice-versa, this will still result in a change of science culture. PUS is thus an additional, but not a necessary contribution to the science culture.

Model Ib: Science Culture (SciCult) = STS x PUS ⇔ ln(SciCult) = a [ln(STS)] + b [ln(PUS)] + error

The stronger Model Ib stipulates a product function; science culture is the multiplicative function of STS and PUS. This states that, if PUS = 0, science culture would also have no existence. This model defines that PUS is a necessary component of science culture. Logarithmic transformation makes this relationship additive for purpose of empirical testing. In the dynamic version, a change in structure without a change in PUS, or vice-versa, will not result in a change of science culture. Both models allow for a compensatory function of PUS, a lagging science structure (STS) might be compensated by a higher PUS.

2.3 What are cultural indicators?

The term 'cultural indicator' has been used differently in the literature depending on the context and a few examples are given below.

Firstly, the term refers to the **performance of the culture industry**, the sector of the economy that includes design, architecture, advertising, cinema, arts, music, museums, the production and consumption of products and performances. Culture is seen as a productive sector, also known as the 'creative industry'. Indicators account for it like for any other sector of the economy, by its added value to GNP, its share of employment, its relative growth and expert value (e.g. for the UK the Work Foundation, 2007). The advertising sector is well documented globally and closely tied with economic growth and its cycles (e.g. Chang & Chan-Olmstead, 2005).

Secondly, UNESCO uses the term to compile statistics on **cultural diversity** including languages, religions, festivals, sites of nature and heritage, museums, communication and translation efforts, and the consumption of cultural goods like cinema or museum visits and concert going [see http://www.unesco.org/culture/worldreport]. Diversity is a problem of differential access, but also a source of creativity and thus an intangible economic asset. The system of indicators is still in development, but aspires to global reach and consistency.

Thirdly, FAO sponsored an initiative on 'Cultural Indicators for SARD', i.e. sustainable agricultural development (FAO, 2003). Here the term serves as the title for a questionnaire among indigenous peoples and their representatives to assess the significance of local and traditional knowledge in their agricultural practices. Here the term confers significance to traditional knowledge as an asset of traditional agriculture.

Fourthly, the term has a history in mass media research. Here cultural indicators refers to the 'cultivation' research programme which studies the mid-range power of the mass media to cultivate ideological beliefs about the world, such as 'the world is generally mean' (see Gerbner, 1969). This programme combines systematic mass media scoring, the cultural indicator, with large scale survey research, the public belief, to assess the extent to which belief is 'cultivated' in function of exposure to television: the more hours a day you watch TV the more you assimilate your worldview to that of the average TV program. These studies were paradigmatically focussed on the presentation of **violence on TV** and the resulting **belief in a mean world**. Similar effects were found on gender images, or public opinion on Science and technological developments in society. Here culture mostly means the **'unrealistic world of television'**, empirically de-facto mainly in the US, which is a driver of everyday beliefs, the independent variable in the research programme.

***Fifthly*,** the term cultural indicators arises in cultural sociology that maps **cultural change on the bases of mass media analysis** (e.g. Klingemann, Mohler & Weber, 1982). Here the data stream is mass media material coded with the systematic rationale of longitudinal content analysis. An interesting feature of these discussions is the distinction between 'social' and 'cultural' indicators. Social are **indicators of actions**, metrics by which one evaluates social interventions. They can indicate the successes and failures in the management of social affairs like poverty, infant mortality, crime, analphabetism etc. By contrast, cultural are **indicators for action**. They map a context to be considered for action, but not to be acted upon at least in the first instance. This context might be very diverse and uncontrollable (see Melischek, Rosengren & Stoppers, 1984). Before the climate was anthropogenic, one would have used the metaphor of 'moral climates' as opposed to the 'daily weather of opinions'. This notion suggest to open the view for alternative data streams other than the representative survey based on standardised questionnaires responses, e.g. to map the public climate for science through systematic mass media monitoring (see Bauer, 2000).

Sixthly, the term 'culture' appears in forms of **co-variance analysis** of literacy data. For example the international assessment of mathematical literacy (TIMSS) uses a variety of scales that measure different cognitive demands of mathematical problem solving. With differential profiles of average strength and weaknesses, these scales characterise '**national cultures of mathematics':** The US focussing on declarative and procedural knowledge, France emphasising advanced concepts, Sweden oriented towards practical problem solving, and Germany is good in graphical representations. These profiles reflect traditions of teaching some mathematical competences at the expense of others (e.g. Klieme E & J Baumert, 2001).

Finally, the term cultural indicators appears in large scale survey research to refer to **a class of questionnaire items** which tap into cultural dispositions with a long cycle of change, namely **values**. By contrast more 'superficial' opinion, attitudes and beliefs have a shorter life cycle. Here the problem is to operationalise this class of variables with survey items, and to monitor the long-term changes in and across populations. Examples are the research into 'post-materialism' (e.g. Inglehart, 1990) and subsequent global efforts of the 'world value survey' around values orientations of survival, life style, well-being and happiness [http://www.worldvaluessurvey.org]. These efforts must be seen as a part of the **subjective social indicators movement**, which since the 1970s gathered pace and established monitors of the 'subjective state of the nation'. For example, the measurement of 'confidence in institutions' has received critical methodological reflection as to potential sources of error: the measures vary with the company that does the survey, inferences on a change of state must be based on large differences in order not to be misleading (Turner & Krauss, 1978).

For the present purpose, we would like to retain several, but not all of the above concerns, in particular the concerns for

- The global quest for a routine science culture index with a global validity;
- Culture as a context for action rather than a focus of management; and
- Datasets based on representative surveys of the population.

2.4 Subjective science indicators

The efforts of measuring the subjective attitudes to science have come some way. For example the US NSF publishes an annual report on 'Science Indicators' since the 1973 that includes an assessment of public sentiment. However, despite its tradition there is little or no attempt to integrate public sentiment with other, more objective indicators of science, neither nationally nor internationally. Nor is there an academic research stream that would discuss such efforts. Only recent late-comer activities point in a different direction, where both objective and subjective indicators enter the picture of constructing indicators jointly, for India (Shukla, 2005) and for Latin America (Polino, 2005). It seems that the two exercises, science indicators and indicators of public understanding, develop in parallel universes, the one widely institutionalised, the other depending fragile and shifting co-operations civil servants and interested academic researchers.

Table 1: The two-culture model of public understanding of science

Industrial PUS	**Post-industrial PUS**
Knowledge is bi-modal [sd(K) ~ large]	Normalized knowledge [sd(K) ~ small]
High social stratification of science knowledge [R^2 >> 0]	Less social stratification of science knowledge [R2 ~ small]
Knowledge increases interest, interest increases knowledge; [K x int >> 0]	Interest decreases: science is taken for granted; [K x int ~ 0]
There is a unified canon of popular science knowledge [one dimension]	Even popular science knowledge tends towards specialisation [several dimensions]
Higher knowledge leads to more support of science [K x att >> 0]	People are informed about science but vary in their conclusions about the significance of science for society. [K x att ~ 0]

The measurement of adult public sentiment of science has received its fair share of academic attention and reflections, and made some modest progress. A recent review of 25 years of research (Bauer, Allum & Miller, 2007) has made three observations. Firstly, over the years the research has shifted from 'literacy' to 'public understanding' (literacy + attitudes), exploring in some detail the relationship between literacy, knowledge and attitudes. Secondly, the use of such measures might shift **from assessing the public understanding to evaluating exercises of public engagement** for science, science festivals, consensus conferences, organised national debates, hearings, tables rondes etc. Science event making and exercises of public engagement have received much attention in recent years under the heading of 'science and society' or 'technologies of humility' (a term used by S Jasanoff). Indicators of this kind might be increasingly used as performance indicators: what does public involvement bring? Thirdly, the debate on such indicators has been focusing on limited alternatives. On the one hand on the demonstration of **public deficits** of literacy and acceptance of science & technology, on the other hand, it was argued that such data is useless or at worst misleading data, because they serve to buttress elite prejudices vis-à-vis a 'public' that is construed to be ignorant and therefore with limited goodwill towards science or even anti-science. What this bifurcated polemic omits? it's the notion of the public as an asset, configured differently in different contexts. Public sentiments are indicators of the **public as a resource** for the development of science and technology, but this could manifest itself differently in different contexts. Public sentiments are a resource for science development, a non-tangible asset that requires investment and repair. The question remains how to define and to assess this asset.

The models of 'science literacy' and of 'public understanding of science' have defined public sentiment as a complex of interest, knowledge and attitudes. The expectation is that all these are positively correlated. This fact can be achieved by fiat of definition: a person is 'scientifically literate' if and only if she shows 'a level' of interest, is 'sufficiently' knowledgeable, and holds 'positive' attitudes towards science in its various contributions to society. Empirically this expectation motivates efforts to demonstrate the positive correlation between interest, knowledge and positive attitudes: whoever is knowledgeable, will also be more interested, and will display positive attitudes. The paradigm is summarised by the common sense saying 'the more you know, the more you love it'.

Previous cross-national analysis of surveys of public sentiment towards science has suggested that this model, might not be entirely wrong, but has a limited validity within the path of science and technological development. It depends both on the subject matter (Allum et al, 2006), for controversial issues the correlation is weaker, and on the level of economic development. The 'two-culture' model of PUS suggests that positive correlations between interest, knowledge and positive attitudes are a special case, mediated by the position of a context on a scale of development measured by level of industrialisation (Bauer, Durant & Evans, 1994). Table 1 contrasts schematically the differences between the polar ends of a scale of societal development. In an industrial society, the classical model of PUS largely holds true, while in a post-industrial society the distribution and relationship between these three variables systematically differs, in particular the relationship between knowledge and positive attitudes is no longer expected. Preliminary evidence within Europe shows that the two-cultural idea cannot be dismissed easily (Durant et al, 2000; Allum, Boy & Bauer, 2002).

2.5 Comparing Europe and India

Two survey efforts in India and Europe, by Eurobarometer in 2005 and NCAER 2004 (Annexure 1-A), were partially co-ordinated and made comparable by the present authors. This allows us to assess the 'two-culture model' in a cross-sectional context on a larger scale of development disparity.

The two surveys were integrated at micro level. The common core of variables includes **engagement** (visits to science expositions and fairs), **interest** and **informedness** of science, nine items measuring **science literacy**, and seven **attitude** items, together with socio-economic information about the respondent such as **gender, age**, and level of **education**. These items had either exactly or functionally equivalent formulations - in some cases we needed the collapse of response alternative to the common set - and were integrated into the combined dataset for the purpose of statistical analysis (Annexure 2).

Scalar analysis of all these items allows us to construct the following scales with fairly reliable characteristics across the two populations:

- Knowledge or literacy
- Attitudes (AttA and AttBc)
- Interest: scales
- Confidence (felt informedness)
- Engagement with expository science

Attitude is compared on two different scales. This arises from the fact that EB63.1 includes two different version of the questionnaire (split-half designs). One set of attitude items (AttA) is comparable only to one half of the EU population, while a second set (AttBc) is comparable to the other half. AttA includes the following two items 'Science & technology are making our lives healthier, easier and more comfortable' and 'Scientists should be allowed to do research on animals'. AttBc includes the following two items 'New technology makes work interesting' and 'Modern science and technology will create better opportunities for the next generation'.

2.5.1 Knowledge and attitudes

Examining the relationship between knowledge and the four other concepts interestingly challenges the linearity assumption of the standard model of PUS. Plotting knowledge against each of these indicators, allows us to examine the linearity and non-linearity of aggregate measures across the 55 units of analysis in Europe and India.

Figure 1: Correlation between 'Knowledge (know)' and 'Attitude (AttA)'

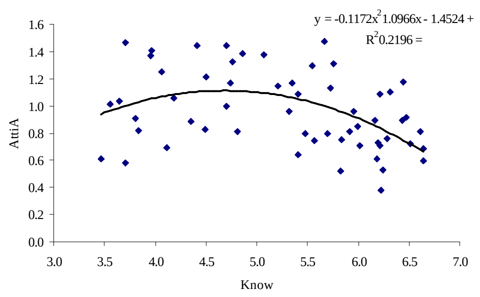
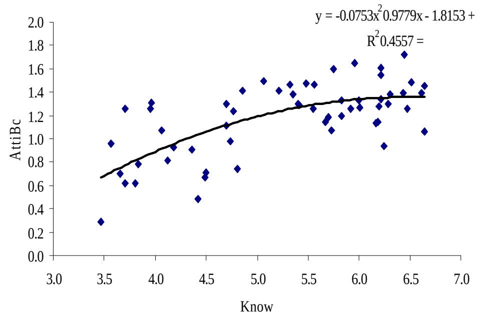


Figure 2: Correlation between 'Knowledge (know)' and 'Attitude (AttBc)'



The knowledge scale varies from around 3.50 to just under 7.00, and the Indian and the European context are fairly well split by the value of 5.00 on the knowledge scale; to the left of that point are the Indian states, to the right of that point are European states, with some overlap in the middle.

Now, examining the relation between mean levels of knowledge and levels of attitudes in Figures 1 and 2 shows that on the Indian side (if $K < 5.0$, $r > 0$) the relationship is directly linear: the more people know the more positive are their attitudes. On the European side (if $K > 5.0$, $r < 0$), the relation is reversed, still linear, but the more you know, the more sceptical the attitude. This observation is more clear cut for AttA than for AttBc, for the latter it looks like there is no relationship between knowledge and attitudes in Europe (if $K > 5.0$, $r = 0$). This observation on the correlation between knowledge and attitude is consistent with the prediction of the two-culture model of PUS (Table 1). We can no longer expect a positive correlation between knowledge and attitude under post-industrial conditions.

Taking AttA as the model, we might assume that knowledge and attitude can have both a positive and a negative relation, and this depends on a threshold level of knowledge. This assumption is modelled by fitting a non-linear function: and indeed the best fit is given by a non-linear taking the inverted U-shape with a high turning point. Mathematically this is expressed in a quadratic function between knowledge and attitudes, both for AttA and AttBc.

2.5.2 Knowledge, interest and confidence

By contrast, if we examine the variables interest and confidence in the same way, we find that here the linearity assumption holds across the entire spectrum of knowledge levels. The higher the knowledge, the more then people are interested and consider themselves also informed. On average Indians are less interested than Europeans, thus the two contexts form two clusters of higher and lower interest, confidence and knowledge. The linear relation holds: the more knowledge, the more interest and confidence of being informed (Figures 3 & 4).

Figure 3: Correlation between 'Knowledge (know)' and 'Interest'

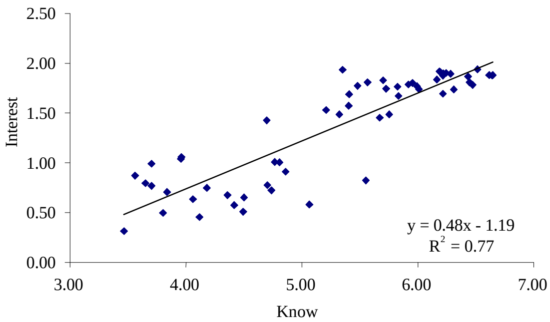
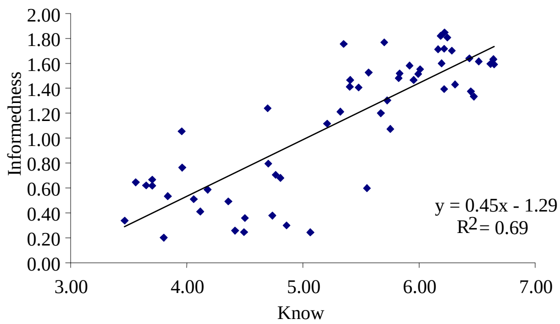


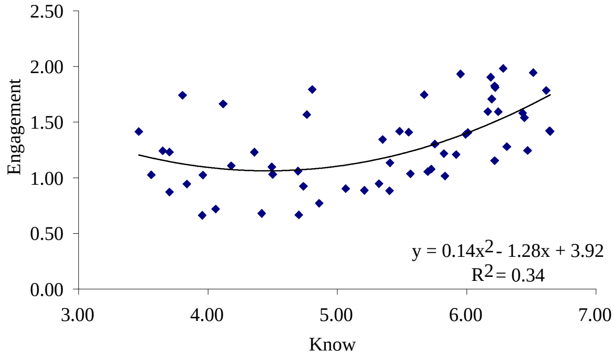
Figure 4: Correlation between 'Knowledge (know)' and 'Informedness'



2.5.3 Knowledge and engagement

Finally, we examine the variable engagement, which measures the frequency with which people visited zoos, science exhibitions or agricultural fairs etc. Here again we start by looking at the two sides of the scale, the Indian context on the left lower end, and Europe at the higher right end of the scale. Now, we find that in India, the engagement with science is declining as we move up the knowledge scale (if $K < 5$, $r < 0$): the more knowledgeable, the less visits to exhibitions and fairs. On the other hand in Europe, the relation is reversed (if $K > 5$, $r > 0$. The more knowledgeable, the more likely is an encounter with expository science. Considering the entire range of the knowledge scale, we find that a non-linear quadratic function fits best the data, however, but this time round in U-shape with a low turning point (Figure 5).

Figure 5: Correlation between 'Knowledge (know)' and 'Engagement'



2.5.4 Implication of linear and non-linear relationship

As a matter of fact for any statistical analysis of such relationships i.e. the linear and non-linear relationships among the PUS indicators, need to be addressed appropriately. Some of the meaningful observations are as follows.

Firstly, the observation of a range of levels of knowledge allows us to confirm a key expectation of the two-culture model of public understanding of science: the variable knowledge-attitude relation. We find a lower knowledge culture in India, where the relation between knowledge and attitude is positive, and a higher knowledge culture in Europe where the relation between knowledge and attitude is negative. The more people know, the more positive they are in India, in Europe this is reversed: the more you know, the more sceptical you become.

Secondly, we ask ourselves is this state of affairs really a matter of **public deficiency**, or do we need another interpretation. Under a conception of public deficit, Europe suffers an attitudinal deficiency. The acceptance of science is not guaranteed, and hence the result is a reason to worry. This might be an interpretation that flatters some audiences who are concerned with conflicts and controversies over nuclear power, genetically modified food and plants, BSE, acceptance of vaccinations and other Science and technological controversies. An alternative interpretation might endorse a **resource model of the public**. The public is a resource for science, both in terms of legitimacy but also in terms of critical engagement and loyal scrutiny. One of the operational rules and values of science is its 'organised scepticism', and one can expect that with rising public literacy this scepticism is spreading beyond the confines of the republic of knowledge, its laboratories and seminars into the public sphere. What we are observing is a **de-facto extended peer review system** on the outcomes and course of sciences: higher levels of public knowledge lead to considered judgment and not to automatic acceptance of whatever is offered by science and technology. The key point is to see a critical public as part of the solution and not of the problem of progress of science and technology; an informed and critical public is an intangible asset needs investment and maintenance.

Thirdly, under the assumption of a resource model of the public and considering the empirical observation across a wide range of contexts (i.e. India and Europe), we therefore consider positive attitudes to science as the asset in some contexts, while negative attitudes to science as an asset in others. We thus need to define a criterion by which to separate the contexts. For the construction of a culture index, we have to take into account the non-linearity of the relationship between knowledge and attitudes along the scale of knowledge, and we will do that by introducing a **conditional transformation of attitude scores**. This means that below a certain level of knowledge, positive attitudes count as cultural assets, above a certain level of knowledge, negative attitudes count as such assets. The criterion for this condition will be the extreme value, either maximum or minimum, of the non-linear function (see Annexure for linear correlation between knowledge, attitudes and engagement after transformation).

Fourthly, because linearity has been observed between knowledge, interest and confidence, the latter enter the index of public understanding of science in a direct additive function. The more interest and the more confidence, the higher is the asset 'Science culture'.

Fifthly, the relation between knowledge and engagement again is non-linear, but reversed from that between knowledge and attitudes. Interesting and unexpected as this result was, it might be a function of the particular construction of the indicator. The question asked includes the visit to 'fairs', which in the Indian context means visiting one of the numerous agricultural fairs of a majority rural population, while in Europe, 'fairs' mainly means the recently developed science fairs. The non-linear relationship might mean, that in the Indian context, with higher knowledge one is less likely visiting rural agricultural fairs, while in Europe with higher knowledge, one is more likely to visit science fairs which are newly proliferating in many countries. Be that as it may, for the construction of a cultural indicator, non-linearity again suggests to introduce a conditional transformation beyond a certain threshold level of knowledge.

One of the assumptions to apply the principal component is to test the indicators for their linear relationship as a pre-processing step (Box 2). Examining the linearity and non-linearity relationship between knowledge and attitudes (attA and AttBc) and 'engagement' are conditionally transformed to fulfil the linearity assumption to undertake the suggested statistical framework (i.e., considering both main effects of indicators and their interactions). A mathematical formulation of conditional transformation is as follows.

Let k_i is the knowledge score of the i^{th} (i=1, 2, …, 55) country/state; k_p is the point of inflexion (knowledge score) where the score for a particular indicator is statistically and reasonably higher. Value of k_p and corresponding scores for the indicators AttA, AttBc and engagement is decided individually seeing the scatter plots of these indicators as it is presented in Figures 1, 2 and 5.

a) $AttA_i$ = $AttA_i$ if $k_i <= k_p$ where k_i is the knowledge score for i^{th} country/state

= $2*Atta_p - Atta_i$ if $k_i > k_p$

Delhi is appeared as point of inflexion for the indicator AttA with k_p (Delhi) = 4.77 and $AttA_p$ (Delhi) = 1.32.

b) $AttBc_i$ = $AttBc_i$ if $k_i <= k_p$ where k_i is the knowledge score for i^{th} country/state

= $2*AttBc_p - AttBc_i$ if $k_i > k_p$

Bulgaria is appeared as point of inflexion for the indicator AttBc with k_p (Bulgaria) = 5.21 and $AttBc_p$ (Delhi) = 1.42.

c) $Engage_i$ = $Engage_i$ if $k_i <= k_p$ where k_i is the knowledge score for i^{th} country/state

= $2*Engage_p - Engage_i$ if $k_i > k_p$

Delhi is appeared as point of inflexion for the indicator engagement with k_p (Delhi) = 4.77 and $Engage_p$ (Delhi) = 1.57.

With these preliminary observations on the two-culture model of public understanding of science, AttA, AttBc and Engage have been transformed following above transformation rule to make them linear while constructing the PUS index which measures the **public sentiment as an asset** for the science productivity and the well-being of the nation. The results generated with transformed indicators show the higher and improved statistical reliability which is presented in Figures 6 to 8 and Tables 2&3.

Figure 6: Correlation between 'Knowledge (know)' and 'Attitude (AttA-transformed)'

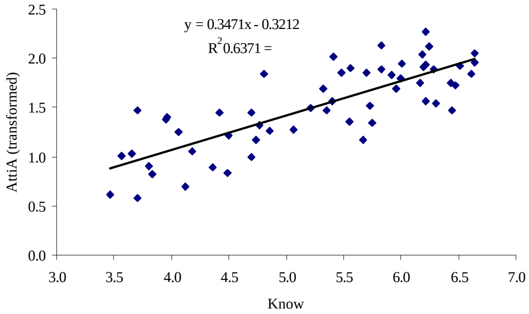


Figure 7: Correlation between 'Knowledge (know)' and 'Attitude (AttBc-transformed)'

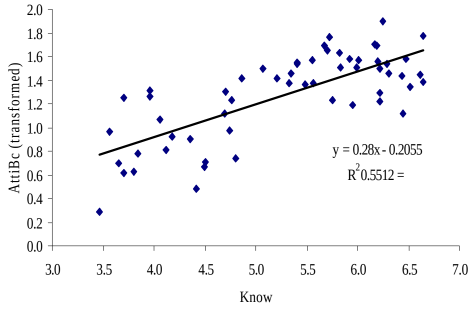


Figure 8: Correlation between 'Knowledge (know)' and 'Engagement (Engage-transformed)'

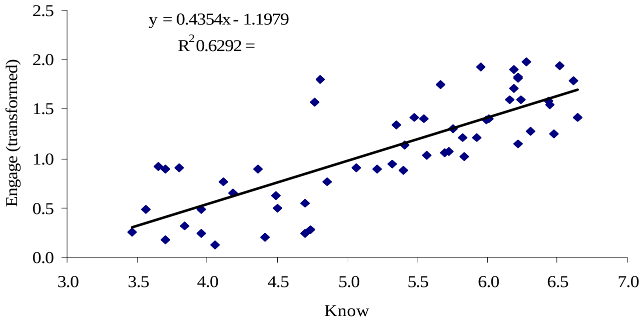


Table 2: Correlations matrix (Before conditional transformation)

		Knowledge	Attitude		Interest	Informed-ness	Engage-ment
			AttA	AttBc			
Knowledge		1.000					
Attitude	AttA	-0.344	1.000				
	AttBc	0.648	0.128	1.000			
Interest		0.879	-0.399	0.670	1.000		
Informedness		0.830	-0.475	0.596	0.972	1.000	
Engagement		0.494	-0.513	0.114	0.435	0.446	1.000

Table 3: Correlations matrix (After conditional transformation)

		Knowledge	Attitude		Interest	Informed-ness	Engage-ment
			AttA	AttBc			
Knowledge		1.000					
Attitude	AttA	0.798	1.000				
	AttBc	0.742	0.740	1.000			
Interest		0.879	0.834	0.772	1.000		
Informedness		0.830	0.818	0.750	0.973	1.000	
Engagement		0.793	0.634	0.534	0.736	0.702	1.000

In the following we will take this asset model of public understanding of science and integrate this with traditional science indicators within a combined model of 'Science culture'.

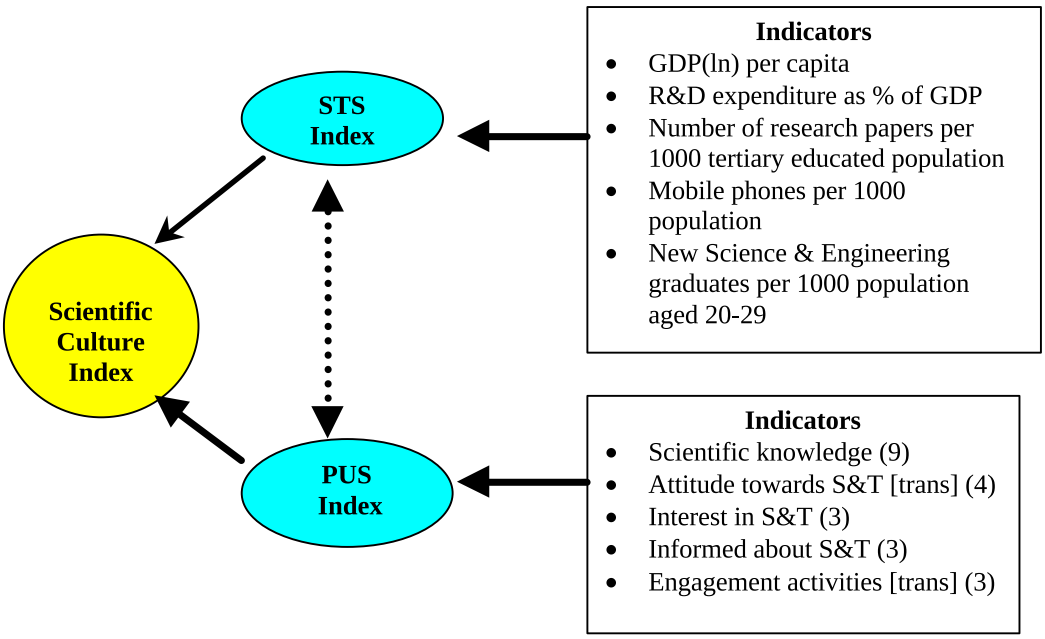
3. Science Culture Index (SCI): Concepts, Methodology and Benchmarking

3.1 The conceptual framework of SCI

In the light of the above discussion, we have conceptualised a composite index named "Science Culture Index (SCI)" developed by combining "STS" performance indicators as well as "PUS" indicators to determine the level of "Science culture" of 32 European countries and 23 Indian states. It reflects the level of Science culture of a country/state considering indicators related to input, output and impact (public understanding) of STS progress and focuses on how well the country/state as a whole is participating in creating and sustaining a scientifically cultured society.

Both objective and subjective indicators, both quantified, were integrated in the construction of SCI to capture the **multi-dimensional nature of Science culture (**Gingras & Godin, 2000). 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. Figure 9 presents the conceptual framework of the SCI. To get the detail of the indicators, which form these indices (Annexures 1&2).

Figure 9: Conceptual framework of SCI



3.2 Selection of indicators

What factors go into the complex interplay of SCI? This question was posed while selecting the indicators, as the objective is to construct an Index which focuses more on cultural outcomes and achievements rather than on effort or inputs such as numbers of scientists, R & D expenditures, or policy environments. . It was not easy to capture the interactions among the constituent parts of SCI in a single numerical figure. The choice of indicators and methodology assumes special significance in this regard. Therefore, the methodological challenge, which is the focus of this section, is how to put these complex concepts into operation.

The validity and reliability of all available indicators were assessed during the early stages of quantitative analysis, and a ‘short-list’ of indicators was produced. A description of the indicators under the different components of the two indices (STS Index and PUS Index) as well as the criteria for their retention and their use is given below. Attention was paid to data coverage in terms of both number of European countries and Indian states as well as cross-countries significance and widespread acceptability were also considered. The choice of indicators is taken up below.

3.2.1 STS Performance indicators

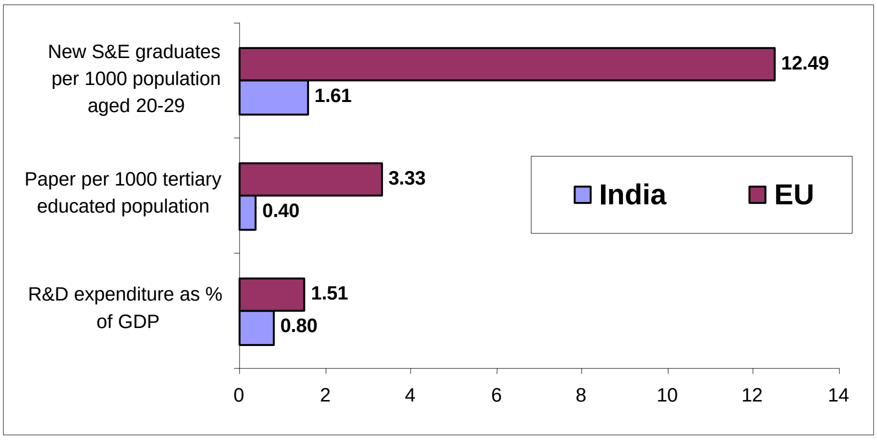
The choice of indicators to calculate ‘STS index’ was done in view of availability of comparable data for entire sample in our analysis. The choice of indicators -constituted a key process, keeping in view the objective of the exercise.

An extensive literature survey was therefore conducted to select possible indicators for inclusion in the “STS Index” framework. Regression analyses were carried out using a generalized linear model to find coefficients of these candidate indicators capturing the strength of their relationship with a SCI made up of Human Development Index (HDI) which served as a screening device. The selection process yielded the following 5 indicators:

i. **GDP:** GDP (ln) per capita 2004-05;
ii. **R&D:** R&D expenditure as % of GDP;
iii. **Papers:** Number of research papers per 1000 tertiary educated population;
iv. **Phones:** Mobile phones per 1000 population; and
v. **S&E graduates:** New Science & Engineering graduates per 1000 population aged 20-29.

Figure 10 gives the weighted average of indicators used in calculation of STS index for EU and India. The aggregated value of these indicators for EU is significantly higher than India. For instance, the number of new S&E graduates per 1000-population aged 20-29 is 6 times higher for EU than India. The per capita GDP in $PPP for EU is about 23,209 for EU and 3,769 for India. Similarly, penetration of mobile phones is very low in India (167 per thousand people) as compared to EU (800 per thousand people). Similar pattern is observed for other indicators.

Figure 10: STS performance indicators



However, all such indicators of development or science and technology capability have to be looked at in a broader context. India's huge population is a crucial factor that cannot be ignored. Social indicators such as literacy rate, expenditure on education, health, etc, has improved significantly during last 60 years and India has achieved showcase success in exploiting the opportunities of the network age.

3.2.2 PUS indicators

We used five key variables in the calculation of 'PUS Index' which is derived from the integrated data sets of Eurobarometer (EU63.1) and National Science Survey (India): Science knowledge, attitude towards science, interest in STS, level of informedness about STS and engagement with expository science (Annexure 2). The details about each variable are as follows.

Components of scientific knowledge: The integrated data contained nine standard Science knowledge items. Each item may be judged as correct or incorrect taking standard Science wisdom as a baseline. Summing each individual's correct answers (value 1 for a correct answer, value 0 for an incorrect answer) gives overall individual scores for Science knowledge. We constructed a serviceable one-dimensional scale of Science knowledge: the scores for the entire sample for both EU and India separately are normally distributed and results show an acceptable level of internal consistency (Table 4)

Table 4: Average score of scientific knowledge

	Mean	SD	Skewness	Cronbach's alpha
EU	5.89	0.55	- 1.036	0.67
India	4.31	0.54	0.821	0.82

Components of attitude towards S&T: Four questions are used to measure the Science attitude of the people. Attitudes are compared on two different scales. This arises from the fact that EB 63.1 includes two different version of the questionnaire (split-half designs). One set of attitudes items (AttA) is therefore comparable only to one half of the EU population, while a second set (AttBc) is comparable to the other half. Attitude A includes the following two items 'science & technology are making our lives healthier, easier and more comfortable' and 'scientists should be allowed to do research on animals'. AttBc includes the following two items 'new technology makes work interesting' and 'modern science and technology will create better opportunities for the next generation'.

Scaling was done in same way as in the case of Science knowledge. We obtain higher level of internal consistency between answers on different items within scale for India than EU particularly for AttA (Table 5).

Table 5: Average score of attitude towards S&T

		Mean	SD	Skewness	Cronbach's alpha
AttA	EU	1.71	0.326	-1.039	0.29
	India	1.16	0.315	-0.304	0.61
AttBc	EU	1.49	0.226	0.062	0.51
	India	0.93	0.380	0.227	0.75

Considering the interaction effects and non-linearity between knowledge and attitudes we incorporated the conditional transformation of attitudes into the PUS index as discussed in the previous section. All the results here reported are based on conditional transformed indicators for AttA and AttBc.

Components of interest in S&T and informed about S&T: It is measured by response to questions in which respondents were asked to their own interest and informedness in various issues including new Science inventions and discoveries. The average score for both indicators are significantly higher for EU than India (Table 6).

Table 6: Average score of interest and informedness about S&T

		Mean	SD	Skewness
Interest	EU	1.73	0.158	-0.73
	India	0.76	0.273	0.69
Informedness	EU	1.51	0.194	-0.18
	India	0.58	0.301	0.71

Box 1: An empirical note on SCI components

The tables below present empirical results showing degree of independence among the components of SCI. We also investigated the relationship between Human Development Index and the various indicators used in the calculation of STS Index and PUS Index.

Table 7: Correlation matrix – STS indicators

	GDP	R&D	Papers	Mobile phones	S & E graduates
GDP	1.00				
R&D	0.20	1.00			
Papers	0.80	0.40	1.00		
Mobile phones	0.91	0.15	0.74	1.00	
S&T graduates	0.74	0.16	0.62	0.72	1.00

Table 8: Correlation matrix – PUS indicators

	Scientific knowledge	AttA	AttBc	Interest	Informedness	Engagement
Scientific knowledge	1.000					
AttA	0.798	1.000				
AttBc	0.742	0.740	1.000			
Interest	0.879	0.834	0.772	1.000		
Informedness	0.830	0.818	0.750	0.973	1.000	
Engagement	0.793	0.634	0.534	0.736	0.702	1.000

Table 9: Rank correlation between HDI and components of SCI

STS indicators	HDI-2003 values	PUS indicators	HDI-2003 values
GDP per capita ($PPP) 2004	0.873* (0.000)	Scientific knowledge	0.502* (0.003)
R&D expenditure as % of GDP	0.717* (0.000)	AttA	0.672* (0.000)
Paper per 1000 tertiary educated population	0.722* (0.000)	AttBc	0.676* (0.000)
Mobile phones	0.534* (0.002)	Interest	0.654* (0.000)
S&E graduates per 1000 population aged 20-29	0.417* (0.018)	Informedness	0.443* (0.011)
		Engagement	0.686* (0.000)

* Correlation is significant at the 0.05 level (2-tailed).

Results indicate that all indicators included in STS Index and PUS index are positively and significantly related among them and individually with HDI.

Box 2: Constructing the index: The statistical approach

Principal component analysis (PCA) is a multivariate statistical approach, which transforms a set of correlated variables into a set of uncorrelated variables, which are 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. Maximizing variances helps to maximize 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 principal components analysis 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 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, principal component analysis 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 = $a + b_1 X_1 + \dots\dots\dots\dots\dots + b_n X_n + e$..............(1)

where, $X_1, X_2, \dots X_n$ 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.

1

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 normalize all components.

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

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

Correlation matrix R is computed from standardized variables, followed by solving the determinant equation $|R - lI|$=0 for l where R is an n x n matrix, this provides a n[th] degree polynomial equation in l and hence K roots. These roots are called eigen values of correlation matrix R. The l is arranged in descending order of magnitude, as $l_1 > l_2 > \ldots > l_n$. Corresponding to each value of l, the matrix equation $(R - lI)a = 0$ is solved for the nx1 eigenvectors a subject to the condition that $a'a = 1$ (normalization 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

$$l_1 = \text{var}(P_1),\ l_2 = \text{var}(P_2) = ...l_{11} = \text{var}(P_n)$$

Thus, the index is:

$$\text{I} = \frac{\lambda_1 \text{P}_1 + \lambda_2 \text{P}_2 + ... + \lambda_{11} \text{P}_n}{\lambda + \lambda_2 + ..._1 + \lambda_n} ....(4)$$

Finally, the estimator of the index is computed as the weighted average of the principal components. In order to compare the levels of inherently different variables compatible scales of measurement are needed. This is also essential if the indicators are to be added together in some way to construct composite indices; the different measurement scales introduce distortions by acting as unintentional and inappropriate weights. For analysis of the individual indicators it is, of course, appropriate to use the original data range in the indicator-specific unit of measurement.

There are different methods that can be used for the scaling of indicators. The selection of a suitable method however, is not trivial and deserves special attention (Ebert and Welsh, 2004). In present context, we used the standardization technique which converts indicators to a common scale with a mean of zero and standard deviation of one. This technique is used as some of the indicators may contain outliers that inhibit to use the most common re-scaling method. Moreover, it also avoids one variable to have an undue influence on the principal components obtained in the construction of indices. For indicators where a high value is "bad" and a low value "good", the formula should be inverted. A general effect of using scaled indices is, of course, to convert the variables to relative rather than absolute values. This aids comparability, but it must be remembered that the indices need to be interpreted in the right context.

Components of engagement in S&T activities: Engagement in S&T activities is an important mode to gain practical Science knowledge. Three questions with two-point scale are considered**:** zoo/aquarium, museum and exhibition/Science fairs to measure public engagement component of PUS index. The scaled measure for EU is 1.26, which is significantly higher than that of India (0.61).

Table 10: Average score of public engagement

	Mean	SD	Skewness
EU	1.26	0.384	-0.284
India	0.61	0.496	1.189

Like attitudes, engagement enters the index in a conditional transformation discussed in the previous section.

It is evident that on an average the level of knowledge about science concepts is very high in both groups. On the other hand average values for the three indicators i.e. interest, information and engagement is quite lower for India. All indicators are highly related to each other, thus, it is appropriately chosen to measure PUS index.

3.3 Index values and benchmarking results

All three indices, namely, 'STS Index', 'PUS Index' and 'Science Culture Index' (SCI) were calculated for 32 EU countries and 23 Indian states. These indices are conceptualised as having a positive relationship with Science development of society. In other words, a higher value of SCI reflects a higher scientifically cultured society, and vice versa. So, ranking of any country/state based on its index value gives an assessment of its relative performance to the whole sample.

The estimates and corresponding rankings based on all three indices for EU countries as well as Indian states are shown in Annexure 3. The results show a huge disparities and diversities within as well as between the European countries and Indian states. For instance, the average value of SCI for EU is 0.720 (ranging from 0.378 for Turkey to 1.000 for Sweden) which is significantly higher than India at 0.196 (ranging from 0.000 for Bihar to 0.459 for Chandigarh). Similar trend is observed in the case of STS Index and PUS Index. Variability among Indian states is much higher than that of EU countries for all three indices (Figures 11 to 13).

Figure 11: Estimates of STS index

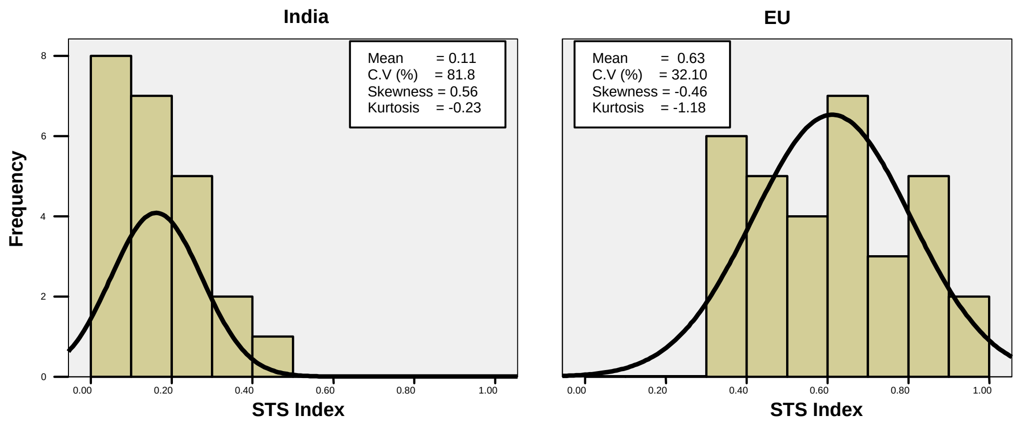


Figure 12: Estimates of PUS index

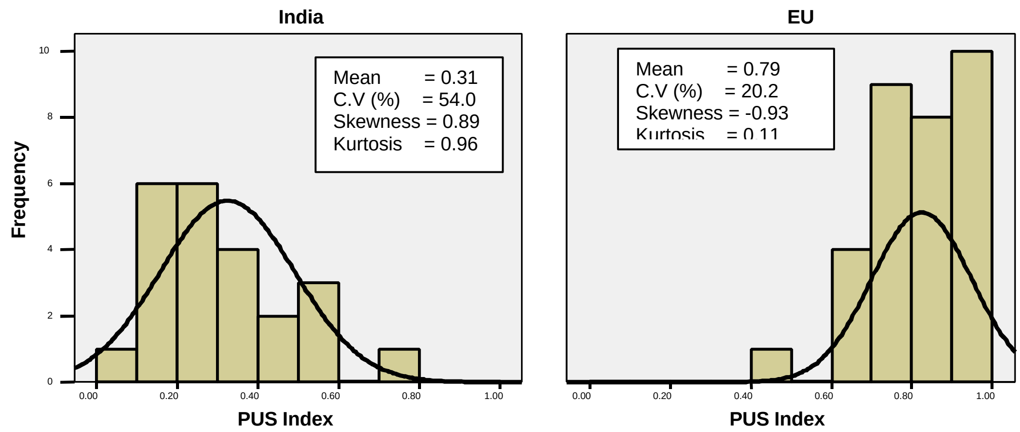
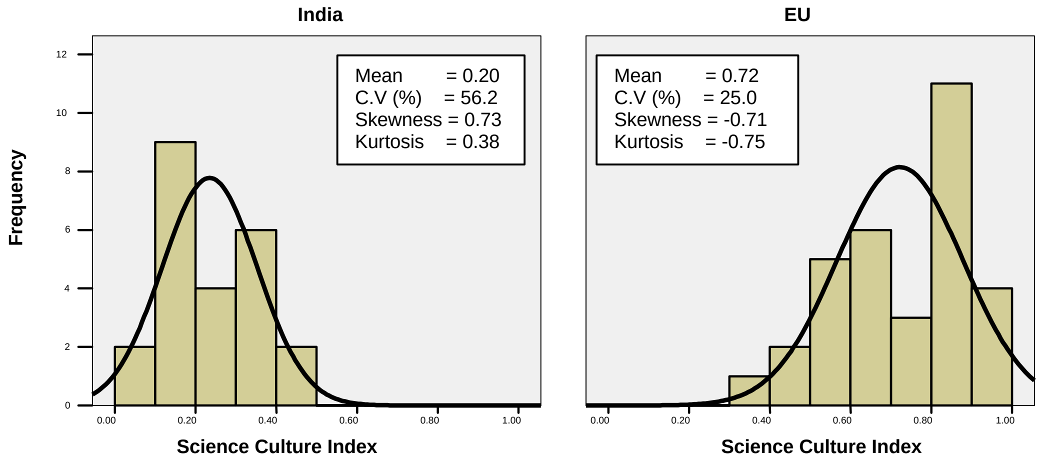


Figure 13: Estimates of SCI



3.4 Interpreting index values

In the present context, entire sample comprising of EU countries (32) and Indian states (23) have been grouped into 4 clusters[4] on the basis of SCI values to facilitate a proper understanding and a meaningful interpretation. Twelve EU countries belong to first cluster named 'Leaders' with SCI values greater than 0.80. The second cluster or 'Competent' comprises of 15 EU countries, which is a step below with SCI values ranging between 0.56 and 0.80. 'Potential', the third cluster comprise of those with SCI values between 0.22 and 0.56, which include 5 EU countries and 9 Indian states. Finally, at the bottom of the SCI ladder is the cluster of 'Aspirers' comprising of remaining 14 Indian states with SCI values less than 0.22.

The average per capita gross domestic product ($PPP at 2004 prices) is much lower for 'Potential' ($7,862) and 'Aspirers' ($3,012) than those for 'Leaders' ($30,257) and 'Competent' ($24,930) indicating the level of economic advancement. Also, the top two categories spend significantly higher percentage of total GDP on R & D and related activities in comparison to bottom two. The other indicators also show similar trend (Table 11).

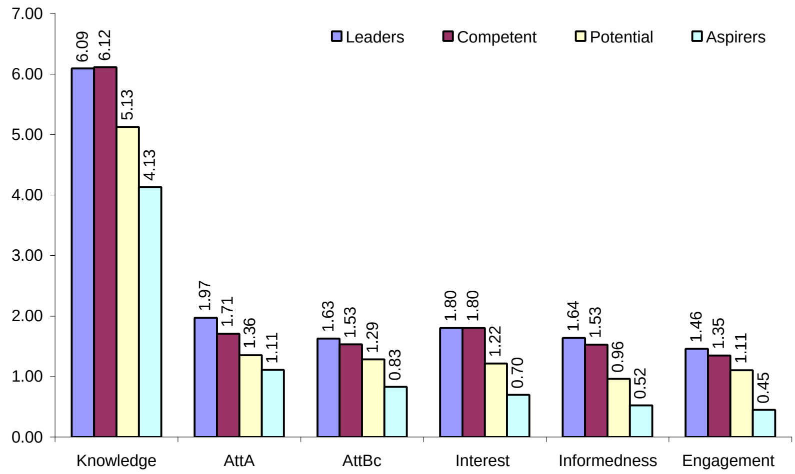
Table 11: Socio-economic indicators

Indicators	Leaders	Competent	Potential	Aspirers
GDP per capita ($PPP) 2004	30,257	24,930	7,862	3,012
R&D expenditure as % of GDP	1.9	1.7	1.0	0.7
Number of papers per 1000 tertiary educated population	4.9	3.0	0.7	0.4
Mobile phones per 1000 population	874	882	437	121
New S&E graduates per 1000 population aged 20-29	18	10	4	1

Similarly, with respect to the PUS indicators, 'Leaders' and 'Competent' are having higher scores for all the indicators as compared to the bottom two clusters. For instance, the average score for Science knowledge is 6.09 for 'Leaders' and 4.13 for 'Aspirers'. Similarly, for attitude towards S&T, score for 'Leaders' is 1.97 as compared to 1.11 for 'Aspirers' (Figure 14).

[4] Leaders (SCI >0.80), Competent (0.56 < SCI $\leq$ 0.80), Potential (0.22 < SCI $\leq$ 0.56) and Aspirers (SCI $\leq$ 0.22)

Figure 14: Scores of PUS indicators



3.5 Indices values and rankings

Regional disparity is a major concern for policy makers and such disparity is evident among the four categories of states in this research as well. Does it follow that states that perform better in terms of the STS indicators are also the ones to have a higher level of public understanding of science and finally high level of science culture? Or are there inter-state differences, within each of the four categories, with respect to S&T and economic growth? To understand the complexities, index values for each constituent of the entire sample are standardized taking EU at 100 is aimed to know how they differ in terms of their overall scientific development. Table 13 gives the scores and corresponding ranking of entire sample grouped into four categories which provides a relative assessment of a state/country's performance and could be considered as an indicator of changes over time.

Table 12 provides a summary of scores of all three indices in terms of the weighted scores[5] for all the four categories. It is clearly evident that there is a huge difference between the top and bottom groups across all indices. For instance, the 'Leaders' score a high 114 on the SCI compared to the 'Competent' which score 99, followed by the 'Potential' (53) and 'Aspirers' (22). For each of the two sub-indices ('STS Index' and 'PUS Index'), the scoring pattern is similar – with the 'Leaders' recording the highest scores followed by the 'Competent', 'Potential' and 'Aspirers'.

[5] Since EU countries and Indian states have different populations, so weighted scores are calculated by taking population into consideration. For example, to calculate weighted SCI score for 'Leaders': SCI score of each constituents of the group is multiplied by its corresponding population and then the weighted average is taken.

Table 12: Summary of indices score

	Leaders	Competent	Potential	Aspirers
STS Index	98	80	32	11
PUS Index	133	124	83	40
Science Culture Index	114	99	53	22

On the ‘STS Index’, while the ‘Leaders’ lead with a score of 98 followed by ‘Competent’ with a score of 80. The two bottom groups however fall way behind with scores of 32 (‘Potential’) and 11 (‘Aspirers’). Similarly, the ‘Leaders’ – with a score of 133 – are the best performers on the ‘PUS Index’ as well. The last two groups which is dominated by Indian states while being far behind to top-two groups (dominated by EU countries) with respect to all three indices, however, does comparatively well on the ‘PUS Index’.

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 bottom two groups have undoubtedly put a lot of efforts in caching up to do with the top-two groups in terms of all three indices.

3.6 Intra-group comparisons

The ‘Leaders’ and ‘Competent’ perform much better across all indices – ‘STS Index’, ‘PUS Index’ and ‘SCI’. However there are differences in index rankings among the countries/states within each group. For instance, Sweden is ranked first for ‘STS Index’ and ‘SCI’ but emerges at No. 6 on the ‘PUS Index’ (with a score of 114). Switzerland and France – in that order – are ranked third and fourth on the ‘SCI’. However, when it comes to the ‘PUS Index’ ranking, Switzerland and France are at No. 1 and 2. The ‘STS Index’ ranking for these two respectively are No. 4 and No. 6 (Table 13).

The Index also reveals that it is not mandatory that if a country/state scores high on the ‘STS Index’, its ‘PUS Index’ will be of an equal ranking. Take the example of United Kingdom which ranks third in the ‘STS Index’ but in terms of ‘Pus Index’ and ‘SCI’ its rank is 13th and 6th. Though Luxembourg is ranked 13th on the ‘STS Index’, it is ranking 3rd on ‘PUS Index’.

Most of Indian states that are at the bottom group of the table – in terms of all three indices – have more or less similar rankings and scores for all indices. However, some the developed states such as Delhi, Kerala, Chandigarh and Himachal Pradesh perform fairly well with respect to all three indices and ranked closely with EU countries such as Poland, Hungry, Bulgaria and Romania.

Table 13: Indices scores and ranking of EU countries and Indian states

Grouping	States	STS Index		PUS Index		SC Index	
		Scores	Ranks	Scores	Ranks	Scores	Ranks
Leaders	Sweden	149	1	114	6	132	1
	Finland	137	2	111	8	124	2
	Switzerland	125	4	120	1	123	3
	France	122	6	120	2	121	4
	Denmark	123	5	112	7	118	5
	United Kingdom	125	3	104	13	114	6
	Luxembourg	103	13	120	3	112	7
	Netherlands	102	15	116	4	109	8
	Austria	114	9	103	14	108	9
	Italy	121	7	94	23	107	10
	Norway	103	14	110	9	107	11
	Belgium	103	12	109	10	106	12
Competent	Ireland	117	8	95	20	106	13
	Germany	104	11	107	12	105	14
	Iceland	110	10	101	15	105	15
	Slovenia	91	17	115	5	103	16
	Czech	88	19	108	11	98	17
	Greece	94	16	100	16	97	18
	Spain	89	18	91	26	90	19
	Slovakia	69	23	99	17	85	20
	Estonia	72	22	93	24	82	21
	Croatia	65	24	99	18	82	22
	Portugal	80	20	82	29	81	23
	Cyprus	64	25	94	22	79	24
	Lithuania	79	21	78	31	78	25
	Latvia	56	29	94	21	75	26
	Malta	57	28	92	25	75	27
Potential	Poland	60	27	88	28	74	28
	Hungary	49	32	95	19	72	29
	Bulgaria	51	31	74	32	62	30
	Romania	46	35	79	30	62	31
	Chandigarh	32	40	89	27	60	32
	Delhi	47	33	65	35	56	33
	Kerala	35	38	70	33	52	34
	Himachal Pradesh	54	30	50	38	51	35
	Turkey	46	34	54	36	50	36
	Karnataka	26	43	68	34	47	37
	Pondicherry	36	37	50	37	43	38
	Punjab	36	36	47	40	41	39
	Uttaranchal	62	26	21	54	40	40
	Haryana	30	42	39	42	34	41
Aspirers	Madhya Pradesh	12	48	47	39	29	42
	Maharashtra	23	45	35	43	28	43
	Tamil Nadu	24	44	33	44	28	44
	Assam	32	39	22	53	26	45
	Gujarat	30	41	23	51	26	46
	Uttar Pradesh	4	53	46	41	25	47
	Andhra Pradesh	23	46	23	52	22	48

Grouping	States	STS Index		PUS Index		SC Index	
		Scores	Ranks	Scores	Ranks	Scores	Ranks
	West Bengal	15	47	29	48	21	49
	Jharkhand	9	49	32	45	20	50
	Chattisgarh	8	50	30	46	19	51
	Orissa	8	51	30	47	18	52
	Rajasthan	6	52	24	49	14	53
	Meghalaya	1	55	23	50	11	54
	Bihar	2	54	19	55	8	55
EU Countries		**100**	**-**	**100**	**-**	**100**	**-**
India (All States)		**17**	**-**	**35**	**-**	**25**	**-**

Note: Rank 1st is the highest and 55th is the lowest.

3.7 Index scores: Driving factors and its implications

What drives the results presented in the previous sections? To respond to this question, coefficients of each of the dimensions of the "STS Index' and 'PUS Index" were obtained. These coefficients make it possible to work out the relative dominance and/or importance of the respective dimensions in determining the scores. A straightforward rearrangement of the weighted components of two indices helps to express it as a weighted sum of the actual value of their constituent indicators. Hence,

$$STS_{Est.} = 0.065*GDP + 0.069*R\&D + 0.035*Paper + 0.0002*Mobile + 0.012*SE\ Graduate$$

$$PUS_{Est.} = 0.0576*Knowledge + 0.1240*Attitude\ (A) + 0.1249*Attitude\ (B) + 0.0973*Interest + 0.0941*Informedness + 0.1186*Engagement$$

However, these coefficients should not be interpreted as partial regression coefficients since the left-hand side variables are not observable. For instance, it should not be interpreted as if as 'science knowledge' increases, 'PUS Index' will increase by a figure that is proportional to the knowledge. The above identity can be used to compute the share of each dimension in these indices for each state/country and for the average value for the sample as a whole.

Table 14 presents share of each component in the average 'STS Index' and 'PUS Index' scores for EU countries and India. The contribution of GDP per capita to 'STS Index' is the largest and explains almost 61 per cent and 81 per cent of the 'STS' score for EU and India respectively. The contribution of R&D expenditure is the second highest followed by penetration of mobile phones for the EU countries. However, in the case of India, the contribution of R&D expenditure is the lowest. The second highest contributor in India is penetration of mobile followed by population of SE graduates.

Table 14: Summary of the contribution of indicators to sub-indices

(Per cent)

Index	EU	India
STS Index		
GDP per capita	61.1	80.6
R&D expenditure	7.0	10.8
Publication (Paper)	8.6	1.9
Mobile	13.7	4.1
SE Graduate	9.6	2.5
PUS index		
Scientific knowledge	28.5	39.8
AttA	17.7	22.1
AttBc	14.8	18.8
Interest	14.2	11.6
Informedness	11.5	7.7
Engagement	13.1	12.4

The pattern of contribution of various indicators to ‘PUS Index’ score is more or less similar for both EU countries and India. It shows that the importance of knowledge, attA and attBc is higher for India than EU countries. For instance, while their contribution to ‘PUS Index’ is around 80 per cent for India as a group, it falls to about 60 per cent for EU countries. In other words, these indicators played a much larger role in explaining the ‘PUS Index’ scores in the case of India than in the case of EU countries. All three indices are positively and significantly correlated with HDI, TAI and also per capita GDP (Table 15).

Table 15: Rank correlation between HDI, TAI and components of SCI

Indices	GDP per capita ($PPP 2004)	HDI-2003 values	TAI-2003 Values
STS Index	0.93* (0.000)	0.869* (0.003)	0.689* (0.000)
PUS Index	0.91* (0.000)	0.782* (0.000)	0.543* (0.000)
SCI	0.95* (0.000)	0.902* (0.000)	0.694* (0.000)

* Correlation is significant at the 0.01 level (2-tailed).

The highest SCI scoring countries tend to score uniformly high in different components. In other words, these countries display a relatively low variability among contributions of individual components. Variability is defined by the coefficient of variation. The variability increases as one move down to list in decreasing order of SCI scores. The highest variability is found among the ‘Aspirers’ scores. This pattern is evident in Figures 15and 16. It is observed quite clearly that the higher scoring countries exhibit lower variability in the contribution of individual components, while lower scoring countries have higher variability. Therefore, the following general rule appears to hold: The higher the score, the lower the variability in the contribution of its components and vice versa.

Figure 15: Estimates of variability – PUS indicators

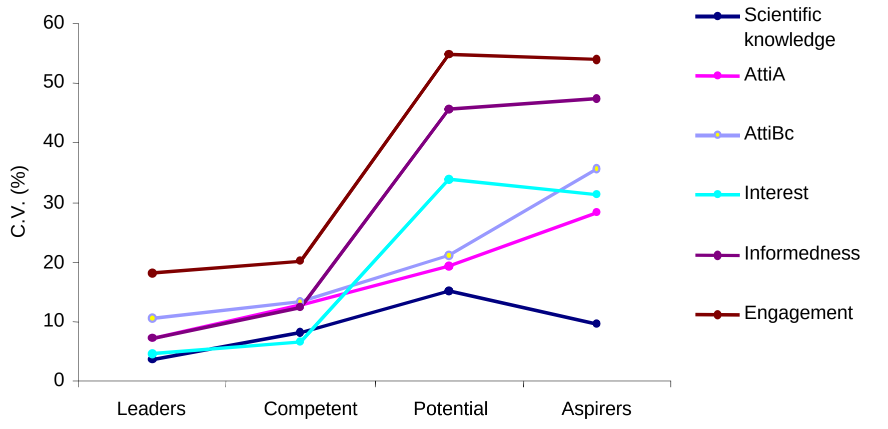
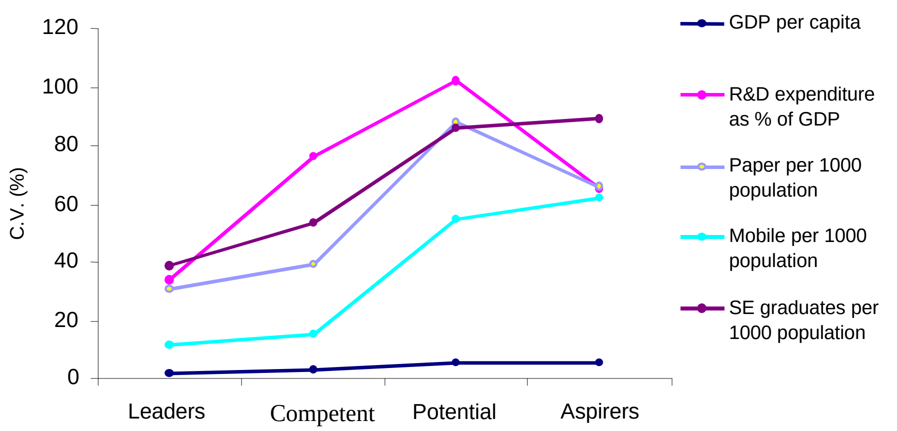


Figure 16: Estimates of variability – STS indicators



An implication of this finding is that while changes in the value of scores over time could be regarded as a quantitative indication of trends in the S&T development, public understanding and finally better scientific cultural performance of countries, those in respect of the variability could be seen as qualitative changes. Therefore, in addition to scores of three indices, the coefficient of variation will serve as a tool to track the progress of countries in respect of these indicators over time.

Reducing the variability in the contribution of different components should be an important objective of S&T policies and strategies. In other words, to be successful, a country must put a simultaneous thrust on multiple goals within a coherent S&T strategy, while emphasizing reduction of the existing gaps in areas where performance is lagging. By demonstrating significant inter-group variations in the coefficient of variation, the analysis points to the importance of country-specific approaches to S&T strategies.

The above analysis also has implications for development partnership. For example, a comparison between the disaggregated results of the EU countries and India indicates what works: a simultaneous thrust on a broad-based development agenda to be pursued with a well-defined time frame under strict institutional discipline. Indeed, the European experience could provide important insights into the formulation of development partnership paradigms for India aimed at fast improving SCI performance.

4. Discussion

In this report we outlined the rationale and the methodology of the construction of an index of science culture, the SCI. This is the first attempt to construct such an index with the **ambition of global validity**. Such an index should be able to depict the full range of variability across the globe. Several considerations went into the construction of the SCI.

Science indicators have come a long way in definition and global standardisation since the 1960s mainly under the auspices of international organisations like the OECD. However, these efforts focus entirely on objective indicators of input (R&D, number of personnel) and output (patents, innovation, balance of hi-tech trade) with an economist bias. They neglect the subjective and symbolic features of culture, the attitudes, morale, imagination and public sentiment vis-à-vis science and technology. Culture is both a precondition and a catalyst of science and technological development. **Objective structures and subjective meaning** are two sides of the same coin of science culture, to take one as a proxy of the other is cutting short a complex story of compensation or substitution.

The definition of subjective indicators such as literacy, attitudes and interest has its own history, but progresses institutionally isolated from mainstream science indicators developments. ‘Subjective’ shall mean that data is collected at the level of individual interviews with respondents who are selected from a nationally representative sample. Such data, if collected at all, is reported in different chapters without any cross-references to other science indicators. With few exceptions, subjective indicators are not part of the science indicator routine. Our SCI seeks re-open this discussion by integrating both objective (STS input and output) and subjective indicators (PUS) into a meaningful **composite index: SCI = f [STS, PUS].** We suggested two versions of this model: a ‘strong’ multiplicative or a ‘weak’ additive functions for this index, with implications as to the relative importance of the objective and subjective element of culture.

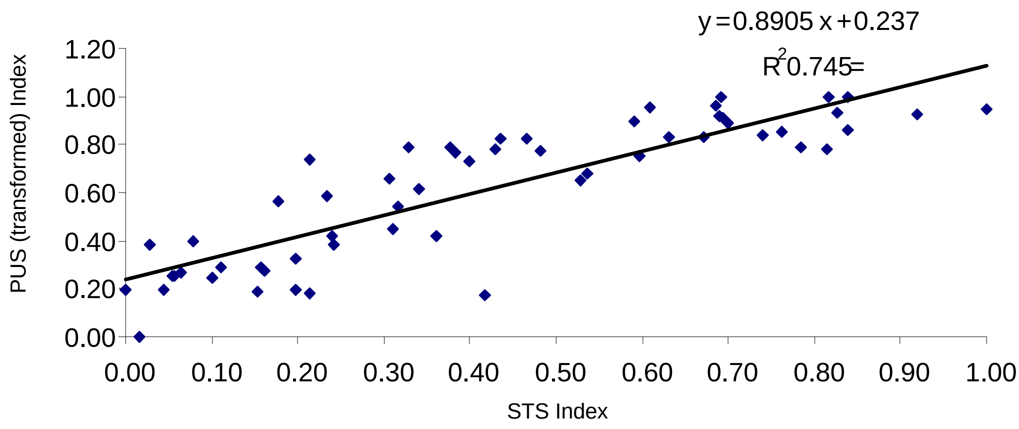
There is a global corpus of data emerging that addresses issues of knowledge and literacy, attitudes, interests and engagement. For the moment, we are bracketing the partially valid critique addressed to these measures and offer an **innovative usage of these existing indicators**. We define an index of PUS in function of five subjective indicators: PUS = f [Knowledge, Attitudes, Interest, Informedness, Engagement]. The higher PUS, the stronger is the subjective science culture of a particular context.

The discussion of subjective indicators of science under the headings 'adult science literacy' and 'public understanding of science' has had its fair share of debate and polemic. In particular the relationship between knowledge and attitude has been controversial. The standard model suggests that knowledge is a driver of positive attitudes, but there is little evidence for this in general. More valid on a global scale is the two-culture dynamic model, which suggests that **knowledge and attitudes are in a non-linear, inverted U-shape relation**. On lower levels to development, the standard model applies, on higher levels the correlation between knowledge and attitudes are likely to be negative: the more we know, the more sceptical we tend to become. Enthusiastic attitudes are an asset in lower average levels of literacy, while with higher average levels of literacy critical attitudes are the asset. The science ideal, of a 'community of sceptics' is generalised. Our SCI index thus makes productive use of PUS research over the last 25 years: attitudes enter the model after a **conditional transformation**. Above a certain level of literacy, negative attitudes score positively. A similar conditional transformation applies for 'engagement'. High engagement below a certain average level of literacy scores negatively.

For the construction of the index we build a database that **combines 23 Indian and 32 European states**. STS data (GDP, R&D, phones, education, science education) and PUS data (knowledge, attitude, interest, informedness, engagement) is aggregated and analysed for each of these 55 units of analysis. PUS data derives from the integration of the most recent PUS surveys, EB 63.1 of 2005 (EU, N=32,000) and National Science Survey of 2004 (India, N=30,000). These 55 units cover wide range contexts, from very underdeveloped regions in India to very developed countries in Europe. This allows us to simulate the global range of context and to validate the index within that range.

The SCI is constructed based on principle component analysis and standardised on a scale from 0 to 1. For the moment the index is a **relative measure**, the lowest unit is defined as 0, the highest unit as 1. In this definition, the index is not suitable for measuring changes in the absolute level of science culture over time. In this definition, it is however possible to assess changes in the rank order between the units over time.

Figure 17: STS Index & PUS (transformed) Index



The **reliability of the index** is tested through the internal consistency of each component (Cronbach's Alpha) and principle component loading. The inter-correlations between the single indicators is sufficiently high for both STS and PUS to justify their combination into an index. It was also shown that indeed, the conditional transformation of attitudes and engagement scores improves the internal consistency of the PUS index. STS and PUS are correlated (r = 0.86), but make an independent contribution to SCI. Both PUS and STS are highly correlated with the combined SCI (Figures 17 to 19). Also the rank ordering between the three indexes is highly correlated (Tables 13 and 16).

Figure 18: STS Index & SCI

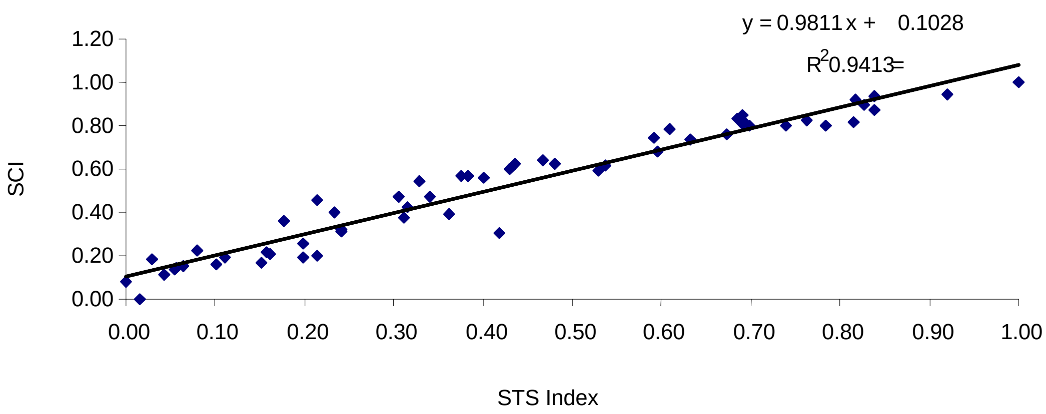


Figure 19: PUS (transformed) Index & SCI

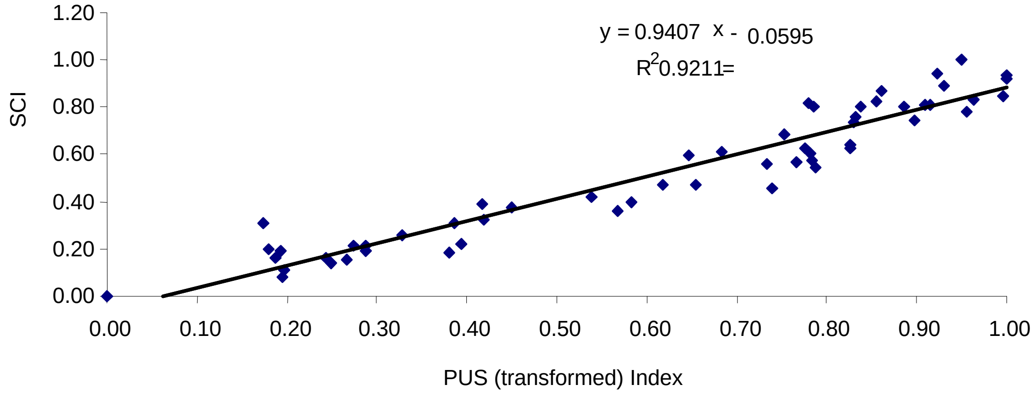


Table 16: Rank correlation

	GDP per capita	STS Index	PUS Index	SCI
GDP per capita	1.00			
STS Index	0.93	1.00		
PUS Index	0.91	0.88	1.00	
SCI	0.95	0.98	0.95	1.00

For each sub-index, STS and PUS, the **relative contribution** of each indicator is calculated. This gives a clearer sense of what drives the index, and that the drivers have a slightly different weight in India and in Europe. STS is dominated by GDP per capita, the other components making a much smaller contribution. For PUS the weights are more equally distributed, knowledge being the most important input in both contexts (Table 9). These different columns show that some countries overall standing on the SCI is raised or lowered by their standing on PUS relative to STS. For example the UK, 3rd on STS drops to 6th on SCI because of being 13th on PUS. Italy and Austria behave similarly. On the other hand for example Luxembourg, Norway and the Netherlands improve their standing on SCI with a good PUS score relative to their STS.

We validated all indices on existing measures of development, such as Human Development Index (HDI) and the Technology Achievement Index (TAI). They are all positively correlated suggesting that they measure some common aspect of having a notion of 'development' (Table 15).

We also grouped the 55 units into four **sub-groups of regions** or countries and provided a differential profile for each group. The four groups differ in the variability of the indicators. Generally we observe the higher SCI, the less variability on the component indicators. These profiles are **diagnostic** and suggest that both to increase the level and to reduce the variability of the SCI and its components should be targets of policy interventions, and depending on the level of SCI in a region a different interventions might be indicated.

A final consideration might be the **presentation of the SCI index**. There are different ways of basing the comparisons. Results show versions of the SCI relative to different bases, taking the EU or India, or the overall mean or median as the baseline for comparison (Annexure 4). The ranking among the units is not affected by this variation, but the presentation of the index might be. What changes is the range between the lowest and the highest score of index scores. Here the rhetoric of numbers might come into play, and suggest a particular choice among these alternatives for particular purposes.

With this report we hope to re-open and stimulate the discussion on the place of public understanding of science, the subjective side of the culture of science, within the science indicator enterprise. And, instead of brushing aside existing measures of PUS as 'snow of old days' we suggest a new and innovative way of using existing data, which might also suggest future uses of them.

What is needed in the near and mid-term future is a more global collaboration of bringing existing data into comparisons of this kind to make it speak as a diagnostic tool. A comparison of India and Europe, with its vast divergence of contexts, is clearly a step in the right direction. In a global culture, science is clearly not just a matter of and for developed countries.

Too much of the existing data on PUS is underexploited and remains hidden in often unknown places once it has been presented as the 'latest news' to local mass media and created the buzz for the researchers at the time. The existing PUS data is clearly more valuable than just hitting the news of the day. What is needed is a considered and concerted approach to collect, integrate and analysis data on a global scale, and to develop their diagnostic power through systematic comparison. SCI is our opening gambit for a more considered and technical discussion to take off from here, so that in the near future we might be in the fortunate position to evaluate and to compare several alternative indexes with a similar ambition: to assess the science culture, its objective and subjective features, with a globally reliable and validated instrument. There is still some way to go, indeed.

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Annexure 1: Data sources

A. PUS Indicators

India (*National Science Survey, NCAER, 2004)*

"National Science Survey–2004" was an all India field survey undertaken by the National Council of Applied Economic Research, New Delhi. Sample respondents, individuals over 10 years of age, were selected by adopting a multistage stratified random sampling design from a wide cross-section of people (age, education, and sex) in the country. In view of India's diversity in terms of languages and locations, the sample size and selection procedure were designed to provide state level estimates.

Respondents were selected from the entire country by covering both rural and urban areas, with the objective of enhancing the precision of the estimates. The rural sample was selected from a representative number of districts from across the country, while the urban sample sampled from big metropolitan cities to small towns with populations below 5,000. A total of about 347,000 individuals (115,000 rural and 232,000 urban) were listed covering 553 villages in 152 districts as rural and 1128 urban blocks in 213 towns as urban. Over 30,000 individuals were selected from the listed individuals to collect detailed information through a questionnaire approach involving face-to-face interviews. The detailed survey methodology, please refer Appendix III – **India Science Report** available at *www.insaindia.org/India%20Science%20report-Main.pdf*

Europe (Eurobarometer 63.1, 2005)

The special Euro barometer $N^0$224 is part of wave 63.1 and covers the population of the respective nationalities of the European Union Member States, resident in each of the Member States and aged 15 years and over. It has also been conducted in the candidate countries (Bulgaria, Romania, Croatia and Turkey) and in three EFTA countries (Iceland, Norway and Switzerland). The Basic sample design applied in all states is a multi-stage, random (probability) one. In each country, a number of sampling points was drawn with probability proportional to population size (for a total coverage of the country) and to population density.

In order to do so, the sampling points were drawn systematically from each of the "administrative regional units", after stratification by individual unit and type of area. In each of the selected sampling points, a starting address was drawn, at random. Further addresses were selected as every nth address by standard "random route" procedures, from the initial address. In each household, the respondent was drawn, at random (following the "closest birthday rule"). All interviews have been conducted face-to-face in people's home and in the appropriate national language. *Computer Assisted Personal Interview (CAPI)* was also used in few countries where this technique was available.

B. S&T Performance Indicators

- GDP per capita ($PPP)

  EU: OECD key figures, 2004
  India: Economic Survey, 2004/05

- R&D expenditures as % of GDP

  EU: Public and Business expenditure as reported in EIS 2005 for the year 2003. It is simple addition of these components.
  India: Share R&D expenditure for covered states were estimated using total R&D expenditure available in the State Sector R&D expenditure, DST. It is matched with national share (0.78%)

- Mobile phones (Penetration per 1000 population)

  EU: CIA statistics
  India: National Survey of Household Income and Expenditure (NCAER, 2004/05)

- Scientific publications by 1000 tertiary educated population

  EU: Total numbers of SCI articles for 1999: E Inonu (2003), The influence of cultural factors on scientific production, Scientometrics, 56, 1, 137-46.

  Tertiary educated population per 1000 population aged 25-64, EIS 2005.

  India: Publication for 1998: Basu A & R Aggarwal (2006) India Science Literature in Science Citation Index: a report http://itt.nissat.tripod.com/itt0104/scirep.htm.

  Tertiary educated population per 1000 population aged 25-64: National Science Survey, NCAER, 2004.

- New science & engineering graduates 20-29 per 1000 population

  EU: European Innovation Scoreboard (EIS) 2005
  India: National Science Survey 2004 (NCAER)

Annexure 2: Summary of PUS Indicators

(Results from Integrated data set of EU and India)

a. Scientific Knowledge

Q. Whether the following statements are True/False? (Percentage of respondents)

Issues	EU			India		
	True	False	Don't know	True	False	Don't know
The centre of the Earth is very hot	84.5	6.7	8.8	56.9	9.8	33.3
The oxygen we breathe comes from plants	83.1	12.2	4.7	85.7	2.6	11.7
The new born baby is a boy or girl depends upon his/her father	62.5	18.9	18.6	38.3	28.6	33.1
Electrons are smaller than atoms	44.2	28.9	26.9	30.4	8.9	60.7
Antibiotics kill viruses as well as bacteria	44.3	43.9	11.9	8.2	39.4	52.4
The continents on which we live have been moving their location for million of years and will continue to move in the future.	83.8	6.2	10.0	32.0	11.9	56.1
Human beings developed from earlier species of animals	64.2	23.5	12.3	55.6	10.9	33.5
Earth goes round the sun	66.1	30.1	3.8	70.3	13.1	16.6
It takes one year for the Earth to go around the Sun	66.7	15.8	17.5	40.8	28.6	30.6

b. Attitude towards S&T

Q. Please tell your views for the following statements. (Percentage of respondents)

AttA-Non transformed

Issues	EU			India		
	Agree	Disagree	Don't know	Agree	Disagree	Don't know
Science & Technology are making our lives healthier, easier and more comfortable.	76.2	7.2	16.6	76.7	4.7	18.6
Scientists should be allowed to experiment on animals like dogs and monkeys if this can help sort out human health problems	47.3	31.3	21.5	52.0	18.5	29.5

AttBc-Non transformed

Issues	EU			India		
	Agree	Disagree	Don't know	Agree	Disagree	Don't know
The application of science and new technology will make work more interesting.	71.3	8.7	20.0	60.6	9.6	29.8
Thanks to science and technology, there will be more opportunities for the future generation.	77.5	7.1	15.4	53.5	12.0	34.5

c. Interest in S&T

Q. How interested are you regarding the following Issues? (Percentage of respondents)

Issues	EU			India		
	Interested	Not interested	Don't know	Interested	Not interested	Don't know
Politics	73.1	26.5	0.4	36.5	45.5	18.1
Environmental pollution	86.7	12.5	0.8	45.3	31.8	22.9
New Inventions and Technologies & New Science Discoveries	90.1	9.3	0.6	29.5	40.3	30.2

d. Informed about S&T

Q. How informed are you regarding the following Issues? (Percentage of respondents)

Issues	EU			India		
	Informed	Not informed	Don't know	Informed	Not informed	Don't know
Politics	75.6	23.2	1.2	37.6	37.8	24.5
Environment	74.5	24.1	1.4	36.2	35.8	28.0
Science & technological discoveries	76.9	21.2	1.8	22.3	42.3	35.4

e. Engagement activities

Q. Have you visited any of the places during last 12 months? (Percentage of respondents said 'YES')

Places	**EU**	**India**
Zoo or Aquarium	27.2	34.3
Science Museum /Technology Museum /Science Centre	29.8	18.2
Science Festival or Science Week	8.1	33.2

Annexure 3: Estimated value of Indices

Sl.No.	States/Countries	STS Index	PUS Index	SCI
1	Andhra Pradesh	0.15	0.19	0.17
2	Assam	0.21	0.18	0.20
3	Bihar	0.02	0.00	0.00
4	Gujarat	0.20	0.19	0.19
5	Haryana	0.20	0.33	0.26
6	Himachal Pradesh	0.36	0.42	0.39
7	Karnataka	0.18	0.57	0.36
8	Kerala	0.23	0.58	0.40
9	Madhya Pradesh	0.08	0.39	0.22
10	Maharashtra	0.16	0.29	0.22
11	Meghalaya	0.00	0.19	0.08
12	Orissa	0.05	0.25	0.14
13	Punjab	0.24	0.39	0.31
14	Rajasthan	0.04	0.20	0.11
15	Tamil Nadu	0.16	0.27	0.21
16	Uttar Pradesh	0.03	0.38	0.19
17	West Bengal	0.10	0.24	0.16
18	Pondicherry	0.24	0.42	0.32
19	Chandigarh	0.21	0.74	0.46
20	Delhi	0.32	0.54	0.42
21	Chattisgarh	0.06	0.25	0.14
22	Uttaranchal	0.42	0.17	0.31
23	Jharkhand	0.06	0.27	0.15
	India	**0.11**	**0.31**	**0.20**
24	Belgium	0.69	0.91	0.81
25	Denmark	0.83	0.93	0.89
26	Germany	0.70	0.89	0.80
27	Greece	0.63	0.83	0.74
28	Spain	0.60	0.75	0.68
29	France	0.82	1.00	0.92
30	Ireland	0.78	0.79	0.80
31	Italy	0.81	0.78	0.82
32	Luxemb	0.69	1.00	0.85
33	Netherlands	0.69	0.96	0.83
34	Austria	0.76	0.85	0.82
35	Portugal	0.54	0.68	0.61
36	Finland	0.92	0.92	0.94
37	Sweden	1.00	0.95	1.00
38	Cyprus	0.43	0.78	0.60
39	Czech	0.59	0.90	0.75
40	Estonia	0.48	0.78	0.63
41	Hungary	0.33	0.79	0.55
42	Latvia	0.38	0.78	0.57
43	Lithuania	0.53	0.65	0.59
44	Malta	0.38	0.77	0.57
45	Poland	0.40	0.73	0.56
46	Slovakia	0.47	0.83	0.64
47	Slovenia	0.61	0.95	0.78

Annexure 3: Estimated value of Indices (Cont..)

Sl.No.	States/Countries	STS Index	PUS Index	SCI
48	United Kingdom	0.84	0.86	0.87
49	Bulgaria	0.34	0.62	0.47
50	Romania	0.31	0.65	0.47
51	Croatia	0.44	0.83	0.63
52	Turkey	0.31	0.45	0.38
53	Iceland	0.74	0.84	0.80
54	Switzerland	0.84	1.00	0.93
55	Norway	0.69	0.92	0.81
	All EU	**0.63**	**0.79**	**0.72**

Annexure 4: SCI score to different bases

States	Alternative SCI score			
	EU=100	India=100	Mean=100	Median=100
Andhra Pradesh	22	87	32	30
Assam	26	104	38	35
Bihar	5	20	7	7
Gujarat	26	102	37	35
Haryana	34	136	50	46
Himachal Pradesh	51	206	76	70
Karnataka	47	189	69	64
Kerala	52	210	77	71
Madhya Pradesh	29	117	43	39
Maharashtra	28	114	42	38
Meghalaya	11	44	16	15
Orissa	18	74	27	25
Punjab	41	163	60	55
Rajasthan	14	57	21	19
Tamil Nadu	28	112	41	38
Uttar Pradesh	25	98	36	33
West Bengal	21	86	31	29
Pondicherry	43	171	63	58
Chandigarh	60	243	89	82
Delhi	56	223	82	75
Chattisgarh	19	74	27	25
Uttaranchal	40	163	60	55
Jharkhand	20	81	30	27
India (Total)	**25**	**100**	**37**	**34**
Belgium	106	427	157	144
Denmark	118	472	173	159
Germany	105	423	155	143
Greece	97	389	142	131
Spain	90	360	132	121
France	121	486	178	164

Annexure 4: SCI score to different bases (Cont…)

States	Alternative SCI score			
	EU=100	India=100	Mean=100	Median=100
Ireland	106	424	155	143
Italy	107	431	158	145
Luxemb	112	448	164	151
Netherlands	109	438	161	148
Austria	108	434	159	147
Portugal	81	324	119	109
Finland	124	498	182	168
Sweden	132	528	193	178
Cyprus	79	317	116	107
Czech	98	394	144	133
Estonia	82	331	121	112
Hungary	72	289	106	97
Latvia	75	302	111	102
Lithuania	78	313	115	106
Malta	75	300	110	101
Poland	74	296	109	100
Slovakia	85	339	124	114
Slovenia	103	413	151	139
United Kingdom	114	458	168	155
Bulgaria	62	250	92	84
Romania	62	249	91	84
Croatia	82	330	121	111
Turkey	50	200	73	67
Iceland	105	423	155	143
Switzerland	123	493	180	166
Norway	107	428	157	144
All EU	**100**	**402**	**147**	**135**

Note: Bihar is having lowest rank next to Meghalaya.