CHAPTER 7

Conclusion and Policy Implication

The aim of the study is to visualize the sectoral systems of innovation in general and how it is used in the biomedical R&D to deal with the challenges of health problems with specific focus on health biotechnology firms in India. The present study shows the development of biomedical innovation system in India during the past two decades. It has started establishing a strong position after the introduction of recombinant hepatitis B vaccine in 1997 and launched of alpha interferon ‘Shanferon’ in 2002 by Hyderabad based Shantha Biotecnics in the Indian market. It has achieved well position in the emerging market in health biotechnology sector. Biotechnology is regarded as S&T based sector and it is characterized by the several innovation activities such as R&D collaborations, interactions between S&T institutions, technology transfer, the development products and services, standardization and market. Indian firms are being engaged in various activities to ensure nourishment by manufacturing bio-generics, developing technology and expanding into services in other areas.

The literature survey based on systems of innovation (SI) has provided the framework for interactions between firms and other organizations that provide the creation of knowledge, its dissemination as well as its application within specific areas and have different approaches like national systems of innovation (NSI), sectoral systems of innovation (SSI), technological systems of innovation (TSI) and the regional innovation systems (RIS) approach. The study reveals that most of the knowledge transfer, linkages, facilitating factors and systematic boundaries are varied across the NSI, SSI and RIS approaches. The innovation performance of individual actors such as firms involved an extensive set of institutions and forms of interactions.

Literature related to systems of innovation have focused on various aspects like the importance of institutions and organizations, role of interactive learning, a broad set of innovation inputs such as R&D, interactions between agents and the role of social capital. It provides a useful tool in understanding of innovation activities like knowledge generation and dissemination. So, all systems of innovation approaches
are potentially important in terms of efforts as well as innovations leading to achieve socially desirable goals. These approaches help in providing conceptual frameworks and the tools which are very important in making policy decisions regarding innovations within a variety of systems including highly complex, non-linear and interactive systems.

In this study, several issues have been found related to institutional changes in biomedical innovation. One of the major issues is the ethical debates on patenting living organisms and the patenting of life, in general. Biotechnology R&D is principally focused on genetic engineering and the IP plays a major role in the pace of technological development in the related fields. The protection of IP is the core of the firm’s innovation and has an important relation to the creation of new knowledge in profitable activity. In 1994, the WTO TRIPS Agreement was established to standardize the IPR regime at the international level. It is the first global set of rules covering IPR protection and specifies the minimum standards for the protection of IP.

India has made three amendments in the Patent Act 1970 in 1999, 2002 and 2005 to comply with the WTO TRIPS obligation. Final amendment of the Patent Act came in 2005 in which product patent for pharmaceutical drugs was introduced including biotechnology, food and chemical products and patent term was also increased up to 20 years. The TRIPS agreement provides some flexibility for government in domestic legislation according to the needs and objective of its people. The Indian Patent Act is carried out a number of different kinds of flexibilities such as scope of patentability, pre-grant and post-grant opposition, parallel importation, provision for compulsory licensing and exceptions to patent rights. In 2012, India granted its first compulsory license by the Patent Office for the treatment of kidney cancer and liver drug.

India’s biotechnology industry has a lively impact on the growth of revenue from its product and services in the health sector after the changes its patent regime for the fulfilment of TRIPS Agreements. The major evolution came after the second amendment of the Patents Act 1970 in 2002 and the Act is very significant to encouraging and promoting biotechnological inventions in India. The Patents Act 2002 allows patenting of products related to biochemical, chemical, microorganism as well as biotechnological process. Article 27.3 (b) of TRIPs has given members the freedom
to exclude animals, essential biological processes and plants from patentability. A drug patented after 1 January 1995 in India can be classified as new NCEs, NMEs and NBEs and developed as a new composition and formulation, new chemical derivatives and new combinations.

The study has found that the Indian health biotechnology industry has been growing after the post TRIPS period. It shows that the introduction of product patent has given rise to business opportunities for the Indian biotechnology firms and has encouraged the development of the industry. The industry also has increased its exports to the regulated market in some developed countries like the Europe and US. The regulated market is more profitable than domestic market because drug prices are relatively high in regulated market. India is a major supplier of affordable generic drugs and supplied many drugs like vaccines in the poor developing countries because of cost effectiveness. There are various international health organizations such as the WHO and PATH which collaborated with the Indian companies to access the essential medicines.

The analysis of R&D activities of the firms shows that it has significantly increased in R&D investment to overcome firm competition and to create product pipeline and strengthen their presence in regulated and emerging market. It is pushing the boundaries of innovation to meet unmet medical needs. Leading firms like Biocon, Biological E, Serum Institute of India, Wockhardt and Zydus Cadila have increased their focus on R&D. R&D activities of the firms are focusing on novel drug discovery and development (NDDD), generics and biosimilars. Vaccines, diabetes and anticancer treatment are attracting the large investments. Several firms are spending more than 5 percent of their total sales on R&D activities. It has increased in R&D spending in terms of setting up new infrastructure facilities and human resource capabilities.

This adoption of IP regime has encouraged many of India’s firms to dedicate innovative research programmes to the development of biological products. For instance, Biocon is developing several novel biologics for cancer, diabetes and autoimmune diseases. Recently, it has introduced the world’s most affordable product trastuzumab in India. It is currently under phase III trials for global markets. “Rotavae”, developed by Bharat Biotech is the first oral rotavirus vaccine which is
currently under clinical trials of phase III. In Indian history, it is one of the largest phase III clinical trials being conducted on around 10,000 infants. It has received funding from the Gates Foundation and the Department of Biotechnology, Government of India. The R&D activities of the firms are increasingly focused on lifestyle diseases at global nature and they do not find any prospect in terms of the local diseases such as tuberculosis and malaria except a single biotechnology company namely Bharat Biotech International Limited.

Presently, a number of biotechnology based products are in various phases of development. Some of the firm’s drug development pipelines are in the advance stages and the company is expected to launch them soon. The results regarding patents, the biotechnology firms and public research organizations seem to respond well in post TRIPS period. The number of patents applications filed and patents granted has increased not only domestically but also more significantly internationally. There are many reasons for the increase in gene patenting, including increased R&D investment in genetics by the firms and by the government, and support on inventions and discoveries for the public needs of drugs. Overall, the results showed that the R&D activity of the firms as well as public research organizations have enriched in the Post TRIPS period.

Firms have established world class manufacturing facilities and modern laboratories to meet the global product demands. In the study, it has been found that the Bharat Biotech International (Hyderabad), Biocon (Bangalore), Biological E (Hyderabad), Serum Institute of India (Pune), Shantha Biotechnics (Hyderabad), Wockhardt (Mumbai) are the main developers of the rDNA drugs like insulin, interferons, streptokinase, GCSF and erythropoietin. It seems that these firms have well positioned to control their cost effective manufacturing abilities to corner some of this market share and enter on a global level. The manufacturing facilities of the firms are in accordance to various standards approved by important international regulatory agencies like USFDA, UKMCA, UK-MHRA, KFDA, NRA, EMEA, ANVISA, SA-MCC and WHO CGMP.

The increasing impact of affordable biomedical products such as vaccines is felt in both domestic and international markets. For example, Biological E supplies several
essential and lifesaving drugs to the UN agencies such as UNICEF, PAHO, and many
global markets and in India to the National Immunization programme. It supplies
more than 60 percent of its paediatric vaccine to the Government of India. A Delhi
based Panacea Biotec is involved in a supplying a vaccine namely Easyfive TT
vaccine (pentavalent vaccine) that protects against five diseases- diphtheria, tetanus,
pertussis, hepatitis B and Hib type b to PAHO, UNICEF, and other international
agencies involved in procurement of vaccines at global as well as national levels in
various countries. The Serum Institute of India supplies vaccines to international
health agencies such as the GAVI, WHO, PAHO, UNICEF and more than 140
countries across the globe. Shantha Biotechnics has been supplied Shanvac B-
hepatitis B vaccine to UN agencies and also directly to more than 20 countries. It is
also supplied Shanvac-B and ShanTT to the Indian Governments for the Universal
Immunization Plan (UIP).

The study reveals the Indian firms have collaborated to foreign organizations to catch
up with the new technologies and formed a global research network for higher
growth. The biomedical firms are collaborating with foreign firms so as to get access
to their expertise as well as resources to meet health issues at global level. Foreign
firm’s help in providing the knowledge that Indian firms are lacking including know
how about discovery, procurement process of regulatory approval and marketing for
new drugs. Indian firms have expertise in the field of lead optimization, preclinical
development, scaling up, manufacturing and bioinformatics, but they lack the
expertise in lead generation, toxicology studies, patenting and regulatory affairs.
Currently, the Government of has taken several initiatives, policies, regulations for
improving skills in drug discovery and development research programme to boost
R&D activities in health biotechnology sector. The primary aim for Indian firms to
collaborate with foreign firms is to cut the cost and phase times of product
development.

Indian pharmaceutical firms have gone under substantial change, due to the
introduction of the new product patent regime in 2005. The introduction of the new
patent regime as well as the challenges of globalization has drawn the focus of Indian
firms towards more innovative and research products by expanding their global
generic business, contract research services, contract manufacturing services, and
R&D services. Indian biomedical firms have developed numerous products such as AIDS diagnostics kits, recombinant human insulin, hepatitis B vaccines as well as other recombinant therapeutics with high quality but significantly lower cost that it proves the potential of technology innovation in the Indian health biotechnology sector.

The study shows the co-development alliances, manufacturing and marketing alliances, contract manufacturing, out-licensing and in-licensing agreements, marketing and distribution alliances, joint venture between Indian health biotechnology firms as well as their international counterparts are increasingly developing. The merger and acquisition trends in Indian biomedical industry have reached new heights among biotechnology firms. The reason behind is that the lack of R&D productivity, generic competition and expiring patents are driving the mergers and acquisition activity in the biomedical sector. The Indian health biotechnology firms are making acquisitions abroad to speed up their entry into foreign markets, especially in the US and Europe. The major drivers for acquisitions by Indian health biotechnology firms are the increasing revenue through global presence, strengthening R&D capabilities, gaining access to new technologies, better market access, widening product portfolios, establishing new areas in the biopharmaceutical value chain and strengthening distribution networks.

Indian firms have established a significant presence in Asia and Eastern Europe and now increasing their operations in the West. The primary question is that why Western companies have become attracted towards India during the past few years? The reason is that India offers various means for the cost reduction. Another reason is that India offers specialized knowledge and skills in the pharmaceutical sector. “India is one of the largest and the cheapest producers of the therapeutic drugs in the world and has excellent technology and R&D production facilities” (Chowdhury, 2011). In the initial phase the biopharmaceutical sector only shined reverse engineering, modification of drugs, and focused to sell in the domestic market. After the product patent, the major players in this sector have shifted their business models strategically.

One of the main concerns of developing countries with the implementation of the WTO TRIPS Agreement is the transfer of technology to foster economic
Researchers and scientists in Indian public research institutions are playing a major role in that direction. In case of biotechnology products, it requires billions of dollars to come out a new biological molecule in several years. Biotechnology firms have been benefitted by collaborating with R&D institutions such as universities, institutes that provided basic research facilities for the product development. Many Indian biomedical firms have introduced products by the original research activities using technology transfer from Indian R&D institutions in the fields of vaccines, therapeutics, and diagnostics. The firms have introduced their several products into the Indian and international market with the framework of IPRs laws. This is the best way to create a win-win situation for industry, academia and governments objective for providing a better healthcare to their people’s needs.

The study exhibits that the collaboration between public research institutions and biotechnology firms are emerging. Biotechnology firms have worked closely with the universities, primarily with biotechnology research institutes and the number of such collaborations is growing. There are various joint research with industry and university collaborations are now both more numerous and their rate of growth more rapid. Indian firms and public research institutions also work with several international non-government organizations such as the Wellcome Trust, Bill Melinda Gates Foundation, WHO, UNDP for capacity building in the field of biomedical R&D and services which are helpful in addressing the local as well as the global health needs.

The study also reveals the India’s global collaborations with other countries have been growing during the past decades in the areas of biomedical and health research. India has several bilateral, regional and multilateral collaborations agreements with countries like Australia, Brazil, Canada, Denmark, Estonia, Finland, France, Germany, Japan, Netherlands, Russia, Spain, Vietnam, United Kingdom, and United State to facilitate collaboration in the areas of biomedical through the joint R&D projects, exchange of scientists, training and fellowship for scientists, joint workshop and seminars, exchange of information, development of infrastructure and facilities, exhibition and electronic informatics network.
The Indian government also tries to promote better collaboration between public institutes and biomedical firms. The Ministry of Science and Technology and DBT have recently developed a draft of the country’s National Biotechnology Development Strategy (NBDS). The draft stresses a shift in policy to support collaboration rather than competition among science agencies, R&D institutions and industries. It is also dealing with the promotion of public private partnership through various agencies like DPRP, TDB, NMITLI, BIPP and SBIRI, allowing 100 percent FDI, exemption from the requirement of compulsory licensing, promoting and supporting biotechnology park, creating several technology transfer cells, establishing a centre for translational research, introducing new grants and loans for promoting small business innovation and finally, it has establishment a National Biotechnology Regulation Authority (NBRA) to provide faster and more efficient regulatory clearance.

Several agencies like ICMR, DBT, DST, CSIR and DRDO have played a major role in developing the biomedical research ecosystem for undertaking leading programs, major investments, development of model curricula, initiating joint university-industry projects, establishing centres of excellence and enhancing laboratory facilities, developing human resources and building international collaborations. The Indian government has launched a new policy which deals with increasing access to healthcare at local, building more hospitals with good medical facilities, improving the quality of medical training, and also increased the public expenditure on health care from 0.9 percent to 2-3 percent of the country’s GDP (MoHFW, 2011). The Planning Commission has allocated USD55 billion under the 12th five year plan to the Ministry of Health and Family Welfare which is about three times the actual expenditure under the 11th five year plan (GOI, 2012). The 12th plan focusses on providing universal health care, strengthening health care infrastructure, promoting R&D and enacting strong regulations for the healthcare sector.

The lacks that happen today, particularly in human resources, regulation, financing, and infrastructure, present significant difficulties in developing new vaccines, drugs, and diagnostics. India ranks among the top 10 countries having highest mortality due to communicable diseases (especially tuberculosis), also including a high maternal and child mortality. Rapid changes in epidemiological profiles have led to the double burden of communicable and non-communicable diseases in India. The number of
facilities currently available to support the growing population is insufficient. On the basis of finding of the present study, it is concluded that to achieve better health outcomes in India, there is a need of doubling or tripling its existing health expenditure along with the proper allocations.

Other important issues are found associated with the regulatory framework for biomedical research, development and innovation in India. It ideally involves a host of actors and institutions, including research bodies, promotional agencies, planning bodies, nodal ministries, other ministries, regulatory agencies, implementing agencies etc. These agencies jointly regulate the development, manufacture and supply of biologics making it a very complex regulatory system. In other countries where biomedical sector is very successful, have a single regulatory agency such as USFDA, National Health Surveillance Agency Brazil (ANVISA), European Medicine Agency (EMA), Therapeutic Goods Administration (TGA) Australia, Korean Food and Drug Administration (KFDA) and others that administer and regulate all aspects of the industry. For responsible governance of biomedical R&D in India, it is essential to the government of India should merge all the regulatory activities to make a single regulatory body.

There is a need to develop, support and frame effective policies that promote the development of capacities in India related to biomedical innovation. The important areas of investment are capacities relating to science and technology, domestic production of drug, clinical trials, intellectual property and regulation. The following policy implications emerge from this study, which must be combined in to a national policy for improving and encouraging continued development of health biotechnology sector in India.

- Reconcile the all drug regulatory system into a single regulatory agency and ensure sufficient training for regulatory personnel.
- Increase the advanced training programmes in biotechnology fields and formulate a single body to provide scientific and technological guidelines.
- Providing the framework which supports academic scientists and researchers in the field testing innovative ideas and translating new ideas into products.
• Promotion of more R&D programmes that will strengthen the Indian biomedical firms to find efficient and complete treatment for neglected diseases.

• Creating a favourable and supporting financial atmosphere for the development of the private sector, including support for the initial phase research as well as product development.

• Encouraging effective collaborations pattern between industry and academia institutions and motivating scientists to follow business ventures to commercialize research.

• Improvement in public health infrastructure and encouraging biomedical firms to develop innovative supply strategies.

• Increase R&D funding projects to help in innovation of novel products and services that can meet local health needs efficiently.

The thesis has provided insights into the sectoral systems of innovation and its facts by exploring actor, network and institutions on the basis of selected Indian health biotechnology firms. Further, the facts and future scope of the research will depend on varying choice of the study firms, selection of methodology, analytical framework and investigating the process of innovation systems.