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National Innovation Systems: Role of Research Organizations and Enterprises

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Abstract

The rapid pace of technological change and globalization pose special challenges for industrializing countries as well as opportunities. While each nation charts its own path based on its resources and culture, there is now the imperative for all to develop a national innovation system to help formulate policies for setting priorities and allocating resources, develop strategies for scientific research and technology development in public, university and corporate laboratories; build the technical human resources for a knowledge society; strengthen the technical support systems for quality, information flows and new venture creation; mobilize financial resources in the face of competing needs and the common concerns of alleviating poverty, preserving the environment and defending the nation; and to look outwards towards attracting investment and alliances.

In these tasks all players have clear responsibilities: The government has to reinforce the technical and business infrastructure while the knowledge system helps build the new-age skills and develop the technology needed. Business, large and small, needs to stimulate innovation at the shop-floor and in-house labs, towards international competitiveness. Public-private partnerships are essential to generate the resources required. The key players have together to address the cross-cutting concerns for gender balance, environmental sanity, human rights and growth with equity. Importantly, inter-action among nations in technology and trade, competing and cooperating, can be the gateway to a better world.

This paper outlines some critical areas for action in the key components of a national innovation system, to make the knowledge economy work for all citizens.

Introduction

Three inter-related forces are dramatically changing the economic landscape today: *technological progress, entrepreneurship* and *competitive global markets*. These are accompanied by social and economic changes, democratization, concerns for the human condition, and environmental preservation. For our purposes:

Technological innovation is the process that drives a concept towards a marketable product or service. It is essential for firms to stay competitive, as it contributes towards raising productivity in local and international markets.

The entrepreneur is the agent of change who identifies an innovation to match a market opportunity and mobilizes the human and financial resources to deliver the product at competitive costs and quality, in order to meet (or create) customer needs

Competitiveness is the state achieved at enterprises by wise decisions on the use of factor endowments, within an environment of supportive state policies and rivalry.

The national innovation system integrates the roles and efforts of all the key players – in government, education, business, finance, and civil society – towards nation-wide economic development

The interactions among institutional players are taking place in the framework of **globalization** -- the rapid movements of ideas, lifestyles, advertisements, trade, business and finance. Those already strong are prospering, others falling behind. Computing and communications have the potential to help the developing nations leap-frog in some fields, but it is also widening the gap between the knowledge-haves and have-nots, between countries and within them. A part of the solution lies in *quickening the pace of technological innovation,* with the impetus for change coming from all sections of society under competent political leadership.

Challenges in Restructuring the National Innovation System

Science, as we know, attempts to understand the world while **technology** helps to change it –hopefully, for the better. Distinctions between high or low technology are irrelevant. What is important is that the product or service is useful, it is 'friendly' to society and the environment, it contributes to the overall priorities of economic growth, social justice, and employment. Further, knowledge at the root of science may be value free, but technology is conditioned by context and culture.

Constraints to innovation in developing countries are well known: The weak political commitment and infrastructure, vast bureaucracies, misdirected education and training, scarce financial resources, poor research productivity and inadequate demand on the national R & D system. Hierarchies of authority, lack of delegation, and lack of trust in home-grown technology frustrate the creative scientist at home (but who flourishes when resident abroad). As restrictive are the constraints of superstition, pseudo-science, corruption, the legacy of colonization, and pervasive poverty.

In this framework, all countries – industrial and industrializing, need to design their innovation system with wide participation and the commitment of intent and resources at the highest political and community levels.

The innovation system can be considered in terms of six sub-systems, as outlined below.

1. **S & T policy** comprising the setting of priorities and allocation of resources for learning, basic research and advanced science-based technologies for national priority sectors together with the technical support required. This also includes policies to promote competition.
2. **Innovation strategy**, both short and long-term, based on the nation's competitive advantage, the management of research and its commercial utilization, the roles of publicly-funded and corporate research, knowledge management, the cost-effective

acquisition of technologies, defending the nation, preserving the environment. Measures are needed for targeting the special needs of large rural communities, and the 'deepening' of technical competencies for adaptation, application, dissemination and customer-led innovation. The strategy must be based on the local conditions of culture, climate, and colonization.

3. **Technical human resources** including science education starting in primary school and its progression through technical universities and continuous learning, vocational training, new disciplines such as knowledge management, technological entrepreneurship development, and competitive intelligence. The computing and communication technologies (ICT), biotechnology, environment and energy can have crucial roles in alleviating poverty and accelerating economic growth.
4. **Technical support services** required to raise productivity, lower production costs, and develop an integrated marketing-research-production-quality system, especially the support services for strengthening technology-based small enterprises.
5. **Mobilizing financial resources:** The over-arching problem is generating the finance for S & T (which is much more than R & D), particularly in countries where programs for the survival of its people must itself be the highest priority.
6. **International cooperation** through strategic alliances, design and production sharing in the supply chain, and technical and financial collaboration while safeguarding the intellectual property of the inventor.

When each of these sub-systems is strengthened at the national and firm levels, the movement towards transformation to make the knowledge economy work for all can gather momentum. The annex outlines some issues in addressing the above components.

Essential ingredients in effective innovation process

A survey of national innovation systems in 15 countries, large and small, high- and low-income (Nelson, 1993), summarizes the basic features that are typically common to effective innovative performance, and are lacking where innovation is weak. The main characteristics of *the firms* in sectors where a country is strong are:

- High competence on what affects their competitiveness, with the main efforts made by themselves. They may be large, but many are small as in Italy, Taiwan and Denmark.
- Firms should be exposed to strong competition, in their own countries and abroad.
- Effective interactive linkages with their upstream suppliers and customers,
- Conditions that promote exports force firms to innovate; otherwise, they remain stagnant and seek protection in home markets,
- Public funding of research in universities and government laboratories in specific sectors of national concern, with results linked to business.

Overall, the decisive factors are considered to be:
-*Investments in education and training* that provide a flow of people with requisite knowledge and skills in a range of functions and opportunities of continuous learning,
-*Macroeconomic conditions* including a package of fiscal, monetary and trade policies, supportive regulations and good business infrastructure

Role of Government

To realize the opportunities of the rapid changes in technical and trade regimes, the industrializing countries must face the challenges of technological transformation. They can start with honest assessments of the political framework and available endowments, followed by commitment and resources to building the knowledge and skills, the institutions and mechanisms. This has to be a team effort involving all the stakeholders and international players, in the framework of the national innovation strategy.

The government has overall responsibilities for the formulation of policy and legislation providing fiscal incentives for entrepreneurial activity and venture creation; strengthening the infrastructure for broadband communication, learning and innovation, preserving the environment; and protecting intellectual property and the rights of the customer. Public-private partnerships can help in identification of strategic, generic technologies suited to local endowments, 'prospecting' for research results capable of rapid patenting, prototyping and market entry; and the promotion of the culture of informal net-working, information sharing and risk-taking.

It would also involve a university linkage, some engineering, production and marketing capabilities, and almost always require a committed entrepreneur or champion to mobilize resources, start the venture, survive, and (with luck!) thrive.

Role of Research Organizations

For governments in developing countries, the responsibility is to restructure the publicly-funded *research and technology organizations*, improving the facilities and the incentives for researchers, making them more accountable in their performance and more responsive to the needs of business. Institutes operating for a decade or more should now recover say, three-quarters of their annual operating expenses through contract research and services. Many claim to do this, some using creative accounting.

In most industrializing countries, the bulk of the formal R & D is done in publicly-funded laboratories, much less in the universities and corporations. Nevertheless, the extent of improvisation and improvements taking place on the shop floor are impressive.
Military R & D and space/nuclear power programs, usually with the largest proportion of research expenditures, support enabling technologies or leadership in chosen sectors such as telecom and aircraft. Spill-overs in to private business vary on local conditions.

The innovation strategy has to be based on internal strengths and external challenges, the unique competencies, resource endowment, geographical location and defense preparedness. Poor and small countries have to choose a path that shares factor endowments with neighbors and partners. The large have the tasks of reaching out to backward regions, of replicating good practices in manufacture, agriculture and health on a nation-wide scale. The core technologies they select may vary, but all will soon need to master the application of information, energy, manufacturing and biotechnologies.

Innovation-related indicators, of course, do not provide a single proxy for good resulting performance; R & D spending ignores the productivity and pattern of research. Further, much of the technology comes embedded in equipment or through patents and know-how licensing. A better measure is the 'total technology intensity' which combines R & D spending and the embodied technology.

Studies of technology-based competitiveness (Roessner et al, 1997) reviewed seven indicators in 30 countries, covering inputs (such as the nation's commitment to directed action, socio-economic and technological infrastructure, physical and human resources dedicated to manufacturing) and outputs (current production and success in exporting high-tech products). It concludes that high tech production will shift from a steep slope among nations on to a broad plateau over the coming 15 years, with Japan and US maintaining their lead but others such as Malaysia, China, Philippines, India and the Asian tigers as well as Mexico, Brazil and Argentina narrowing (not closing) the gap.

The data in Table below for selected countries indicates that those with low technical capabilities (in terms of their R & D personnel, royalty receipts, access to Internet, etc) tend to have lower GNP PPP. (Their military expenditures in proportion to GNP may however be twice as high !). Others who are in the forefront of innovation see good results in enhanced incomes and higher living standards. Good indicators of a country's technological prowess are the high levels of high-tech based exports as percent of total manufactures high levels of royalty receipts as well as payments. Examples are the NICs. High technology products exports are also rising rapidly -- to 33% in 1997 in Mexico and to 67% in Malaysia. Other factors the good-performers have in common are: ***bold strategic plans, high investments in human resources, and strong infrastructures.***

Knowledge-Related Indicators – Selected Countries

	GNP PPP US$ 1997	PCs per 1,000 1997	R&D Personnel per 1 mill. 19885-95	R&D Expend. % GNP 1985-95	High-tech exports, % mfg export 1997	Royalty Receipts US $ mill. 1997	Patent Appls by Residents 1996	Patent Appls by Non-Res. 1996
Argentina	10,100	39.2	671	0.4	15	6	n/a	n/a
Brazil	7,430	26.3	168	0.6	18	32	2,655	29,451
China	3,070	6.0	350	0.5	21	55	11,698	41,106
Hong Kong	24,350	230.8	98	0.3	29	n/a	41	2,059
Egypt	3,080	7.3	458	0.5	7	54	504	706
India	1,660	2.1	149	0.8	11	12	1,660	6,632
Jordan	3,350	8.7	106	0.3	26	n/a	n/a	n/a
Korea	13,430	150.7	2,636	2.8	39	252	68,446	45,548
Malaysia	7,730	46.1	87	0.4	67	0	n/a	n/a
Mexico	8,110	37.3	213	0.4	33	130	389	30,305
Poland	6,510	74.4	1,299	0.7	12	27	2,414	24,902
Singapore	29,230	399.5	2,728	1.1	71	n/a	215	38,403
S. Africa	15,690	41.6	938	0.7	n/a	73	n/a	n/a
Turkey	6,470	20.7	261	0.6	9	n/a	367	19,668
Germany	21,170	255.5	2,843	2.4	26	3168	56,757	98,338
Japan	24,400	202.4	6,309	2.9	38	7303	340,861	60,390
USA	29,080	406.7	3,732	2.5	44	33676	111,883	111,536

Sources: World Bank, *World Development Indicators and World Development Report, 1998/99*

Making the Knowledge Economy Work for all

In the *short term* a nation at the early stages of development can make good progress (and money) by acquiring generic technologies from others and purchasing embodied research in capital equipment. But this must be accompanied by rising investments in adaptation, improvement and reverse engineering. Consider the case of Japan after World War-2 when the number of technical collaborations and fees paid were increased by eight-fold in the period 1960 – 70; concurrently in this period, it spent nine times more on assimilating and upgrading this technology, to build manufacturing capability for the subsequent export of products and technology.

For the ***longer term*,** however, the nation has to move from imitation to innovation, more so as the pace of technical change is accelerating and advanced proprietary technologies become difficult to buy. This requires:

- Political commitment and the requisite resources for strengthening education, health, business infrastructure, industrial and production engineering,
- Analyses of the strategic implications of global change and competitive advantage for niches in regional and international markets,
- Realistic assessments of current capabilities and resources, to identify the gaps and take action on technical support services, human resource development, special financing instruments,
- Formulation of legislation providing fiscal incentives for entrepreneurial activity and small business promotion, for protecting intellectual property and the environment,
- Identification of strategic, generic technologies suited to local endowments, and 'prospecting' for concepts and research results capable of rapid patenting, prototyping and market entry,
- Creation of research-university-industry interfacing and business support services
- Nurturing of industrial clusters that can compete, cooperate and catalyze, in environments of high domestic and international rivalry,
- Promotion of the culture of net-working, information sharing and risk-taking.

The strategy has to be adapted to specific national needs and conditions. It must build upon what exists in the region, the store of local lore, the culture and climate. It must also attempt to reinforce environmental sanity, gender balance, and growth with equity.

As important as the strategy for encouraging innovation are the imperatives to promote the diffusion of the knowledge gained and foster competition. Without the compulsions to continuously improve product and process, an industry can lose its competitiveness in changing markets. In a rapidly changing environment, a country or corporation needs the agility to move quickly from one product and market to another, or get left behind.

WAITRO–the World Association of Industrial and Technological Research Organizations – has undertaken an extensive *benchmarking program* at 60 Research and Technology Organizations. The range of RTO processes were studied and best-practices identified in governance, financial management, services, business development, organization, project management, personnel management, networking and policies.

After initial support from DANIDA-Denmark and IDRC-Canada, funds to continue this exercise are not there (nor are laboratories enthusiastic to be compared to their peers!)

For the development banks and donors the continuing challenge is to sustain and strengthen the ***coalitions of partners in scientific research*** on tropical diseases and HIV/AIDS, agriculture and aquaculture, communications and computing, environmental, bio-diversity and clean energy concerns.

Role of Corporate Innovation

Everywhere, managements have to be receptive to new ideas, to listen. Corporations in countries such as Japan and US are adopting unconventional innovative ways to stimulate creativity in their personnel. Further, as researchers better understand the physiological, psychological and biochemical roots of the creative process, the left-right-front-back functions of the brain, they expect to be able to instill more creativity in more persons

The traditional wisdom is that the first to enter a market has advantage (but this is not necessarily so), and that the product must be based on the needs of the market (but where there was no existing market -- as for the now ubiquitous 'Post-It', paper clip, stapler and photo-copier– it takes a little more persistence to succeed). In promoting innovation, the large enterprises are mimicking the small, by out-sourcing supplies and services and breaking out into small intra-preneurial groups, while the small are acting like the big through alliances and virtual consortia. The flexibility and creativity of an early-stage entrepreneurial venture may lead to more break-through innovations than can be generated by larger sized firms in many sectors.

In most industrializing countries, the bulk of the formal R & D is done in publicly-funded laboratories, much less in the technical universities and corporations. Nevertheless, the extent of improvisation and manufacturing improvements taking place on the shop floor are impressive. Further, as researchers better understand the physiological, psychological and biochemical roots of the creative process, the left-right-front-back functions of the brain, they now expect to be able to instill more creativity in more persons

Whether corporate strategy is built around its core competencies or is based on the forces shaping its industry in a global context, formal strategic planning is essential for positioning the enterprise towards profitability and growth. The process of innovation is unpredictable, and companies which appeared unbeatable in the 1980s are being overtaken by those who were down. The decline of the dot.com ventures in the late 1990s demonstrated the results of exuberance and disregard for the laws of the market.

For an enterprise, long-term success is the capability to undertake the following steps:

- Prepare strategic plans which delineate its strengths and challenges, its product and expected market share, the financing requirements and sources, and its managerial, manufacturing and marketing capabilities. External consultancy services can supplement this.
- The corporate sector needs the national institutions, from which to draw personnel with basic skills, then to be augmented on the shop floor by the firm itself.

- Acquire, adapt and master the total production process. This involves technology sourcing, , pilot work, together with collective learning based on feed-back from the market. In-house or contracted research can assist this process.
- Direct foreign investment and know-how licensing can also facilitate this, but this itself requires local negotiating capabilities and access to information, despite an imperfect market. For an early-stage venture, the critical transit is from reliance on private funding sources, to short-term bank loans and on to venture capital.
- Once in production, the learning process continues towards integrating every part of the corporation in the value chain, managing managers, increasing productivity, pursuing total quality and the 'triple bottom line' of economic, social and environmental responsibility.

Attaining the best practices for the specific sector is the desired goal of the corporation, but strategic thinking may call instead for diversifying rapidly to new product or process.

Role of the learning system

What has changed in this decade is the *function of the university*: It is no longer teaching alone. It must be restructured to take responsibility for an active role in the more complex field of economic development, covering a portfolio of applied and basic research, consulting and community services, specialized training, distance learning and tech-based venture formation. While it moves towards becoming an *'entrepreneurial university'*, the corporation moves towards becoming a *'learning enterprise'*.

Also being changed the world over are the education curricula. New courses being introduced are on the *management of knowledge*, which provides knowledge on key issues at the interfaces of science, engineering, business and civil society. Young and old are being exposed to *entrepreneurship development*, which seeks to transform the nascent entrepreneur into a successful enterprise-owner. And every person needs to be proficient in the *English language and computing*, because without these one cannot work, play, or participate in the expansion of knowledge products and services and electronic commerce. Unfortunately, the gap between the *information haves* and *have-nots* is widening rapidly, between countries and within them.

A good example is the Monterey Institute of Technology in Mexico which runs technology incubators and a virtual university in Mexico with a consortium of 13 universities outside, addressing 9,000 degree and 35,000 non-degree student annually in Latin America. At the national level, Singapore is among the best, providing significant funds for: Foreign training and attracting experts, tertiary education directed to the needs of industry, subsidizing small and large companies for training, and specialized training courses by MNCs and foreign governments.

Interestingly, high school students in the US fare poorly in mathematics and sciences, but they seem to acquire the questioning attitudes and computing skills, which produce good results at the university level. The research universities have become seedbeds for innovation, with the University of California system earning $ 61 million in royalties and its 528 patents in 1997, while Stanford and M.I.T. each created 15 start-up companies.

National Innovation System

Within the research universities, the Media Laboratory at MIT, Robotics Institute at Carnegie-Mellon, and the electrical engineering department at Stanford have been the creators of continuous innovations. Some such as artificial intelligence, expert systems, fuzzy logic and biochemical computers will become the industries of the 21st century.

In countries at the leading edge such as Korea 20 percent of tertiary enrollments are in sciences and engineering while the Scandinavian and former soviet Union countries spend up to 8 percent of their GNP on education. Countries with poor technological capabilities enroll and spend less than half as much. In some cases, there is the misallocation of resources resulting in high unemployment among engineering graduates along side high illiteracy rates!.

The source of competitive advantage has shifted from resource endowments and factor costs to knowledge, based on information and experience. In our work on technology venture creation in 40 industrializing countries, businesses and planners express the need for help on business planning, actionable information, counseling and practical mentoring, negotiating strategic alliances and positioning, legal and tech-transfer arrangements, marketing, raising quality and productivity. Building the capabilities to address these issues is no longer the responsibility of governments alone, but of ***public-private-NGO partnerships***.

There are no life-time jobs anymore, and the mental agility and entrepreneurial energy of a 25-year old is now worth more to the down-sizing firm than the 25 years of experience of the veteran. Just-in-time employment requires just-in-time education, forcing people to *renew skills continuously*. Many will have to *work at home offices* or what are called 'serviced offices' by the hour. Today in the US, some 40 million households already have home offices, based on broad-band Internet access and east-to-use peripherals.

Another source of acquiring knowledge is by developing *engineering and management consultancy capabilities*. In many situations, when local consulting companies are given prime responsibility for designing a new plant or process however complex, they can supplement their know-how by buying the best from abroad. The experience gained by the mistakes made stays within the country. This self-reliant approach has helped strengthen India's design and engineering prowess and its recent IT capabilities.

Small companies can access expensive consultant and research organizations by forming coalitions for generic, far-from-market solutions. Costs of such cooperative research can be partially matched by governments, as is done effectively in many European countries.

In addition to formal university and vocational training, much learning takes place at the informal level, with firms learning from their partners, suppliers and competitors, from consultants and industry associations. Firms can also benefit by utilizing the empathy, expertise and access to finance of expatriate nationals, as the UNDP program for Transfer of Knowledge through Expatriate Nationals–TOKTEN– has demonstrated since decades.

Finance for innovation

Risk money is essential which a venture capital facility can provide, along with useful mentoring. The in-flow of capital to the US venture funds rose from around $ 1 billion in 1991 to over $ 10 billion in 1997, and then declined sharply.. To meet the needs of smaller amounts, a new breed of angels and venture catalysts has emerged. Interestingly, despite all the enthusiasm about venture capital, in the US which has the most successful experience, venture capital constitutes only a tiny percent of the total funds provided to the small enterprise sector, the bulk coming as equity from the entrepreneurs themselves, their families, trade credits, bank loans and other debt sources.

At the firm level, commercial banks do not usually have the capability to assess the clear risks and potential benefits of financing the creation and expansion of a technology-based enterprise. So also, multi/bilateral donors and international development banks often lack the knowledge to make a rigorous appraisal for a technology project. But with recent World Bank experience of credits for industrial technology development in Brazil, India and Turkey, such investments can be expanded, provided the countries give this priority.

Among industrializing countries, Korea was an excellent example of strong state incentives for in-house research in targeted fields by the corporations, for importing technology, for participation in national R & D projects with state institutes and universities. Government was also pro-active in promoting special technology windows in banks, guarantees for loans to SMEs, and a strong venture capital industry. The recent financial crisis has been a set-back to such financing.

Like venture capital, tech transfer involves measured risks. Consequently, public agencies for promoting commercialization such as MITI-Japan, ANVAR-France, Office of the Chief Scientist-Israel, and NASA have moved toward a semi-autonomous status.

Technical support services

These cover the technical infrastructure of institutions and capability to support the innovation system. They include productivity centers, metrology and total quality management, indigenous consultancy organizations and services to strengthen small enterprises, on which large proportions of employment, incomes and exports depend.

The pursuit of scientific inquiry and the utilization of technology can be enhanced through innovative structures and mechanisms which help enforce product quality, distribute information, facilitate the access to knowledge sources and the financing of business, deliver the requisite business development services and required work spaces. An existing service institution may be radically re-structured, or totally new structures may have to be established to cope with new environment.

A clear government responsibility is to establish the *metrology, standards and quality* centers, to support the transition to high-international standards. The state has to secure and process the national financial information, ensuring effective transparency and disclosure; the trade information to facilitate exports; and the environmental quality information to ensure compliance by industry.

National Innovation System

While there is consensus that small enterprises will be the prime creators of employment and growth in the future, these ventures need special help. Various financial and non-financial mechanisms are converging in a synergistic system. There is a current debate on the outreach, impact and financial sustainability of alternative means to strengthen new ventures. Such services have to be initially subsidized, which the developing country governments can ill afford and donors usually resist (although such support receives major state funding in OECD countries). Initial subsidies of 20 – 40 % to pre-competitive research and business support are in compliance with the new world trade policies.

Typically, industrializing countries have less-effective institutions, which need to be reinvigorated and new ones initiated. An existing structure can be strengthened, or a new one built around a charismatic leader. This person must be given the responsibility and resources, then held accountable

Business development services While there is consensus that small enterprises will be the prime creators of employment and growth in the future, these ventures need special help. Various financial and non-financial mechanisms are converging in a synergistic system. There is a current debate on the outreach, impact and financial sustainability of alternative means to strengthen new ventures. Such services have to be initially subsidized, which the developing country governments can ill afford and donors usually resist (although such support receives major state funding in OECD countries).

In this context, *technology business incubators and technology parks* are now becoming important means for new venture creation. Business incubators, evolving in the early 1980s from experiences with other business development services, have the purpose of assisting the new venture creation process. They provide affordable work space as well as shared facilities, counseling, training, information and access to external networks for entrepreneurial groups. This focused help to selected firms has been shown to increase many-fold their chances of survival; the evidence also indicates that the initial subsidy provided by the state is returned as taxes to the exchequer, in addition to other social benefits such as stimulating entrepreneurship and cultural change.

Provisionally, in 2001, of the total 3,500 worldwide, the numbers in north America and in Europe are estimated at about 1,100 plus each; Asia has roughly 700, and the balance are in South America, Africa and other countries. In Europe, majority are in Germany, France, U.K. Interestingly, while incubators in industrial countries serve a variety of objectives, those in industrializing nations are predominantly focused on technology.

Assessing, evaluating, monitoring

The methodologies to evaluate the outcome of S & T programs, including social benefits not readily quantifiable, can be learned and national evaluation and monitoring capacities augmented. Governments and donors have only themselves to blame when they do not rigorously and self-critically monitor progress and take corrective actions on such programs, or fail to analyze, disseminate and apply the lessons learned, particularly from those that failed. Rigorous evaluations of the outcomes and sustainability from the use of scarce resources has to cover all seven sub-systems of the national innovation system.

The ability of a BDS to replace the resources it consumes and become *financially sustainable* can be shown by an analysis of the flow of funds in and out of the system over at least 5 years. *Sustainability* implies the ability to continue achieving positive outcomes and the durability of the benefits achieved. *Effectiveness* can be expressed in terms of all the benefits derived at the whole system in relation to the use of all resources and the overall satisfaction of those involved. O*utreach* depends on the replicability of the embodied concept and the means of reaching larger numbers of enterprises. The metrics and criteria of assessing BDS performance require common understandings by donors and governments as well as by the businesses they serve.

International cooperation

In a world shrinking rapidly with the advent of instantaneous, low cost computing and communications, the S & T system -- and those who design, operate and evaluate it – have to think and act globally. Efforts to promote such international cooperation and strengthen endogenous technical capacities calls for outward looking advocacy associations and networking together with the commitment and mindset to learn from wherever good practices can be found.

International cooperation requires a renewed, continuing dialogue between the poor and the rich, without arrogance, with the purpose of finding joint solutions and sharing the benefits of human knowledge fairly.

Conclusion

The design of an innovation strategy calls for prompt decision-making, not study-talk-study-talk!; for rapid access to the international experience, on to its adaptation and application; and for a stable, open macro-economic system at home, with linkages to the world outside. At the same time, the development of technologies required for the country's security, defense preparedness and national harmony has to be among the foremost priorities.

References

Abetti, P. et al., *Technological innovation and economic growth,* IC2 Institute, Texas, 1987.

Conceicao, P., Gibson, D., Heitor, M., Shariq, S., *Science Technology and Innovation Policy, Opportunities & Challenges for the Knowledge Economy*, Quorum Books, 2000

Lalkaka, R., *Supporting the start and growth of new enterprises,* UNDP, New York, 1997

Nelson, R. Ed., *National innovation systems*, Oxford University Press, New York, 1993

Mowery, D. and Rosenberg, N. *Paths of Innovation: Technological Change in 2oth- century America*, Cambridge, 1998

Raymond, S., *Science-based Economic Development: Case Studies Around the World,* Annals of NY Academy of Science, 1996.

Roessner, J.D., Porter, A.L., and Newman, N., *Indicators of technology-based competitiveness of nations*. Georgia Institute of Technology, Atlanta, Ga., 1997.

UNDP, *Human Development Reports,* Oxford, 1999 and 2001

WAITRO, *Human resource needs for changes in R & D institutes,* NISTADS, New Delhi, 1996.

World Bank, *Knowledge for development,* Oxford University Press. 1998/99.

World Bank, *World Development Indicators,* Washington DC. , 1999

Annex: Issues of concern in restructuring of innovation sub-systems

Issues for S & T Policy Sub-system:

1. What promotional measures are being taken to build a national consensus on the role of science-based development in strengthening the economy and improving lives of its people?
2. What are the country's natural endowments on which to build, and its weaknesses that can be addressed?
3. What are short, intermediate and long term goals to which the innovation system must be organized to contribute?
4. What special measures are needed to identify and strengthen acquisition and application of advanced technologies such a biotechnology, ICT, remote sensing?
5. How can the processes of formulating the national S & T strategy be made more effective through better involvement of stakeholders in rural and urban communities, civil society and defense establishment, particularly women, youth, and ethnic minorities?
6. How are the legislative bodies that formulate the policy instruments and regulations prepared for the content and implications of their actions? What are the present arrangements for providing advice on S & T issues to the executive and legislative authorities in Government?
7. What methodologies are appropriate to make candid evaluations of the effectiveness of a particular type of intervention?
8. What are the experience and qualifications of persons on an inter-disciplinary teams for specific evaluation tasks and how can their competencies be strengthened?

Issues for Innovation strategy Sub-system:

1. What is the overall allocation for research and development in the national budget, and how is this distributed among industry, social, agriculture, health, education, defense sectors?
2. What are to be the roles of basic and applied research, scientific break-through and incremental innovation, public, corporate, university research?
3. What is the organization system in public laboratories and the means for prioritization of the research portfolios to deal with the special needs of small and large enterprises?
4. What are the incentive systems to promote research productivity in private laboratories?
5. What needs to be done to implement a program of bench-marking performance of research?
6. How does the policy and process of international technological and financial collaborations stimulate (or restrict) the acquisition of selected technologies?
7. If a specific research program is under evaluation, how do the outputs and outcomes compare to the original design? How will the research results be scaled-up and taken to market? Will the benefits be replicable and sustainable?
8. What are the mechanisms at the public, university and private research institutes for assisting the commercialization of research?
9. How can a technology foresight mechanism be initiated to anticipate and manage change?
10. What are the legacies of culture, climate, colonization and corruption, for which adaptations must be made for a successful innovation system?

Issues for Technical human resources Sub-system:

1. What is the Government priority and support for science and technology related education and training at all levels, in schools, university, continuous and distance learning, vocational training?
2. How are the new computing, CD-ROM and Internet technologies being applied in preparing students, formulating training materials and methods?
3. What are special measures to improve proficiency in English language and computer literacy at all age levels, including senior citizens?
4. How is tertiary education being prepared for the new millennium? What programs are underway to create the 'entrepreneurial university' and the 'learning enterprise'?
5. Are special programs and methods underway for new curricula specific to local needs and conditions, such as 'Management of technology' and Entrepreneurship development'?
6. What are the special programs targeted at education of women, ethnic minorities and disadvantaged groups?

Issues for Technical support services Sub-system:

1. What are the main needs and difficulties of entrepreneurs and early-stage ventures for which a support services should be designed? Importantly, what are the longer-term outcomes expected?
2. What kinds of innovative means are appropriate for supporting technology business creation (technology parks, business incubators, industrial and free trade zones, small business centers, voucher schemes, developing private service providers, etc)
3. How do the operations of the TSS fit in to the larger strategy for the development of the concerned sector? What are the expectations regarding the levels of cost recovery for services and financial sustainability?
4. What are the levels of competence and training of the centre managers? What are the autonomy and accountability given?
5. If the service is in the public sector and receives public subsidy, does this affect private sector or non-governmental providers of the same service?

Issues for International cooperation Sub-system:

1. As a matter of state policy, is the S & T activity such as can benefit significantly by linkages to other countries or donor agencies?
2. What will be the main purposes of international cooperation: developing local skills, acquiring special technology for adaptation/equipment? Bench-marking and learning?
3. In pursuit of international relations, would the project experience and results obtained be shared with other international agencies, other developing countries?
4. What are the benefits and costs related to forming an international association or other mechanism for collaborative efforts in future?