Strategic Alliances and Entrepreneurship in Innovation Diffusion and Technology Management — The Emergent Paradigm

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The paper dwells on aspects of innovation diffusion in the context of technology management. The linear model of innovation diffusion has been replaced by two-way models. This calls for diffusion mechanisms based on cooperative or consoritum type alliances for strategic advantages. It also calls for science based entrepreneurship even in public funded research agencies. The linkages with potential client have to be forged through specific policy initiatives and diffusion mechanisms like those found in OECD countries. The corporate vision in CSIR in India is aimed at creating conditions for contract research and an entrepreneurial research environment in public funded laboratories. Strategic research and promotion of tacit knowledge as well as people networks and high-tech training centres are found to be important component. The Japanese S&T policy and the changes in its key points are pointers to the importance of an innovation oriented industrial policies. S&T policies in India are also undergoing a transformation due to internationalization. The new science and technology (S&T) policy should facilitate proactive networking among research labs, private enterprise, and public agencies including financial institutions. The concurrent developments in research management practices are also highlighted.

Introduction

Innovation diffusion is vital to technology management in industry, aimed primarily at competitiveness and marketing advantages as well as new technology based entrepreneurial initiatives. One can distinguish between: (a) Product innovation, (b) Innovation to improve a process product or m/c, (c) Input saving innovations, and (d) Economic industrial engineering management innovation to improve organizational dynamics, workplace motivation, security, etc. Innovation diffusion denotes the process by which a particular innovation is adopted by the industry.

One of the earliest models of innovation diffusion is the linear model of technology change. According to the proponents of this model, innovation occurs in a linear model with straight line progression through the successive stages of basic research, applied research, development, and commercialization. Someone in the R&D Center comes up with an idea which he initially works out at the lab scale. This is then taken through the stages of bench and pilot scale and finally through the engineering and industrial scale, involving system design configuration and engineering consultancies. The final manufacture is based on the specification identified at this stage. This model appealed to the policy makers, especially because of its simplicity. One of the early exponents of this model was V Bush the Science Adviser to the US President. His document "The Endless Frontier" continued to influence the US Science Policy until recently and also set the tune for science policy in other nations.

But data on innovative output from science support and its industrial links proved that basic sciences as such are not enough to automatically proceed to the subsequent phases in the linear model. Thus, arose the need for a new model of innovation diffusion. The science push-market pull model ensured. This stressed the linear model's short comings in the light of the diversity of the activities that make-up the innovation process and its variation across industry lines. This is particularly true of R&D in firms since this is done mainly for two reasons: (i) Learning new techniques, (ii) Innovations in existing product processes.
A study in the US showed that over 70 per cent of firm's R&D efforts are aimed at new product and less than 30 per cent at processes. But in most other OECD nations the greater focus is on process. Most of the industrial firms enter into the innovation process at the stage of applied research. But in most of the government labs and Universities, facilities for applied developmental work are rather limited and they are better equipped for fundamental basic research. As per the linear model basic research findings in government labs would have automatically lead to applied developmental work in industries which does not happen even abroad. Hence in Germany they have chartered in the joint sector (Government/Private) technology transfer organization; they found out the basic research findings in German Government labs and tried to work them out at a larger scale in partnership with industry. In Japan, MITI has also initiated similar centers, mainly with industry support. Most of the research labs, in the government sector do not start pilot plants of their own unless industry partners involve themselves through co-operative or consortia type alliances, nucleated through avowed technology transfer agencies or by the government industry. Efforts are also made to tap the entrepreneurial energies of small groups of scientists in government labs and University faculty, particularly in emerging area like biotechnology and advanced ceramics through contract research equity participation, etc. It is also often found that even small firms with the rudimentary R&D are in a better position to interact entrepreneurly and they tap on the resources of the research centre more often than not, as compared to the large firms with no in-house R&D (however MNCs do most of their own basic research).

There is also very little interaction among academic scientist and engineers with industry and society. Locality specific foresight studies are also lacking, whereas in the US, Europe, Japan and Korea, S&T agencies in government, like NSF, STAMITI undertake studies to improve the industries' competitive advantages. The process of organized R&D in the developing world has relied largely on a top-down approach as compared to a two-way process. The agenda for basic research is largely determined by current literature which is largely dominated by the US and other OECD countries. One way, this is needed for competence and expertise build up for technology transfer and technology adaptation. The internationalization of R&D also necessitates such efforts. However, if research stops at this level of knowledge generation without diffusing to the field, on account of lack of awareness, communication issues or coupling mechanisms, the cost benefit analysis will yield such results as not to justify the sunk in costs.

Corporate Vision

The emerging focus on corporate vision in government labs in the developing countries, like India, arising mainly out of the need for external cash flow to supplement scarce public funds for research has brought to lane the possibilities for setting an R&D agenda by involving clients and customer from industry and government agencies.

Strategy for R&D business should aim at learning by training and learning by searching. R&D teams from government labs and academia can help industry specific firms in technology acquisition as well as salvaging of existing or even obsolete technology through emphasis on overall cost advantages. Small and medium firms which form a large segment of the production enterprise in most of the developing countries and even in newly emerging countries, like Taiwan or OECD nations, like Italy are aided in competitive positioning through such strategic alliance.

This may involve some training programme for new analytical quality control protocols, testing and analysis and consultancies on plant selection and acquisition and process optimization assumes importance. This will help to build up a client base.

Many laboratories in CSIR have successfully experimented with this model for generating technology-based business. A business incubator like
models are envisaged for new product development and its marketing, particularly in agroprocessing, biotechnology, food processing, chemicals, electronics and advanced material/engineering sectors.

At the next phase, technology generation and leadership capabilities are engineered by involving more firms in an industry specific consortia type alliances or cooperative set up. A niche area focus is developed for situational advantages in product formulation and marketing strategies. This may also involve a fair amount of learning by searching which means that the R&D team agrees to find out an alternative to provide competitive advantage (for more details, kindly refer Proceeding of R&D Management Conference 2000, on Levering Research & Technology Alliances, organised by CSIR in December, 2000 at New Delhi).

This also proceeds partly by learning the best practice abroad and trying to adapt to local situation. Japan has gone through the stages of initiation research, adaptation, minor innovation, and finally efforts aimed at the stage of technology leadership through pioneering S&T. It has developed its science enterprise and infrastructure like Tsukuba Science City essentially by periodic restructuring exercises mandated by government agency like MITI/STA.

In India the stage is somewhere between obsolete technology salvaging and new technology acquisition for most firms. The role of R&D is like that of a consultant. Some firms are conforming to a "niche" area focus, relying mostly on in-house R&D and linkages with government R&D through strategic alliance. This occurs essentially in high tech area like electronic/advanced materials, biotechnology and new energy sources. Internationalization of R&D has brought in foreign firms who are setting up their research unit in the country with a large indigenous manpower component. The government sector can suitably set up alliances with these units for mutual benefit.

**R&D Intensity Factor**

OECD has classified industries according to R&D intensities (i.e R&D expenditure unit for output).

- Aerospace, 23 per cent.
- Office machine and computer, 18 per cent.
- Electronic materials, 10 per cent.
- Drugs and pharmaceuticals, 9 per cent.
- Instrumentation, 5 per cent.
- Cars, 3 per cent.
- Chemical, 2-5 per cent.
- Rubber and polymers, 1.5 per cent.
- Non-ferrous metals, 1 per cent.
- Clay and minerals, 9 per cent.
- Food and Agroprocessing, 0.8 per cent.
- Petroleum, 0.6 per cent.
- Textiles and leather, 0.3 per cent.
- Ferrous metals, 0.5 per cent.

But when reckoned for the basis of a parameter like average R&D expenditure per unit sale, the chemicals and pharmaceuticals area had the highest intensity of 7-8 per cent followed by computer and office equipment 6 per cent. Instrumentation and commercialization 5 per cent and aerospace 3 per cent. This reinforces the finding that R&D inputs are of an high order in low volume high value added industries. Basic research and system development capabilities are of vital importance in ensuring lab to field translation of research results in high R&D intensity area. Such coupling mechanism are very strong abroad, whereas, in India, this is at a very rudimentary stage. Some of these mechanism abroad like science parks and incubators are yet to be successfully launched in India to yield widespread results. Nevertheless, a few schemes exist aimed at new technology diffusion in industry (like PATSER, Spread, TAAS and TDB). A few government labs have also embarked on a vigorous technology transfer and commercialization effort through co-operate entities launched for this purpose.

Efforts through alliances with technology transfer agencies, project engineering companies or through their own corporate subsidiaries are the usual forms.

**Diffusion Mechanisms**

It will be pertinent here to mention the findings of the US-Japan Technology Transfer Joint study panel (charted in the mid 90s). The study was aimed at a better understanding of the elements critical to innovation and its diffusion. Quality of S&T
infrastructure in university. Government labs and industry were found to be of critical importance. Even in the US and Japan, it was observed that market forces often result in too little basic research being conducted under its impulse. Governmental support was sought to compensate for this. The US government funds nearly 50 per cent of R&D, whereas in Japan it is only 30 per cent. However, government support in the US was much more defence-oriented though it is undergoing a marked change in the post-cold war scenario. Japanese Government R&D funding is directed towards strategic research for civilian industry, whereas the US has focused most of its basic research funds on mission mode programme more in the nature of blue-sky or fundamental research. The component of explicit knowledge in the form of technical literature like patents and copyrights was significant in the US, though tacit knowledge was of greater significance in Japan. Tacit knowledge consist of expertise-learning by doing training of personnel, consultancies, etc.

The modes of diffusion and resulting S&T infrastructure are also qualitatively different. The transfer mechanisms are better developed in Japan to enable the promotion of tacit knowledge till the early 90s. Consortia people networks and high-tech training are more advanced in Japan. Mechanisms like technical literature patents and computer networks are stronger in the US. The US approach was also more entrepreneurial and individualistic. Since the mid 90s the picture is slowly changing. Cooperative networks are proving to be a success in the US and Japan had taken avidly to large scale patenting in the US. Moreover the science linkages of Japanese patents are also on an increase.

The components of technology transfer infrastructure at the micro-level are management practices, human ware and infoware networks and training. On a macro level are national S&T and industrial policies, funding patterns and socio-economic situation. These affect the kinetics of technology flows from research to industry. Industry association provides a powerful process for industry to interact in terms of S&T inputs. Professional societies are also active in publishing S&T literature and sponsoring get-togethers. R&D consortia bring together companies for joint R&D sponsorships. Networks of technical people form a dense set of formal and informal contacts so critical to success in innovation and diffusion. Most of these are evidently lacking or less conspicuous in India. R&D industry meets and conferences and workshops do provide a forum for establishing necessary contacts to help in S&T resource mobilization.

The most ambitious example of deliberate high-tech development is the Technopolis concept in Japan, Tsukuba Science Universities now the home of many universities and national research institutes. It serves as prototype for many other technopolis and research cores. The criteria used by MITI to select these locations include topical set of urban attributes like proximity to a metropolitans city center with well endowed transportation communication network and an integrated complex of industrial, academic and government agencies. However, Tsukuba has been unable to spawn commercial spin-off, largely because of dependence on government R&D rather than that of industrial research. The MITI response to this has been to create a tier of research cores to further decentralization of technological development to the local level. French high-tech policy also combines traditional top-down strategies with local initiative, as embodied in initiative like Regional Center for Innovation and Technology Transfer (CRITT). In Germany too, local government initiatives were significant in promoting technology parks with appropriate research academic and industry linkages coupled with infrastructure support and significant local initiatives. Science parks can support regional development through an entrepreneurial atmosphere.

The American government has been pursuing active policies and programs in support of New Technology Base Forms's even though they represent only a fraction of the US total investment in R&D, they have a significant historical part. They represent a national commitment to encourage small technology-based business to address federal research needs and to create and commercialize new products/process.

In this program the government and private sector are partners in developing and displaying new technologies. This includes Small Business Innovation Research (SBIR) program, the Small Business Technology Program (ATP), the Manufacturing Extension Partnership Program (MEP). The program stresses on commercialization potential, non-financial assistance and better intellectual property rights protection. Most of the giant corporations dominating the economic landscape began as small business. The role of small business as
commercializers of new technologies is largely a new phenomenon. The easy answer to the failure to generate indigenous growth is the relative scarcity of R&D carried out in some regions and countries. Technological place are being created in the developing countries, like India of late particularly in information technology and software through technology parks like in Andhra Pradesh, Karnataka, and Kerala. Many other State governments also have diffusion and S&T-oriented programs in association with CSIR labs, selected Universities and IITs. There are a few large pharma firms investing heavily in R&D for novel drugs and intermediates. Regions and localities having high S&T entrepreneurial activity have characteristic similar to those of technically programmed large firms with in-house R&D.

Research Entrepreneurial Culture

- Entrepreneurial innovation could occur in any of five ways (Schumpeter 34:60)
- The introduction of a new good or of a new quality of good.
- The introduction of a new method of production.
- The opening of a new market.

Japanese S&T policy is a pointer in this direction. Key points in Japanese S&T policy have changed with time. The issue of S&T in the 50s was survival, including war rehabilitation. STA was established in 1956 to drive government S&T policy. Also the Council for S&T was established in 1959 to make recommendations for S&T. But by the mid 60s the issue was growth to expand society and economy through S&T policy decision was taken to create a national R&D programme called the large scale programme. But in the 70s the issue was energy and environment, which called for strategic research and try the 80s issue was basic research, as such.

The government policy made a transition from technology to science. These are reflected in programmes promoting basic research like ERATO in 1981 and Frontier Research Program of RIKEN and the R&D project on Basic Technology for Telecom, Agriculture and Forestry. These have given a boost to science linkages of Japanese innovations and patents.

Science agencies and S&T policies in India are also undergoing a transformation due to internationalization. CSIR vision document seeks to incorporate an entrepreneurial mode. The technology policy statement of 1983 needs revision as an innovation policy, facilitating proactive networking.

Combined with the economic rationale of market failure which justified a state role, government grants for R&D remain a popular policy in keeping with the linear model. This social contract has been renegotiated based on empirical evidence. Largely supporting an alternate model of science-push, market-pull as we have already seen. This shift in the thrust of government S&T policy based on this alternate model reflects a concern with the set of barriers to innovation which R&D efforts alone cannot address. Such a concern has been lacking in the linear model leading to its waning support. This concern is also reflected in the CSIR Vision Document.

Along with this development was the growth of research management as a separate field. Corporate organizational patterns with venture groups focused on emerging technology and think tanks focussed on strategy groups to foster greater creativity and entrepreneurship in research are notable contributions from the field of research management. This, in turn, lead to strategy formulation based on technology forecasting and foresight studies in the US, Europe and Japan. Even basic research became an economic activity. Such a corporate vision was essential because funds for research for getting scarce even in the developed world mainly because political lobbies which argued that the linear model had to be abandoned. In the developing world, this was an economic compulsion. Hall and Preston have summarized the role of technology thus: clusters of key inter related technology developing through backward and forward linkage are the real triggers of long waves. The diffusion rate of basic innovations are very important.

Technological change in the Third World is handicapped essentially by imitative research, relatively poor infrastructure, inadequate focus on higher education, divergence in industrial and S&T policies and insufficient linkages with university and industry segments. Communication and peoples 'network' and lack of market pull factors are also other major aspects bedeviling diffusion of research results.

The disparity in educational opportunity among the nations is perhaps the most critical factor. While
the African countries have less than two per centage of age group enroll in tertiary or higher secondary education, the SE Asian countries have on an average 15-20 per cent, whereas OECD countries have over 30 per cent. The gap between education, R&D was also another example of the dualistic nature of S&T even in countries like India, and Brazil with a reasonably well endowed S&T infrastructure. Data on S&T personnel per million population and those engaged in R&D (per million) are pointers.

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<th>Geographical area</th>
<th>S&amp;T (per million)</th>
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<td>Africa</td>
<td>3500</td>
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<td>Asia</td>
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<td>Latin America</td>
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This gap in technological capacity in terms of higher educational infrastructure and S&T personnel translates into technological dependence. This, in turn, leads to inappropriate technological transfer from the developed world to the developing nations. This is quite evident in respect of agricultural research and biotechnology. As for industrial research the themes has been essentially set in the western laboratories. A scientific elite divorced from the needs of society has been growing in countries like India. The green revolution in India has been an exception, largely because of policy intervention by government through diffusion-oriented policies with emphasis on lab to field feedback loops.

Production in most of the developing world has very little connection with formal R&D. Consequent to the internationalization of the R&D after the liberalization policies this scenario is fast changing with multi-nationals are opening research centers with a fairly large local content in a few developing countries in Asia.

Moreover the corporate vision for R&D in countries like India and South Africa are helping to bring about greater industrial linkages. In countries like Malaysia, Thailand, and Tanzania, though there is a greater deal of investments by multinationals, technological proficiency is at a low level. But policies in other South East Asian nations and the NICs have helped to generate local linkages, skills, and content in terms of technological capabilities. "Niche" focus in technology transfer in countries like Brazil and India has also helped to nucleate technology skills.

An extra-centre R&D set up for a collective network of industries under the aegis of a research agency in the government sector and involving academia suitably has been successfully implemented in Europe as the Triple-helix model. This was also found by the survey as a suitable model for the Indian context, particularly in the R&D internationalization milieu.

The recent CSIR initiative to identify mission-mode core programmes will be a major step forward in establishing networking systems for R&D and its engineering for field implementation, suitably supported by focused government funding. The concept of foresight studies, as carried out in OECD countries, is significant for the initiation and evaluation of R&D core programmes and networking agencies.

References