

smaller elements and pricing each element separately.

With forging of strategic alliances, mergers and acquisitions worldwide the post-technology sale improvements are taking a beating depending on the strategic importance placed by the new owner of the technology and patent rights. This has led to technology suppliers making technical services as part of separate agreements.

Conclusion

We are moving towards an era of the global village characterized by global presence, strong brand identification, cross-border manufacturing and marketing, strategic alliances and heavy investment in future oriented research and development. In such an era there will be no such thing as sustained long term success and growth in chosen fields.

Publicly funded R&D institutions in the post-liberalization era

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The changing scenario

In the new global order, there are vast changes in the political, social, economic and technological spheres. Marginalization from the global process will be on cards for the developing world, if it does not make some strategic moves. Indeed the developing world will find it difficult to get an access to the world market and also difficult to compete successfully, if R&D and technology are not used as powerful strategic tools to surge ahead. Publicly funded R&D institutions will have a major role in the scheme of things, if only a major transformation is planned and executed now.

Let us view the Indian scenario in the global context. The recent initiative of the government to integrate the Indian economy with the global system has posed new challenges for the publicly funded R&D institutions. The new environment is characterized by deregulations and abandonment of import substitution strategies. A new definition of the role of the state is emerging slowly but surely. Privatization of the previously state operated services is on the cards. Restructuring of the productive system has become as important as obtaining access to new technologies and promoting a deep process aimed at technological innovation. Publicly funded R&D institutions in India have to be viewed in this context today. Notwithstanding many contrasting views, the Indian R&D institutions, with appropriate government support, could play an increasingly important role in the process of global competition, restructuring of the industry and economy and in upgrading the local industry to gear it to face the

international competition successfully. This will only happen if an *enabling environment* is created with the support of the government and the industry in which these institutions will flower and flourish. This paper deals specifically with the question of creation of such an enabling environment.

Need for change

Publicly funded R&D institutions are under clear pressure all around the world today. Many old styled industrial research institutions had largely employed the *supply push* approach. They believed that just doing good science will automatically produce results for improving the economy and the society. This thinking has been shown to be wrong. In the past, there has been a lack of an organic linkage between these institutions on one hand and the productive sector on the other. This has proved counterproductive. There has been a harsh reassessment of the role of these institutions and an agenda for change has been already drawn out.

In many countries, different types of organizations and management structures for publicly-funded R&D institutions have been proposed. They have been also implemented boldly. For instance, in Australia, CSIRO was questioned in the early 80's as to whether it provided value for money in terms of its contribution to economy. In 1986, CSIRO organized itself into a number of institutes with clear missions and targets for cost-sharing with the private sector. DSIR in New

Zealand went through an even more drastic surgery. DSIR and other publicly funded institutions were restructured last year and they have now been replaced by 10 crown research institutions, which are registered as independent companies under the companies act. These have been given freedom to enter into joint ventures with the private sector, borrow money in open market for development, sell the intellectual property to the highest bidder, etc. Whereas such far reaching changes are sweeping the world, we in India, continue to discuss and debate about the need for change, forgetting that the others have already done it! We need to have a quick and serious look at our publicly funded R&D institutions, reassess their role and prepare our own Agenda for change. We can view the publicly funded R&D institutions of today and tomorrow in this context.

The role of publicly funded R&D institutions

We must clearly recognize that there is an important role for publicly funded R&D institutions in India. They are expected to advance frontiers in science and engineering. Independent basic research is an investment for the future. A nation prepares for modern technologies essentially through the efforts of publicly funded R&D institutions, whether they are in advanced materials, biotechnology, information technology and so on. It is only by exploring these frontiers vigorously that one develops a capability to receive and understand the technology from abroad. Other roles of these institutions include public services and societal missions connected with the improvement of quality of life and attainment of sustainable growth. This includes agriculture, health, environment and energy, national resources surveys, etc. The publicly funded institutions have also the mandate of producing well-trained post graduates and doctorates to ensure that the technological performance of the state is kept at a high level by a highly qualified work force. In addition, especially in the developing world, where the industrial R&D culture has not grown fully, there is an extra demand on them to develop industrial technology and transfer it.

We have CSIR, ICAR, ICMR, the IITs, the university system and many independent research institutes and associations aided by the government. Out of these, the maximum demands for creating a linkage with the productive sector of our economy and producing deliverables at an internationally competitive level today have been put on the CSIR system. An obvious personal bias towards CSIR from this author is to be expected and so will it be in this article. However, a reference to the other vital elements of the publicly funded R&D set up in India will also be made at the end. The role of the government and the industry will be emphasized.

Assessment of the past

It is good that CSIR has an open system and that it has been questioned repeatedly. However, the evaluation of CSIR's performance has to be done in the context of the overall R&D scenario, the industrial environment in which it operates and its share of the national S&T expenditure.

The investments in CSIR by the Government have been only about 6 to 7% of the total S&T expenditure during the past few years. However, the expectation seems to be that CSIR should provide an answer to all the ills of the country. While this has been the demand on CSIR, the industry has never been asked as to what its outputs are from the 20% of the national S&T expenditure incurred by it during the same period of time. One sees that a major portion of this input has gone in quality control, trouble shooting, etc.

Let us not forget that out of the total industrial production, the portion that can be attributed directly to the contribution of R&D efforts in the country does not exceed about 5%. The returns from investment in R&D in economic terms can be achieved only if the industrial firms participate fully in the innovation chain namely, research, design, development, production and marketing. Unfortunately, there is no intrinsic desire in the industry to innovate and be ahead of the rest. The Indian industry, by and large does not look at technology as an instrument of growth. It has by and large failed not only to invest in R&D but also in showing a visible output based on its R&D. Today in industry, one rarely finds leaders, who are willing to take risks with unproven and new technologies and new markets as well as champion the cause of R&D. India is making mid-course corrections only now by opening up the industry to market economy and building gradually the competitive forces in which industrial R&D thrives. This will be, however, a slow process lasting at least a decade. The questions today are what happens in the transition period? Who does the R&D? Who pays for it? We will have to address these issues seriously.

Today's paradoxes

It is obvious that the publicly funded R&D institutions will have to play a major role in managing this transition. But the publicly funded R&D institutions are at a cross road today. At a time, when the potential importance of technology institutions is increasing on account of the role they could play in the process of competitive restructuring and in upgrading the capabilities of local industry to compete successfully in the open market situations, most of the S&T agencies in India are facing worsening conditions due to poor funding.

It is ironic that this should be happening when the basic and pre-competitive research worldwide is receiving state support. Japan, who is the most successful nation technologically, is actually increasing its funding in basic research. As regards applied research, practically all the governments indirectly support this by way of subsidies or earmarked funds. Only the details of the way in which this is done differ from country to country. The fact that emerging technologies will not be available for love or for money should be clear to us. As regards issues such as public services, societal missions, training etc., one has to ask the question as to whose responsibility will this be? The policies of the government vis-a-vis the public sector undertakings and publicly funded institutions need an examination. One observes that the money spent on sick public sector undertakings is a thousand times more than that spent on publicly funded R&D institutions. The public sector undertakings, which are not in the core sector of economy continue to lose money but the funds for publicly funded R&D institutions continue to dwindle! What has to be realized is that the extra support that is needed for survival and success is not large. The crisis that CSIR faces today is such that it has no money for doing research and development. The grants available are not even enough to pay for the salaries and the infrastructure. What it means is that the status of publicly funded R&D institutions today is that of an industrial unit, which has been asked to produce goods and survive on the basis of sales realization without being given the working capital to purchase raw materials, pay for utilities, etc.!

There is a clear danger looming large on the horizons. If a sudden pressure for generating funds by whatever means for survival is applied, then the quality of R&D will certainly go down. The high quality scientists and technologists, which are our real assets and only on the basis of which we can hope to build the future competitiveness of the Indian industry, will simply move to greener pastures elsewhere in industry in India or even abroad. Such a disaster has to be avoided at any cost.

Managing the transition

There has to be a grand plan for managing the transition from completely funded public R&D to partially funded public R&D. The publicly funded R&D institutions will have to look for industrial partners today of a special kind. They should be the champions of R&D with an appreciation of technology and willingness to invest in R&D. They should take risks and should have patience to wait for returns. They should be partners, who have the technical, financial

and marketing strengths to take ideas to the market place.

Publicly funded R&D institutions should be used as *idea generators and providers of new concepts*. Industry cannot simply look at them as super markets where off the shelf technologies are sold. The industry should willingly integrate national R&D resources into their business strategy. All this would be possible only when we can change the climate for an interaction between the national laboratories and the industry with an improved communication and understanding, faith in mutual growth and development of healthy working relationships. Today there seems to be a difficulty because the laboratories and the business units have different cultures. For instance, the laboratories have a long term horizon on R&D, whereas the business units have a short term horizon. As regards the financial structure, R&D units are a cost centre whereas the business units would want it to be a profit making centre. As regards the products emerging from R&D laboratories, these come out as some package containing knowledge and information, whereas the business units will have to convert these into goods and services, which are saleable. There is even a difference in the orientation between the laboratories and industry. The R&D laboratories work on the basis of scientific novelties and perceived needs, whereas the business units work on the basis of attractiveness in the market and potential for profit. There is a need for both the R&D institutions as well as the business units to change their culture. Only then will there be a meeting point and harmony and synergy of action.

Till this happens, the government's mandate should be clear. It will have to create a scientific and technological environment, which will encourage industrial growth and competitiveness. There are a variety of direct and indirect measures through which this can be done. These would, for instance, include reintroduction of the fiscal incentives for undertaking R&D that were withdrawn in 1985. Several other measures can be taken to make R&D done by industry attractive by itself. These include making products based on R&D tax-free for a limited period, allowing R&D companies to be promoted as commercial ventures without any tax liability, making income from technology sale tax-free, etc. There are several other measures that one can suggest—but the key point is to re-establish the feeling of mutual trust between the government and industry.

The government should fund research and development particularly in basic and strategic research areas with a strong commitment. The government can pay for the R&D services and appoint R&D laboratories as executive agencies for the role that is played today by the government. The government should enhance the autonomy of research institutions by self management of their planning, Accounting, personnel and organiza-

tional structure, removal of bureaucratic controls and unrealistic audit of R&D are a few of the steps that need to be taken.

We have explained our expectations from the government and the industry vis-a-vis the publicly funded R&D institutions. We believe that with a progressive and forward looking policy framework, such institutions can grow and flourish. However, the institutions themselves will have to undergo transformations. As an example, we will take CSIR as a system and explain what can be done. Our deductions are generic and certainly applicable to other publicly funded R&D institutions at large.

CSIR today

CSIR of today has a large multidisciplinary expertise and state-of-the-art facilities in many areas of S&T and close linkages with industry in some sectors. These are clear strengths, but there are weaknesses too. Inability to bring together its laboratories and the scientists to accomplish major missions, absence of a goal setting mechanism, lack of selectivity, etc. are obvious problems. Inadequate strengths for techno-commercial evaluation of projects, marketing, legal aspects of patenting, contracting etc. have created barriers for growth. Absence of real incentives for industrial research, with poor salary scales in comparison to both universities, and industries and lack of real autonomy has also adversely affected it. CSIR has also suffered from some other factors, which are a national malaise. There is a serious problem of value system in India today. Applied research is considered desirable but fundamental research is applauded and rewarded nationally. This has created an identity crisis for many scientists including those in CSIR. There is a growing realization in CSIR today that it is important to be a global player in the technology game, otherwise the rest of the world will pass it by. At the same time there is lack of appreciation of what it takes to enter and consolidate one's position in the international technology game.

The question is how do we convert CSIR into an efficient, performance-driven, result-oriented and a globally competitive organization. Let us focus on this issue first. We must have a major relook at CSIR's ability to create knowledge base and markets in the emerging competitive environment. In many cases revolutionary changes will have to be thought out. An extension of CSIR's past cannot determine its future.

Marketing CSIR

With the changed economic scenario, unpackaged technology holds little prospect for marketing. Intimate

contacts with other constituents in the innovation chain becomes essential. This calls for a strong pre-marketing and post-marketing effort. Marketing of all components of knowledgebase such as invention sale, consultancy capabilities, training, S&T services, etc. needs to be done urgently and aggressively.

CSIR cannot survive by just paying a lip service to marketing. There is a need to induct motivated and qualified specialists in these groups. CSIR should be able to attract high level talent in business management (for technology marketing), law (for patenting and contracts) and cost or chartered accountancy (for finance, budgeting, project monitoring and control). International game in technology is tough and demanding. Only the highest levels of professionals can play these games. Novices will be losers.

However, will such professionals want to join the CSIR system? Why should an IIM educated business management graduate want to join and look at CSIR's problems on technology management or its technology marketing? We must recognize that there are many competing career opportunities for such professionals in conventional industrial management and marketing areas. If we want to attract them, then these professionals will have to be given a place in CSIR along with its scientists. They will have to be given the same remuneration packages and promotional avenues. We will have to realize that a first-rate technology cannot be marketed by a second rate marketing man! In a culture, where science was considered the first and the last word, induction of such professionals is bound to create tension and conflict between the R&D scientists and the marketing professionals. This transition will have to be handled sensitively and carefully.

CSIR should not only have tie-ups with industry but also with several other agencies and institutions involved in technology generation, transfer, finance, etc. Formation of consortia with other R&D agencies, design and engineering consultants and financial institutions for technology packaging should be aggressively pursued. In some cases, CSIR itself will have well-developed infrastructure and expertise. This should be advantageously utilized. CSIR can greatly help other R&D organizations to package and exploit their knowledgebase. CSIR laboratories should make strategic alliances with such R&D and technology transfer agencies. This twinning can be for mutual benefit.

Need for flexibility and freedom

The intensity of CSIR's effort on industrial research will have to undergo a step jump. This simply cannot be done unless there are enough incentives for CSIR scientists to work on industrial R&D projects. The scientists must get benefits, both professionally and

monetarily, so that they are spurred on to do industrial research. There is an evidence to suggest that whenever such incentives are given, there is a greater motivation for the scientists to take up user-oriented work. In fact the earnings from consultancy in CSIR have increased by ten folds in the last six years, since scientists found that they could share the earnings.

There is another reason why we need to create these incentives. The salaries in the corporate sector have become extremely attractive vis-a-vis the salaries in CSIR. The best of minds in CSIR, who are tuned to commercialization of results, are being offered extremely attractive remuneration packages (sometimes even five to six times of CSIR offerings) today by industry. CSIR obviously cannot make such a large compensation through normal salaries. Therefore, other means of enhancing the remuneration packages, especially in the case of those who are contributing productively to the commercialization of CSIR knowledgebase, must be sought.

CSIR should recognize that it is not only the technology generators but also the technology facilitators, that are important in the total chain of exploration, exploitation and generation of wealth. Honours, awards, recognitions, etc. must be available to these facilitators also.

Need for bold measures

Some hard decisions will have to be taken by CSIR. Performance-based budgets is one way to put pressure

on laboratories. However, the present allocations by the Government are so inadequate that this year, CSIR has been left with no money to provide for equipment, chemicals and so on. The R&D support budget, rather than increasing, has reduced in the last three years from 28 crores to 16 crores. Note that this is a support for over 40 CSIR laboratories! The result this year is that some laboratories have been forced to pay for their electricity and water bills through their earnings from industry! Such earnings, as an incentive, were earlier planned to be reploughed into R&D activities of the laboratory. Rather than providing incentives, we are now in the process of creating a major disincentive for the scientists to go out and seek funds from the industry. The situation is extremely serious and alarming. One wonders whether CSIR will now have to sell its assets to survive!

CSIR should become a truly entrepreneurial organization. CSIR should offer its technology or any other component of knowledgebase against equity participation in the licensee's companies in lieu of payments by the licensee. CSIR laboratories will have to be allowed to establish commercial arms to sell technologies, products and services. Professional technology transfer agencies from India and abroad, design and consulting organizations, technology marketing experts, etc. should be hired on a commission basis. This may be a cultural change for CSIR, but everything that shortens the path from discovery to market place must be done, boldly and urgently.

Technology policy in a liberalizing economy

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The value of technology

It should be useful to remind ourselves about the importance of technology development before discussing technology policies. Many attempts have been made to estimate the contribution made by technology to economic growth, and a gratifying consensus appears to be emerging¹. Robert Solow, the Nobel Prize-winning economist, concluded from an early study that 'half of economic growth is due to technological improvement'. An analysis of the US economy by Moses Abramowitz for two periods separated by nearly a century (1869-73 and 1944-53) also found that about half the growth experienced in either period could be directly attributed

to technological improvement, including that in human resources. The well-known Stanford economists Boskin and Lau have analysed five major industrial nations, viz. UK, USA, FRG, France and Japan, and found technical progress to be the most significant source of growth—explaining more than 50%—followed by growth of capital input (20%). In Japan, which emerged as an economic and technological power house in about one generation after a catastrophic war, the investment in R&D has exceeded capital investment since 1986; in 1990 it was 26% higher². Another Nobel laureate, Sir Arthur Lewis, has shown by detailed analysis how the poverty of India in colonial times could fundamentally be seen as due to technological