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NIS and Emerging Technologies: A Case of Biotechnology

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Innovation System and Emerging Technologies

In the literature on National Innovation Systems (NIS),the role of country specific institutional framework in the light of technological capabilities has been discussed at length. However, the analysis of an innovation system in the light of emerging technologies is a rather new phenomenon. Bartholomew (1997) and Senker (2001) have attempted to analyze such an innovation system for biotechnology. In these studies, effort have been made to develop and define the contours for a National system of Biotechnology Innovation(NSBI). Incidentally, both the studies have a predominant focus on developed economies.

Some of the developing countries are viewing biotechnology as a panacea for economic growth. One of the most aggressive of them is Singapore, where the biotechnology industry is being promoted with the target of achieving an economic growth rate of 6%.Unlike its earlier technology policies, Singapore now supports public research institutions to a great extent. It has already invested about US $ 20 billion in research and industrial parks, as against US $ 15 billion by South Korea and US $ 13 billion by Taiwan. Singapore has also promoted specific financial assistance schemes. Start up companies from Singapore are now eligible for access to a US $ 20 million government fund,set up exclusively to promote the bioindustry.

Today Knowledge economies are a key asset for global competitiveness. Biotechnology is a knowledge driven sector because it consists of knowledge working on knowledge to create value, decoding in genomics and proteomics being paradiagmatic knowledge based economic activity. Like many other new economy industries such as information and communications technology, new media and advanced finance, firms cluster in proximity to knowledge sources. In the case of biotechnology, Universities are key magnets. But to transfer science from the laboratory bench to the market involves complex, interactive chains of transactions among Scientists, entrepreneurs and various intermediaries. Chief among the latter are investors and lawyers. Proximity to such services and in biotechnology, research hospitals for clinical trials creates an innovation system. This article anatomizes the functioning of regional sectoral innovation systems in Germany, Cambridge, Massachusetts etc.

Innovation through knowledge creation and diffusion

A Knowledge based economy is said to be an economy based on the production, distribution and use of knowledge and information, as reflected by growing high technology investments, high technology industries, demand for highly skilled labor, and associated productivity gains. Innovation through the creation, diffusion and use of knowledge has become the primary engine for growth in a knowledge based economy. The determinants of innovation performance too have accordingly changed. While individual firms play a significant role in the development of specific innovations, the innovation process that nurtures and disseminates technological change, as reflected by interaction among a range of firms, public organizations and institutions and the government itself, is the crucial determinant of the performance.

The concept of National Innovation system was born two decades ago, to highlight the complex and interactive web of knowledge flows and relationships among industry, government and academia, making them work systematically to sustain innovation and science and technology development efforts. A new and enchanting field of economics and policy research has spawned a myriad of theories, models and studies, mostly concerning NIS in Europe, US and Japan. A few country specific studies for the Asia-Pacific region have dealt with local/national aspects and features on a descriptive basis. However, it may be simply defined as “A nation's institutions and policies, governing or inducing the innovative activity of research, invention, development, and adoption of new technologies”.

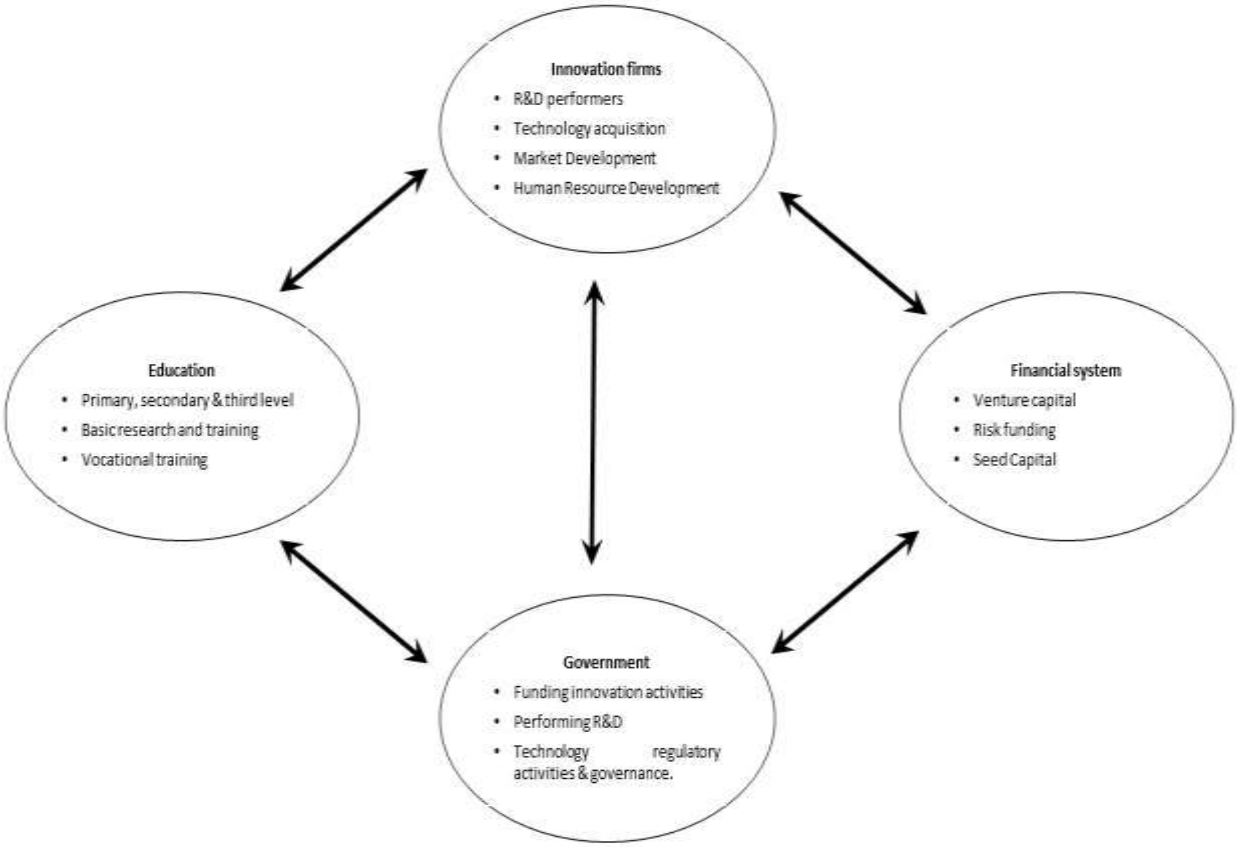

Figure 1

National Innovation Capacity & performance of NIS

The National Innovation Capacity(NIC) defined as the ability of a country, both as a political and economic entity, to produce and commercialize new-to-the world technologies over the long term. The NIC depends on (i) the presence of a strong national innovation infrastructure including, but not limited to the cumulative stock of S& T knowledge and personnel, overall S&T policy framework and mechanisms (ii) innovation environment for industry and services and (iii) the strength of interaction and linkages between the two. Thus at the national level, the NIS and NIC approach are based on the interactive model that emphasizes market and non-market transactions among the different sectors. The performance of NIS is dependent on the efficiency of such transactions. Creating and implementing a responsive NIS implies a holistic policy design and formulation that basically fosters and encourages collaboration and partnerships among firms, and between public and private institutions.

Technology Incubation System (TIS) has now emerged as a preferred component of the NIS in nurturing high tech start ups and fledgelings. TIS is a constructive intervention process to nurture technological enterprises and to enhance and realize higher levels of innovation. Thus as a part of NIS, it is necessary to evolve the requisite policies, programmes, infrastructure and instruments to promote and strengthen TIS with the focus on the development of high -tech and knowledge based enterprises. Each country has to evolve its own NIS/TIS model, taking into consideration factors such as socio-economic priorities, level and status of S&T and industrial base, and also culture of entrepreneurship. Over a period of time, corporate incubators are expected to gain momentum as effective value and knowledge creation tools, and facilitate the growth of technology intensive enterprises.

It is observed that there is great national diversity in technological capacity and in the development of institutions. Thus, each country has its own unique profile, depending on the organization of the educational sector, the level and orientation of public funded knowledge generators, the competition and governing regime for corporates etc. In the productive sector, the core competencies of firms across nations are different as a consequence of corporate-specific innovation strategy. Thus the interaction among firms and between firms, other players and the government differs across countries. In spite of the differences,, the wave of globalization has given rise to several fundamental policy

issues, not only for developing and newly industrializing countries, but also for industrially advanced countries. This prompts a policy shift, transferring from the macro to the micro level, where governments seek to influence the overall performance of firms and local industries. Secondly, there is increased globalization of R&D resources as exemplified by (i) global exploitation of technology, which is directly related to export flows in products and services; (ii) global technological collaboration, which has become highly prevalent in almost all knowledge sectors e.g.IT, pharmaceutical industry etc; and (iii) global generation of technology, as exemplified by small R&D units, of great significance to the mother companies, being located in well recognized R&D Centers. As a result, technological resources tend to accumulate in certain geographical clusters or environments. The issue requires an increasingly close national interaction with a global system of innovation.

This pattern of technological development has powerful market and political effects. Today, we see a widening of disparities in technological capability between more and less technologically advanced countries. Countries and firms that start with less sophisticated technological competence may be left behind, and often find it very difficult to catch up, as more intense competition among firms propels the development of even more sophisticated technology. The process of competition thus reinforces the advantage of those in the lead, and takes them further up the learning curve. The tendency of technological development to reinforce existing competitive advantages thus has significant policy connotations.

Policy Implications

In the globalized economy, firms from foreign countries are involved not only in the long term development of the national technological base, but also in short term commercial applications of technologies. The innovation base of a country is open to exploitation by companies to strengthen their competitiveness in the global economy, and national support for the pertinent technological and labor base is essential if company operations are to remain within a particular country. Thus the dynamic character of global competition requires nations to pursue policies that provide significant elements, which are critical for a firm's competitive advantage. A firm pursuing a competitive advantage in the global economy would look for access to skilled and trained manpower, good infrastructures, good political and economic environment and access to government research institutes.

There are indications that global companies have actually exerted their market power and exploit the opportunities in the setting of relations between corporate technology strategy and national innovation system. Governments generally pursue current challenges to address fiscal, regulatory, and institutional reforms to promote innovative behaviour among firms, to support R&D as a national strategy in expanding knowledge stock, to make the S&T enterprise more efficient and effective, and to improve the function of the innovation system. However policy designs are primarily confined within the limits of the nation. In the globalized and networked economy, a closer coordination of science and technology policies among countries has become necessary for the following reasons: Firstly, small countries are greatly affected by the operations of large cross-border multinational corporations through their exploitation of technology and natural resources in an international setting. Secondly, many firms that operate as global innovators can be attracted by certain technological infrastructures provided by the governments.

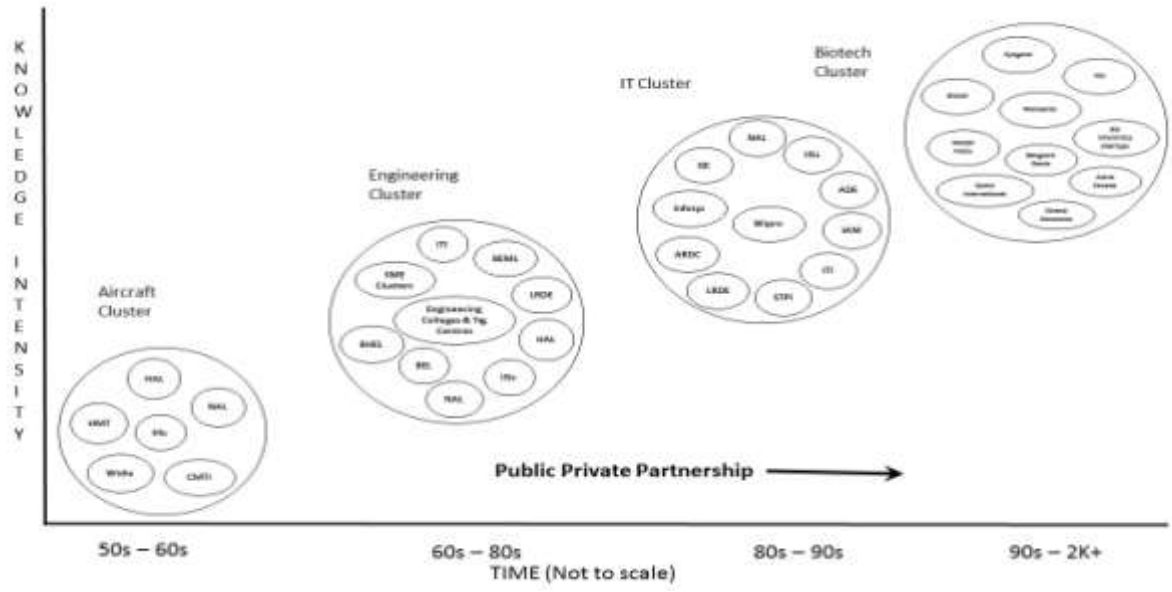

Figure 2

Innovation Policy framework for the national system of innovation

Studies on performance of NIS across several countries have shown that the common enabling and favourable factors for success of innovation are:

(i) Effective mechanisms for interaction between science base and business sector & between public and private sectors;

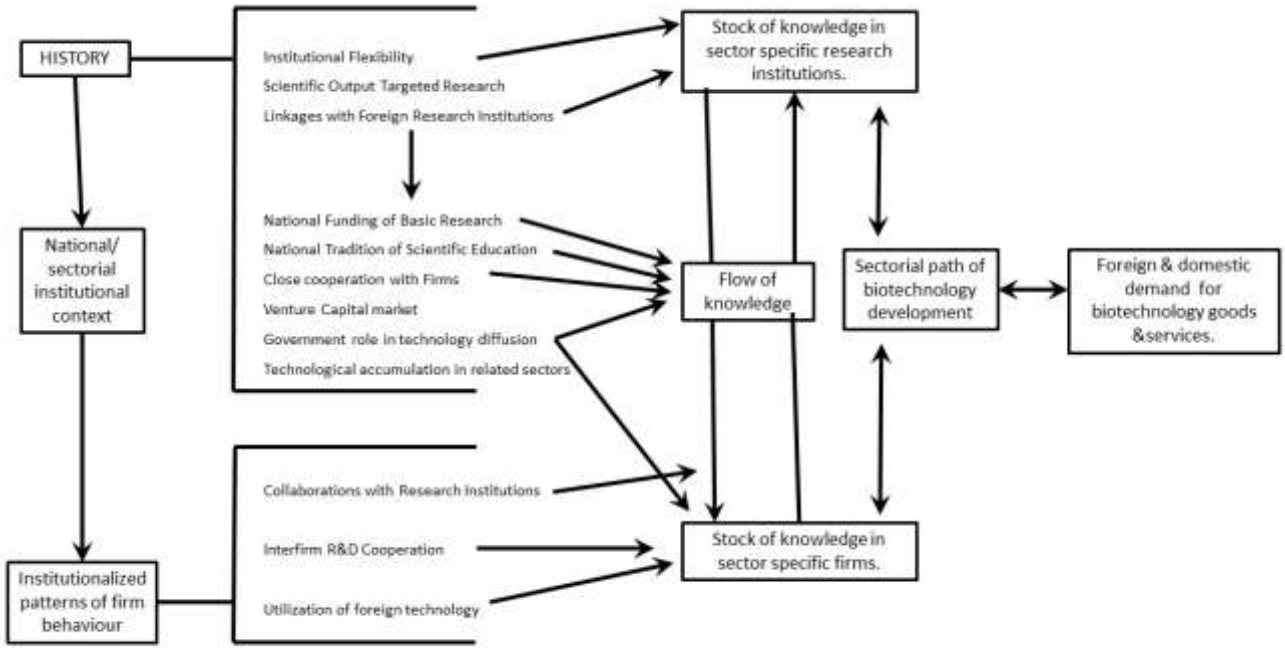

Figure 3

(ii) Competitive markets that are stable, and devoid of barriers to trade;

(iii) A Culture of networking and collaboration among firms and other actors at national, regional and global levels;

(iv) Facile technology diffusion policies, mechanisms and instruments that encourage commercialization; and

(v) Mobility of personnel across organizations and borders.

In the emerging scenario, the government needs to play an integrative role to make innovation policy dovetail with economic policy, education and training policy, industrial policy, competition policy, labour policy etc.

Thus each country would need to specifically seek out and respond to:-

(i) What the national innovation system can achieve in innovative learning, efficient technological diffusion, and enhanced accumulation of technological capacity?

(ii) How mobility of personnel can be facilitated and entrepreneurship capability enhanced?

(iii) How the corporate innovation system can be improved through market competition and a given set of institutional reforms?

(iv) How links can be developed to improve the interaction between the above two systems of innovation, and the global system of innovation?

(v) What type of initiatives are required for technological capacity building among the relevant agencies/institutions/enterprise/industrial clusters/traditional sectors?

The determinants of innovation performance too have accordingly changed. While Individual firms play a significant role in the development of specific innovations, the innovation process that nurtures and disseminates technological change, as reflected by interaction among a range of firms, public organizations and institutions, and last but not the least, the government itself, is the crucial determinant of the performance.

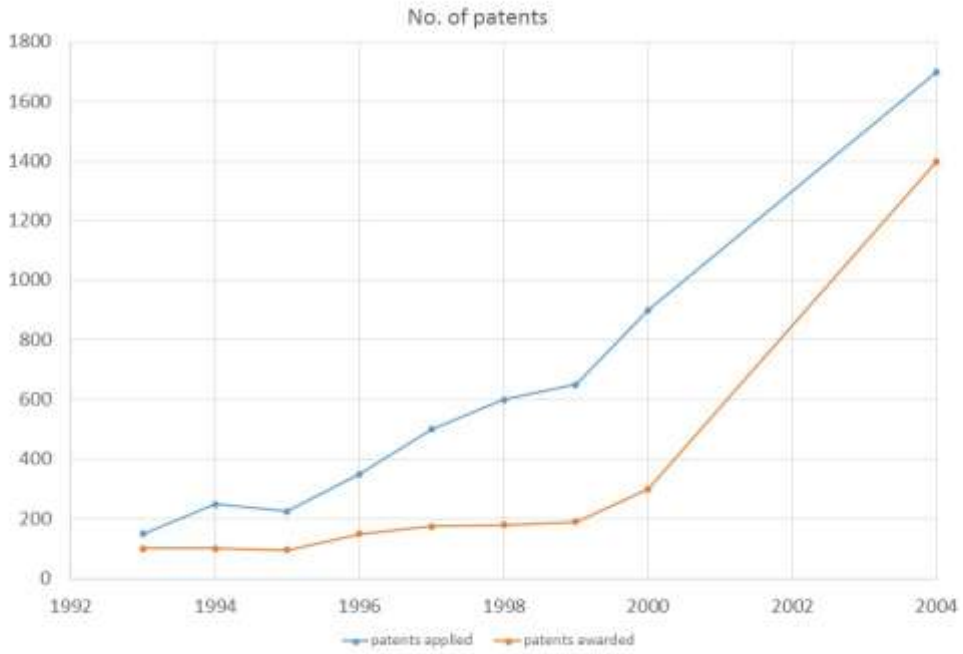

Figure 4

National systems of biotechnology innovation: A framework for analysis

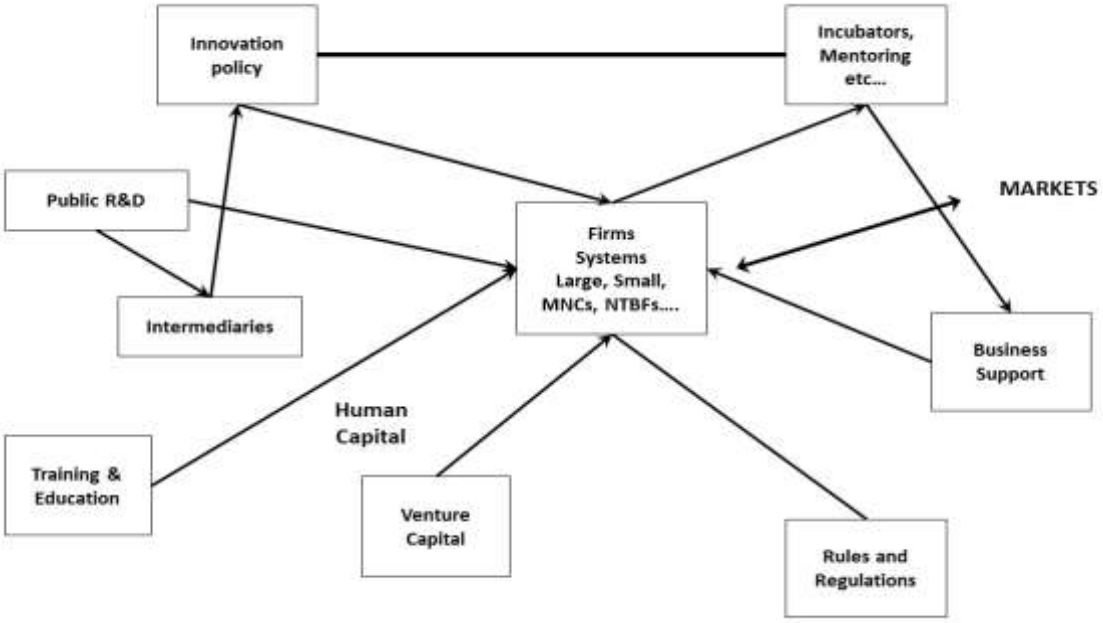

Figure 5

Singapore has undertaken several measures to promote equity investments in commercial projects in biomedical sciences. A Biomedical Science Investment Fund was created to attract leading international companies to conduct research and development through corporate research centers in the country. Singapore Bio-innovations (SBI), a company funded by the Singaporean Ministry of Trade and Industry, makes equity investment in foreign companies that have opted for alliances with firms in Singapore for research and development, manufacturing, marketing and

distribution. In the light of limited domestic expertise in the bio-medical sector, Singapore has adopted an open policy to allow skilled manpower in this field. Training in Biotechnology Scheme has been introduced to provide additional training by encouraging individuals the industry and academic institutions to attend short term courses. Close cooperation between firms is a vital component of NSBI.

Biomedical Grid for technology diffusion

The Government is taking steps for technology diffusion. It is looking into setting up a Biomedical Grid that will facilitate sharing of data and computing resources, and enhancing collaboration and co-operation among biomedical research organizations in Singapore. The proposed grid is a sophisticated IT infrastructure facility that will enable biomedical information to be shared and distributed along a secure data network, linking high performance computing resources. The stock of knowledge in specific firms would also grow with increasing inter-firm research and development cooperation. In case of life sciences, domestic companies have a very high share in the total private sector R&D expenditure, which is very close to,or in some cases, even higher than the share of well established older industries like engineering and electronics.

Company	Purpose
Biosensors (SG)	A locally minimally invasive surgical company has gone into R&D of its own version of stents for people with cardio-vascular diseases. This is one more of the innovative local manufacturing capabilities.
S*BIO (SG)	Fully integrated drug development company.
ES CELL INTERNATIONAL (SG)	Develops and commercializes human embryonic stem cell technology.
International Medical Centre	To provide high quality patient care, initially in the field of oncology; conducts cutting edge research in drug discovery, clinical education programs and degrees in conjunction with NUH and NUS.
Parkway Group (SG)	Gleneagles Clinical Research Centre.

Figure 6

Several Contract Research Organizations (CRO) have come up at the global level. They provide health care support services, including a full spectrum of product development and commercialization. These companies or centers take over from where pharmaceutical or biotechnology companies lave the chain of product development to focus more specifically on drug development and generic R&D. Singapore has established itself as a major CRO in the Asian region. The following table depicts the strength of domestic firms in this field.

Conclusion

The regional Innovation systems in biotechnology display megacenters with large variety of organizations and Institutions, research Universities, SBFs, Venture Capital firms and many CROs. These large megacenters are made of two different subsystems. The SBF/University/Venture Capital one is the most recent one. University research has spun off nearly half of these new SBFs and venture capital firms have provided them with seed capital, management services and expertise as well as credibility. The second system is centered on the large laboratories of pharmaceutical MNCs, most of which are foreign owned and controlled. Cointract research organizations provide services mostly to these MNCs but also to the local SBFs as well as exporting services to the US. Some of the MNCs research is contracted out to local Universities and/or their research hospitals. MNCs have developed research alliances with foreign based SBFs on the basis of R&D interests and complimentaries. Local SBFs have created alliances with overseas pharmaceutical international corporations on similar foundation of complimentary knowledge. Both MNCs and SBFs cooperate with research Universities and both use the services of local CROs.

Public-Private partnership can effectively meet the emerging demand pattern, and help in building domestic capability building. The sectoral approach of NSBI has also brought a change in the concentration of industry. Now Industrial locations may be linked to a major University or a research facility. This will play an important role in industrial development. It will also help in improving the domestic science base, and ultimately would enhance its utility for domestic emerging start up firms in this sector.

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