After retiring as chairman and research director of an Indian oil company in the mid-1990s, the distinguished scientist Pranab Kumar Mukhopadhyay became a technical consultant for the Indian Institute of Petroleum (IIP). The IIP, one of India’s premier national laboratories, is situated at the foothills of the Himalayas, bordering the Rajaji National Park in Dehra Dun. On his visits to IIP, Mukhopadhyay would unfailingly begin his day with a morning walk through the Institute’s tea gardens and the neighboring villages. By the byways of a route that he frequented, was a small furnace that a farmer used to make jaggery from sugarcane.

Mukhopadhyay, who holds a doctorate in the sciences and spent the bulk of his professional life researching hydrocarbon fuels, combustion, and energy, intuitively felt that the furnace design and efficiency could be improved. Fueled by bagasse, waste generated after sugarcane had been squeezed of its juice, the furnace had been designed and built by the farmer himself. The inquisitive and thoughtful Mukhopadhyay soon befriended the farmer and persuaded him to let IIP engineers examine the furnace.

Mukhopadhyay also convinced his good friend, the director of IIP, to assign the project of examining the furnace and improving its design to a staff combustion engineer. Combustion scientists and engineers from the IIP were able to improve efficiency and design such that jaggery production went up by 20%. Almost a decade later, the improved furnace design to make jaggery and its consequent benefits to local farmers is an achievement that IIP leadership never fails to highlight in presentations to visiting politicians and administrators.

This story highlights the potential for scientific research and development (R&D) in developing countries like India and vindicates the belief that India’s first prime minister, Jawaharlal Nehru (1889–1964), had in science and its transformative capabilities. Even so, the example also depicts the failure of Indian science to show relevance to Indian needs. After all, it took a visiting technical consultant to spur IIP to address a technical need in its neighboring community of thirty years.

The pursuit of science for its own sake is noble and certainly worth encouraging. At the same time, a portion of scientific and technological research must address economic and social problems, particularly so for the developing world where there are competing demands for scarce resources. Leading Indian scientific agencies are acutely aware of this and one of them, the Council of Scientific and Industrial Research (CSIR), has begun a systemic analysis of this issue through an expert committee chaired by the renowned Indian economist and policy maker, Vijay Kelkar. In the fall of 2003, the authors were invited by the Kelkar Committee to author a background paper on this subject to highlight key issues. This contribution is based on that background paper.

**Background: The Council of Scientific and Industrial Research**

The CSIR was established in the early 1940s to provide the scientific and technological underpinnings of an industrializing nation. The CSIR is India’s largest scientific establishment and probably the world’s largest chain of publicly funded research laboratories (Rajagopal et al., 1991). Through its network of thirty-eight research laboratories and institutes and eighty field stations and extension centers, CSIR is almost ubiquitous in India. Covering a wide spectrum of science and technology, CSIR’s research laboratories are classified as discipline- and business sector-specific. The National Chemical Laboratory (Pune) and the National Physical Laboratory (New Delhi) are examples of discipline-specific laboratories, while the IPP (Dehra Dun) the Central Leather Research Institute (Chennai) and the Central Drug Research Institute (Lucknow) are examples of business sector-specific laboratories.
With almost 21,000 employees, an elaborate management structure dominates CSIR, which, although federally funded, is structured as an autonomous and independent organization. CSIR reports to and is advised by what is called the Society, chaired by India’s Prime Minister, with other members usually being the ministers for science and technology, finance, and human resources development. The chief executive officer of CSIR is designated as director-general, while directors preside over each of the constituent laboratories. The director-general and the directors are almost always well known practicing scientists and engineers. A Governing Body and the Advisory Board advise the director-general. The director-general presides over the Governing Body (occupied by members of the bureaucracy and Indian scientific community and a few CSIR laboratory directors), which approves fiscal, management, and administrative policies. The Advisory Board is composed of eminent scientists, technologists, and businesspersons and provides intellectual inputs to the director-general. A Management Council assists directors of the constituent laboratories on administrative decisions, while the research philosophy and direction of each constituent laboratory is vetted by a Research Advisory Council usually headed by a scientist of eminence in the laboratory’s field of expertise.

CSIR embarked on a series of organizational and administrative reforms through the 1990s to improve its research and technological productivity and relevance (Turaga, 2000). Business India, corporate India’s leading and most respected business fortnightly, devoted its June 1999 cover story to the transformation of CSIR and shift in research priorities from “research for its own sake” to “research relevant to the needs of economic agents” (Advani, 1999).

Evaluation of CSIR Socio-economic Benefits

Consistent with this new commitment to public accountability, CSIR recently created a committee chaired by Dr. Vijay Kelkar to “assess and value the socio-economic-environmental benefits arising from CSIR’s R&D outcomes and science and technology activities” (Council of Scientific and Industrial Research, 2003). It is in this context that this paper discusses the ways in which the economic and social benefits of CSIR’s research could be evaluated.

Per the terms of reference, the Kelkar Committee is charged with two tasks. The first is an analysis of CSIR’s economic and social impact. The second is to identify metrics to enable evaluation of a publicly funded R&D organization such as CSIR and, finally, recommend measures to optimize the effectiveness of public investments. The focus of our paper, however, is on the first task, i.e., assessment of social and economic benefits.

In this article our aim is to provide an overview of various economic and social benefits that the Kelkar Committee might want to consider, in the context of what we know about CSIR’s activities. We do not discuss the metrics that could be used to quantify the benefits.

We first outline the economic benefits of R&D, which are well recognized now and on which a good deal of literature already exists. Then we suggest a few possible social benefits that are relevant in the context of CSIR’s research portfolio and make some recommendations for the Committee.

Economic Benefits of CSIR’s Research and Development

It is now well understood that science and technology are critical instruments to improve quality of human life, industrial competitiveness, and economic growth. In fact, the Organization for Economic Cooperation and Development (OECD) now labels the emerging economic order as the “knowledge-based economy.” Although such assertions reflect recognition of the increasing role played by knowledge and technology in economic growth “the exact relationship between public support for scientific research and the level of economic performance and social well-being remains more a matter of affirmation, than a set of facts based on measurement and analysis by science policy researchers” (Wolfe and Salter, 1997).

In a recent review of literature on economic benefits of public-funded research, Salter and Martin (2001) identified six possible benefits from publicly funded research. This review was primarily based on research in developed countries. Nevertheless, we think that all these benefits are relevant for assessment of CSIR’s research. In the following sections, we use the
classification of economic benefits identified by Salter and Martin to discuss their applicability in CSIR’s context.

1. Increasing the Stock of Useful Information

One can think of government funding for basic research as expanding the technological opportunities available to society. Individuals and firms need to expend significant resources to use the information generated by publicly funded research in ways that result in new technologies and products and hence increased benefits. CSIR’s contributions toward expanding the “stock of useful information” that has facilitated technical and technological development capabilities of Indian industry must be addressed. A specific question, for example, would be how CSIR has enabled Indian industry to successfully implement and integrate technologies licensed from abroad.

2. Training Skilled Graduates

The supply of new graduates, equipped with training, knowledge, networks, and expertise, to industrial research activity is considered one of the primary benefits of publicly funded research. CSIR has concrete and well-publicized achievements in this area, e.g., the exemplary financial, infrastructural, and intellectual support that CSIR provides to doctoral students and the examination process of unimpeachable integrity that CSIR conducts along with India’s University Grants Commission to “certify” the caliber and quality of college and university teachers. These efforts have had implications more profound and valuable in sustaining India’s intellectual enterprise than generally recognized. Research is a critical component of modern higher education and the inability of Indian universities to provide for that component has been offset, to a certain extent, by CSIR. It is important that studies to quantify CSIR’s achievements in this area be conducted.

3. Creating New Scientific Instrumentation and Methodologies

Scientists often create new instrumentation, techniques, and analytical methods that eventually are adopted and used in industrial processes. Examples of CSIR’s technical and analytical services to either certify industrial products or evaluate the efficacy of domestic or imported industrial processes and products are numerous. Of greater import are CSIR services in providing expert input on scientific and technical issues of national concern. Specific and contemporary examples include the services that the CSIR constituent laboratory, Central Food Technology Research Institute, provided to the Joint Parliamentary Committee that investigated the issue of pesticide residue in popular soft drinks sold in India. Similar technical advice was provided in the past to Mashelkar Committee on Auto Fuel Policy, the Ramar Pillai synthetic renewable fuel controversy, and the Bhopal gas disaster.

4. Forming Networks and Stimulating New Interactions

Government funding brings together the producers of knowledge (scientists funded through government) and the consumers of knowledge (firms) through informal networks resulting in an increased pool of technological opportunities and research activity relevant to firms. If this benefit is narrowly interpreted, one manifestation would be consortia focused on specific technical subjects, e.g., the National Chemical Laboratory’s effort to organize a consortium focused on fuel cells, on which there is very little work currently underway in India. Such an initiative to organize and implement such a consortium strongly highlights the positive and creative role that CSIR and its laboratories are playing in helping Indian players penetrate new and important fields of research. An attempt to identify other similar examples by CSIR laboratories must be made.

5. Increasing the Capacity for Scientific and Technological Problem Solving

Basic research helps in technological problem solving for firms through supply of skilled problem solvers as well as by increasing the general pool of knowledge. Firms often find applied research rather than basic research more relevant to their technology base. However, this relevance varies by sector. Science-based sectors such as pharmaceuticals use basic research more directly than engineering-based sectors such as automotive industry. One example of CSIR’s success in providing a pool of skilled labor is its emergence as a destination for outsourced R&D (Turaga, 2003). This is one form of global recognition of CSIR and thus, the nation’s improved scientific and technological problem solving capacity.
6. Creating New Firms

It is well known that start-up companies often implement the commercialization of breakthrough research. Such organizations are instruments for generating employment, creating economic activity, and, of course, reducing abstract research concepts to concrete reality. While there are some good examples of regional agglomeration of new firms clustered around research-intensive universities, the evidence for this benefit is mixed because of the failure of several such spin-offs as well as the very low growths registered by many others. A detailed analysis of CSIR’s contributions in this area should be conducted. While successful examples are often widely publicized, a complete inventory is critical for a meaningful assessment.

Social Benefits of R&D: More Questions, Few Ideas

While quantification of economic benefits of R&D has received significant attention in the developed world, the same cannot be said for quantifying the social impact. Here there is a conspicuous lack of literature on methods, models, or problems. A significant hindrance to measuring R&D social benefits stems from the difficulty of defining “social benefit.”

More often than not, social benefits are linked to economic benefits, which explains why there has been so little focus on identifying social benefits themselves. For example, higher quality health care could be a social benefit of scientific progress. However, it is also known that an individual’s access to quality health care typically improves with growth in his or her economic situation. Therefore, it is not clear how the accruing social benefits of science should be evaluated independent of derivative economic benefits.

We argue that such quantification of scientific and technological benefits only in terms of economic benefits is too narrow, especially in a developing country context. That most economic benefits result in social development is indisputable, but the valuation of R&D’s social benefits as a mere derivative of economic benefits is an incomplete and shallow analysis. Nevertheless it remains very difficult to quantify any kind of effort, not just science and technology, in terms of societal benefits.

In this section, we outline a few social benefits that the Kelkar Committee might want to consider. We do not claim to present an exhaustive list of social benefits, but our aim is to direct attention to what we consider some of the more important possibilities.

Before going into specifics, we suggest that the Committee should consider getting answers to some broader questions that will set the stage for a more specific assessment. Such questions include:

- How does CSIR define socially relevant research?
- What percentage of R&D expenditure is for socially relevant research?
- What percentage of CSIR output results in products?
- How do CSIR’s accomplishments in socially relevant research, e.g., low-cost housing, compare with the initiatives of other organizations?
- What kinds of incentives exist within CSIR to encourage socially relevant R&D?
- For example, of CSIR’s Bhatnagar, Young Scientist, and Technology Development awards, how many have been awarded to scientists active in socially relevant research? What have been the career paths and progression of scientists pursuing socially relevant R&D?

1. Benefits to Weaker Sections of Society

One indicator of R&D social benefits concerns contributions to the economically weaker sections of society. Such benefits are particularly important in the context of a country such as India, where millions live below the poverty line and cannot afford minimum basic needs. Examples of efforts focused toward achieving such objectives include research on effective and low-cost housing and sanitation. CSIR institutions such as the Central Building Research Institute (CBRI) and the National Environmental Engineering Research Institute (NEERI) have engaged in similar activities.

2. Informing Indian Society

In the past decade, CSIR has quickly responded to global scientific developments. For example, soon after genomics and nanotechnology became globally recognized scientific challenges, CSIR responded with major initiatives, e.g., by renaming one of its biochemical laboratories as the Institute of Genomics and Integrative Biology and establishing a national collaborative research initia-
tive on nanotechnology. Although these are important and laudable contributions that reflect CSIR’s scientific consciousness and its deep commitment to position India as a stakeholder in the emerging global scientific agenda, there are several other global problems that require immediate and equal attention. Some examples include global climate change, depletion of stratospheric ozone, and introduction of genetically modified (GM) foods.

The Kelkar Committee must ask what research CSIR has generated to help India protect its economic and environmental interests in the face of international pressure to comply with treaties such as the Kyoto Protocol. While the western world is the main contributor of greenhouse gas emissions, the impact of global climate change is more likely to be felt in developing countries such as India, in ways disproportionate to their contributions to emissions. In order to present India’s case in international forums correctly and forcefully, research on understanding the impacts of global climate change on Indian society is extremely important. Additionally, the Kelkar Committee must ask what research CSIR is conducting to help equip Indian industry to respond to an environment where carbon dioxide emissions would be subject to environmental regulations.

Along with preparing India for the future, the Kelkar Committee must evaluate CSIR’s record on informing Indian society to help its citizens live a safe, healthy, and meaningful life. The recent controversy about the quality of popular soft drinks and colas in India is a good example. How has CSIR contributed toward identifying and solving such problems? Although it must be recognized that CSIR has little regulatory jurisdiction or responsibility, it is respected as one of the most advanced and high profile scientific institutions of India. This reputation along with the public funding it receives make it responsible to contribute proactively to scientific and health issues of national interest.

3. Generating Scientific Awareness

The eminent science educator Carl Sagan has reportedly cautioned that “it is suicidal to create a society dependent on science and technology in which hardly anybody knows anything about science and technology” (Sejnowski, 2003). Scientific literacy in society is considered beneficial for several reasons: it increases the understanding of strengths and limitations of science so that the public has realistic expectations about what science can and cannot do; it generates awareness about and interest in issues that affect society, and hence enables democratic decision making in public policies; it prevents the public from being prey to dogmatists; and in general it promotes an intellectual culture (Laugksch, 2000).

Having said this, it is equally important for science administrators and institutions to create improved awareness about the limitations of modern science and technology. The passion for their profession ensures that scientists will publicize the capabilities and benefits of science and technology. However, it is far from a sure thing that they will do an equally proactive and qualified job in educating Indian society about the limitations and downside potential of new science. Such balanced scientific literacy, especially on current issues of national and global importance, cannot be fostered only through classroom education. CSIR, as an institution boasting research activity in a wide range of scientific disciplines and with a presence in almost every part of India, has great potential to generate, through its vast community of scientists, the right awareness and understanding of the current scientific issues and controversies.

4. CSIR and National Integration

By 2010, the European Union wants to become “the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion” (Lisbon European Council Presidency Conclusions, 2000 [emphasis ours]). Leaders of European governments consider R&D in science and technology as a vital mechanism to achieve these objectives, and agreed at Barcelona in 2002 to devote, by 2010, 3% of their Gross Domestic Product (GDP) to R&D and to develop science policies that foster research programs of not parochial but common “European” interest (Papon, 2003). The confidence that the makers of the European Union have placed on science and technology as a promoter of “social cohesion”—a concept that the Indians know by the phrase, “national integration”—is remarkable.
National integration, whose relevance never ages in India, is nevertheless an old concept for the country. It is therefore ironic that India should learn from the faith the European Union has placed in science and technology to achieve integration and cohesion. Notwithstanding the several creative means in which leaders of independent India, particularly Jawaharlal Nehru, furthered the idea and importance of national integration, we are unaware of science and technology being explicitly cited as one. Only in recent years has R. A. Mashelkar of CSIR made a reference—that too, an indirect one—to national integration via science and technology when he articulated the concept of “Team India” and “Team CSIR” (Council of Scientific and Industrial Research, 1999).

In any case, just because national integration was not explicitly articulated in India as a social benefit of science and technology does not imply the absence of such a relationship. We are, in fact, certain that a strong sense of national integration was facilitated in a subconscious mode by CSIR R&D activities. After all, there is no region in the country where a CSIR lab does not exist. Further, science and scientists by their very nature seek collaborative work, and one may expect inter-laboratory collaborations to have furthered the cause of national integration.

Less directly, CSIR labs by their very presence in different parts of the country should have resulted in cosmopolitan communities populated by highly educated individuals possessing a strong sense of national and social responsibility. It is reasonable to expect such centers of conscious citizenry to influence local communities in cohesive and inclusive ways. This, of course, might not be a direct outcome of CSIR’s R&D activities but is no less valuable.

Conclusions

Research and development as a critical instrument for economic growth is now well ingrained in economic tradition and significant effort exists on quantifying R&D’s economic benefits. Consistent with this trend, previous efforts (e.g., Abid Hussain Committee, Mashelkar Committee) to examine CSIR activities, while no less important, have focused on improving the organization’s effectiveness in terms of scientific output, economic impact, and relevance to the marketplace. In comparison to economic benefits, little effort, even in the developed parts of the world, has been directed toward understanding, let alone quantifying, the social benefits (independent of economic benefits) of science and technology. In this context, the emphasis that the Kelkar Committee’s terms of reference place on determining the social effectiveness of CSIR makes its constitution a landmark in the history of both CSIR and Indian science.

Further, if there is one element of the Indian scientific enterprise that has received unflinching criticism from civil society, it is the inadequacy of its social relevance. An effort to quantify and formulate ideas to improve the social relevance and impact of one—albeit large—quarter of India’s scientific enterprise is a huge step in the right direction.

Equally significant is the explicit emphasis in the terms of reference to developing performance indicators appropriate for evaluating publicly funded R&D organizations (such as CSIR). Implicit in that emphasis is the realization of CSIR’s responsibility for directing precious public resources for public good. There are few publicly funded institutions in contemporary India that seem to reflect that concern and responsibility through their activities.

Having said that, the authors strongly believe that the issues that the Kelkar Committee will need to examine are so extensive in breadth and momentous in philosophical import that its report is only the beginning. It is also important to ensure that this Committee will not be a solitary effort but rather a catalyst for a systemic effort to continually evaluate research programs for social benefits in CSIR and eventually all Indian scientific institutions. In broad philosophical terms, the Kelkar Committee is an effort to further “democratize” science and technology by including social performance indicators. The challenges of putting India’s public resources to good use will only increase in the future and a democratization of that process in science will stand in good stead.

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SCIENCE POLICY FOR INDIA

89


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