

Bangalore Biotech Cluster

An analysis of the competitiveness of the
biotechnology cluster in Bangalore and
opportunities for its development

Microeconomics of Competitiveness

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India

Geography and Population

Bordered by Pakistan, China, Nepal, Bhutan, Myanmar, and Bangladesh, India is roughly the size of one third of the United States. Its soil is very fertile, and the country is endowed with many natural resources such as iron ore, bauxite, natural gas, and coal. While it has some oil reserves, these are too small to satisfy its demand. India has seven major ports, and its coastline is strategically located on the Indian Ocean trade routes.

With a total population estimated at 1.1 billion, and growing by 1% per year (WDI, 2008), India is the second most populous country in the world, and is expected to surpass China within twenty years. Life expectancy is 66 years for women and 63 for men. The country's total literacy rate was 61% in 2001 but it varied by gender. Female literacy rate was 48% and male literacy rate was 73%. India's population is 70% rural, and in 2000, 29% of the population lived below the country's poverty line (WDI, 2008).

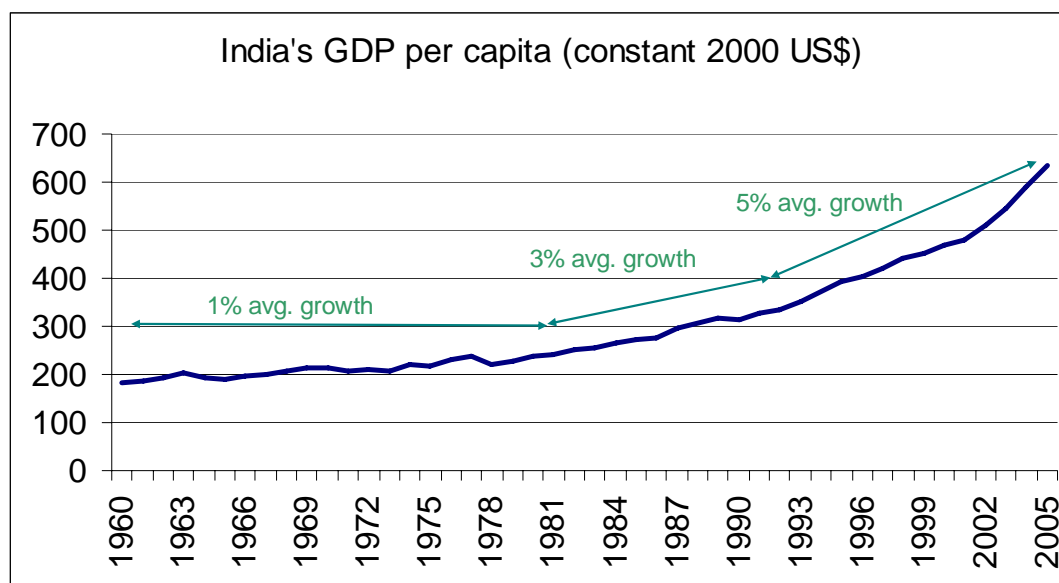
Political System

India gained independence from the United Kingdom in 1947. At the same time British India was partitioned to create Pakistan and what was later to become Bangladesh. This partition, which led to a number of armed conflicts with Pakistan, still weighs heavily on India's foreign policy, and on its fiscal deficit, since investment in the army takes a heavy toll on the national budget. Currently the world's biggest democracy, India is organized as a federation of 28 states. The partition of power between the federal and state levels has been the subject of much tension over the decades since the original constitution gave overwhelming strength to the central government. Currently, national defense, railways, currency, income, banking and insurance are managed at the national level. Police, public health, local government, agriculture and sales tax

are managed at the state level, and economic and social planning, education, criminal law, trade unions and bankruptcy are managed jointly at the state and federal levels, though preeminence is given to the federal level over the state level (Iyer, 2008).

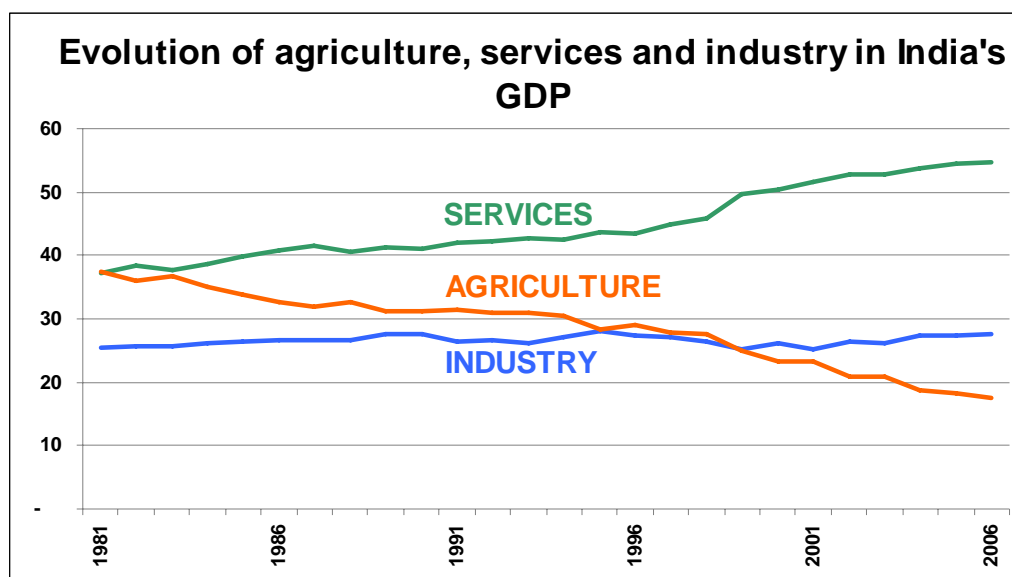
High Growth Increasingly Fueled by Services

Until 1991, India's development was based on import substitution with state-directed and highly controlled economic development. The 'socialist' model led to a so called 'Hindu rate' of growth of 1% from 1960-1980, which increased marginally to 3% from 1980-1990. An economic crisis in 1991 forced the government to liberalize and deregulate the economy. These actions paid dividends; after liberalization, the annual per capita GDP growth rate has increased to an average of 5%. Further, India has become one of the fastest growing economies in the world, with an average GDP growth rate of more than 7% in the decade since 1997 (WDI, 2008).



India's GDP per capita in 2006 was \$2393 (measured in constant 2005 dollars), making it one of the poorest countries on earth (ranked 118th out of 145 countries) (CIA World Fact Book 2008). While about 25% of India's population lives below the poverty line, the country is also home to more than 100,000 millionaires, including some of the richest people in the world. Over

the last 20 years, the source of India's wealth has increasingly been due to the growth of its services sector, while the share of agriculture in its GDP has been eroding and the share of its industrial output has remained stable.



Today, services account for more than half of India's output and less than one third of its labor force, while agriculture accounts for less than 20% of its output but employs three-fifths of the work force. Regional disparities have also increased as some states, most notably those located in South India, have grown at a faster rate. Additionally, the urban population has steadily increased from 18% in 1960 to 26% in 2006 (WDI, 2008).

Fiscal and Monetary Policies

While inflation has decreased in the 2000's compared to the 1990's, inflationary risks remain due to India's strong growth, the real estate boom and a general increase in oil prices, such that real interest rates in 2008 are at 6% and are not expected to decrease in the short run. In the last decade, the rupee has appreciated against the dollar to 41 INR per USD. While this signals a growing economy and rising wages, India's exports have also been adversely affected.

According to the Economist Intelligence Unit, the textile and the pharmaceutical industries have been hardest hit due to the decrease of their cost competitiveness (EIU, 2008).

India's Openness to FDI and Trade

In 2007 FDI in India amounted to \$19.2 billion USD, an increase of 72% over the previous year. The top five investors were Mauritius (44.4%), USA (9.1%), UK (7.8%), Singapore (5.8%) and the Netherlands (5.7%). The top three sectors receiving these investments were: services (19.8%), computer hardware and software (15.7%) and telecommunications (8%), indicating the strength of the services sector in India. The drugs and pharmaceuticals sector ranked 9th, receiving 2.6% of total FDI (RBI, 2007).

India's top imports in 2006 were oil (\$57Bn), machinery (\$32Bn) and electronic goods (\$15.9Bn). Its main exports were engineering goods (\$26.2Bn), petroleum products (\$18.6Bn) and textiles and clothing (\$16.1Bn). In 2006, imports amounted to \$128.1Bn, and exports to only \$87.7Bn, creating a significant trade deficit, reflective of the poor overall competitiveness of India on the global stage (EIU, 2008).

In 2007, India's trade deficit increased with imports growing at 4.5% and exports growing at a slower rate of 2.5% (WDI, 2008). A large part of the deficit in the trade account is made up by the huge remittances, which are the highest in the world for any country (\$23 billion in 2004).

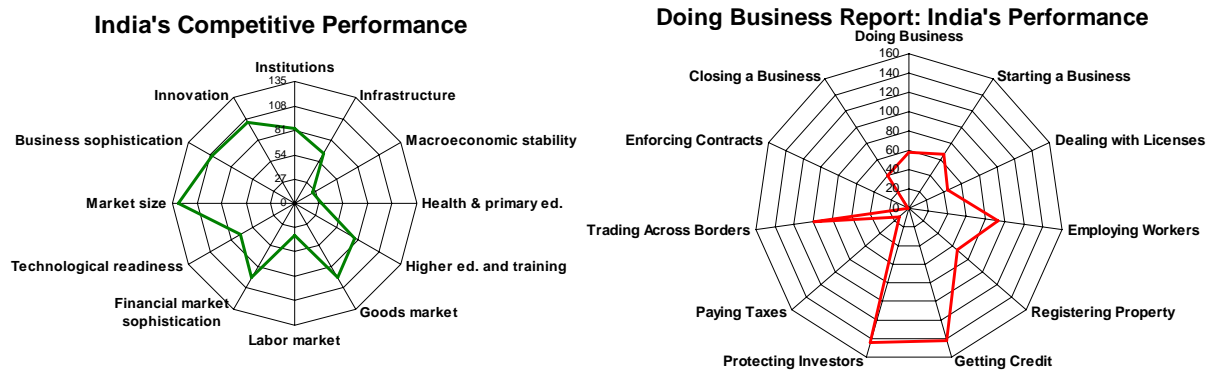
Unemployment

90% of the work force is employed in the "unorganized sector;" 60% of the workforce is self-employed; and 70% is either illiterate or educated below the primary level. Out of the 10% of the workforce in the formal sectors, two fifths are employed by the public sector. India's workforce is grows at an annual rate of 2.5%, but employment is growing at only 2.3%, such that demand for job is increasing more quickly than the supply. One of the reasons accounting

for to the huge unorganized sector labor force is the stringent labor regulations for the formal sector, which prevent firing of workers by firms.

Country competitiveness

The graphs below show India's performance both in the Global Competitiveness Report (green graph) and the World Bank's Doing Business report (red graph):

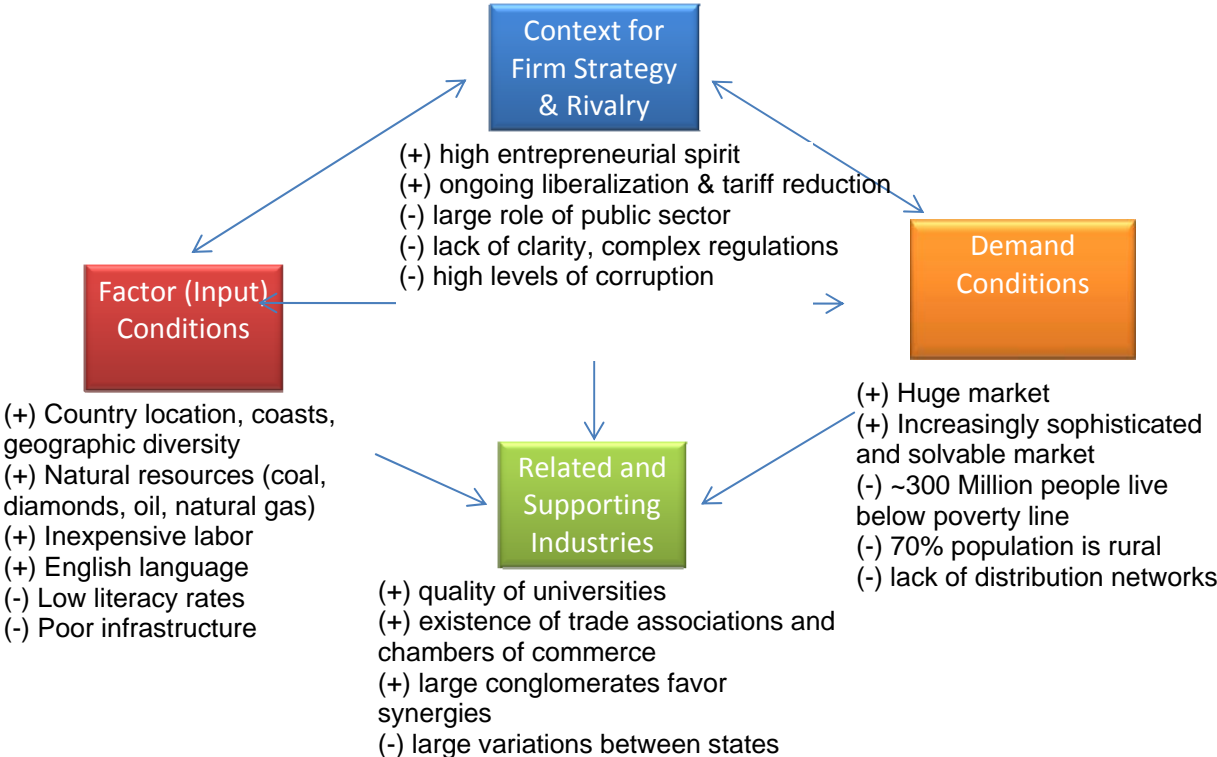


The competitive strengths of India are first its huge population, which is increasingly become rich enough to participate in the market economy. The high sophistication of business and financial markets coupled with India's strong rating on access to credit and investor protection favor sectors which require investment and depend on technological innovation.

The competitive weaknesses of India's market are first its rigid labor market regulations, which makes hiring and firing complicated. While this aspect is particularly negative for manufacturing, its impact on services is less important. India's poor rating on macroeconomic stability is a very important factor to take into account for the country's capacity to export its goods and services. Enforcing contracts, registering property and dealing with licenses are three intertwined weaknesses which are especially detrimental to sectors relying on intellectual property, administrative authorization and licensing.

Country diamond

**India Business Environment:
The Diamond**

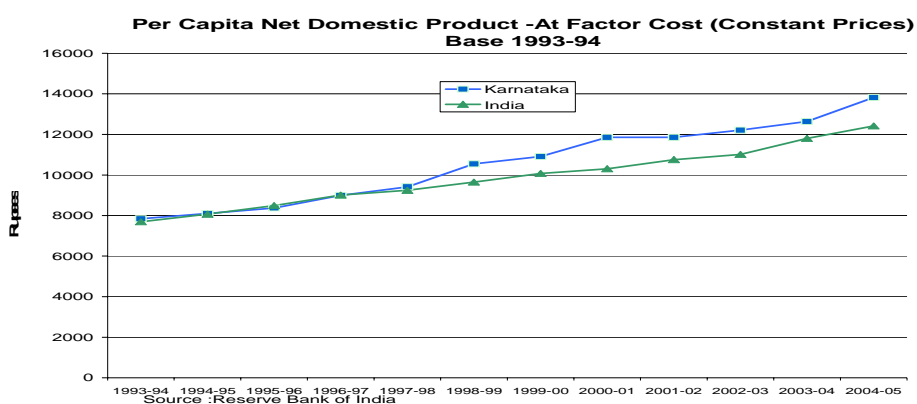


Karnataka

Macroeconomic Context

Karnataka is situated on the south west coast of India. It is the eighth largest state, both by geographical area (191,791 sq km) and population (53 million, or 5.13% of India’s population) (Department of Economics and Statistics, 2008). Incorporated in 1956, Karnataka’s economy has transformed from agricultural-based to services-led, similarly to the rest of India. According to the Karnataka Human Development Report (2005) the agriculture sector contributed 60% to the state GDP in 1960, decreasing to less than 20% in 2006-07. The services sector grew from 24.8% to nearly 58% in 2006-07. The rate of GDP growth has also increased, especially in the

last two decades after India liberalized its economy. Karnataka quickly took advantage of the economic reforms as India liberalized its economy in 1991. It registered the highest growth among Indian states for the period 1991-2001 (the state GDP grew at 7.56%, compared to the national average of 6.1%). It ranks 6th among Indian states in terms of state GDP, growing by 8.7% during 2005-06 and by 13.6 % in 2006-07. Karnataka contributes around 5.5% of India's GDP (Frontline, September 2007). The faster growth rate is evident in the increasing gap in per capita income between Karnataka and India.



FDI and Exports

The economic growth in Karnataka has attracted FDI. There are more than 150 MNCs, with nearly \$1 billion of FDI during 2006-07; this was the second-highest in India and accounted for 17.57% of all FDI. The competitiveness of the services and manufacturing sectors versus India is captured in the magnitude of exports. Karnataka accounts for nearly 15% of India's exports (Directorate of Industry and Commerce, 2008).

Growth areas:

Karnataka's biggest success story in recent years has been the IT sector. Karnataka accounts for 37% of India's IT and IT-enabled services firms. Its manufacturing sector growth rate registered at 14% in 2006-07, though the contribution of the manufacturing sector to the

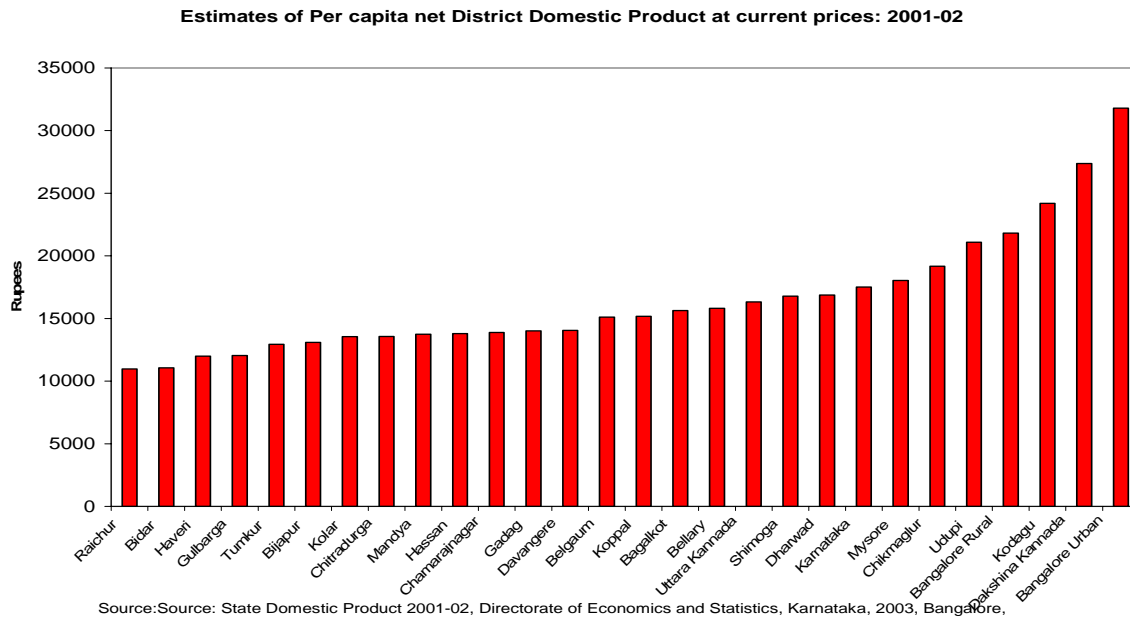
composition of GDP has remained constant over the years. Karnataka has accounted for 8% of all India enterprises in the manufacturing sector mainly due to its strength in the petrochemicals and engineering sectors. It also has rich natural resources in gold, iron ore and china clay.

Karnataka has the following achievements to its credit:

- Leads the IT revolution with software exports of over US \$ 1.6 billion
- Emerging center of Biotech with 40% of the firms in India and 40% of the exports
- Contributes 70 % of India's coffee and 70% of silk.
- Major source of processed food products with exports worth US \$ 408.16 million.
- Produces 20% of India's electronic hardware
- Major apparel sourcing center with exports worth US \$ 714.28 million
- Major producer of Steel and Cement

Poor Social Indicators

There are concerns about Karnataka's growth expanding inequalities by being lopsided or too Bangalore-centric, as in the graph below which shows per capita domestic product by district.



The per capita income in different district ranges from a high of over Rs. 30,000 per annum in urban Bangalore to Rs. 11,000 per annum in rural Raichur. The growth patterns in Karnataka are essentially urban, based around Bangalore and the city of Mangalore in the District of

Dakshin Kannada, explaining the higher per capita income in these districts versus the outlying rural and agriculture districts. By social indicators, Karnataka's progress is average. The state economy has diversified characteristically for a developing economy; but there is cause for concern as nearly 56% of the workforce is dependent on agriculture, which is much higher than the share of agriculture in the state's GDP. 25% of Karnataka's population registers as "poor," compared to 27.5% across India (2004-05 NSSO Data). Karnataka's Human Development Index is above India's average but only 7th among India's states and 120th at the international level (Karnataka Human Development Report, 2005). Bangalore appears to be an urban exception of wealth and progress set amidst a rural Karnataka.

Productivity Growth and Unemployment

Estimates of labor productivity for all the 27 districts for the year 2000-01 (Karnataka Human Development Report 2005) reveal that labor productivity was highest in Bangalore Urban district, followed by Kodagu and Dakshina Kannada districts. The increase in state GDP per worker over the 1991-2001 decade was 5.3% per annum. Compared to India, Karnataka did better in terms of reducing unemployment; but the pattern of unemployment varies across rural and urban areas. From 1993-94 to 1999-2000 rural employment growth was marginal and decelerated in the agricultural sector while Urban Karnataka sustained 2.54% employment growth. Overall employment declined in agriculture, mining, utilities, and social and personal services, but increased in manufacturing, construction, trade, transport, storage, communication, finance, insurance, real estate and non-agricultural activities. It appears that concentrated development in urban areas balanced by stagnant employment and labor productivity in rural areas are the cause of Karnataka's divergent social and economic performance.

Advantage in Human Resources:

Karnataka can also be singled out in terms of its distinct advantage in human resources and research and development capabilities. The state has a strong tradition in education, science and technology and is home to a number of premier research institutions including Jawaharlal Nehru Centre for Advanced Scientific Research, Central Food Technological Research Institute (Mysore), Indian Space Research Organization, Indian Institute of Astrophysics and Indian Institute of Science. The National Law School of India and an Indian Institute of Management are also located in Bangalore. Recognized as a centre of learning, Karnataka was one of the first states to privatize higher education. At present it has 12 universities, 98 engineering colleges, 107 medical colleges, 916 arts and sciences colleges, over 100 R&D centers, 184 polytechnics and 188 industrial training institutes. It ranks 2nd in the country in terms of the institutes offering professional degrees and third in terms of research and development centers (Frontline, 2007).

Government Initiatives and Policies

Karnataka has a relatively proactive, industry-friendly government. The state government set up the “Karnataka Udyog Mitra” agency as a “single contact point” for all investors looking to set up businesses; its role is to facilitate investments and execute initiatives to enable a smooth transition to operation, from receiving an investment proposal to the eventual implementation of the project. The state has also identified certain industries as focus areas for growth: coffee (and food processing), silk clothing, mineral based industry, tourism, gold and jewelry, offshore IT, BPO, biopharmaceuticals, engineering and automotive components. The state has proactively developed policy frameworks to provide a unified approach to address issues related to these sectors. The government works with industry associations so that policy reflects the combined viewpoints of the private and the public sector in these areas. Various policy statements include the 2006-2011 New Industrial Policy, the Millennium IT Policy 2000, the Millennium Biotech

Policy 2000, the Millennium BPO Policy 2002, the Karnataka Tourism Policy 2002-2007, the Karnataka Export Promotion Policy (2002-2007), the Agro Food Processing Policy 2003, the Karnataka Industries (Facilitation) Act 2002 and Infrastructure Policy 2007 (Directorate of Industry and Commerce, 2007).

The slow growth of the infrastructure sector is one of the major constraints for economic growth. Recognizing this, the government of Karnataka developed its Infrastructure Policy 2007 with a view to involve the private sector in creating infrastructure in a transparent manner. Since then, Karnataka has embarked on a massive infrastructure expansion program aimed at providing industry with world-class facilities, featuring fast-tracked projects such as the new Bangalore International Airport, Bangalore-Mysore Expressway and Bangalore Mass Rapid Transit system.

Karnataka also enjoys a highly stable political set up. Karnataka was one of the first states in India to decentralize power to lower levels, hence making governance more participatory.

Karnataka has a strong financial sector and has long been the cradle of India's banking sector, with as many as seven of the country's leading banks having originated there.

Karnataka Diamond – Strengths and Weaknesses

Factor Inputs: Karnataka is a leading state in terms of R&D capabilities and professional graduate institutions and thus both quantity and quality of human resources is a distinct advantage. Karnataka was one of the pioneers in privatizing graduate education in India. It also has increasing labor productivity. However, employment and growth have been skewed mostly to urban areas, thus creating inequalities. Its performance on social indicators such as literacy and poverty lag behind its performance in economic terms. One of the major constraints has been infrastructure, which has not kept pace with industry's requirements. Karnataka has a

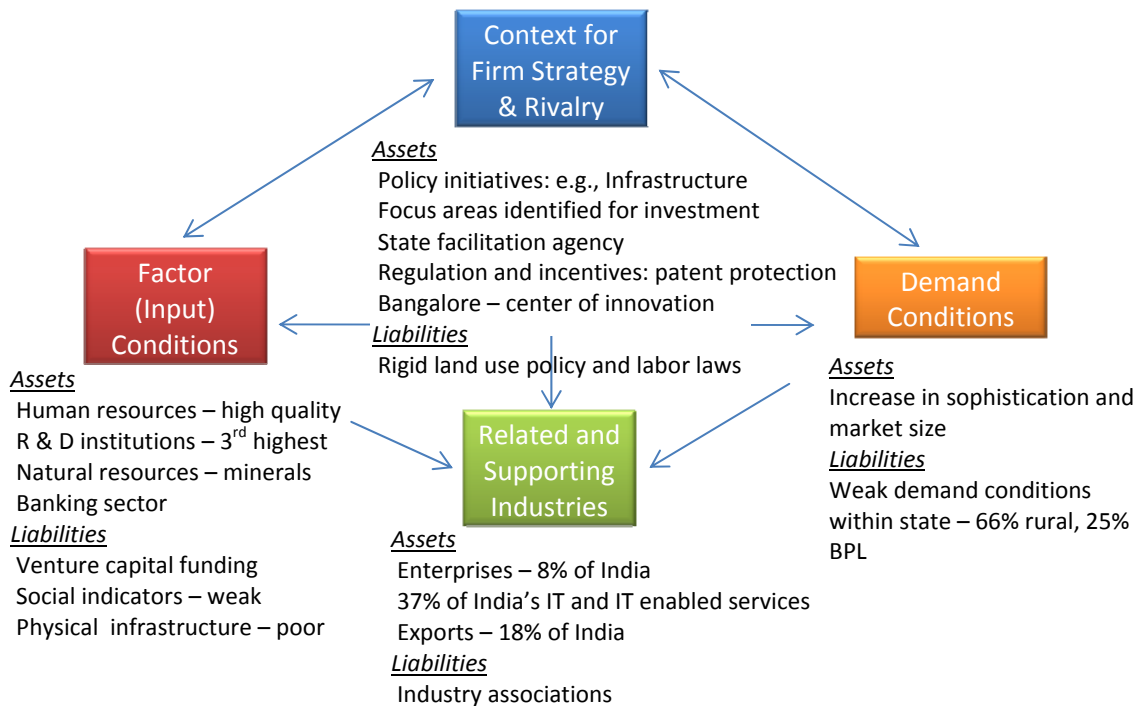
strong financial sector but, like India, does not have a have a venture capital culture. Whatever venture capital funding is available is channeled to the IT sector due to its liquid exit market.

Demand Conditions: The state has a rapidly growing middle class fueling growing demand for consumer goods, electronics, automobiles, telecom and other services like construction, transport, tourism, health care and finance. However it also has 25% of the population below the poverty line, with over 60% of the population living in rural areas. This section of the population does not create a high demand for manufacturing or services industry products, but there is a demand for basic agricultural commodities and also consumer items which are low cost.

Context of Firm Strategy and Rivalry: The state has been industry friendly and has made attempts to create business friendly environment. It interacts with industry associations and has identified focus areas and clearly defined policy frameworks for various sectors. Karnataka has a good track record in terms of enforcing contracts, harmonious labor relations, macroeconomic stability and rules and laws governing industry. However, the federal laws relating to land and labor regulation are rigid and cause inefficiencies for industrial growth.

Related and Supporting Industries: The industrial density in the state is good. The state accounts for 8% of the enterprises in the country. It is very strong on strong heavy machinery, IT, garments and now biotechnology. It is also the number one producer in coffee and silk and also has a strong agricultural sector. It has generic Institutions for Collaboration which interact with the government and participate in policy making.

Karnataka Business Environment: The Diamond



Biotechnology Cluster

Definition of Biotechnology

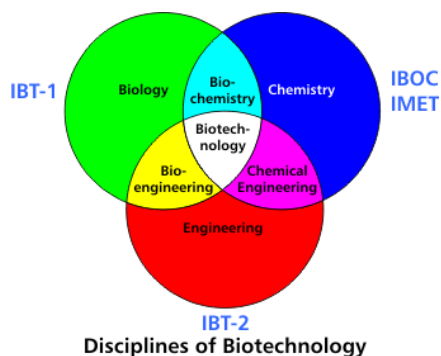


Figure 1 from presentation by Biocon

Biotechnology is an interdisciplinary fusion of biology and technology, through which living organisms and their products are modified to manufacture food, drugs and other substances.¹ Biotechnology can be divided into five subgroups: Bio-Pharma, Bio-Agri, Bio-Industrial, Bio-Services and Bio-informatics. Bio-Pharma, probably the most well known, is the field of biotechnology that produces

¹ Sarx, Johannes (2006) Biotechnology – the next Indian success story?

drugs such as insulin through the use of recombinant bacteria as “biological factories.” Bio-Agri encompasses the genetic modification of foodstocks to increase yield and nutritional value, through solutions such as genetically modified (“GM”) crops. Bio-industrial involves the production of enzymes for use in manufacturing or consumer goods such as biological washing powders. Bio-Services encompasses service providers that help bring products of the other parts of the biotechnology sector to market, namely through research services, clinical trials testing and contract marketing. Finally, Bio-Informatics is the use of information technology in biotech applications, particularly for R&D and drug discovery.

Bangalore Biotechnology Cluster

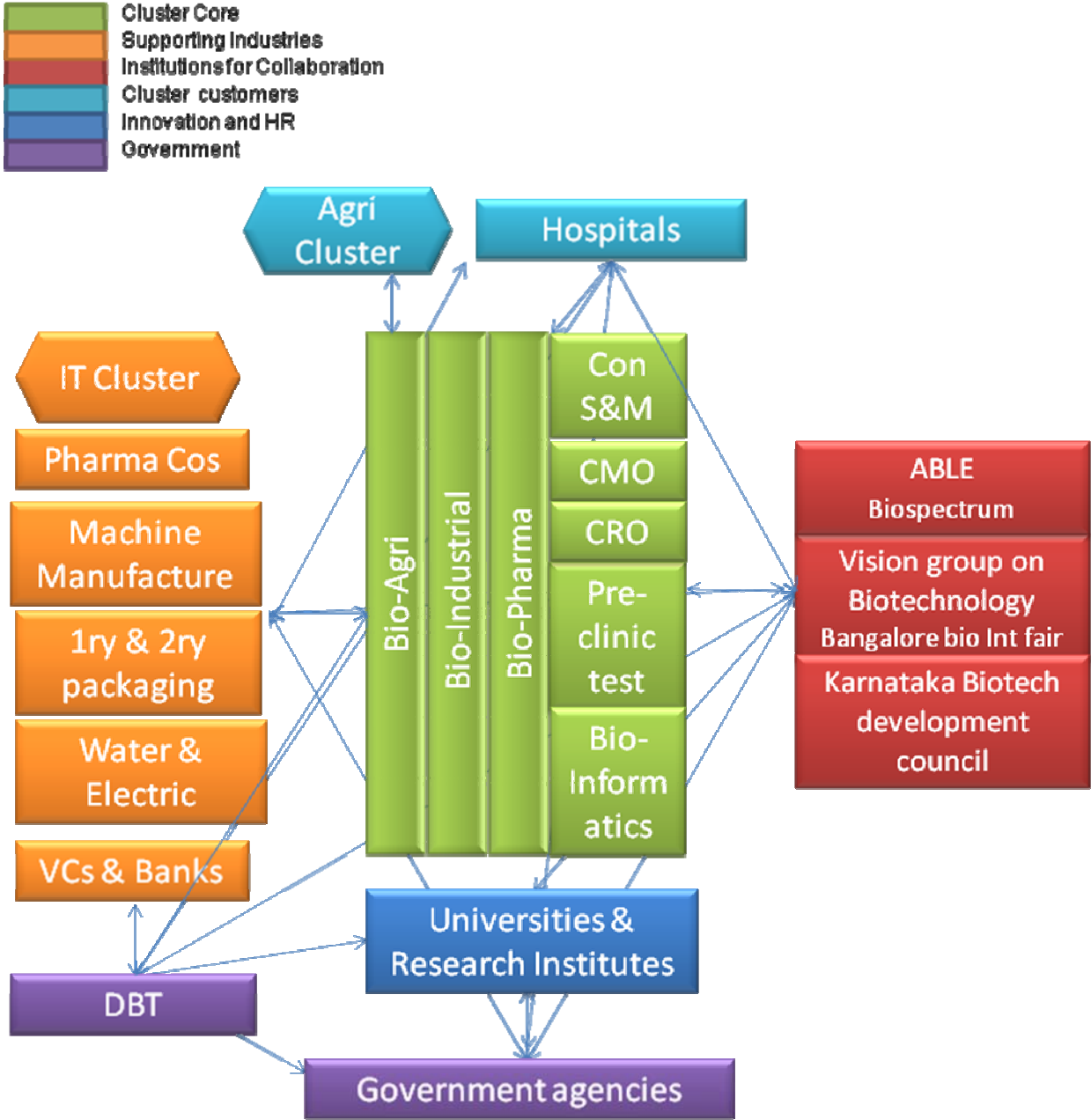
The biotechnology cluster in Bangalore is one of six biotech clusters or hubs in India, which include Bangalore, Hyderabad, Chennai, Pune-Mumbai, Delhi and Ahmedabad-Badodara (Biospectrum, 2007). While precise estimates of each cluster’s size are hard to find, revenue of major biotech firms in each cluster gives a rough sense of their relative size (see table below):

Cluster	Revenue (\$ millions)	Major Firms and Revenue (\$ millions, 2005, out of top 20 firms)
Bangalore	191.8	Biocon (145.8), Novo Nordisk (30.4), Novozymes (15.6)
Pune	169.8	Serum Institute of India (127.4), Venkateshwara Hatcheries (42.4)
Hyderabad	99.1	Mahyco Monsanto (37.5), Indian Immunologicals (16.3), Shantha Biotechnics (15.8), Bharat Immunological (12), Bharat Biotech (9.3), Biological E (8.2)
Mumbai	87.5	Aventis Pharma (19), Bharat Serums (18.3), Chiron Behring Vaccines (17.6), GlaxoSmithKline (17.5), Wockhardt (15.1)

Source: Enright, 2007

Bangalore is considered the India’s chief biotechnology hub, housing roughly 40% of India’s total firms and capabilities in enzymes, biopharma, bioinformatics, plant genetics and genomics, contract R&D, bioprocessing and bioinstrumentation (Enright, 2007).

Cluster Map



The figure above outlines the complex and interrelated activities of the cluster. At the center is the core of the cluster – the three integrated subgroups of Bio-Agri, Bio-Industrial and Bio-Pharma. Augmenting these core subgroups are the different segments of the value chain where Bio-services companies operate, from research and development through clinical trials testing

and marketing activities, which help move products to market; to the lower right is Bio-informatics which mainly caters to the R&D needs of the other subgroups. At bottom (in blue) are Universities and Research Institutions which provide inputs to the core. At top (in light blue) are customers of the core, including the agricultural sector and hospitals.

On the left hand side (in orange) are the supporting industries such as pharmaceutical companies, equipment manufacturers and packaging material manufacturers. Notably, the biotech cluster in Bangalore overlaps with two other prominent clusters – IT and Agriculture. On the right (in red) are Institutions for Collaboration (IFCs), which focus on cluster communication and collaboration. Examples include the Association of Biotechnology Led Enterprises (“ABLE”), which produces Biospectrum India, the main Indian biotech quarterly magazine featuring cluster surveys and interviews with important stakeholders; and the Vision Group on Biotechnology, which has organized the nation’s flagship annual biotechnology exhibition, Bangalore-Bio International Fair (“Bangalore-Bio”), since 2001. Lastly, all parts of the cluster are influenced by various government agencies on the state and national levels, including the Department of Biotechnology (“DBT”).

Why India? Why Bangalore?

"With all the opportunities prevalent in India, there can be no doubt that India is positioned to become a global player in the biotech Industry by the year 2010. India has built a strong market with the growth of biopharmaceutical companies, CROs and biogenerics."

-- Gregory Summe, chairman and CEO, PerkinElmer².

The competitive strengths of India play well into supporting a biotechnology cluster. India’s huge population is advantageous both as a base of consumers of biotechnology products and as a source hub for clinical trials testing. The sophistication of the services sector in Karnataka,

² Global Biotech industry is on mission transformation (2008) biospectrumindia.ciol.com

namely the financial markets and IT industry, is high, which lends strength to the cluster in Bangalore because of the close interaction (see the cluster map). Due to the high R&D and capital demands of most biotech companies, India's high ratings on access to credit and investor protection are key strengths. India's competitive weaknesses, particularly its rigid labor market regulations, have less impact on the biotech sector because firms tend to rely on small, highly skilled workforces. While contract enforcement, property registration and dealing with licenses are three intertwined country-wide weaknesses which are especially detrimental to the biotech cluster, Karnataka's relative strength in these areas lends to Bangalore being a natural hub.

Global Value Chain

Outside of the US, several countries have developed a significant biotech presence within their national economies. Countries such as the United Kingdom, France and Sweden have focused initiatives in place along with strong government financial support and rich research traditions. While these countries have historically occupied the leading positions in international biotech, countries such as Brazil, India and China have made surprising moves ahead in the value chain, moving from their traditional position of generics manufacturers to playing significant roles in mapping and publishing draft sequences genome (R&D intensive).

Regionally, Singapore has made headlines due to the billions of dollars its government has offered to MNCs and entrepreneurs willing to enter and build its domestic infrastructure to position the country as the Asia-Pacific biotech hub.

Many biotechnology activities going on today are related to genomics, proteomics and gene therapy, particularly directed at higher-efficacy therapeutics for the developed world. However, emerging economy biotechnology has started to focus on "third world diseases" and also the growing intersection of agricultural biotechnology, as food supply and prices become critical

issues for emerging economies. This offers a tremendous opportunity for new entrants such as India to gain a foothold in as-yet-untackled problems that may have biotech solutions.

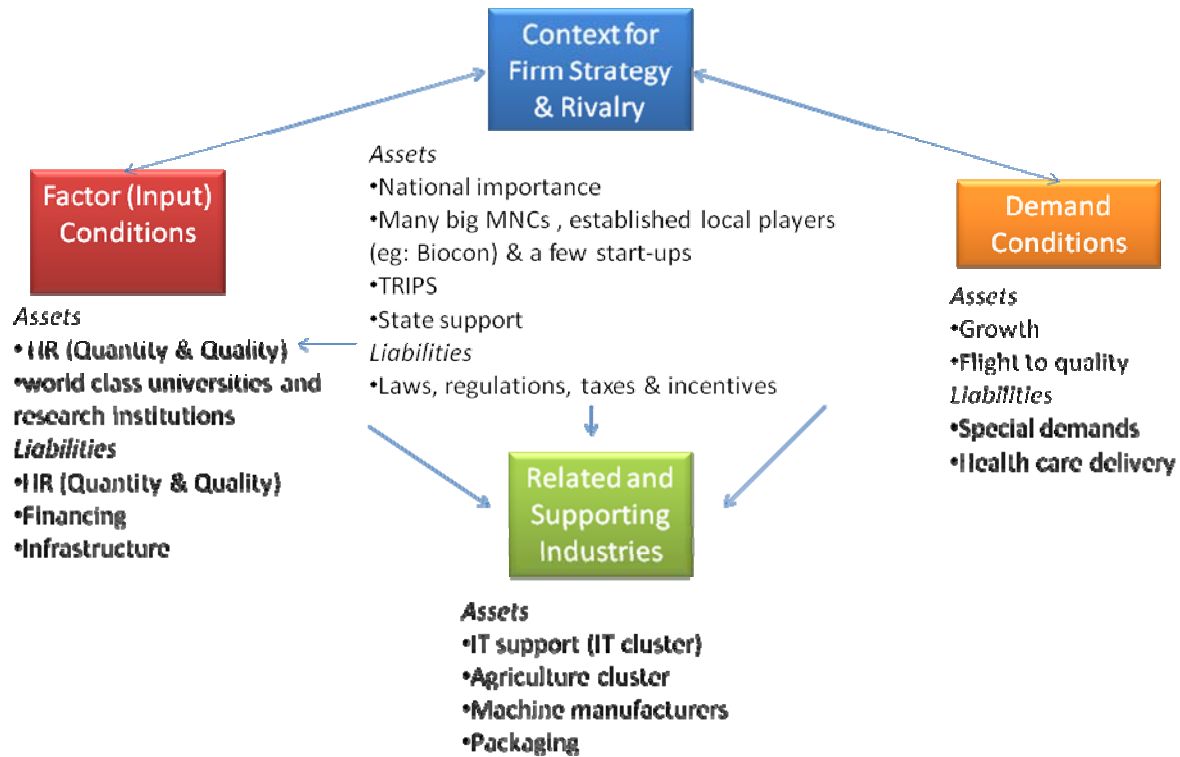
Cluster Performance

In 2006-2007 India's biotech industry crossed the \$2 billion revenue mark, inline with growth to meet 2010 projections of \$5 billion. The industry registered an impressive 30.98% annual revenue growth rate, with exports increasing to 58% of the total sector revenues (Biospectrum, 2007). It is estimated that the cluster will comprise over 400 companies by 2010, of which nearly 10-15 companies will be public, with about 100 biotech (domestic and imported) products in the market and have 50,000 scientists working in the industry (Biospectrum, 2008).

The cluster has been very successful in fostering partnerships between local firms and MNCs. Prominent deals with the cluster's largest firms include Advinus' \$150 million research partnership with Merck and Biocon's co-development of intranasal insulin with Bentley Pharma, USA. Smaller firms in the cluster are also beginning to participate in transnational partnerships, as evidenced by Strand Genomics' alliance with MediBIC to develop biotechnology information solutions, and Avesthagen's alliance with BioMerieux to develop diagnostic instrumentation.

International partnership has also extended to the research and development segment of the value chain. One such example includes the attraction of NIH funding by the Institute of Bioinformatics (IOB) in Bangalore in 2002, which led to cutting edge research in annotation of the X chromosome and publishing in the world's major journals ahead of leading research institutions such as the UK's Wellcome Sanger Institute (Jayaraman, 2005).

The Cluster Diamond



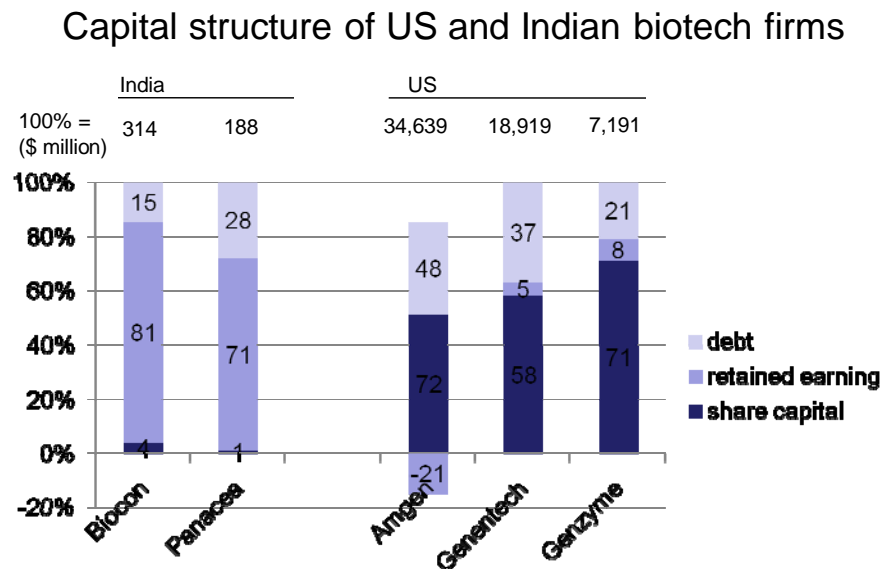
Factor conditions

Three factors stand out for the biotech industry:

- **Human resources:** the quality and affordability of English-speaking scientists the state is one of the original drivers behind the growth of investments in Biotech of Karnataka. For instance, 15 out of the 30 universities offering degrees in biotech in India are based in Bangalore. But, as biotech investments increased and companies started growing at a remarkable rate talent is becoming limited. India as a whole produces around 1500 PhDs the demand is estimated at 5000 PhDs³ . Programs to reach out to Non resident Indians NRI around the world to entice them to return to India although without much success.
- **Capital availability:** biotech requires high initial investments and has a high risk of failure. In Bangalore, many world class VCs exit since 2001 like: Carlyle Fund, AIG capital,

³ Anu Jayasree (2008), HBS India Conference, Health Care Panel Presentation

Citibank PE, ICICI ventures and Warburg Pincus, but they focus exclusively on the IT cluster. From interviews with industry participants it appears that biotech VC investing is in its infancy and most investments are in later stage and thus less risky companies. The graph below shows how the comparison of capital structure of major publicly traded biotech firms in the US and India illustrates lack of access to equity investment facing Indian firms. A risky industry like biotech is typically not highly leveraged in both countries, but in India share capital is significantly low.



Source: Authors' calculations based on annual reports

Smaller and private firms face similar challenge. The government had announced in 2001 that it would encourage the formation of specialized biotech VC funds with private participation. This has not happened until this day (Karnataka Biotechnology, 2008). On the grants side, the Department of Biotechnology (DBT) currently gives out grants of \$115,000 to start-up companies based proof of concept research as well as it gives out low interest loans for product development and commercialization (Jayaraman, 2005).

- **Physical infrastructure:** The state of Karnataka and Bangalore suffer from major deficiency in the road infrastructure. One of the greatest challenges facing employees nowadays is getting to work and back. This is an issue that needs attention especially if companies need to attract talent back from around the world”⁴ Another important infrastructure improvement urgently needed by Bangalore is the opening of the second airport announced in the Millenium policy and still not completed.

Demand conditions

Three points stand out regarding demand conditions:

- **Weakness of domestic health delivery infrastructure:** healthcare delivery is currently only available to 20% of the population. The country has only 1.5 beds per 1,000 people, while other developing countries such as Brazil, China, South Africa, and Thailand have 3-4 beds per 1,000(McKinsey, 2008). Similarly it has 0.6 Doctors and 0.08 nurses per 1,000 people, compared to respective world averages of 1.2 and 2.6. 80% of the healthcare expenses are funded out of the pocket by individuals, and a mere 1-2% is covered by private insurance, which is predominantly employer-funded.
- **High growth:** the pharmaceutical market is expected to triple to US \$ 20 billion by year 2015 and thus move to be one of the world’s top 10 pharmaceutical markets (McKinsey, 2007). With absolute growth of US \$ 14 billion will only be second to the growth of the US and China.
- **Poor country diseases:** India suffers from many diseases such as Tuberculosis and Malaria which do not receive much international R&D funding, because they do not affect rich countries. While in the short run this means that it cannot compete with rich countries for the

⁴ Rashmi, HBS Health Care Conference, India Panel Presentation

testing of treatments for these diseases, in the medium run, it might be an opportunity to host leading institutions and companies interested in these diseases.

Context for Firm Strategy and rivalry

Patent law: Development of generic drug manufacturers has set the important ground for development of healthcare biotechnology cluster in India. The development can be attributed to a series of transition of IP protection regime. The Indian Patent Act in 1970 had radically loosened patent protection, shortening patent life from 16 years to 3 years, protecting only processes but not product, and obliging compulsory licensing to any third parties (Huang, 2002). The change was largely motivated by economic nationalism, and stimulated domestic pharmaceutical firms such as Cipla, Ranbaxy and Dr. Reddy to build reverse engineering capability and process efficiency, and to produce cheap generic drugs for both domestic and export market. The domestic share of MNCs dropped from 80-90% in 1970 to 39% in 1993, while Cipla, second largest domestic drug company, manufactured and sold more than 400 of the top 500 branded drugs in the world for 3%-15% of the US price. In 1995, Uruguay Round of GATT concluded with creation of WTO and introduction of a set of new international trade regimes including Agreement for Trade Related Aspects of Intellectual Property Rights (TRIPS), which would be enacted in 2005 in India and require domestic IP protection regime comply with the international standard much more strict than 1970 Act. Many of the domestic pharmaceutical companies, having expanded manufacturing capacity and improved profitability, turned to R&D and were encouraged to expand from generic to branded drugs. Pharmaceutical industry's R&D spending has shot up from Rs2 billion (\$46 million) in 2000 to Rs8 billion (\$184 million) in 2004 (Jayaraman, 2005). The change in IP protection regime encouraged MNCs, who had suffered domestic copycat drugs, re-enter Indian market and establish R&D facilities.

Government policies: India's sixth Five Year Plan (1980-1985) identified biotechnology as a means to address the developmental needs of its agricultural and health sectors (Kumar et al, 2004). Organized efforts to develop a biotechnology capability in India can be traced back to the setting up of the National Biotechnology Board (NBTB) in 1982. After capacity-building projects during the period of 1982-86 conducted by NBTB, the government set up a separate Department of Biotechnology (DBT) under the Ministry of Science & Technology in 1986, promoting research in biotechnology sector through research grants, supported teaching programs in selected universities and institutes, and helped form new institutions (Krishnan et al, 2003). The government also established the Biotechnology Consortium of India Ltd. (BCIL) in 1990 to facilitate industrial projects based on new applications of biotechnology, guide start-ups, and facilitate finance and technology transfers. On the level of the state of Karnataka, a vision group was formed that drafted the Millennium policy in April 2001. The vision group included leading members of the private sector, local research institutions, local as well as other governments. This policy set in 2001 aimed to encourage the growth of the Biotech cluster in Bangalore. This policy highlights important pillars as; Biotechnology Industry partnership program, Biotechnology Industry research Assistance Council (BIRAC) for funding innovation, exploring shared facilities, Public-private partnerships and nurturing human capital.

Related and supporting industries

Universities and research institution: Karnataka is home to many world class universities. The state also has many leading research institutions, including the Indian Institute for Science, which is the leading biotech institution in terms of publications (Business World, 2003), the National Center for Biological Science, which focuses on R&D in biochemistry, bio-physics,

bio-informatics, neurobiology, cellular organization, and signaling and genetics and the Jawaharlal Nehru Center for Advanced Scientific Research, which focuses on human genomics.

Government agencies: India has created many government agencies relevant to biotech, such as the Indian Council of Medical Research (ICMR), which formulates and coordinates biomedical research to deal with national health priorities, the Council of Scientific & Industrial Research (CSIR), provides industrial competitiveness, subsidies for fundamental research, and oversees research projects in health biotechnology as one of the strategic sectors.

Suppliers: Major biosuppliers from around the world such as Bio-Rad, GE Healthcare, Invitrogen, Millipore, Pall, Perkin Elmer, Shimadzu, Thermo Electron, and Waters Corporation have strengthened their presence in India to take advantage of the growing market and inexpensive labor. Biosuppliers' revenues have increased five-fold between 2002 and 2007⁵.

Barriers to Biotech Development

A comprehensive analysis of the cluster indicates four distinct categories of barriers that are impeding development of the cluster. These fall broadly into the areas of human capital, funding and finance, legal and regulatory, and collaboration. Analysis indicates that while most of these areas are pure weaknesses, the cluster maintains strengths in some of these areas but could benefit from improvement.

Human Capital

The three primary barriers in human capital are:

- Scarcity of qualified personnel and dissatisfaction with those out there
- Shortage of advanced training programs
- Little entrepreneurial ambition among Indian biotech academics

⁵ Global Biotech industry is on mission transformation (2008) biospectrumindia.ciol.com

As previously detailed, there is a shortage both of qualified graduates and technicians. This shortfall is exacerbated by the fact that there is high variability in the skill level of employees with the same education or tenure. The shortage of advanced training programs is also affected by the lack of standards in higher education and the government's monopoly on granting of degrees. Complicating matters is the fact that Indian academics that may be perfectly situated to commercialize research are not trained in business and have little awareness of either the upside or what it would take to start companies.

Funding and Finance

The key barriers to the development of the biotech cluster that relate to funding and finance are:

- Competition within India between biotech and other sectors
- Lack of specialized VC firms
- Funding limited to late stage
- Lack of FDI foreign firm partnerships

The most critical issue at play is that India's biotechnology industry appears too risky to most investors when risk-reward profiles of so many other asset classes are dominant. This has led to a lack of investment from financial players and a limitation of investment to the later stage.

Legal and Regulatory

The key legal and regulatory barriers to the development of the biotech cluster are:

- Poorly coordinated regulatory agencies
- Slow, confusing federal and state approval
- Lack of expertise among state and federal officials in dealing with biotech products

The overarching theme of legal and regulatory barriers is one of lethargy and poor coordination. It is difficult for businesses to gain proper licenses, and professional civil servants are not properly trained to understand the nuances of regulation of biology-based companies.

Coordination

Academia, startups and established firms are not engaged in regular and productive interaction across the entire frontier of possibilities, whether from commercializing innovations, training workers for industry positions or meeting the market demand for graduates.

Policy Recommendations

A host of policy recommendations could be targeted at these four areas of barriers in order to improve the cluster's competitiveness. Overarching themes include deregulation of the industry to remove barriers to doing business, and harmonization of standards in education and training so that human capital issues are solved.

Human Capital

There are a variety of actions that cluster players should take regarding human capital. Institutes for collaboration, such as the Karnataka Biotech Development Council, must perform up-to-date studies on demand for biotech professionals across public and private sectors. Further, such IFCs could focus efforts on marketing the prestige and salary of biotechnology careers to high school students, so that these students are aware of opportunities and making informed choices when college selection occurs. Focusing on scientists, IFCs could create programs to educate scientists, academics and technicians about the process of commercialization so that they are trained to recognize opportunities for cluster development.

Universities must focus on the creation of advanced training programs by working with biotech companies to create tailored education programs to meet specific corporate skill needs, and expanding education capacity to supply the volume of graduates needed.

The national government should create sets of standardized tests (comprehensive national exams) for bachelors and post-graduate education in biotechnology to ensure minimum standards.

The state government should create housing for professionals near biotech parks in order to combat difficulties caused by poor infrastructure, which hurt Bangalore compared other cities.

Lastly, the state government and IFCs should focus on programs to recruit talent by starting a Young Entrepreneurs Initiative of India (“YEII”) to attract scientists with entrepreneurial skills to the state with prize money and tax breaks for entrepreneurship. Further, the federal government should recruit non-resident Indian (“NRI”) scientists, who may have exposure to more entrepreneurial environments, with funding and tax breaks.

Funding and Finance

The national government should focus on several areas to improve the ability of various capital sources to fund development of the cluster. A good start would be to improve funding for the Department of Biotechnology to allow it to take on some of the promotion activities advocated earlier. Further, the national government should offer improved fiscal incentives such as relaxed price controls for drugs, accelerated capital depreciation schedules and tax holidays for research and development spending while attracting overseas companies by removing all hurdles in contract research and collaboration and allowing 100% FDI in the sector.

The state government should speed up the formation of incubators in order to leverage VC investment and concentrate good investment prospects so that they can avail themselves of shared resources, collaboration and services in order to lower startup costs.

Finally, institutions for collaboration should market Bangalore's biotech industry to VC firms investing in biotech in other countries in order to get them to open local offices, and create collaboration events at the cluster's annual biotech conference (BangaloreBio) to educate startups and VCs about finding funding.

Legal and Regulatory

Because all legal and regulatory authority rests in the hands of the federal government, it has a particularly large role in implementing policy reform that would spur entrepreneurship and competitiveness. The most important recommendation would be to pass a Bayh-Dole-type act so that the fruit of public research can be commercialized by the private sector. Further, the government should simplify regulatory and procedural formalities by replacing the multiple agencies with a single National Biotechnology Regulatory Authority, removing federal and state customs duties on inputs of R&D, and clearing national guidelines for product characterization.

Coordination

Institutions for collaboration play a critical role in improving coordination in the cluster. Existing IFCs such as the Karnataka Biotechnology Council should use publications such as BioSpectrum to analyze and showcase success stories of entrepreneurship and commercialization, create collaboration events at the annual biotechnology conference (BangaloreBio) and promote incentives for construction of biotechnology parks through BOT concessions.

Universities should work closely with biotech companies to create tailored advanced education programs to assist academics with entrepreneurial ventures and create year-long sabbatical programs for entrepreneurial faculty that would allow them to move more easily between the academic and professional worlds.

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