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PARTICIPATIVE TRANSFER OF TECHNOLOGY: MEETING THE EMERGING CHALLENGE OF R&D COMMERCIALIZATION IN PAKISTAN

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Summary

Restrictive public sector funding to R&D with the expectation of greater participative investment by the end-users has led to the emergence of "third generation R&D management". The concept has been accepted internationally in variant forms, which in the present paper are described in respect of South Africa, India, Malaysia and Australia. ISO regulations on industrial quality assurance and the competition threats posed by GATT are the conducive elements for investment in technology-driven R&D by the private sector in Pakistan. Within the foregoing context a tiered mechanism for tripartite involvement of universities, R&D organizations and the industry in S&T projects of national worth under the institutional umbrella of cooperative business technologies is proposed. The proposal gives details of the role each segment of the tier will play at the respective levels of implementation. Possible modes of project financing have been discussed in the backdrop of current technological imperatives and the reluctance of national commerce sector to rely on indigenously developed technologies. Capital formation for S&T research is suggested through active participation of stakeholders. A say in the selection of technology-driven research projects of those who will benefit therefrom is regarded as a key element in the success of R&D commercialization in Pakistan.

Why the Third-Generation R&D?

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 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 bench-mark 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-setting 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 of 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 measureables. This has much influenced a change in the S&T orientation. The thus evolved culture has introduced elements of sensitivity to client needs, significance of time constraints on the resolution of problems, judgement on the interpretation of observations and a commercial awareness of revenue and costs. The spawning of R&D corporatization was the evident corollary, which in the following will be discussed with special reference to Pakistan.

International Directions in Corporatized R&D

Variants of 'the third generation R&D' have been sussessfully implemented to national advantage in some countries. CSIRs in South Africa (with India in initial stages), SIRIM in Malaysia and CSIROs in Australia and New Zealand are among those that are successfully undergoing R&D corporatization. The level of public sector funding to them is now available on the proportionate availability of external funding, recovered through R&D commercialization, ranging between 30-60% of the total budget.

a. **CSIR, South Africa.** The country's premier R&D organization in 1987, taking cognizance of the *pros* and *cons* involved, decided that the university-style structure based on disciplines and professions had to be transformed into a carefully coordinated structure of strategic business units according to the markets they served. The organization was accordingly restructured to match the country's projected market needs. A corporate industrialization group was created which facilitated coordination of the key manufacturing-related skills across the organization. A vigorous export-oriented industry was viewed as the key to achieving economic growth. The major component of the strategy, nevertheless, was to ensure close collaboration with both government and industry in developing and implementing a coherent national industrial and technology policy. The process of transition by 1993 had converted CSIR into a contract research organization, managed on business principles, having many commonality elements of private sector companies. Government participation in R&D funding by international standards was, however, low comprising just over US$ one billion, compared with General Motors, Siemens and Hitachi, respectively, spending US $5.9 billion, 5.3 billion and 3.9 billion. By 1996 external funding from both private and public sector projects constituted 55% of the CSIR budget; the remaining being met through competitive bidding for government grants. Private sector participation in such a massive scale was made partly possible through tax incentives. Legislation covering the treatment of R&D expenses for tax purposes is duly provided for in the South Africa Income Tax Act. The Act outlines manners in which R&D expenditure can be offset against taxable income, *viz.*, costs of a revenue nature incurred on scientific research undertaken for the development of business or contributions made to S&T institutions are regarded as legitimate business expenditure and is deductible from taxable income; contributions to other national institutions are tax deductible, however, only on the certification of CSIR that such contributions will be used in research undertakings, which indicates the strong legislative strength that CSIR enjoys nationally; and costs of a capital nature can be deducted from taxable income as a tax allowance on 25% of expenditure for four years. Further support is provided through complete autonomy enjoyed by CSIR while government's role is that of an enabling nature through implementation of R&D proactive procurement policies, encouragement of innovation funding and facilitated imperative of private sector funding.

b. **CSIR India.** The political patronage provided at all levels of government has contributed significantly to the high profile enjoyed by the Indian CSIR. The council is not only headed by the Prime Minister, both Nehru and Indera Gandhi made it a point to regularly attend its meetings. The head of CSIR additionally holds the *ex-officio* position of Secretary of the Ministry of Science & Technology. Allocating nearly 1% of its GDP, India spends more on R&D than Peoples Republic of China, being in the same range as those of Singapore, New Zealand and Spain and greater that the currently emerging South-East Asian technology giants Malaysia and South Korea. CSIR, the apex body for 40 research establishments in the public sector, with its complement of 10,000 highly qualified S&T experts, is amongst the largest industrial technology R&D organizations in the world. Over the years, CSIR has contributed to the nationally vital scientific, industrial, strategic and human resource development endeavours. Through appropriate organizational and management adjustment, around 30% funding is derived from contract R&D and technical services. Much of it has been facilitated through the Indian industrial technology devleopment project allocating US$ 40 million; $ 25 million of which were given to 19 selected institutions for improving facilities and reorganization to meet industrial needs, and $ 15 million to the CSIR headquarters for its own restructuring. Budget allocations to laboratories have been linked with performance measured on defined output parameters with time dependent weightages.

Towards meeting global S&T markets and the national industrialization needs, CSIR laboratories are on the way to ISO (International Standards Organization) accreditation and refurbishing the decades old equipment and infrastructure. The recently released "CSIR 2001: vision & strategy" is setting such high standards of accomplishment over the next five years as: generating over Rs. 7 billion from external funding, a patent bank of 500 foreign patents, annual earnings of $ 40 million from overseas R&D technical services, and realization of 10% operational expenditure from intellectual property licensing. For achieving the vision, CSIR has initiated among other measures its integration on a regional basis with academic institutions and twinning with other R&D institutions for symbiotic R&D programmes.

c. SIRIM, Malaysia. Blue-print to set Malaysia on the path of development was provided in 1987 in the national Action Plan of Industrial Technology Development. During the eight years that followed, the manufacturing sector recorded unprecedented average growth rate of 14% shifting the Malaysian industrial activity from import-substitution to an export-led path. The plan was duly aided through public sector funding amounting to 0.8% of GDP (less than 0.2% of GDP in Pakistan). Further government support was provided by appropriate legislative measures which included: fiscal and non-fiscal incentives to companies investing in R&D; venture capital for funding R&D; innovative R&D syndication scheme and encouragement to researchers through incubator centres, concessionary loans, payment on commercialization expenditures, etc. The policy thrust as provided in the 7th Malaysian 5-year plan envisages public funded R&D institutes and universities to work in joint collaboration with the private sector so as to ensure that R&D activities are relevant to industrial needs. Seven areas, *viz.*, materials and advanced materials, chemicals and chemical products, electronics, textiles, transportation, food and agriculture and biotechnology are recognized as high-tech strategic industries in Malaysia. The core element of the plan was the concept of corporatized R&D which has manifested itself in the SIRIM corporate plan 2000, which has been developed within the following framework:

- **i. Statutory.** All such activities that are carried out with the purpose of protecting the interests of the country but do not yield immediate financial returns fall within this category. Theses are run in a government-owned-company-operated (GOCO) principle wherein government is the client.
- **ii. Strategic.** Participation in strategic S&T development is considered to be an essential vehicle in capability building for technology problem solving, funding for which is provided by the government.
- **iii. Commercial.** This is done, by undertaking contract research, quality assurance services, materials and products testing, information selling and technology dissemination.

Corporatized SIRIM is viewed in Malaysis as the agent for development; its vision is to be a nationally renowned and globally respected organization; its mission is to build national competitiveness.

d. CSIRO, Australia. The approach adopted in Australia for development of technologies with private sector participation is particularly innovative. Included within its basic elements is the mechanism of transfer of technology to industry from R&D institutions and universities through linkages and joint ventures. The specific technology needs of the nation and business sector, both present and projected, remain the principal imperative. The tripartite collaboration between the industry and business, universities and R&D institutions in Australia has been integrated into a programme called Cooperative Research Centres (CRCs). Initiated in 1990, the programme for the contract period of 5-7 years envisaged a commitment of $ 2.2 billion to 62 CRCs in six major sectors of national productivity (agriculture & rural-based technologies, environment, health, mining & energy, information & communication, manufacturing). The resource provision was through a real input of $ 140 million per year through public sector allocation, $ 450 million contribution from industry for the period of seven year contracts, with the balance principally as kind contribution from the collaborating univesities and R&D institutions. The programme is revised periodically and depending upon the national priorities more CRCs are added and the funding level enhanced. CRCs operate as collaborative ventures bringing together researchers from universities, government-funded research organizations and business enterprises, thereby promoting R&D interaction between public and industry sectors with the ultimate objective of corporatization. The R&D thrust, therefore, remains commerce-driven. Success of the programme has been made possible through the government fiscal and legal policies that encourage/force investment in R&D. The real dollar funding, though apparently coming from the private sector, is in fact a convenient mechanism of indirect funding through the public sector. Flow of funds to support R&D is available through 150% tax concessions on all industries and 2% levies on all primary produce with the facility of drawback when invested in R&D through recognized channels. The CRC model of Australia has the potential to be adapted with modifications, to the unusual industrial business culture prevailing in Pakistan for technology extension of joint ventures involving public and private sectors.

The Basis of Commercialized R&D Imperative in Pakistan

The business culture in Pakistan in the past has generally lacked the R&D imperative relying heavily on the importation of black box/turn-key technologies. Efforts by technical universities and industrial research organizations to establish a relationship with industries, both in public and private sectors, for undertaking product-oriented joint research ventures have been responded to poorly by the business community. It pains to admit that the culture of interaction and cooperation between the industries and R&D/academic institutes exists at the minimal in the country. The large industrial units have, therefore, rarely had the need to approach the national R&D institutions and universities for technology assistance. PCSIR over the decades has, nevertheless, contributed substantially in the development of indigenous technologies for small and medium level entrepreneurs (SMEs). The number of SMEs benefitting from PCSIR in this manner run into thousands. SMEs are, therefore, the prime target for commercial R&D linkages and joint ventures with the national S&T researchers. With the world-wide acceptance of industrial operations quality acceptance in the framework of ISO-9000 and subsequent series and the signing of General Agreement on Tariff and Trade (GATT) by Pakistan, the national business is expected to come under heavy international pressures for survival and sustainability. Socio-economic development of any country leading to self-reliance is now well recognized to be dependent on "technology". It can either be developed through applied research or reverse engineering. Economic strength and progress can be achieved by exploiting the available natural resources or by making long term technological investments in the industrial sector and manpower development. In order to exploit natural resources the nation must develop a strong will to make best use of the skilled manpower for maximum utilization of the resources by transforming them into value-added products. For an effective contribution of science and technology in the national economic growth there is an urgent need for adopting a policy of industrialization focussing mainly on the acquisition, assimilation and development of scientific processes and their transformation into technologies suited to indigenous needs for the improvement of economic productivity. The main objective under the current scenario, nevertheless, must remain the involvement of private investment in R&D for technologies development. It is opportune for the government, therefore, to put in place a technology development policy based on such collaborative R&D that will help prevent erosion of the industrial base due to current international pressures from ISO and GATT and building confidence in the expertise/capability of national researchers. The policy must take care of the issues identified below:

a. The process of national technology development is not only long-term in nature, the scope of its breadth is also wide. Vision and mission must, therefore, be broad-based.
b. An effective linkage among all the players in the technology game- the business community, the researcher and the government machinery- is the basic fundamental for industrial technology development and absorption.
c. It is necessary to support strategic long-term high-quality S&T research which contributes to national objectives of economic and social development.
d. Transfer of the benefits of research through active involvement of R&D users.
e. Promotion of collaborative research with the ultimate objective of corporatization of commerce/industry-oriented R&D institutions.
f. Efficient use of national resources through R&D.
g. Development of an internationally competitive national industrial base.
h. Stimulate the process of technical education and training, particularly through the participation of researchers of the R&D institutions, in the post-graduate research programmes of national universities and other seats of higher learning.

National Expectations from Technology-Driven R&D

Having considered the national imperative, important issue is as to what is expected out of R&D endeavours in the process of transfer of technology from the developmental to applied status. The following should be the principal elements of the national R&D role and objectives:

a. R&D should be geared to ensure transfer of technology.

b. Development of local capabilities for ensuring assimilation of imported technologies. It has to be emphasized in this connection that the government should enact laws to discourage import of such technologies for which local know-how is available.
c. Indigenous technologies should be oriented to meet the country's immediate needs.
d. Utilization of local raw materials and import substitution leading to increased exports.
e. Value-addition to local raw-materials and products.
f. Moulding imported technologies to local needs through reverse engineering.
g. Laying foundation for the development of indigenous technologies rather than continuously borrowing it from abroad without any real technology transfer taking place.

For the achievement of the above stated expectations from technology-based R&D, human resource development is of fundamental importance. The role of universities within this context is that of dough-raisers and lead providers. It is a matter of serious concern that the knowledge gap between the national universities and their counterparts in the industrialized countries has reached yawning proportions. Fortunately, however, fundamentals of the university faculties are still quite strong. It is their national obligation in the current situation of crisis to share these with their students in a manner so as to train manpower with strong theoretical and applied background to help in the identificaiton of avenues for solving industrial problems. This they can best achieve by redesigning curricula that have bias for practical applications. The academics must endeavour further to restore the status of universities as leaders of basic research. Such research efforts must necessarily have relevance to national needs capable of being dove-tailed to technology-driven R&D. This can be best achieved through collaboration of universities with R&D institutes and *vice versa.*

Structural Component of Implementation Mechanism

Within the foregoing the following institutionalized implementation mechanism is proposed for the development of an effective and lasting linkage between the business, R&D institutions and universities. The mechanism envisages a tiered arrangement flowing from policy-making at the top level of government, facilitating arrangements through high-powered coordination, collaborative stakeholder management to the competent executing project leaders.

a. Executive Committee on National Technology Priorities (NTP)

Priority-setting is perhaps the central issue in the technology research domain. Though scientific excellence must remain a goal, the guiding principle should be the encouragement of conduct of strategic and applied research that would support the national economic, social and environmental objectives. Since these objectives fall in the decision-making domain at the highest level of government and are reflective of the national political direction, a prioritized framework can best be prepared at the cabinet level. An Executive Committee headed by the President/Prime Minister, with 6-7 relevant ministers as members, may define 8-10 priority areas of technologies that the nation should prefer to pursue over the next decade. This will not only spell out the political will but also lend the necessary credence and invite the requisite commitment from the various cooperating segments. A suggested list of prioritized technology sectors may be as below:

i. Chemicals-based manufacturing
ii. Biotechnology & agro-based manufacturing
iii. Textile & leather manufacturing
iv. Minerals, metallurgy & materials-based industries
v. Coal, solar, wind & hydro energy
vi. Electronics, informatics & communications
vii. Plant production engineering
viii. Environment
ix. Health technologies

b. Industrial Technology Coordination Agency (ITCA)

No amount of priority indicators identification will succeed until the nation is properly trained to appreciate and draw upon the benefits that accrue from the S&T/R&D inputs. For the achievement of this purpose an Industrial Technology

Coordination Agency, comprising 8-10 high-profile members of national stature from the industrial sectors, academia and industrial research organizations, may be appointed to assist the NTP Executive Committee. The ITCA will additionally coordinate the industrial technology extension and linkages through:

i. Inducement of an S&T culture at appropriate levels by creating a positive communication and interaction between the industrial sector and the R&D institutions. This may be achieved through necessary legislation.
ii. Identification of problems and needs of the country and assessment of R&D efforts for the development of demand-oriented research projects.
iii. Defining product specifications commensurate with national/international standards to ensure quality.
iv. Development of feasibility reports and target-setting.
v. Coordination of various R&D agencies.
vi. Inclusion of eminent scholars as expert members in the teams negotiating international contracts for high-tech goods.

Efforts of ITCA for the establishment of linkages between researchers and industries within the aforestated will set in motion a collaboration for the development of technology-driven R&D. This will inevitably lead to the seeding of a symbiotic relationship for cooperative business technologies in a tripartite involvement between universities, R&D organizations and the commerce sector.

c. Cooperative Business Technologies (CBTs)

Within each of the NTP sector may be selected 6-12 CBTs. Selection of CBTs may be done according to the existing and projected potential of attracting joint venture capital. For each NTP sector may be appointed a Board with membership from R&D institutes, universities, government representatives from the relevant ministries, and the major external stakeholders representing business/industry. The Board's decision on selection of CBTs will aim at securing maximum benefits, both to the business and society, among the competing research opportunities. The criteria will cover (i) potential benefits (ii) ability to capture benefits (iii) R&D potential and (iv) R&D capacity. The Board will review the above criteria within the following elements:

i. **Potential Benefits.** Identification of potential users and how will they benefit; identification of the segment of society likely to benefit; level of contribution to industrial growth and enhanced technology competitiveness; quantification of size of the potential market related with the CBT for domestic use and export and the nature of spillover benefits, if any.
ii. **Ability to Capture Benefits.** Identification of the sector's commitment to R&D; factors, such as government policies, that will promote/impede technology absorption; incentives for commercialization of R&D-based technologies; the status of ability to capture the technology; and the national/international competitive ability of the technology.
iii. **R&D Potential.** The level of technology maturity/development; the speed with which the technology is moving its frontiers and the prospects of developing intellectual property or major improvement in mature technologies.
iv. **R&D Capacity.** National/international competitive status; competitive technical advantage available; whether a similar technology can be purchased at a substantially low cost from international vendors; and the national capacity to translate R&D efforts within an advantaged time-frame as related with the available skills, technical facilities and market framework.

Relevant with the above issues, some suggested CBTs within the NTP sector of Biotechnology & agro-based manufacturing may be (i) sustainable cotton production (ii) meat industry (iii) aquaculture (iv) food industry innovation (v) disease-free crop culture (vi) wood and non-conventional fibres (vii) pulp and chipboards and (viii) industrial biotechnology.

Likewise, some suggested CBTs within the NTP sector of Chemicals-based manufacturing may be (i) dyes and pigments manufacturing (ii) essential oils, perfumes and flavours industry (iii) plastics, resins and adhesives manufacturing (iv) cosmetics and house-hold chemicals (v) textile auxiliary chemicals (vi) pharmaceutical chemicals manufacturing (vii) leather auxiliary chemicals (viii) pesticides and insecticides and (ix) general industrial chemicals.

d. CBT Management

This is the level whereat all the three players, *viz.*, industry, R&D organizations and universities will interact for the achievement of physical targets of the CBT. It is important, therefore, that their respective interests remain duly protected, the management is flexible enough to adjust itself to the external changes and influences, the project execution domain remains sufficiently motivated and flow of technology to end-users is smooth. The following components are envisaged to facilitate the CBT management:

i. **Stakeholders Board (SB)** will have the constitution as in joint ventures. R&D organizations, universities and the business sector will have participating shares based on in-kind and real cash contribution levels. The SB will decide on the policy issues.
ii. **Executive Management Committee (EMC)** will be responsible for development of projects and plans, project selection and their appropriate siting in R&D organizations/universities, consideration of budget and reports, receiving and evaluation of progress reports of programme leaders and ensuring communication between various components of the CBT.
iii. **Managing Director (MD).** The most crucial role in the management of the CBT will be that of the Managing Director. The position on the one hand will receive policy direction from the SB while on the other hand will be responsible for its implementation through the EMC. The MD will provide leadership to the entire CBT, be a facilitator to Programme Leaders and enabler of technology outflow through such subsidiaries as Director of Extension and Business Manager.
iv. **Programme Leaders.** Each CBT may run 10-12 technology-driven business-oriented R&D programmes, each headed by a programme leader. Depending upon the expertise, each programme may be carried out at the most competent national site in a university department/R&D institution. Some of the projects that have, for example, potential in the CBT for Food Industry Innovation may include: yoghurt and cheese technology; value-addition to fruits/vegetables products; development of poultry and animal feeds from agro-industrial wastes; probiotics; mushrooms; biocontrol and microbial preservation; food products based on fermentation biotechnology; food microbiology. Similarly, different projects that can be conceived/developed for import substitution in the CBT for Textile Auxiliary Chemicals, which are being presently imported worth millions of rupees, may include: stiffening agents; softeners; flame retardants; water repellents; moth proofing; sizing; scouring and bleaching agents; emulsifiers; dyeing and printing reagents.
v. **Project Awarding.** Competitive bidding at the national level will determine project awarding. SB through EMC will periodically invite researchers to submit project proposals within specified CBT targets. While deciding the award of projects such factors as competence of Project Leaders, economic viability for the achievement of targets, level of contribution expected to further the scope of NTP and the time-frame within which tangible technology outflow can be achieved will be the guiding principles.

Project Financing

Fiscal aspects are the key factor in the successful implementation of the technology-driven corporatized R&D through CBTs. Since the entire concept presented heretofore is based on cooperative venture, all the stakeholders must make contribution proportionate to the respective interests. It is accordingly envisaged that a part of resource inputs will come from budgetary allocations of R&D institutes/universities. Various stakeholders may further meet their resource allocations portfolio through kind contribution of the technical manpower, R&D facilities, infrastructure and utilities. The remaining real-rupee contribution for running the project may come through the cooperating business/industry with matching grants through public sector funding. Such a participation is essential in any corporatized approach for industrial technology development. To get money from the business/industry, in the current void of the national R&D culture, however, is perhaps the most limiting factor for the establishment of linkages being discussed.

Money input through public sector funding in the national S&T development todate has remained too meager at 0.2% of GDP. Most of which, furthermore, can at best take care of establishment and utilities bills forcing many institutes to operate on negative R&D budgets. Such a level of allocation, alongwith some major policy directions including encouraged importation of turn-key industries and the lack of reliance on domestic capability building, has down-played the R&D imperative in the national technology development. In the current scenario of the highly competitive nature of technology know-how availability and the prohibitive cost of procurement in the international markets, it has become essential to develop a technology capacity relevant with local resources and culture. Financial allocation for this purpose is suggested within the fremework given below.

a. **Level of Allocation.** The current level of GDP allocation on S&T is hopelessly low. It needs to be gradually increased to

2%. Malaysia, an industrial giant developing in Asia, was spending 0.8% in its 6th 5-year plan increasing to 1.5% in its current 7th 5-year plan. It is further necessary, however, that investment portfolio in industry/commerce-oriented R&D is to be at least 1.0% of GDP.

b. Development *vs.* Non-Development Expenditure. Allocation for the development of infrastructure, training and capital investment in R&D facilities is suggested to be 70% of the total allocation. Non-development expenditure covering establishment/utilities bills and recurrent expenditure on R&D is suggested to be the remainder 30% of total allocation. The ratio of establishment/utilities bills vs. recurrent expenditure on R&D is further suggested to be worked out at 1:3.

c. Private Sector Contribution. The target for participative risk capital and R&D investment from the private sector may be set at the matching level of public sector input in the recurrent R&D expenditure. Modes for attracting/forcing private sector investment are as below:

i. Government should devise policies that are conducive to the development of indigenous technologies and restrictive on the import of turn-key industries.
ii. Strong legislative controls on the quality of products in accordance with the national/international standards are available.
iii. Introduction of regulations to drawback on investments made on R&D will greatly facilitate project financing by the private sector. Many recently developing technology giants have provided 150-200% income tax rebate. Some countries levy R&D cess on primary produce, which the payees can invest in R&D suitable to their needs.
iv. Export surcharge for international quality certification within the ISO and GATT frameworks can generate sufficient funds, drawbacks wherefrom may be invested in the technology of choice of the exporter.
v. Industries may be encouraged to employ trained manpower. This will raise awareness for investment in S&T for the advancement of business objectives through better production targets.

Concluding Remarks on Imperatives for Tripartite Collaboration

Technologies imported from advanced countries suit mainly their own conditions. Unfortunately, developing countries are dependent on imported technologies because they do not have sufficient infrastructure or technical know-how to develop these on their own. Moreover, provision of heavy investments for advanced levels of R&D needed to develop indigenous technologies is a major constraint. Looking at it from a different perspective, however, the nation cannot afford a perpetual technological dependence on developed countries. A start must be made, however modest, towards developing local technologies which are suitable for the prevalent economic conditions and social environment. One of the gravest problems is the manpower unemployment. Unless this resource is scientifically utilized, many problems will remain unsolved. It is, therefore, necessary to be careful in the selection of technologies, avoiding import of such technologies that tend to aggravate further the problem of unemployment. The following are some concluding suggestions for successfully affecting a tripartite collaboration between industries, universities and R&D institutions:

a. There is a need for synergistic approach and collaboration for national economic development.
b. All donations or endowments for R&D should be tax deductible. Industry may then be allowed to draw out of that fund to the project-oriented research programmes in universities and research institutions. This will greatly assist in the success of the above projected concept of CBTs.
c. A standing committee comprising representatives of all the three participating components may be established to bring about and develop liaison among themselves and thus bridge the existing communication gap.
d. A free exchange of personnel between universities, research institutes and the industry is strongly recommended at the advisory and management levels.
e. A data base needs to be created for available expertise and technologies and made available to users.
f. Representatives of the industry and R&D institutes need to be placed on curricula committees of universities to reorient them to the country's industrial needs.
g. Skilled workers (so-called *mistries*) should be encouraged and their status upgraded. This will be greatly facilitated if they are afforded opportunities to work alongside engineers in the design and fabrication work.
h. Development of pilot projects within the research institutes need to be encouraged to serve and demonstrate economic feasibilities of new processes.

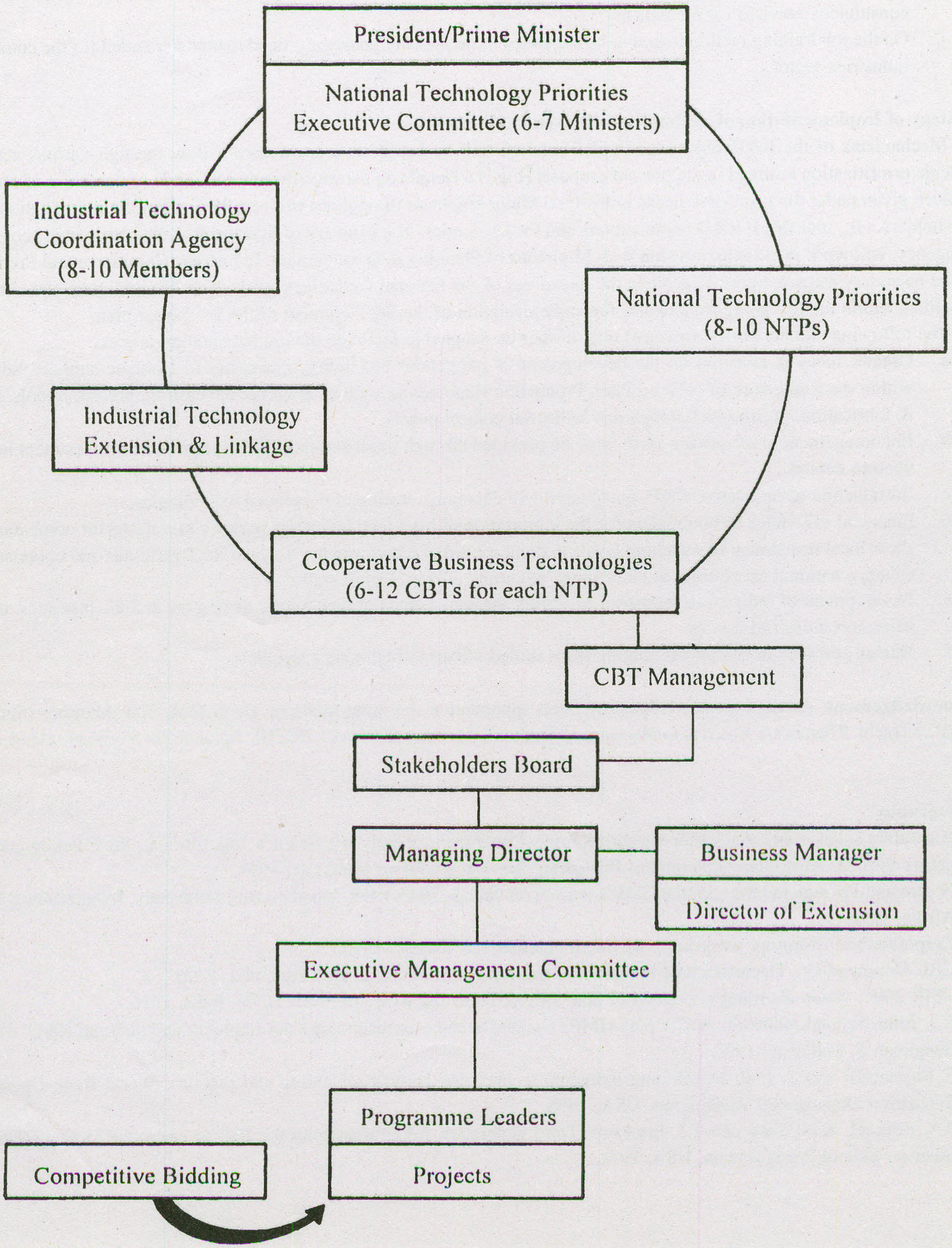

Fig. 1. Implementation mechanism of technology-driven R&D in the national technology priority areas through cooperative business technologies.

i. University professors and R&D personnel may be provided with the necessary freedom to carry out advisory and consultancy services for the industry.
j. On the job training facilities need to be expanded to perpetually generate trained manpower suited for the commerce-industries sector.

Strategy of Implementation of Technology - Driven R&D Objectives

Mechanisms of the R&D objectives implementation will be based on a down-stream flow through various stages of strategic prioritization outlined in the present proposal (Fig. 1). Details on the specific role and mode of operation of each unit has been given under the respective heads in the text. Major emphasis throughout will remain on tripartite participation of the stakeholders, *viz.*, industries, R&D organizations and the academics. The Ministry of Science & Technology as the coordinating agency, will work in close association with Ministries of Planning & Development, Industries, Commerce and Production for the necessary steps required to achieve the objectives of the national technology goals. The Ministry may also work out modalities within the foregoing framework, for implementation of the S&T segment of the 9th 5-year plan.

The following adjunct policy measures may further be adopted to facilitate the implementation process:

a. Greater focus is essential on the development of indigenous technology capability in strategic support industries within the framework of NTP on Plant Production Engineering such as mould & die casting, precision tools, design & fabrication, plastics technology and industrial control panels.
b. Encouragement to the private sector may be provided through fiscal and non-fiscal incentives for investment in R&D venture capital.
c. Introduction of innovative R&D syndication will encourage testing of developed technologies.
d. Financial assistance through loans for the importation of high-tech industries to those private sector companies that show local investment of matching levels in domestic R&D projects in the national S&T institutes and universities to enhance national capabilities at close range of cutting edge of technologies.
e. Development of indigenous industrial capability through a chain of technology incubators at S&T institutes, universities and industrial estates.
f. Human resource development ranging from skilled labour to high-tech specialists.

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