EMERGING DIRECTIONS OF R&D COMMERCIALIZATION IN PCSIR

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ABSTRACT

Development of commercializable technologies in Pakistan is a formidable task. Reduced public-sector funding for routine R&D has necessitated the emergence of participative investment by the end-user industrialists and entrepreneurs. ISO regulations on industrial quality-assurance and the competition threats posed by WTO to the national industrial base are conducive for investment in R&D on commercializable technologies. Under such a scenario, our national industrial base is faced with stiff challenges from international competition for their survival. Innovation is widely recognized as a key-element for national industrial competitiveness. Traditionally, the amount of R&D carried out by the private sector in Pakistan has remained negligible on the scale of international standards. Within this background, PCSIR provides the necessary base for encouraging SMEs to invest in the development of technologies that are suited to indigenous materials and local conditions. Linkages for such type of arrangements are possible through institutional clusters of cooperative business technologies and through business mode of technology-incubators. Such arrangements have been successfully operated in several developing countries. Venture-capital investment by SMEs is suggested for incubation of technologies at the pilot-plant facilities of PCSIR and their eventual graduation into the industrial sector. A mechanism of implementation based on the so-called Third-Generation R&D is proposed for extending a variety of technical services by PCSIR.

INTRODUCTION TO PCSIR

Pakistan Council of Scientific & Industrial Research (PCSIR) had its beginning in 1949, immediately after the inception of Pakistan in 1947, as the Department of Industrial Research. The Department was given its present name in 1953. Despite numerous constraints, however, PCSIR continued to contribute to the realization of objectives of its charter. A major policy decision was again taken in 1973 when around PCSIR was created the Ministry of Science & Technology (MoST). PCSIR, at present, is the largest applied/ industrial R&D organization in the country. Starting with PCSIR as its only R&D council, MoST now has under its folds more than a dozen autonomous councils, institutes and a science foundation, covering a wide spectrum of S&T disciplines. PCSIR, nevertheless, continues to be the ministry's largest R&D body receiving the largest chunk of its budget and employing almost the same proportion of technical manpower.

PCSIR has four multifunctional research laboratories in Karachi, Lahore, Peshawar and Quetta; Karachi and Lahore are by far the larger and therefore set-up in the structures of "laboratories complexes". A wide-range of S&T disciplines are organized into quasi-independent Centres/Divisions, such as Applied Chemistry, Minerals & Metallurgy, Glass & Ceramics, Food & Biotechnology, Environment Protection, Medicinal Botanics, Fine Chemicals & Pharmaceuticals, Rural Technologies, Instrumentation & Electronics, Research Industrialization, Polymers & Plastics, Marine & Applied Biology. The monofunctional units include National Physical Standards Laboratory at Islamabad, Fuel Research Centre at Karachi, Leather Research Centre at Karachi, Solar Energy Center at Hyderabad, and Fruit Processing-cum-Demonstration Unit at Skardu. Also, there is a Scientific Information Centre at Karachi; the Centre, in addition to other information-related matters, puts out, now in its 46th volume of publication, the Pakistan Journal of Scientific & Industrial Research which publishes articles from national and international contributors after international refereeing. The trained-manpower needs of the industrial sector are met through two centers in Karachi, viz., Pak-Swiss Technical Centre for middle-level technicians, and the National Institute of Industrial Electronics Engineering producing graduate engineers. The administrative headquarters are located at Karachi, with the Chairman's Secretariat at Islamabad.

The charter of PCSIR activities, in general terms, relates to providing a broad base to the industrial

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sector, through better utilization of indigenous resources. These may be categorized as:

- Optimum utilization of indigenous raw-material resources for the development of industrial processes.
- Development of technologies around local resources, from bench to pilot-plant stages, and leasing them out for industrial exploitation, leading to import substitution and export-enhancement.
- To conduct R&D work on problems faced by the industrial sector and maintain linkages with the industry through advisory services.
- Dissemination of technological knowledge through seminars, workshops, publications and provision of services to academic institutions.
- To undertake cooperative research, with local and foreign R&D organizations, on projects of mutual interest.
- Training and grooming of manpower for industry and research centres to create a sound S&T base in the country.

Over the years, the primary target of PCSIR scientists has remained the development of low-cost technologies attracting the attention of small and medium-level entrepreneurs (SMEs), since this class of investors is internationally recognized to be the backbone of economies in developing countries. The number of technical processes developed for such SMEs is well over a thousand. A survey carried out in the 1990s indicated that out of 84 technical processes developed until 1990, 367 were leased out to SMEs. These were estimated to turn over Rs. 612 million to the national economy, which in terms of foreign exchange savings amounted to Rs. 7 billion. The spin-offs, such as job creation and down-stream industries, remained unaccounted for within the scope of this survey. In addition to these technical processes, the organization's scientists have obtained about 350 patents and contributed more than 5000 research publications in national and international journals. In the domain of human-resource development, the number of Ph.D. and M. Sc. research theses supervision is well over a hundred and a thousand. PCSIR is also running its own degree- awarding Institute of Industrial Electronics & Engineering, and a diploma-level Technical Training Centre. The number of graduates and trainees from these institutions runs into thousands. As the principal national R&D facility, PCSIR is extending advisory and technical services to various ministries and public- sector organizations. It is also playing its due role in enhancing the national self-reliance capability in the production of much needed defence-related supplies.

Analytical and technical reports issued by the PCSIR scientists have gained international credibility and acceptance. Among the specific recognitions accorded to PCSIR are by Saudi Arabian Standards Organization, Japanese Ministry of Health, ISO- 9001 and ISO-17025. This facility is being used by importers and exporters for the quality-certification of products in large numbers, which on a daily basis ranges between 80-100, collectively at the various PCSIR laboratories located in different parts of the country. This activity is particularly relevant, since Pakistan is a signatory to the General Agreement on Tariff and Trade (GATT), and to the rules and regulations of World Trade Organization (WTO). With the likely implementation of WTO by the year 2005, PCSIR is destined to play a very vital role in quality-certification of Pakistani products of export.

FIRST GENERATION R&D

The mechanism of technology-development in PCSIR has remained, what is typically dubbed as "First Generation R&D". Researchers in this system operate in isolation, having little or no linkage with end-users. Budget provisions are made for the total project-framework. The research operator receives little or no guidance from the top management in the defining, development and conduct of projects. The researcher is not pushed for a time-frame. The finance allocators view the activity as a generally wasteful input. The non-scientists industry outfit vs. the research scientist are locked in a continuous debate to under-rate each other's perceptions and contributions. The business community believes that researchers lack appreciation of the technology-needs of the industry, that they are strong-headed and not prepared to communicate, and that they lack confidence in putting their research-findings to a test. Researchers, on the other hand, believe that any industry-targetted research-objective kills in them the motivation to explore new frontiers of knowledge, that administrative and management disciplining hits at their creativity potential, and that predicting a time-frame for completion of projects is not possible. With a few exceptions, indeed, the

psyche of researchers and the managers in the industries/commerce in developing countries, including Pakistan, is a typical reflection of the fundamentals of first generation R&D.

Whereas significance of creativity, intuition and spatial reasoning, as the basic elements of the first-generation R&D management, are un-questionable, yet there are serious concerns when these are followed unbridled. Difficulties, for example, may arise when R&D is pursued, without the nod or commitment of an end-user, since, on completion thereof, the linkage with the one prepared to take it up and commercialize may be difficult to establish. The developed technology may then have to wait on the shelves for unspecified periods, or may be traded off haphazardly, or sold to the industry at throwaway fees. From the management point of view, another difficulty relates to measuring the results; in simple words the R&D progress-evaluation tends to be ritualistic. This is experienced, owing to vaguely defined objectives, such as: "the project, on completion, will render the process cost-effective", "process-innovation will increase output", "use of indigenous raw-materials will reduce the import bill", "it will help augment exports", and so on. All these claims are insufficiently defined output, against which the progress of the R&D project may be realistically weighed. The review ultimately can, at best, relate the output to technical achievements, usually in the shape of research papers and reports. But this, for the end-user in the industry, means little or nothing at all.

EVOLUTION OF THIRD-GENERATION R&D

Internationally, the First Generation has evolved since long, via the Second Generation, to the commonly known Third Generation R&D. This has been mainly due to the continued stripping of R&D funding from the public sector budgetary provisions. Finance planners all over the world, when considering resource mobilization for S&T, are now invariably raising the issue: how will the society benefit from investments made in R&D? This in fact reflects their gut-feeling of fear that the technology outflow may not be commensurate with the allocations made. From their perspective, the concern has a merit in the void of a defined benchmark to measure the often invisible and indirect but benign contributions that accrue from S&T research. An acceptable tangible, now recognized, is the level of real money or in-kind participation in R&D efforts that flows-in from various players in the game. A manifestation thereof in the technologically developed countries is evidenced in the corporatized R&D, having a holistic strategic framework.

The concept, generally dubbed as the "third generation R&D management", is based on the philosophy of partnership that breaks isolation of researchers from the user and integrates R&D with business strategies. The operating principles in such a scenario are:

a. *Technology Selection*: depends upon national priorities, maturity status, competitive advantage and absorption capacity.
b. *Funding*: based on expected financial impact, balance of risk and reward.
c. *Target*: all R&D to be well defined and consistent with business, output and technological objectives.
d. *Priorities*: affordable on cost-benefits balance-sheet and contributive to strategic objectives.
e. *Output Measurement*: quantifiable realization of objectives, relevant with benefits to the society, and the commercial output measured against technological expectations.
f. *Progress Evaluation*: regularly, according to milestone setting, schedules and dictates of external and internal indicators.

The emerging direction evidently alienates the hitherto held view on the convertibility of wealth into knowledge through government patronage at the expense of tax-payer's money. The very idea of selling knowledge was then generally viewed as anathematic. This encouraged ad hocism in project selection centered around ego-satisfaction of scientists, generally with little regard for the stakeholders and end-users. However, the changing economic patterns, political realities and greater awareness on spendings led to submission of such directionless pursuit of knowledge to valuation of the worth it will generate on measurables. This has influenced the change in S&T orientation. The culture thus evolved has introduced elements of sensitivity to client-needs, significance of time-constraints on the resolution of problems, judgment on the interpretation of observations and a commercial awareness of revenue and costs. The spawning of R&D corporatization was the evident corollary, which has a scope, with special reference

to Pakistan, as the future direction of R&D commercialization.

To summarize, the third generation R&D is typically characterized by the following. The latest stage in the evolving concept of R&D management seeks to create a balanced portfolio, jointly conceived, developed and executed, in a spirit of partnership between the business-manager, administrative managers, and the technical managers. The theme of management is strategic and purposeful, with a corporatized outlook. Fundamentals of the approach reflect the following characteristics:

- Responsive to the existing technology-needs of the business.
- Exploitation of the existing technology-opportunities.
- Identification of new commerce-oriented technologies.
- Strategic and operational partnership between technology-developers and users.

The concept of third-generation R&D management, having evolved from the first, through the second generation, is an improvement in the following aspects:

- The spirit of cooperation between different operators of the project jointly explores, assesses and decides on the management of the project, leading to the creation of mutual trust among them, and so the partners are willing to share gains and losses.
- Partners remain motivated and involved, as key-players in their respective areas of responsibility, resulting in better-quality decisions during implementation phases.
- Execution in a horizontal sliding-matrix provides holistic view on the entire range of segmental R&D activities, enabling recognition of the ongoing strategic dynamics and the risk-component, on account of different uncertainty elements.
- Isolation of the researcher is broken, through interaction within the group, with other groups working in the R&D portfolio-range of the organization, and in general with all other managers somehow connected with the project.
- Integration of the operatives of plan-execution, sharing of collective experience, and access to information is helpful in exploiting the technological synergies that may emerge, thus providing a suitable base for continuity of achievements.

It is significant that the third-generation R&D still views academic research as the forerunner of industrial research. Whereas the approach provides sufficient motivation for creativity to researchers, it also introduces a sense of purpose in their pursuits, through the introduction of short-term business-oriented targets, rather than mere ramblings in the dark in the quest for knowledge. The following mechanisms introduce the requisite constraints for the maintenance of vision and mission in place.

- Relevance and importance of the predominantly fundamental research-objectives to the R&D financing partner within a defined period, say in 5 or 10 years.
- Availability of the technical manpower-threshold necessary to convert research-findings into a commercial technology.
- Resource-mobilization potential and availability of cash-flow for commercialization.
- The priority domain of the technology likely to develop from the academic research.

STRENGTHS OF PCSIR FOR ADOPTING THIRD-GENERATION R&D MODE

PCSIR is particularly strong to attract industrial linkages through “Third Generation R&D”, as evident from what it can do in the following areas.

- Expertise to develop small to medium-scale processes, procedures and technologies.
- Facilities to evaluate and test raw-materials and finished products.
- Competence to undertake quality-control and standardization of industrial products and unit operations.
- Experience of extending trouble-shooting services to industry.
- Experience of repair and maintenance of instruments.
- Expertise to extend consultancy-services and undertake feasibility studies.
- Excellent track-record of technical training for human-resources development.

- Availability of pilot-plants for testing of technologies.

VENTURE AND RISK CAPITAL

The above-stated strengths are sufficient indicators for PCSIR to embark upon various innovative approaches of technology commercialization. Among these are the mobilization of venture and risk-capital by SMEs. This initiative is being taken, in consideration of the following current impediments to commercialize PCSIR technologies.

- SMEs are reluctant to invest in untested technologies.
- Venture-capital is not available.
- Risk-factors are too high for SMEs.
- Service mark-up on loans is high and not manageable.
- Capital costs for development of industrial operations is prohibitive for SMEs.
- Importation of black-box technologies is easy.

The following stages are particularly relevant for start-up ventures by SMEs. As the technology-market grows, new ideas normally come from research and development scientists and engineers, who try to solve technical problems. As technical problems are being solved, new ideas are generated for the development of new products. All ideas internal to an industrial outfit go through a close examination and scrutiny, in order to make sure that they match with the commercialization strategy of the industry. As the industry grows, its operations diversify and its needs for R&D expand as well. It may happen that certain category of R&D is outside the scope of a certain SME company's strategy. Frequently, such technologies will be scrapped or ignored by the SMEs administration. The R&D team will then start to look for another SME or modify the technology to suit the product-portfolio of the company. In most of the cases, new ventures are started up by a group of engineers or technologists.

The following are the steps that a new venture goes through to develop, or continue to develop, the product that has been conceived. Marketing will then become a critical activity that needs to be managed. For a new venture at this stage, a marketing executive is needed to manage marketing-programme. As soon as marketing-programme is formed and activity is started, then there is a need for capital to support the operation. A detailed and well thought of plan is therefore needed in order to raise funds to finance the operation. At this moment, a financial consultant is needed to help structure the company in such a way that supportive investors get attracted. Because an entrepreneur normally lacks financial experience, he or she would be put in an inferior position in negotiation with investors. This is the stage when the need for a well organized technology business-incubator becomes critical.

TECHNOLOGY-BUSINESS INCUBATORS

There is increasing emphasis around the world now on strategies and instruments for promoting innovation and creating entrepreneurial ventures. In this context, technology-business incubators are showing evidence of effectiveness in creating growth-potential enterprises, employment incomes, technology commercialization and other benefits. These managed workspaces are growing rapidly in the industrializing countries as well as those in transition to open markets. A recent phenomenon is the sharp increase in internet incubators, based on the concept of venture and risk capital. Technology incubators are longer-term, capital intensive, real-estate driven investments, which take advantage of proximity to sources of intellectual capital and conducive infrastructure, to promote scientific research and its utilization. In many Asian countries, the trend is towards the convergence of services for holistic support.

In recent years, both governments and donors are scrutinizing business-development services for small enterprises, in order to enhance their performance and raise cost-recoveries for different types of support-facilities that are provided in these incubators. An emerging view is that governments should develop supportive policies and business-infrastructure, while private agencies provide the actual training, counseling, information, networking and related services in a business-like manner. It has to be appreciated that the start-up and early-stage businesses in difficult environments require access to good support for management-related activities, technology and infrastructure, all within the context of their very limited financial resources. In most countries, both rich and poor, initial governmental

support is needed for management, technical and infrastructure-support for early-stage businesses, but it must always be with the objective of moving towards a sound level of self-sustainability after three to five years.

The rationale for the incubator as an economic-development tool is generally as follows.

- Facilitating transition from command to market economy.
- Mechanism to promote technology-commercialization.
- Promoting synergy within and among businesses.
- Reducing costs and consequences of business failures.
- Modifying the cultures of risk-taking, teamwork, networking, information sharing.
- Helping reduce market failure, e.g., the lack of affordable, divisible work-space, facilities, services, access to finance, information and other resources.
- It must be realized, nevertheless, that government support makes sense in specific conditions, such as listed below:

– When it helps overcome market constraints, improves access to information not freely available, reduces proportion of failed firms.
– Becomes a visible symbol of the state's commitment to SMEs.
– Is limited to initiate the incubator-establishment process:
not new building construction but a renovated or rented space,
not a continual subsidy but till operations are stabilized.
– When an incubator is an extension of the state's role in providing public goods: knowledge, research, technology transfer, infrastructure.
– Incubators have helped address some of these problems.

It is also appropriate to indicate the justification for public investment, which is as follows:

- Creation of jobs (direct & indirect) per unit public subsidy.
- Taxes paid by corporations and workers per unit subsidy.
- Income, sales and exports generated for community and country.
- Disadvantaged groups empowered.
- Client (incubator tenant) satisfaction at services received, common costs saved, faster time to market.
- Public satisfaction at demonstration of commitment.
- Partner (private) satisfaction at return on investment.
- Promote innovation and entrepreneurship as prime forces in new economy.

VARIANT VERSION OF TECHNOLOGY-BUSINESS INCUBATOR PROPOSED BY PCSIR

There is a great deal of interest in many countries in the contribution made to the economy by the small and medium-sized enterprises. These enterprises not only contribute towards employment but also a sizable proportion can grow to become future large corporations, which form the mainstay of any economy. Because of this, business incubation is now recognized as a very important part in any economy. Business incubators are the institutions that help newly starting enterprises to overcome the difficulties encountered during their vital early stages.

There are many difficulties that start-up SMEs frequently face. The most common among these are: financing, marketing and working out proper business-plans. Many entrepreneurs, owing to lack of experience in business-management and operations, lack of technological skills, and of the ways of marketing and financing their products have caused their businesses to fail. A lot of studies indicate that if such enterprises had access to proper technical and financial assistance, the failures could have been avoided or at least minimized. Business incubators are the organizations that help small enterprises to overcome the factors that cause failure in most start-ups.

There are quite a few definitions given to business incubators; the following is a general definition: "a business incubator is a systematic work-space where new SMEs cluster and share service items necessary for their growth; an ideal technology-business incubator has all the needed facilities within one work-place". The systematic space includes tenant

enterprises, management and service institutions, R&D matching for the development of compatible technologies, and business-operation environment. The tenant enterprises are the objects that a business incubator supports. They are the sources of job-creation, technological innovation and technology-commercialization. The management and technological service institutions are operated by and holdings of the business incubator. They provide various services necessary to the growth of the tenant enterprises. The business operation environment refers to the physical space and shared services required for the R&D and business activities of the enterprises.

Among the most important futuristic initiatives for the commercialization of technologies, PCSIR is planning to take a bold decision of setting up a variant version of Technology Business Incubators (TBIs). Through these TBIs, PCSIR is aiming at popularization of its technologies in an innovative approach. These TBIs will function as pilot plants for the demonstration of technological processes developed by its scientists. These are anticipated to attract venture-capital from SMEs in the environment of a science and technology cooperative mode. The approach is being designed to attract such SMEs who are either shy of investing in untested technologies or do not have sufficient venture-capital resources of their own. On successful completion of this endeavor, PCSIR hopes to spearhead a new wave of small and cottage-scale industrial entrepreneurship in the country. This will create a large volume of job-opportunities, generate several spin-off industries, and make a worthwhile contribution to the growth of national economy. PCSIR has decided to opt for this kind of operation, since:

- Several hundred small technologies/processes have been developed by PCSIR.
- Many PCSIR technologies are sitting on laboratory- shelves waiting to be commercialized.
- PCSIR plans to extend these technologies through “technology business incubators”.

The proposed mechanism of commercialization of technologies through business-incubators will have the following salient features.

- PCSIR will demonstrate viability of the developed technologies on pilot plants to prospective SMEs.
- After successful demonstration, SMEs will be encouraged to develop a partnership with PCSIR:
  - at the technical facilities of PCSIR;
  - under the supervision of PCSIR experts;
  - cost of raw materials to be paid by SMEs;
  - cost of utilities to be paid by SMEs;
  - marketing potential to be explored by SMEs.
- Graduating technologies to be industrialized by SMEs.
- PCSIR to continue providing technical support for quality-control of products.
- Products to be marketed with logo/trade marks of PCSIR/SMEs.

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