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Strategic Approach to Strengthening the International Competitiveness in Knowledge-based Industries: Indian Chemical Industry

Vijay Kumar Kaul*

Abstract: Indian chemical industry, traditionally insulated from rest of the world, of late has been exposed to global competition. The paper examines its coping strategies and sectoral innovation system: industry's evolution, major characteristics, policy and institutional framework, and its competitive edge in the global chemical industry. It prescribes some policy guidelines both for the business enterprises and the policy makers. Enterprises need to develop a strategic intent, choose a right business model to operate, develop technological competence to innovate, and focus on economies of scale, quality and environmental norms. Further, it emphasizes the need for strengthening chemical innovation system, availability of institutional finance for modernization, exports and investment, rationalization of the tariffs on import of strategic inputs, and promoting knowledge and chemical parks

1. Introduction

Chemical industry is a knowledge-intensive and high-tech industry. The performance of this industry and enterprises depends on continuous improvement and innovation. The industry is presently undergoing a process of restructuring and consolidation. In the developed countries, the demand for chemical products has stagnated[1] as the share of manufacturing sector—the main user of chemical industry—is declining in the overall GDP of these countries. Asia Pacific, on the other hand, is emerging as a major market for chemical products. New

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capacities have also been built up in the countries like China and East Asia, during the last decade. This has increased the competition in the basic commodities chemicals. All this has forced the leading enterprises in the chemical industry to focus more on high value added and specialty products. They are also increasing their investment in emerging markets like China and India.

The chemical industry in India has grown in a big way during the last 50 years. It has a presence in all the stages of 'chemical industry value chain'. Government policy favoring import substitutions, creating institutional infrastructure and using tariff walls to protect the industry has played an important role in the development of the industry. The change in the government policy since 1991 has brought in a new dimension of international competition. The tariff rates have been reduced. Industry is now facing global competition in many products of chemical industry. Accelerating the process of globalization and liberalization, India has also proposed to have Free Trade Agreements with ASEAN countries. This raises a question: Is Indian Chemical industry in a position to face the challenges of globalization? Is it internationally competitive? The present study aims at examining this issue. To be specific, it focuses on the following research questions: What is the status of chemical industry in the Indian economy? How has it grown and evolved over time? What has been the role of government policy and institutional mechanism to support the industry? What is the status of Indian chemical industry in the global industry? How has the Indian chemical industry performed? What need to be done to improve its international competitiveness?

There are three broad segments of the chemical industry, basic commodity chemicals, specialty chemicals and knowledge chemicals. The basic commodity chemical segment is high volume, low value-added and limited product differentiation segment where cost competitiveness is critical. India has developed its capability to produce several basic chemicals in a cost effective manner. The knowledge chemical segment consisting of agrochemicals, pharmaceuticals and biotech demand high investment in R&D. Using its intellectual brainpower India has developed an expertise in producing generic drugs and has been able to increase its exports in highly competitive market. The specialty chemicals are characterized with high product differentiation and value addition. Investments in R&D and market responsiveness are the key issues in this category of products. The present paper focuses on the specialty chemical segment of the Indian industry and its potential to be internationally competitive.

The study has been grouped as follows. The following section explores the linkages between innovation, institutions and knowledge industry. Section three presents the main characteristics of global chemical industry, its size, and success factors. Section four looks into the Indian chemical industry, its' evolution, major characteristics, policy and institutional framework, and its status in the global chemical industry. Section five to seven focus on Indian specialty chemical industry using quantitative data and case studies. Section eight examines the innovation system in Indian chemical industry and its dynamics. Last section makes some concluding observations, and offers recommendations for business enterprises and the policy makers.

2. Innovation, Institutions and International Competitiveness

Gaining and sustaining competitive advantages in a science-based and knowledge-intensive industry like chemicals means that enterprises need to focus on dynamic improvements and innovation. Innovation is fundamentally a learning process. Such learning- by 'doing', by 'using', by observing from, and sharing with, others- depends upon the accumulation and development of relevant knowledge of very wide variety. It is the organizational learning that expands the firm's knowledge base, its range of potential behaviors, and its capacity for adaptation (Argyris and Schon, 1978; Daft and Weick, 1984). The basic assumption is that long-term industrial competitiveness is related to the ability of enterprises to upgrade their knowledge base and performance continuously. Enterprises that adjust and innovate survive and thrive. These enterprises are globally oriented, highly productive, and invest heavily in knowledge and skills. While innovation—finding better ways to do things—has always been the predominant factor in sustaining productivity and long-term economic growth, in the high-tech sectors the effective management of knowledge to create new products and processes is a decisive determinant of success.

The recent literature on innovation systems (Nelson, R.R.,1993; Lundvall, B.A,1992) stress the fact that national specificity's of patterns of interaction between users and producers of innovations are at the very core of what defines a national innovations systems (Freeman, C. ,1991; Freeman, C., 1995; Lundvall, 1992, ; Nelson, 1993, Edquist, C., 1997). Being important constitutive elements of national systems of innovation, these patterns of interaction are regulated by institutions in terms of rules, norms and habits. The various authors share the view that nation-specific factors play a crucial role in shaping technological change and innovation. There is enough evidence that shows a variation in country- or region-specific trajectories of innovation. The policies and institutions a country uses for managing innovation are referred to as its "national innovation system" or its "national system of economic learning"(Kim 1997, Mathews and Cho 2000). The national innovation system is defined as the network of public and private institutions that funds and performs research and development (R&D) and disseminates and commercializes the results. The national system of economic learning, as it is applicable in case of East Asian countries can be understood as the institutional framework used to support R&D led and market-mediated efforts to absorb, diffuse, and disseminate, and ultimately improve new technology.

More recently, there has been a growing interest in innovation systems at the regional level. At this level clustering of innovative firms, their emergence and promotion are becoming focus of study. Since Alfred Marshall, there has been a general interest in the clustering of industries in specific geographic location. Recently, various economic geographers such as Walker(1985) and Storper and Walker(1989), evolutionary and path-dependence economist such as Arthur(1994), and business strategists such as Porter(1990) have developed explanations for this economic clustering. All agree industrial growth in globally competitive regions is driven by economic benefits accruing from proximity(Kenney, Martin and Urs von Burg, 1999). Proximity plays a fundamental role in the process of innovation and learning, since innovations are in most cases less the product of individual firms than of the assembled resources, knowledge and other inputs and capabilities that are localized in specific places. This proximity is particularly of great significance in relation to high-tech sectors where a pre-condition for the success is the ability to share and utilise diverse knowledge.

Innovation system can also be defined and studied at sectoral level. Sectoral system of innovation and production is a set of new and established products for specific uses and the set of agents carrying out market and non-market interactions for the creation, production and sale of those products. Sectoral systems have a knowledge based technologies, inputs and demand. The agents are individuals and organisations at various levels of aggregation, with specific learning processes, competencies, organizational structure, beliefs, objectives and behaviours. They interact through processes of communication, exchange, co-operation, competition and command, and their interaction are shaped by institutions. A sectoral system undergoes processes of change and transformation through the co-evolution of its various elements. The main advantages of a

sectoral system view can be identified in a better understanding of: the structure and boundaries of a sector; the agents and their interactions; the learning, innovation and production processes; the transformation of sectors and the factors at the bases of differential performance of firms and countries in a sector. The main building blocks of a sectoral system of innovation and production are the following: knowledge base and learning processes; basic technologies, inputs and demand, with key links and dynamic complementarities; type and structure of interactions among firms and non-firms organisations; institutions; processes of generation of variety and of selection (Malerba2002).

To sum up, in case of high-tech knowledge intensive sector, innovation is key to competitive success, knowledge is a key assets and learning is a key process. As innovation is interactive, non-linear activity, it needs to be studied as a system. Innovation system can be defined at the national, regional, technological or sectoral level. For developing countries, that lack the required capabilities, structures and institutions, the system of innovation at national, regional and sectoral level is different from that of the system of innovation in developed countries. These countries cannot compete by creating new products, processes and services that are the main drivers of competitiveness for advanced countries. Enterprises in developing countries compete by using imported technologies together with lower labour and other costs—and, where relevant, natural resources. Using new technologies efficiently, however, requires considerable technological and managerial effort. Mastering technologies to competitive standards requires new skills, technical information, organizational techniques and marketing and supply chain methods. The hardware of new technologies, along with blueprints and instructions, can be imported. But its efficient deployment necessarily involves local learning. This process is continuous, because technologies change constantly. Industrial development also entails a constant shift from simple to complex technologies. This means moving both across industries (from low- to medium- and high-tech) and within industries (from low to high value-added activities). This process, often requiring costly and risky learning, is in many ways similar to real innovation in industrialized countries. The content, risk, cost and duration of the effort vary—by technology, industry, actor and context. Becoming competitive requires widespread technological effort, which is a constant process of innovation and learning. The efficiency of this innovation and learning determines the success or failure of industrial development (UNIDO, 2002). In case of high-tech industries, like chemicals, it becomes critical.

3. Chemical Industry: Global Scenario

The global chemical industry is valued at 1.7 trillion US Dollars in 2001. The total world trade in chemicals is valued at US$ 595 billion. The industry supplies to virtually all sectors of the economy and produces more than 80000 products. In terms of consumption, the chemical industry is its own largest customer and accounts for approximately 33 per cent of the consumption. In most cases, basic chemicals undergo several processing stages to be converted into downstream chemicals. The growth in the revenues within the chemical industry depends largely on overall growth of the economy and industrial production, and is often measured as a multiple of GDP growth[2]. The strategies and the innovative decisions of chemical firms are dependent upon the characteristics of the branch of the industry in which they operate.

Chemical industry is different from other industries in several respects. It is a large and heterogeneous industry consisting of several segments. Each of them has specific features, faces different problems, is based upon specific knowledge and technological base, and requires companies operating within to adopt different behaviours and strategies (Cook and Sharp, 1992). The industry also has a long tradition of innovation and R&D activity. As health and environmental issues are becoming highly sensitive, it has increased the government involvement in the industry. Another feature of chemical industry is pervasiveness and economic centrality. More than 50% of chemical products are intermediate goods used by a wide range of industrial sectors.[3] The industry is also characterized with oligopolistic structure of the market. It has long tradition of cartels and collusive action by firms.[4] The industry is global by nature both in terms of trade and in terms of production. For many years the industry has shown considerable flows on international investments, and systematic flows of engineering and process licenses.[5]

There are three major product categories in chemical industry: basic commodity chemicals and intermediates, specialty chemicals, and formulated knowledge chemicals. Within these groups a large number of sub-segments exist, which sometimes overlap.[6] The market share of basic chemical segment to the total global chemical industry is approximately 47 per cent. It is a mature segment with lowest profitability[7]. The Specialty chemical segment is characterized with high product differentiation and value addition. It has typically smaller production units with more flexibility and requires low capital investment levels[8]. The market share of this segment is 25 per cent. The Knowledge chemical segment is characterized with differentiated chemical

and biological substances used to induce specific outcomes in human, animals, plants, and other life forms. It requires high investments in R&D and marketing. The market share of this segment is 28 per cent (KPMG, 2002).

Europe as a whole is the largest chemical- producing region of the world followed by Asia and North America. Since 2002, Europe is no longer the largest producer of chemicals in the world. The world chemical market is now dominated by Asia, which includes Japan (with a market share of 33%), ahead of Europe (with a market share of 32%) and the United States (with a 26% market share). In the last ten years, employment in the European chemical industry has decreased by 16% to 1.7 million, and by 40% in Central and Eastern Europe to 1 million. Asia-Pacific, and China in particular, is taking an increasing share of global chemicals production.

Globalization is a key force that is influencing the trend and shape of capital expenditures in the chemical industry. As consumer demand for low cost products is increasing, it has forced many companies to look offshore to lower production costs[9]. Moreover, the world over chemical industry is continued to be plagued by overcapacity, weak demand, and declining prices. It has resulted into a continuous process of restructuring and consolidation in the chemical industry. Many chemical multinational enterprises'(MNE) are expanding their presence in the developing regions of the world to take advantage of low-cost structures as well as growing demand for chemicals in these regions. China, with its low cost labor and rapidly improving manufacturing capability, has been a major beneficiary of the move offshore. It seems that India is also benefiting from the globalization of the chemical industry.

To get more insight into the structural changes taking place in chemical industry, let us look at the major exporter and importers of chemicals in the world and their share in the global trade. The share of European union in the world export of chemical has declined marginally from 58.4 % in the year 1980 to 55% in the year 2002. Their share in the import has also declined from 46.4% to 43.5%. Similarly, the share of US in the export has declined from 14.8% to 12.3. However, US has also emerged as a major importer of chemicals. Its share in the overall world import has increased from 6.2% to 13%. Another large economy of the world, Japan, has maintained its share in export over a period of time. Whereas its share in export was 4.7% and increased to 6 %, it further declined to 5% in the year 2002. There is a lot of restructuring going on in the Japanese chemical industry. Their share in the import has declined marginally (See Table 1).

Table 1: Leading exporters and importers of chemicals, 2002

Exporters	Value Billion dollars	Share in world Exports (Percentage)				Importers	Value (Billion dollars)	Share in world imports (Percentage)			
	2002	1980	1990	2000	2002		2002	1980	1990	2000	2002
European Union (15)	363.34	58.4	59.0	52.3	55.0	European Union (15)	295.64	46.4	50.6	41.7	43.5
United States	81.29	14.8	13.3	14.1	12.3	United States	88.33	6.2	7.7	12.5	13.0
Japan	33.25	4.7	5.3	6.0	5.0	China	39.04	2.0	2.2	5.0	5.7
Switzerland	29.70	4.0	4.7	3.8	4.5	Japan	25.50	4.1	5.0	4.3	3.8
China a	15.32	0.8	1.3	2.1	2.3	Canada	21.60	2.2	2.5	3.3	3.2
Canada	15.27	2.5	2.2	2.5	2.3	Switzerland	18.18	2.5	2.6	2.3	2.7
Korea, Republic of	12.62	0.5	0.8	2.4	1.9	Mexico	17.64	1.5	1.2	2.7	2.6
Singapore1	11.65	0.5	1.1	1.6	1.8	Korea, Republic of	14.89	1.3	2.4	2.2	2.2
Taipei, Chinese	10.09	0.4	0.9	1.6	1.5	Taipei, Chinese	13.43	1.3	2.3	2.6	2.0
Hong Kong, China2	9.64	-	-	-	-	Hong Kong, China2	12.02	-	-	-	-
Russian Federation	7.26	-	-	1.2	1.1	Brazil	10.10	2.4	1.1	1.7	1.5
Mexico	5.64	0.4	0.7	0.9	0.9	Poland	8.18	1.0	0.3	1.1	1.2
Saudi Arabia	5.28	0.1	0.8	0.7	0.8	Australia	7.90	1.2	1.2	1.3	1.2
India	4.78	0.3	0.4	0.8	0.8	Turkey	7.80	0.8	0.9	1.2	1.1
Malaysia	4.42	0.1	0.2	0.6	0.7	Singapore1	7.27	0.9	1.5	1.3	1.1
Above 15	600.59	87.3	91.2	90.8	91.0	Above 15	578.55	74.5	82.5	83.9	85.1

Note: 1 Singapore's export of $ 11.65 billion consists of $8.56 billion domestic exports and $3.09 billion as re-exports.Singapore's import of $ 7.27 billion consists of retained import of $4.18 billion.

2 Hong Kong, China's export of $ 9.64 billion consists of $0.68 billion domestic exports and $8.96 billion as re-exports. Hong Kong's China, imports of $12.02 billion consists of retained import of $3.05 billion.

East Asian countries like, China, Singapore, Taiwan and Hong Kong have emerged as significant players in the international chemical trade. China has increased its market share in the export of chemicals from 0.8% to 2.3% during the same period. Its share in the import has increased substantially over time from 2% to 5.7% in the year 2002. The total export of chemicals by china is to the extent of $15.32 billion and import is $39.04 billion. Singapore is exporting chemicals worth $11.65 billion and importing $7.27 billon. India is also ranking among the top 15 exporter countries. It exported chemicals worth $4.78 billion in the year 2002. Its share in the world chemical market has increased from 0.3% in the year 1980 to 0.8% in the year 2002.

Indian and Chinese companies are benefiting the most from the globalization of the chemical market. These countries are widely recognized as major cost-effective producers of bulk generic chemicals for worldwide distribution. This has motivated the MNE's to move and invest in these countries as they offer a competitive advantage to chemical makers in terms of lower costs of production and growing demand. It is a win-win situation for both MNEs and developing countries. Developing countries get the technology and investment, MNEs get the lower cost production base and market.

In case of chemical industry, particularly in developing countries, regions' performance and competitiveness is linked to the presence of large multinational companies owning knowledge, technology and global marketing networks. The investment by MNEs, in turn, is related to the presence of national or regional characteristics involving local demand, research capabilities, and scientific and technological knowledge base.[10] In this sense, national policies might play a partial role. If they are capable of providing education, training and an infrastructure supportive to science-based industries they will be capable of offering a critical contribution to this kind of competitiveness, because they will create the conditions by which MNEs might decide to locate some of their divisions. Regions that will be able to become centres of information, communication and knowledge application will attract more knowledge-intensive MNEs (Meyer-Krahmer, 1999).

Let us see to what extent Indian chemical industry fulfills these conditions to be competitive. How has it evolved? What are their technological capabilities? What role the Government policy has played? What is the nature of 'Innovation System in Chemical' industry?

4. Indian Chemical Industry

Indian chemical industry is one of the oldest domestic industries, contributing significantly to both the industrial and economic growth of the country. The size of the Indian chemical industry is US $ 30 billion approx, which is equivalent to about 7% of India's GDP. In terms of volume, it is 12th largest in the world, and 3rd largest in Asia. Within India, it constitutes about 20.3% of Fixed capital, 10.3 % Employees, 17.5% Gross Output, 23.2% Net value added of Indian Manufacturing sector, 20% of the Excise revenue to the Government of India. Chemical industry has weightage of about 13% in the index of industrial production. The share of India's chemical sector in the global chemical industry is just 2%. Around 45-50% of Indian chemical industry is concentrated in Western India.

Evolution of Chemical Industry

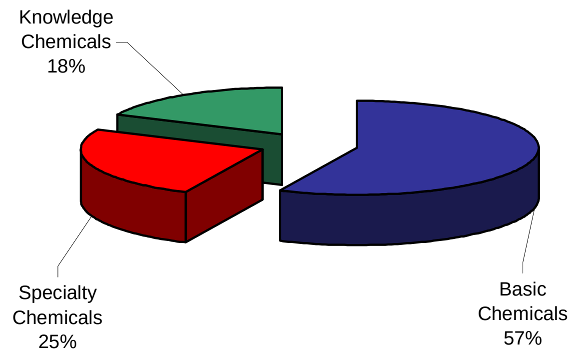
The chemical industry in India has evolved in a phased manner. While late 60s, 70s & 80s saw the rise of fertilizers, pharmaceuticals & petrochemicals; the organic chemical industry had been growing since early 60s. Subsequently, in the 70s to 90s, a group of dyes & dyestuff industry especially in the Small Scale sector and a group of specialty chemicals manufacturers emerged. The evolution of Indian chemical industry can be discussed in five phases. The *first phase, 1950 to 1972*, can be designated as basic need phase as chemical products that protects crops and improve health such as, agrochemicals, fertilizers and pharmaceuticals, were the focus of development. During the *second phase, 1972-1980*, public sector companies were established to develop a downstream petrochemical industry, the basic feedstock was imported and converted to petrochemical products. The *third phase starting from 1980 to 1992* was a period of consolidation. However, the paints, dyes, pharmaceuticals and detergents segments were growing. During the *fourth phase, liberalistion phase 1992-95*, major investment plans by both Indian players and MNEs were initiated, lowering of tariff barriers exposed domestic industry to competition from imports, the role of public sector companies was reduced. The major growth segment in this phase are petrochemicals, engineering plastics, and specialty fibres. Presently, it is an *expansion phase, 1995* onwards. Major investments have been made especially in the petrochemical segment, driven by the growth of end-use segments. Major focus of attention is on petrochemicals, specialty chemicals, fertilizers and pharmaceuticals (KPMG, 2002).

Structure of the Industry

The share of value of output for various sub-sectors of the Indian Chemical Industry is given in Figure 1A. In comparison to the global structure of the

industry, the share of basic chemicals is high and knowledge chemical segment is less in India (see Figure 1B). The share of specialty chemical segment in India is comparable to the global standard (KPMG, 2002). Table 2 presents the production of selected chemical and allied products over a period of time. It shows that India has increased its production based in all categories of production over time, namely, oil and petroleum products, basic chemicals, fertilizers, pesticides, drugs and pharmaceutical, and specialty chemicals. This completes the chemical value chain.

FigureIA: Indian Chemcial Industry-Structure



FigureIB: Global Chemcial Industry-Structure

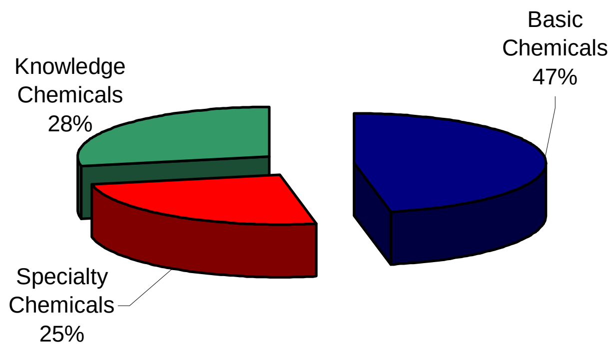


Table 2: Production of Selected Chemical and Allied Products

Products	Unit	1950-51	1960-61	1970-71	1980-81	1990-91	1999-00	2000-01	2001-02	2002-03
Basic Chemicals										
Nitrogenous fertilizer(N)	Thousand tonnes	9	99	830	2164	6993	10912	11025	10747	10559
Phosphatic fertilizer(P205)	Do	9	54	229	842	2052	3374	3745	3532	3885
Soda Ash	Do	46	147	449	563	1385	1515	1631	1560	1610
Caustic Soda	Do	12	99	371	578	992	1425	1642	1732	1539
Carbon Black	Do	-	-	-	-	-	240	256.8	275	295*
Calcium Carbide	Do	-	-	-	-	-		70.6	75	80.2*
Phenol	Do	-	-	-	-	-	66	71.3	75	80*
Methanol	Do	-	-	-	-	-	350	358.5	370	365*
Petroleum refinery products	Million tonnes	0.2	5.7	17.1	24.1	48.6	79.9	96.6	99.8	104.6
Knowledge Chemicals										
Penicillin	MMU	na	na	190	337	25	487	822	1204	1248
Vitamin A	MMU	na	na	38.5	59.9	220.5	64.3	77.4	46.4	76.3
Technical Pesticides		-	-	-	-	-	-	92.2	89.63	Na
Fine and Specialty Chemicals										
Dyestuffs		-	-	-	-	-	-	58.6	28.94	Na
Acetaldehyde		-	-	-	-	-	-	129.6	135	148*

Note: * Anticipated
Sources: Economic Survey; Annual Report of Ministry of Chemicals and Fertilizers.

Table 3 depicts the growth of chemical industry in comparison to other manufacturing industry. The table shows that the chemical industry recorded a highest growth rate during a period of 1981-1991. Again, during the last 10 years from 1993-94 to 2003-2004, it has doubled its production. However, in comparison to other industry it is ranking fourth in terms of growth

Indian Chemical Industry is highly fragmented consisting of more than 6000 firms, dispersed, multi product and multi faceted. The major proportion of chemicals produced in India comprises either upstream products or intermediates, which go into a variety of manufacturing applications including fertilizers, pharmaceuticals, textiles and plastics[11]. Till early 1990s, India was a net importer of Chemicals. Establishment of new plants has reduced imports in chemicals. Moreover, in certain sector like pharmaceuticals, pesticides and intermediate chemicals, India is exporting. India's chemical exports growth has been around 9%. For the year 2001-02, it formed around 16.20% of the total exports that is approximately US $ 4684 million.

The profitability measured in terms of Profit before depreciation, interest and taxes (PBDIT) over sales of different segments of chemical industry is given in figure 2A to 2C.

The figures show that the performance of the different sector over a period of 1995-96 to 2001-2002 varies. Different products in the basic chemicals show a declining trend in their profitability. The polymers, alkalis and fertilizers sectors were enjoying better PBDIT in the year 1995-96. Their performance has declined overtime. The decline in fertilizers is substantial. On the other hand, the profitability of specialty and knowledge segment is improving. The pharmaceuticals, soaps and detergents, and paints and dyes sectors have improved their performance overtime.

Government Policy and Institutional Infrastructure

The government of India's policy and creation of scientific and technological institutions have helped the chemical industry to grow to this level. As the chemical industry is a science based industry, it has been benefited by the overall science and technology policies and institutions created to achieve technological independence and the development of basic science, and creation of scientific and technical manpower. In addition, there have been some specific policies and institutions for the promotions of chemical industry.

Table 3 : Trend of Chemical and other major Industrial Production

	Weight 1980-81	1993-94	1981-82 (Base:1980-81=100)	1990-91	1993-94	1994-95 (Base:1993-94=100)	2000-01	2003-2004
General index	100	100	109.3	212.6	232.6	109.1	162.7	188.7
Manufacturing	77.11	79.36	107.9	207.8	223.5	109.1	167.9	196.3
Beverages, tobacco and products	1.57	2.38	104.3	104.8	137.8	103	200.4	314.7
Cotton textiles	12.31	5.52	99.7	126.6	160.5	99.1	127.3	117.2
Textile products and apparels	0.82	2.54	96.7	103.2	73.4	98.5	162.4	183.1
Basic chemicals and chemical products	4	14	116.9	254.1	297.9	105.3	176.6	207.5
Non electrical mach and machine tools	6.24	9.57	111.1	186.9	189.2	115.8	195.8	232
Transport equipment & Parts	6.39	3.98	108.1	192.5	211.5	112.9	190.3	272.4

Sources: Economic Survey, 2002-3, CSO, Economic and Political Weekly, June12, 2004

Figure 2A: Performance of Basic Chemicals Segments

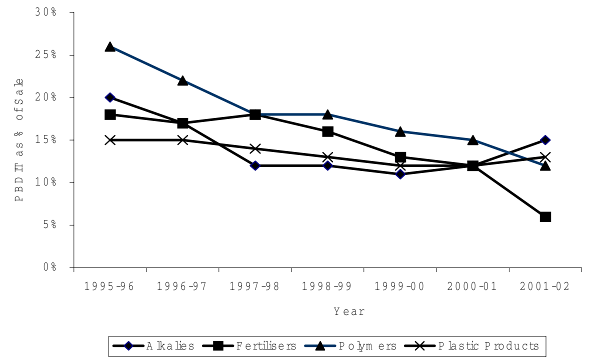


Figure 2B: Performance of Speciality Chemcials

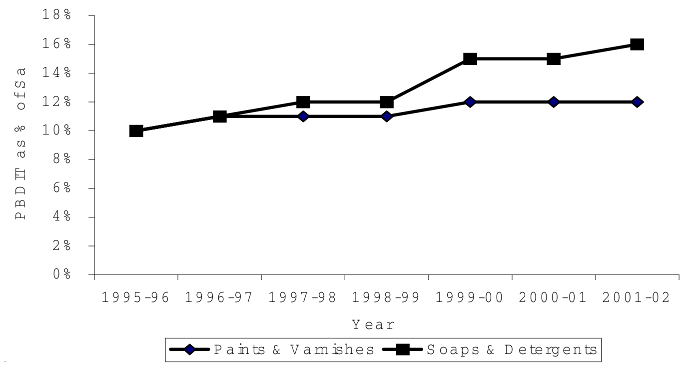
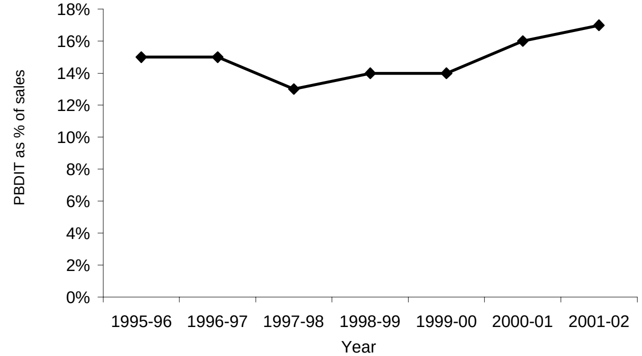


Figure 2A: Performance of Knowledge Chemicals-Drugs& Pharmaceuticals



The government of India formulated various policies-Science policy, 1958, Technology policy-1983, and the New Industrial Policy 1991, to achieve its objective of self-reliance and technological independence. It has formulated number of policies since independence to cope with science and technology development, promotion of trade etc. The focus has been on mega science projects. Some of the prominent policy initiatives that explicitly or implicitly helped the technological development are given in Box 1. India has also been establishing scientific and technological institutions. Some of the important institutions that India established to supervise and implement science and technology development and innovation are also given in the Box 1.

The overall process of industrialization in India in the first four decades after independence was governed by two considerations - import substitution and industrial licensing. The impact of the national policy on import substitution has an impact in all segments of the chemical industry. Domestic supply demand imbalances and availability of licenses drove the growth of the Indian chemical industry till the early nineties, as the industry was effectively insulated from the international markets due to artificial barriers - both tariff and non-tariff. The high tariff levels translated into comfortable profits in the domestic chemical industry and there was little incentive to achieve global cost competitiveness under these circumstances. The Indian chemical industry in the early nineties was characterized by small capacities and high cost structures.

In the first major announcement on Industrial Policy in 1948, the Government emphasized on increasing production along with measures to secure equitable distribution. The heavy chemicals, pharmaceuticals and drugs were identified as sectors, which would be the subject of Central regulation and control. At that time, industries like cotton and jute textiles, iron and steel, paper, sugar, cement, glass had established themselves, partly because of the fillip given by the scarcity conditions created during the Second World War. The chemical, dyestuff and drug industries were at a fledging level.

In the 1956 Industrial Policy Resolution, this sector was included in Schedule B which comprised of industries in which the State was to establish new undertakings, but where private enterprises was also given an opportunity to develop. During this crucial period, the role that science would play in the development of the country was recognized and several institutions were established. For Chemical industry the pioneering laboratory was the National

Box 1: Major Policies and Science & Technology Institutions

Major Policies	Institutions
1948, Industrial Policy Resolution	1909 Indian Institute of Science Banglore
1958 Scientific policy Resolution	1911 Indian Council of Medical Research
1968 Policy on Education	1929 Indian Council of Agricultural Research
1970 The Patent Act	1942 Council of Indian Scientific and Industrial Research
1983 Technology Policy Statement	1947 Indian Standards Institutions
1984 Telecommunication Report, Computer Policy	1951 Ministry of Scientific Research and Natural Resources
1986, National Education Report, R&D Cess Act	1953 University Grant Commission
1990 New Industrial Policy, Agricultural Policy	1954 Department of Atomic Energy
1999 New Patent Act	1958 Defence R&D Organization
2000 Biological Diversity Bil	1970 Department of Electronics
2001 The Protection of Plant Varieties and Farmers Rights Act	1971 Department of Science and Technology
2002 Science and Technology Policy	1972 Department of Space
	1984 Department of Scientific and Industrial Research
	1986 Department of Bio Technology
	1988 Department of Industrial Development
	2000 Ministry of Information Technology

Chemical Laboratory (NCL), Pune. NCL was set up with a goal: to establish in India a world class centre of excellence in fundamental research in chemical sciences, engineering and technology. Its widely acclaimed contributions include development of a large number of indigenous catalysts, new process technologies, commercialization of advanced material and synthesis of drugs. The work done by NCL scientists in the area of biotechnology and plant molecular biology is of far reaching significance. Over 600 scientists are working in NCL's 9 divisions.

Prior to NCL there was Regional Research Laboratory(RRL), Hyderabad(presently called the Indian Institute of Chemical Technology). Many RRL's were established subsequently which have proved to be of great significance to chemical industry in India: Indian Institute of Petroleum, Dehra Dun; Central Salt and Marine Chemicals Research Institute, Bhavnagar; Central Electrochemical Research Institute, Karaikudi and Central Leather Research Institute, Chennai. For drugs, the Central Drug Research Institute at Lucknow and Institute of Microbial Technology were established.

Central Institute of Plastics Engineering & Technology (CIPET) was established at Chennai in 1968 with the assistance of UNIDO to provide technical manpower and render technical services to plastic and allied industries. Institute of Pesticides Formulation Technology (IPFT) at Gurgaon was set up to promote advancement of pesticides formulation technology in India. National Institute of Pharmaceutical Education and Research (NIPER) has been conceived as a Centre of Excellence to meet the major gaps in the areas of pharmaceutical education, research and training, particularly, to cater to development of pharmacy colleges and their curriculum and train adequate number of research and development oriented scientists(See, important institutions in Table 4).

Setting up of engineering and technical institutions has helped increasing technical manpower to manage and operate chemical industry. Universities took lead and started courses in Chemical Engineering and Chemical Technology. Since this course were taught by University Departments, research became important as these departments were measured with the same rigour as other sciences and liberal arts. Thus the PhD programmes were introduced quite early. Jadhavpur University(earlier Called National College), Kolkata; Punjab University, Chandigarh; Andhara University, Vishakhapatnam; Banaras Hindu University(BHU), Varanasi; Calcutta University, Kolkata; Indian Institute of Science, Banaglore; University Department of Chemical Technology(UDCT) ,

Table: 4 Some of the Important Institutions for Chemical Industry

Name	Important Tasks
Indian Association for Cultivation of Science Jadavpur, Calcutta. Founded – 1876	India's oldest institution for basic research in physics and chemistry.
Central Electrochemical Research Institute (CECRI), Karaikudi	Conducts research in Electrochemicals, Electrometallurgy, Electrochemical Materials, Metal Finishing.
Central Salt & Marine Chemicals Research Institute (CSMCRI), Bhavnagar, Gujrat.	Conducts research in Catalysts, Chemicals, Desalination, Polymers (membranes & resins), Non-conventional energy, Economic Plants, Biosalinity.
Indian Institute of Chemical Technology (IICT) , Hyderabad .	Conducts research in Drugs and Pharmaceuticals, Natural Products, Chemicals, Chemical Engineering, coal, Oil & fats, Catalysts, polymers, Design engineering.
National Chemical Laboratories (NCL), Pune, Founded – 1950	Conducts research in catalysts, Polymers, Organic Chemistry, Biotechnology, materials.
Regional Research Laboratory – Jorhat (RRL-J)	Conducts research in Chemicals, Drugs &Pharmaceuticals, Medicinal & Aromatic Plants, etc.
The Mumbai University Institute of Chemical Technology— Founded – 1934.	Engaged in education, training and research in the field of Chemical Engineering, Chemical Technology and Pharmacy in India.
Indian Institute of Petroleum Founded –Dehradun, UP	To develop processes and products for petroleum refining and petrochemical industries, assist refineries in absorption, adoption and selection of technologies. To carry out R&D work on utilization of crude, its products, natural gas and petrochemicals. Etc.
Department of Chemical Engineering, Indian Institute of Technology, Chennai	Applied research as well as fundamental research.

Table 4 continued

Table 4 continued

Name	Important Tasks
Department of Chemical Engineering, Indian Institute of Technology, Kharagpur.Founded – 1951	Involved in activities in the field of Pollution Control, Transport Processes, Coal and Petroleum Technology, and Membrane Processes.
Department of Chemical Engineering, Anna University, Madras	Research and Teaching
Department of Chemical Engineering, Indian Institute of Technology, Bombay.Founded – 1958	Department focus on Chemical Engineering fundamentals in the general academic programme and in research
Department of Chemical Engineering, Indian Institute of Technology, Delhi.	Apart from academic research, Industry-oriented developmental projects are undertaken in the areas of Process Development, Design, Pollution control, Particle Technology, Biomass Utilization, etc.
Department of Chemical Engineering, Indian Institute of Technology Guwahati Founded – 2002	Research interests in the following broad areas of chemical engineering: combustion, heat transfer, slurry Rheology, advanced separation technology, modeling and simulation, environmental pollution control, interfacial engineering, nanofiltration etc.
Department of Chemical Engineering, Indian Institute of Technology Kanpur	Its expertise in chemical process engineering and simulation, optimization and control, polymer engineering and separation processes, interfacial phenomena and nano-systems. The faculty has undertaken several projects for chemical and processing industries
Department of Chemical Engineering, Indian Institute of Technology Roorkee Founded – 1963	Imparts research and training in two new areas of Industrial Pollution Abatement and Advanced Transfer Processes.

Mumbai took an early lead. Later AC college of Technology, Chenai; L.I.T. Nagpur; Annamalai University, Annamalai etc. came into existence. The UDCT was unique as it was planned by industrialist and philanthropists, with substantial financial support. A major event was the establishment in early 1950's of a series of Indian Institute of Technology(IIT). All these institutions opened chemical engineering courses and ushered in a major change, nationally and internationally.

With a special focus on modernization, the Indian government takes an active role in promoting and advancing the domestic chemical industry. The Department of Chemicals & Petro-Chemicals, which has been part of the Ministry of Chemicals and Fertilizers since 1991, is responsible for policy, planning, development, and regulation of the industry. In the private sector, numerous organizations, including the Indian Chemical Manufacturers Association, the Chemicals and Petrochemicals Manufacturers Association, and the Pesticides Manufacturers and Formulators Association of India, all work to promote the growth of the industry and the export of Indian chemicals. The Indian Chemical Manufacturers Association, for example, represents a large number of Indian companies that produce and export a number of chemicals that have legitimate commercial applications, but also can be used as precursors and intermediates for chemical weapons production.

India's Status in Global Chemical Trade

A look at the export and import of different chemical products from India shows that India has emerged as a competitive player in the some of the products of the chemical industry. Table 5 shows the trend of import and exports of chemical products in India from 1960 onward. The import has been growing overtime in case of petroleum oil and lubricants, dyeing, tanning and coloring materials, and medicinal and pharmaceutical product. In some other products such as, fertilizers, plastics materials, and chemical elements and compounds, a decline in import is noticed in recent years. At the same time there is a steady growth in the export of chemicals from US $15 million in the year 1960 to US $ 5880 million in the year 2002-03[12]. Table 6 gives a comparative picture of several segment of chemical industry. It shows that India is net importer in case of organic chemicals, inorganic chemicals, fertilizer, and soaps & detergents chemicals. Incase of other chemicals segments, India has emerged as a net exporter, that is, in pharmaceuticals, dyes and paints, starches, cosmetics and explosives. Even in the case of organic chemicals the gap between import and export is declining. In case of fertilizers the volume of import is declining.

Table: 5 Trend of Imports and Exports of Chemicals Products in India

(US $ Million)

	1960-61	1970-71	1980-81	1990-91	1995-96	2000-01	2001-02	2002-03
Imports								
Fertilizers & Fertilizers Manufacturing	27	113	1034	984	1683	664	621	542
Chemical elements and compounds	82	90	453	1276	281	338	444	452
Dyeing, tanning and colouring materials	2	12	26	94	152	191	238	277
Medicinal and Pharmaceutical products	21	32	107	261	406	377	425	592
Plastic materials, regenerated cellulose etc	19	11	154	610	803	558	674	782
Petroleum oils and lubricants	145	180	6656	6028	7526	15650	14000	17640
Exports								
Chemicals and allied products	15	39	284	1176	2945	5002	4684	5880

The trend of India's share in world exports in chemicals from 1970 to 1999 is given in Table 7. It clearly shows that India's share has been rising steadily in all the major products of chemicals. Whereas in case of Medicinal and pharmaceutical products, it's share has risen from 0.4% to 1%, in Dyeing, tanning and coloring materials, its share moved up from 0.5% to 1.2%. In case of essential oils and perfume materials, its share has declined. The data presented in Table 5 to 7 make it clear that India has increased its competitiveness in several products of the chemical industry. In some products, it has reduced imports and in others it has started exporting. Its share in the world export market is rising. How does India stand in comparison to other countries? To see a comparative picture of India's export performance in chemical industry with other countries, ranking evolved by the International Trade Centre (ITC), a Geneva based agency has been used. ITC arrives at trade performance index(TPI) numbers for various countries across 14 major sectors. The index numbers attempt to capture the export competitiveness of these sectors using different criteria. There are two types of index numbers computed by ITC—the current index of trade performance and the change index of trade performance. The first index measures the existing competitive position of a country in a particular sector. The second index looks at the changes in the competitive environment from a dynamic perspective over a period of five years. Table 6 & 7 gives the results of two indexes for chemical industry over a period of time.

Table 8 shows that in the year 2002 there have been all round improvement in the chemical industry's export performance. It's share in the national export has improved from 11% to 12% and its' share in the world market from 0.64% to 0.90%. In terms of product and market diversification also there is some improvement, though the product diversification level in the year 1998 is yet to be achieved. There has been significant improvement in its Trade Performance Index (TPI) Ranking in the chemical sector. The TPI rank was 42 in the year 1998, which has improved to 14 rank in the group of 123 countries.

Table 9 shows as to where India is lacking and where it has improved its competitiveness. It shows that India improved its market share during the period 1994-98, 1995-1999, and 1998-02. There has been decline in its market share in other two periods. The underlying drivers of this change show that in terms of Adaptation effect and Initial geographic specialization effect, the Indian chemical industry has been lacking. The negative adaptation effect shows that India's chemical exporters have not been able to adjust export supply to the changes in world demand. This shows that there could be a large number of

Table: 6 India's Trade in Chemicals

(in US $ Million)

Chemical Products		1996-97	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003
				Basic Chemicals				
Inorganic	**Export**	234.28	207.75	158.1	159.45	235.57	263.98	402.15
	Import	916.02	1,207.60	1,287.33	1,335.59	1,086.20	1,201.43	1152.8
Organic	**Export**	993.09	1,214.98	1,141.70	1,368.96	1,729.76	1,609.07	2,105.56
	Import	1,973.92	1,989.67	1,625.94	1,745.56	1,599.66	1,844.16	2,209.90
Plastics	**Export**	401.54	382.84	324.12	424.57	700.91	773.93	1002.08
	Import	834.68	744.49	731.59	790.02	657.42	781.27	906.58
Fertilizers	**Export**	23.71	6.93	6.85	2.56	9.17	16.45	3.52
	Import	685.74	844.37	811.63	1,079.42	444.89	455.66	358.72
				Specialty Chemicals				
Dyes etc.	**Export**	438.35	482.29	386.75	443.99	517.5	510.88	608.2
	Import	170.03	180.82	186.67	195.09	192.36	238.58	277.76
Cosmetics	**Export**	148.12	158.35	158.39	170.27	213.17	221.2	233.05
	Import	26.59	40.45	45.97	72.38	79.1	98.9	106.28
Soaps etc.	**Export**	34.83	31.03	25.52	31.85	35.93	56.47	65.2
	Import	64.5	77.14	80.52	95.57	103.09	96.17	99.91
Starches	**Export**	17.56	12.61	20.41	31.74	52.96	52.48	61.96
	Import	20.12	30.01	28.71	29.71	32.45	33.56	41.28
Explosives	**Export**	17.62	15.17	8.05	10.01	13.13	11.92	14.11
	Import	0.97	1.33	0.86	1.17	2.9	2.88	3.59
Photo. Etc.	**Export**	19.52	36.56	41.24	44.86	41.16	25.89	24.76
	Import	150.24	168.62	167.75	168.77	195.84	214.23	210.48
				Knowledge Chemicals				
Pharma	**Export**	672.01	780.5	729.77	855.92	945.11	1,055.76	1400.78
	Import	64.32	122.96	135.5	138.58	150.58	166.56	238.06

Source: Data from DGFT.

Table 7: Trend of India's Share in World Exports in Chemicals

	1970	1975	1980	1985	1990	1995	1999	2000	2001
				Basic Chemicals					
Organic Chemicals	0.1	0.1	0.1	0.1	0.3	0.7	0.9	1.1	1.1
Inorganic chemicals	-	-	0.2	0.1	0.2	0.3	0.4	0.3	0.3
Artificial resins, plastic materials etc.	-	-	0	0	0	0.1	0.1	0.1	0.1
Specialty Chemicals									
Dyeing, tanning and coloring materials	0.5	0.6	0.8	0.8	1.2	1.1	1.2	1.4	1.5
Essential oils and perfume materials	1.1	0.6	1.1	0.7	1.1	0.5	0.3	0.5	0.4
Explosives and pyrotechnic products	-	-	0.1	0.1	0.2	0.3	0.5	0.8	0.8
Knowledge chemicals									
Medicinal and pharmaceutical products	0.4	0.4	0.8	0.8	1.2	1	1	1.2	0.9
Other Chemicals			0	0.2	0.2	0.4	0.4	0.7	0.7

Source: Economic Survey 2003-04, 2001 International Trade Statistics Year Book: United Nation 2003.

Table: 8 Change in Trade Performance Index of India for Chemical sector ('$ 000)

	1998	1999	2000	2001	2002
Value of exports*	3440247	3127392	3340198	3696226	6309469
Share in National export	11%	10%	10%	10%	12%
Share in world market	0.64%	0.57%	.55%	0.59%	0.90%
Product diversification	36	26	26	27	32
Market diversification	-	-	25	26	27
TPI rank	42	41	45	38	14
No. of Countries considered	-	123	125	121	123

Note: * the chemicals sector export include the following products Man-made fibers, plastic products, bulk chemicals, medicines, explosives, pesticides and fertilizersSource: International Trade Centre, Geneva

Table: 9 Changing Market Shares of India's Export in Chemical Industry and Underlying Drivers

	1994-98	1995-99	1996-00	1997-01	1998-02
Percentage change of world market share p.a.	.02%	0.02%	-0.65%	-0.95%	7.35%
Underlying Drivers of Change					
Competitiveness Effect	0.06%	0.48%	4.02%	4.03%	12.91%
Initial geographic Specialisation Effect	0.00%	-0.01%	-0.21%	-0.16%	0.01%
Initial product Specialisation Effect	0.01%	0.02%	0.03%	-0.38%	0.84%
Adaptation Effect	-0.06%	-0.47%	-4.44%	-4.44%	-6.40%

Source: International Trade Centre.

product markets whose relative size in India's export basket has gone up, but that in world trade has fallen; or the other way round. The negative adaptation effect could be partly due to poor trade intelligence among Indian exporters.

The product market segments in the chemical, which has grown up in the world trade, has fallen in India's basket. The initial geographic effect is negative in three different periods, but it has turned out to be positive in the period of 1998-2002. This measure captures whether the destination-wise profile of the exports in the sector at the beginning of the period has proved to be conducive to it's export performance. The negative index shows that the countries, which were major destination of India's exports, have been relatively slower growing. The positive contribution of the Competitiveness Effect means that if the global composition of trade basket has remained constant as it was in initial period then India would have had a higher market share in chemical sector.

This analysis reflects that India's past specialization may not help much in penetrating the global markets in future. It also needs to reorient its strategies with respect to diversification of new markets and improve its trade intelligence systems to remain competitive in future. Indian exporters need to identify the faster growing markets and attempts to redirect their efforts on those markets. India has been focusing on Pharmaceutical sector and improving its competitiveness. In addition, it is also becoming competitive in traditional specialty products such as dyes etc. It needs to focus more on specialty chemical segments. There are several segments in the specialty chemicals, which are growing fast. India does not have any presence in those areas. This takes us to study in details about India's specialty chemical sector.

5 Specialty Chemicals Sector in India

Specialty chemical sector is a US $ 375 billion industry.[13] This segment includes paints and coatings, adhesives and sealants, additives for pharmaceuticals, lubricants and additives, catalysts, water treatment chemicals and plastic additives. Specialty chemicals serve the specific needs of the other industries by imparting special characteristics to their products such as safety from corrosion, providing gloss and feel to textiles and leather. Vastly differentiated products with a high degree of value addition characterize specialty chemicals. Production units are typically smaller than basic chemical units and have greater degree of flexibility in terms of switch capacities as well as fewer imbalances between supply and demand. While capital investment requirements are relatively low, investment in R&D to developing new products and applications is high[14].

Table 10: Size, Characteristics and Major Players in Indian Specialty chemicals

Different Segments	Size	Nature	Major Players
Textile and Dyes chemicals	35%(User of Textile chemicals-Dyeing and printing-13%,Finishing-10%, Optical brightening agents 9%)	Biggest product segment Fragmented(organized sector 72% market)Textile dyes-combating increasing commoditisation and competition from chinaConsolidation	Clariant IndiaCiba SpecialtyColour-chem AtulSudarshan chemicals
Leather Dyes and Chemicals	20%	Under pressure from competition form China and IndonesiaEnvironmental concerns	ClariantColour-chemBASF
Water Treatments	3%		NalcoChemicals
Mater batch and Pigments	18%	Intense competition	Colour Chem
Others Including AddictivesElectronic chem.Fine ChemicalsEtc.	24%	Environmental and health issues, new technologies, demand for metallocense-based polyolefins Competition	ClariantCiba SpecialtyColour-chemJubilant Organsys

Source: Murlidher(2002).

Over the last decade, the specialty chemicals industry has experienced slower growth and lower overall profitability within a more competitive environment than in the preceding decade. Between 1998 and 2001, the 32 specialty chemical segments analyzed by SRI Consulting experienced an average annual growth of 3.5%. Between 2002 and 2006, the growth rate is forecast to be about 3.6%. Four segments which are expected to experience real growth of 5% or more are active pharmaceutical ingredients, specialty polymers, nanoscale chemicals and separation membranes.[15] Five industries are stagnating or declining—pesticides, textile chemicals, lubricating oil additives, synthetic dyes and mining chemicals—with growth rates below 1%.[16] Several specialty chemical market segments have matured and product introductions are only servicing incremental needs[17]. Over time, high-volume segments in textile chemicals, synthetic dyes, pigments, plastic additives, water-treatment and paper chemicals, paint and coating ingredients, surfactants, and photo initiators for radiation curable coatings have turned into semi-specialties or small commodities.[18].

Structure of Indian Specialty chemical Industry

The size of Indian specialty chemicals segment is about 25% of the Indian Chemical industry.[19]. Specialty Chemicals comprise of performance chemicals and fine chemicals.[20] Another way of looking at the specialty chemical sector is by dividing it into traditional and emerging specialty chemical sector. The traditional segments are textiles and leather dyes. And the emerging specialty chemicals are Paper treatment, polymer intermediates, water treatments, electronic chemicals etc.

There are a large number of players in the specialty chemical segment. Organized sectors contribute around 26% of the industry output. Industry can be broadly divided into three groups: first, large Indian Companies- HICO products, Balmer Lawrie, Atul, Jubilant, Sudarshan; second, MNC subsidiaries- ICI, Ciba specialities, colour chem, Foseco, Clariant India; and third, small Indian- Ahura chemicals etc.

India is not a world leader in any of the main specialty chemical product sectors. The restructuring and consolidation is taking place in this industry also. Major commodity chemical manufacturers are migrating to specialty chemicals, as it provides higher profitability and low investment. Most of the erstwhile textile auxiliary manufacturers have now started synthetic exotic molecule and thus emerging as specialty chemical manufacturers.

MNEs have a major presence in this sector. Growing number of MNEs are establishing specialties manufacturing operation in India to take advantage of it's domestic market and competitive export position. Major players having strong presence are BASF, Bayer, Ciba specialty, Clariant. American companies like Rohm and Hass has also established its base and increasing investments.

Major weakness of the Indian specialty chemical industry is that it lacks of pure-play specialties producers. Majority of producers focused either on pharmaceutical or petrochemicals. They have entered into specialties business to maximize synergies with other business. India lacks a dominant player that can help smaller companies develop their own technologies. The industry has basically evolved from textile auxiliary industry.

The size, characteristics and major players in the different segment of specialty chemical industry is presented in table 10. It is clear from the table that Textile and Dyes segment is the largest. Along with leather dyes, it is more than the 50 % of the specialty chemical market. Internationally, this segment is stagnating and becoming semi-specialty or commodities. The emerging specialty chemicals are increasing their share. In every sector, there are dominant MNC players. Competition is growing in all the segments.

6. Specialty Chemicals- A Quantitative Analysis

To examine the success factors for the specialty chemicals in the export market, an attempt was made first to explore the differentiating characteristics of the three broad groups of chemical firms—basic chemical, specialty chemical, and knowledge chemicals; secondly, differentiating characteristics of exporter and non exporters of chemical products were identified; and third, the differentiating characteristics of exporter and non exporters in the specialty chemical groups were examined.[21] For examining the competitiveness of Indian chemical industry, factors affecting the export performance of industry as per the empirical and theoretical literature were identified (Kumar & Pradhan, 2003). The factors are given in the Table 11. The data was collected from CMIE's Prowess Data base. In the CMIE database the data of around 1283 chemicals firms is compiled. After eliminating rubber and rubber product groups firms and firms with missing values, only 385 companies with the complete data for the period 1997 to 2002 were used which form the sample of the present study.

Table 11: Description of Variables

Variable	1997		2002		Description
	Mean	S. D.	Mean	S. D.	
Size	1.675	0.781	1.846	0.794	Log of total sales
Age	1.363	0.280	1.363	0.280	Log of age
Foreign Equity	6.264	17.463	6.264	17.463	Percentage of Foreign Equity in the Share capital
R & D Intensity	0.007	0.052	0.005	0.017	R&D expenditure as a ration of total sales
Technology Fee Intensity	0.001	0.005	0.001	0.005	Royalties, technical and other professional fess remitted abroad as a ratio of sales
AD Intensity	0.008	0.019	0.007	0.021	Advertising expenditure as a ratio of sales
Marketing intensity	0.040	0.045	0.048	0.047	Marketing and distribution expenditure as a ratio of sales
Labour Productivity	4.543	5.446	2.410	4.559	As a net value-added generated per unit of wage cost
Capital Intensity	2.296	14.325	0.191	0.160	Total assets as a ratio of total sales
Vertical Integration	0.221	0.190	0.113	0.151	Gross value added as a ratio of total sales
Export Intensity	0.107	0.188	0.136	0.220	Export as ratio of sales
Import Intensity	0.153	0.208	1.608	4.725	Import of raw material as a ratio of sales
Return on Investment(ROI)	0.108	0.108	0.077	0.107	Profit before interests and taxes as a ratio of Total assets
Return on Sales(ROS)	0.089	0.281	0.061	0.244	Profit before interests and taxes as a ratio of total Sales
Return on Equity (ROE)	0.125	0.535	0.162	1.508	Profit after taxes as a ration of Equity Funds

Table 11 presents the mean and standard deviation of different variable for both the year 1997 and 2002. It is clear from the table that size of the firms has increased over the period of time. The relationship between industry and size, R&D intensity, Export intensity and Foreign equity has been explored with the help of cross tabulation(See Tables 12-15). It is clear from the tables that approximately 50% of the companies belongs to the sales group below Rs 50 crores. The companies falling in the category of sales over Rs 500 crores have doubled over the period from 7.5% to 15%. Approximately 55% companies have reported no expenditure on R&D. their percentage hasmarginally declined over time. Whereas only around 3 % companies in 1997 incurred R&D expenditure over 3% of sales, in the year 2002 , their proportion increased to 5.45% (This is mostly on account of drugs and pharmaceutical companies). As far as export is concerned, around one fourth of the companies are not engaged in export. The number of exporter has increased over time. Only 5.45% companies reported export to the extent of 50 % of their sales in the year 1997. In the year 2002, their number increased to 9.35 %. As far as the presence of foreign equity is concerned, around 80% of the firms have reported no foreign equity participation. Only 6.75% companies are foreign subsidiaries with over 51% foreign equity. These firms are concentrated in Drugs and pharmaceutical, cosmetics/ soap and detergents, and specialty chemical sector.

ANOVA and multinomial regression technique were used to examine the factors which differentiate specialty chemical companies from other two groups. The result is given in Table (See Appendix I Table 1.2 to 1.6). The result shows that in Comparison to Basic chemical firms, specialty chemicals firms are smaller in size, more R&D and advertising intensive, enjoy higher ROI, in 2002, they improve their labor productivity. In Comparison to Knowledge chemical firms, smaller in size, older in age, less intensive in advertising and vertical integration. By 2002, they improved their size also. In terms of R&D intensity and ROI, Knowledge firms are ahead of specialty.

Further, an attempt was made using ANOVA and logistic regression to explore the variables which differentiate exporter from non exporters in the chemical industry as a whole. It was found that exporters are bigger in size, spend more on R&D, have high import intensity, high ROE. Overtime, exporters are becoming vertically integrated. Specialty chemical firms as a whole are not associated with exports significantly.

In order to get further insight, an attempt was made to examine the factor differentiating exporters from non-exporters in the Specialty chemical segment.

Table 12 Size and Distribution of Indian Chemical Firms

Industry		Sales (in crores)						
		0.01-10	**10 – 50**	**50 - 100**	**100 – 250**	**250 - 500**	**500 and above**	**Total**
Drugs & Pharmaceuticals	1997	20	21	18	18	12	4	93
	2002	10	26	8	21	13	15	93
Cosmetics, Soaps & Detergents	1997	0	8	0	2	1	3	14
	2002	1	5	2	2	1	3	14
Paints & Dyes	1997	6	10	3	2	4	1	26
	2002	6	10	0	3	2	5	26
Industrial Chemicals	1997	11	25	8	9	6	2	61
	2002	9	22	10	10	5	5	61
Agrochemicals & Fertilizers	1997	2	14	5	4	6	9	40
	2002	4	9	4	5	5	13	40
Specialty Chemicals	1997	9	22	9	11	5	1	57
	2002	7	20	14	6	6	4	57
Plastic Products	1997	17	27	10	5	4	0	63
	2002	13	30	9	6	2	3	63
Petrochemicals	1997	2	6	4	4	1	9	26
	2002	1	6	3	6	1	9	26
Explosives	1997	0	3	0	2	0	0	5
	2002	0	2	1	1	1	0	5
Total	1997	67	136	57	57	39	29	385
	2002	51	130	51	60	36	57	385

Table 13 R&D Intensity of the Indian Chemical Firms

		0	0 - 0.05%	0.05 - 1%	1 – 1.5%	1.5% - 3.0%	3.0% and above	Total
Drugs & Pharmaceuticals	1997	37	14	16	8	7	11	93
	2002	33	20	7	7	8	18	93
Cosmetics, Soaps & Detergents	1997	10	3	0	1	0	0	14
	2002	10	3	1	0	0	0	14
Paints & Dyes	1997	13	6	5	1	1	0	26
	2002	11	9	3	2	1	0	26
Industrial Chemicals	1997	39	15	4	2	0	1	61
	2002	39	19	2	0	0	1	61
Agrochemicals & Fertilizers	1997	23	10	6	0	1	0	40
	2002	22	13	4	1	0	0	40
Specialty Chemicals	1997	26	13	8	4	3	3	57
	2002	24	16	8	5	2	2	57
Plastic Products	1997	48	7	6	0	1	1	63
	2002	50	8	2	3	0	0	63
Petrochemicals	1997	17	9	0	0	0	0	26
	2002	11	13	1	1	0	0	26
Explosives	1997	0	3	1	0	1	0	5
	2002	2	2	1	0	0	0	5
Total	1997	213	80	46	16	14	16	385
	2002	202	103	29	19	11	21	385

Table 14: Exports of Indian Chemical Firms

		0%	0 – 1%	1 – 5%	5 – 10%	10 – 30%	30 – 50%	> 50%	Total
Drugs & Pharmaceuticals	1997	25	3	22	13	15	12	3	93
	2002	20	12	11	10	17	13	10	93
Cosmetics, Soaps & Detergents	1997	5	6	1	1	0	0	1	14
	2002	6	1	4	1	1	0	1	14
Paints & Dyes	1997	5	4	7	1	2	2	5	26
	2002	7	4	2		3	4	6	26
Industrial Chemicals	1997	21	8	8	7	12	2	3	61
	2002	20	8	8	6	10	1	8	61
Agrochemicals & Fertilizers	1997	13	7	11	1	3	3	2	40
	2002	14	7	9	1	5	1	3	40
Speciality Chemicals	1997	15	7	13	7	12	1	2	57
	2002	11	5	13	11	14	1	2	57
Plastic Products	1997	27	5	7	6	7	7	4	63
	2002	19	10	7	7	8	6	6	63
Petrochemicals	1997	9	8	5	2	0	1	1	26
	2002	9	7	6	1	2	1	0	26
Explosives	1997	0	1	2	1	1	0	0	5
	2002	0	2	0	1	2	0	0	5
Total	1997	120	49	76	39	52	28	21	385
	2002	106	56	60	38	62	27	36	385

Table 15: Foreign Equity Participation in Chemical Firms

	0%	0 – 10%	10 – 25%	25 – 50%	> 51%	Total
Drugs & Pharmaceuticals	73	5	1	6	8	93
Cosmetics, Soaps & Detergents	11	0	0	0	3	14
Paints & Dyes	22	0	1	1	2	26
Industrial Chemicals	56	3	0	1	1	61
Agrochemicals & Fertilizers	34	4	1	0	1	40
Specialty Chemicals	46	1	1	2	7	57
Plastic Products	53	4	3	2	1	63
Petrochemicals	19	3	1	1	2	26
Explosives	3	0	0	1	1	5
Total	317	20	8	14	26	385

Table 16: ANOVA Result of Exporters Versus Non Exporters in Specialty Chemical Industry

	1997				2002			
	All Firms Total 102	Non Exporters Cases 25	Exporters Cases 77		All Firms Total 102	Non Exporters Cases 24	Exporters Cases 78	
Variable	**Mean**	**Mean**	**Mean**	**F**	**Mean**	**Mean**	**Mean**	**F**
Size	1.629	1.025	1.826	30.468***	1.782	1.225	1.954	29.110***
Age	1.428	1.280	1.476	10.321***	1.428	1.383	1.441	0.806
Foreign Equity	9.908	6.974	10.861	0.569	9.908	5.230	11.348	1.381
R & D	0.005	0.001	0.007	3.278*	0.004	0.001	0.005	7.0712***
Tech Fee	0.002	0.002	0.002	0.230	0.002	0.000	0.002	2.151
AD Intensity	0.009	0.006	0.010	0.442	0.008	0.011	0.007	0.403
Marketing intensity	0.041	0.027	0.045	4.197**	0.046	0.047	0.045	0.062
Labour Productivity	3.965	4.113	3.917	0.061	2.704	1.196	3.168	5.936**
Capital Intensity	0.208	0.158	0.225	1.027	0.197	0.190	0.199	0.084
Vertical Integration	0.112	0.076	0.124	2.682	0.119	0.047	0.142	6.225**
Import Intensity	3.841	12.244	1.113	3.128*	1.063	1.158	1.034	0.730
ROI	0.145	0.126	0.152	0.539	0.075	0.025	0.091	10.438***
ROS	0.083	-0.064	0.131	3.127*	0.063	-0.009	0.085	15.653***
ROE	0.178	0.097	0.205	0.481	0.186	0.149	0.198	0.052

Note: * significant at 10%; ** significant at 5%; *** significant at 1%

It is found that exporters are having size advantage, spend more on R&D, enjoy better labour productivity and are becoming more vertically integrated. This has positive impact on their profitability as they enjoy better return on investment and sales. (ANOVA results are given in Table 14 and for other results see in Appendix I, Table1.2 to1.7).

In India, R&D spending by specialty companies are higher than basic, but below international standards. The study on the global specialty chemicals enterprises have shown that size, scale and cost position are important aspects of the competitiveness of a global specialty chemicals producer, R&D and innovation are the true drivers for its competitiveness. They can generate future growth in sales, and particularly profits, and maintain or create entry barriers—either patented or proprietary. In general, in the developed countries specialty chemical companies spend in the range of 3–5% of net sales on R&D. In India, however, it is found that the expenditure on the R&D by the specialty chemical producers is higher than the basic chemical producer, it is not enough in comparison to the global standards. Hence, it is found that the specialty chemicals sector as a whole is not associated with the exporters.

7. Specialty Chemicals: Few Case Studies

To get a further insight into the factors determining competitiveness of specialty chemical sector, case study methodology was followed. Seven companies were analyzed—three MNEs subsidiary and four Indian specialty chemical companies. The MNEs subsidiary are BASF, Ciba specialty and Clariant Ltd. Indian companies are Atul Ltd, Jubilant Organisys Ltd, Sudarshan chemicals and Tirumalais chemicals[22].

The case studies show some mixed results. Table 17 presents the comparative analysis of the selected cases. The MNEs are becoming highly focused. They are consolidating and expanding their activities through M&A and divestments. Their profitability and growth has been excellent. However, they are not oriented towards exports as their import ratio is equally high except in case of Clariant company. They have been improving their cost efficiency, through improving labour productivity and capital efficiency. They are highly focused on research. The research and technology support is from the parent company's network also. They are using India as a base of R&D also. It seems as a part of MNEs strategy they are interested in exploiting the domestic market. Internationally and domestically they are highly competitive. That is the result of continuous improvement in their operation and strengthening technology and research.

Indian companies are a mixed lot. Their performance has not been so good. They are more export oriented. They have been undertaking several measures to improve their cost competitiveness, improving their efficiency. Realizing the importance of IT, they are implementing ERP, CRM packages which are certainly going to help them increase their competitiveness. Presently, the poor performance of these companies is a result of economic recession and increased competition from small players. They are expanding both through M&A and by setting up green venture projects. They are also restructuring. They have set up in house R&D centers which helps these units to absorb and assimilate technology bought from outside. They however, need to increase their R&D expenditure. They should increase their linkages with the domestic and foreign research labs. In India, there is big scope to increase investment in R&D. Like information technology, specialty chemicals is also a knowledge based industry and India has the capability to become a leading player in the world because of its low cost structure, scientific competence and skilled manpower. A Fine Chemical manufacturing facility can be established with modest capital outlay. Here, India has the advantage of a large pool of scientific manpower and hence there is immense potential for the country to become a leading player in this sector. Industry has set the target of doubling India's share of global production by the year 2005. Since Specialty Chemicals have high rates of growth, superior margins; are specific need oriented, non-cyclic and relatively immune to industry cycles, India must not lose the opportunity of investment in this sector offers.

Meeting the customer's requirement is the key to the success of this sector. Research & Development to develop innovative products as well as processes to prolong the life of existing molecules through better formulations is the need of the hour. The industry has to tap its full potential to become a major player in this sector. To what extent the industry can exploit this opportunity depends on the innovation system in the industry. Let us examine the innovative system in the chemical industry.

8. Innovation System in Chemical Industry in India

Chemical industry is a science-based industry. The system of innovation in the sector is a set of new and established products for specific uses and the set of agents and their interactions for the creation, production and sale of these products. India over a period of time has developed the technology and manufacturing facilities to produce a majority of products in the chemical industry ranging from basic chemicals and fertilizers to specialty chemicals

Table 17: Comparison of Specialty Chemicals Enterprises

	BASF	Ciba	Clariant	Atul	Jubilant	Sudarshan	Thirumalai
Sales	265 to 584 crores	243 to 492 crores	168 to 206 crores	481 to 596 crores	280 to 865 crores	213 to 306 crores	139 to 260 crores
Ownership	German MNC	Swiss MNC	Swiss MNC	Indian	Indian	Indian	Indian
Product Range	Specialty+ Agro-chem +	Specialty	Specialty	Specialty+ Pharma	Specialty+ Industrial	Specialty+ Agrochemical chemicals	Specialty
Restructuring	M&A + Consolidation	Result of De-merger	M&A + Consolidation	M&A + Consolidation	M&A + Consolidation	M&A + Consolidation	M&A + Consolidation
IT	Web enabled	Web enabled	Web enabled	Web site + IT	ERP	ERP+CRM Web enabled	Web
JV Abroad	Part of MNC	Part of MNC	Part of MNC	Have JV abroad	No	Have JV	Malaysia
Export	10-12%	28 to 32%	24 to 28%	41%	4-13%	23 to 24%	40 % to11%
Import	17-20%	28 to 35%	5 to 11%	8 to 11%	7-6%	5%	44% to 11%
Vertical Integration	26 to 21%	11-13%	15-18%	31 to 27%	29 to17%	22 TO 19 %	24 to14%
R&D	1 to 0%	2 to 0 %	2 to 1%	1%	1%	1%	1%
Capital Import	212%-6%	—	94 to 48%	219 to 184%	——	99 TO 913%	32%- to 0%
Capital Intensity	114 to 75%	57%	49 to 52%	140 to 123%	117 to 68%	80 to 76%	187 to 117%
Labor productivity	300to 250%	238 to 281%	271 to 294 %	274 to 192%	456 to 303%	276 TO 265%	977%- to 533%
Marketing intensity	6% to 2%	3 to 2 %	4- 5%	3-4%	4%	8%	4%
ROI	10 to 14%	7 to 26%	23 to 24%	6 to 7%	19 to 3 %	8 to 13%	17 to 8%
ROS	15 to 13%	5 to 11%	11 to 10%	16 to 10%	17 to 6%	10 to 7%	17 to 9%
ROE	13%	8 to 18%	22 to 20%	11 to 8%	15 to 80%	12 to 10%	8%

and to knowledge chemicals like, drugs and pharmaceutical products, agrochemicals and biochemical. New products and processes have also been developed in the industry especially in the pharmaceutical, agrochemicals and dyestuffs, which shows the dynamism of the sector. The main agents in the innovation systems are Public research labs, Institutions of higher learning's, including IITs and technical institutions, and enterprises both domestic and foreign. A strong science systems in terms of agents like Public labs and institutions of higher learning have been created overtime and have a inter institutional linkages. But the interaction between the science and industry has not been very strong. There were neither strong demands nor incentives for the innovation. However, some changes in the system are noticed during the last one and a half decade. The reform process started to integrate the Indian economy with the world economy and the implementation of WTO, which has a mandate to implement strong Intellectual Property rights, has changed the demand side of innovation system. This needs a new dynamism in the supply side of the innovation system.

Table 18 shows the number of papers in the chemistry published internationally and the patents registered with US. It shows that in terms of number of papers published India is among the top countries of the world. Its ranking is eighth in the year 2001. However, in terms of Patents registered in US, its ranking is not among the top 20 countries[23]. Even a small country like Taiwan (not shown in the table 18) is having 1558 patents. Even other very small countries like Denmark(233 patents), Finland(200 patents) , Israel(196 patents) and Austria(178 patents) have patents more than that of India. Why is it that with large number of publications in the international journal, India is not able to produce good number of patents, which shows the intellectual capital, and innovation capability of the country in chemical sector? One reason cited by the experts is that there was no culture of product patents in the country. As the culture is changing India is going for patents as it is reflected in the increasing number of patents and the rising ratio of patents to chemical literature which has increased from mere 0.12 to 0.87. This may be true to some extent, but at the same time looking at international competitiveness in the chemical industry, India is not ranked anywhere in terms of important chemicals. It has been able to develop large number of products in the country which were earlier imported and has reduced dependence on import. In some products, it has been able to develop new processes to produce the generic products in more cost effective manner, that is, in the pharmaceutical sector. But in terms of innovation it is not comparable to MNCs and developed countries.[24] How is it

Table 18 Publication of Research Papers and Patents in Chemical Sector

	No. papers Literature 2001	Patents 2001	Populations Papers Per Million	2000 Patents per Million	Ratio of Patents to chemical Literature 1991	1995	2000	2001
U.S.	139,284	23489	495.06	80.72	10.68	9.98	16.31	16.86
Japan	79,213	8189	606.21	59.57	10.27	8.46	9.83	10.34
China	59,281	61	42.40	0.04	0.09	0.06	0.09	0.10
Germany	42,270	3469	489.56	38.42	8.02	5.77	7.85	8.21
U.K.	30,298	1360	482.73	21.07	3.76	2.91	4.36	4.49
France	24,726	1499	406.06	23.24	5.21	3.82	5.72	6.06
Italy	17,820	533	285.12	8.81	3.96	2.69	3.09	2.99
India	15,074	131	12.89	0.10	0.12	0.18	0.80	0.87
Canada	14,660	954	473.08	29.42	3.43	3.31	6.22	6.51
Spain	12,296	75	288.03	1.75	0.57	0.44	0.61	0.61
Poland	9,553	7	237.79	0.18	0.00	0.06	0.08	0.07
Australia	8,678	282	412.92	10.05	2.28	1.76	2.43	3.25
Netherlands	8,552	439	499.12	26.16	4.84	2.69	5.24	5.13
Sweden	7,231	411	749.78	37.53	3.01	3.04	5.01	5.68
Switzerland	7,186	512	929.31	62.78	9.48	6.43	6.76	7.12
TOTAL	606,679	45788						

Source: Chemical Abstracts Service; US Patents and Trade Mark Office; C & En Journal, Dec 28, 2002

possible to convert the intellectual capital in terms of development of literature into more patents? What is the mechanism? This takes us to see the science industry relationship in the chemical sector in the country.

Since independence, India has focused on building science and technology infrastructure. A large number of Public research labs and institutions of higher learning were created to work on basic science (See table 2.4 in Appendix II). Depending on the need of the moments these centers of learning were directed to focus on applied research, which resulted in green revolution and import substitutions of number of products. Foreign aggression on India directed them to the defense, space and nuclear research. Public R&D institutions established a strong research base and became capable of conducting research at frontier level. The result was strong technological capabilities in the defense sector, but little benefit to industrial sector. Indian firms hardy made major innovations. The linkage between the R&D institutions and the industry was nearly absent. The industrial and economic growth and competitiveness were low(See Kaul, 2002).

The same is true in case of chemical sector, the CSIR labs, particularly National Chemical Laboratory, Indian Institute of Chemical Technology (IICT) and University Department of Chemical Technology, Mumbai have done pioneering work in several field related to chemicals. They had linkages with the industry also. Beyond that the linkages has been very limited. Among the Public research lab, CSIR is directly working for the industry. In terms of resource allocation, government increased CSIR's R&D budget from 2155 lakhs in the year 1970-71 to Rs 71332 lakhs in the year 1998-99, but in terms of percentage its share has declined in the overall spending by Public research lab from 24.16% to 9.8%. Looking at the industry, it is found that some sector in the chemical industry(i.e. drugs and pharmaceuticals, and Dyestuffs) have increased their expenditure on R&D over time(see table 2.3 Appendix II), but in comparison to most innovative and efficient chemicals enterprises in the world it is very low.

This takes us to look into the demand side of the innovation system in chemical sector. The economic planners in India from the very beginning focused on import substitutions which directed the science and technology to develop indigenous technology and the products which are essential for the economy, such as fertilizers, basic chemicals, dyestuff for textile industry etc. The demand for innovation—for identifying the alternative process to produce the drugs—increased with increasing the demands for the drugs and pharmaceuticals products, implementation of FERA,1973 asking foreign companies to dilute their equity to 40%, and the implementation of Patent Act 1970 recognizing process patents on medicines. Indian firms focused on developing reverse engineering skills to produce drugs with alternative processes. They could now access the newest molecules from all over the world and reformulate them for sale in the domestic market. This led to the emergence of number of drugs manufacturing firms in India. Large firms started building R&D capabilities. The success of these firms have also motivated other firms to build their research capabilities. The process of globalization and liberalization in the country since 1991 and the implementation of WTO focusing on stringent intellectual property rights has increased the demand for innovation, just focusing on process is not going to work. The supply side also need to be strengthen to match the demand.

The supply side of innovation system is also gearing up to meet the challenge. The public research labs have changed their focus from 'Publish or Perish', to 'Patent, Publish and Prosper' (See Kaul, 2002). Number of institutions of higher learning, like IITs and engineering college are strengthening their research focus and collaborating with the industry. In a developing country like India collaboration with foreign enterprises is also important. Developing new products and technology may take its own time. In a well developed market for technology in chemical industry, foreign collaboration can fill the gap and strengthen the innovation system. After 1991, there has been increased number of foreign collaboration both technical and financial (see table in appendix). The foreign direct investment in the country in the chemical sector is increasing.

In terms of incentives structure to promote innovation, new patent regime under WTO will be important as the innovators will be rewarded and their invention will be protected for longer period. Government of India started taking more interest in supporting for Technology Innovation. Several programmes to support industrial sector were initiated :Absorption of imported technology (PATSER), Commercialization of indigenous technology (HGT), Innovators, Technology-based entrepreneurs (TePP) , New technology development (TDB, NMTLI). Incentives in the form of tax benefits are also available. In the recent budget of 2004, government has given more incentives for R&D. However, it is found that the national expenditure on R&D remains in range of 0.7-0.8% of GNP. One notable feature is the increase in private sector contribution to R&D which has increased from 12.2% in the year 1985-86 to 23.6% in the year 2000-01(See in Appendix II Table 2.1).

Box 2: Cultural change in CSIR

There is cultural change in CSIR, the focus has shifted from 'publish or perish' to 'publish, patent and prosper'. The value of R&D infrastructure in CSIR has increased to over US$1 billion, and has annual Budget of US$250million. The result is that over 1000 CSIR technologies have been commercially exploited. The CSIR scientists publish over 2000 scientific papers per year, and 500 Indian & 650 foreign patents are filed per year. CSIR has Bilateral Scientific Collaboration with 30 Organizations in 17 countries.

CSIR's efforts have been directed towards those sub-sectors that are characterized by a high level of innovativeness and R&D focused on achieving value addition. It enjoys high credibility with the chemical industry especially in the areas of drugs and pharmaceuticals, agrochemicals, petroleum and petrochemicals, catalysis, and chemical intermediates. In some cases its success has been due to the development of viable technologies associated with design engineering packages for commercial plants. Its expertise in all aspects of hazard evaluation, risk analysis and safety management of chemical processes plants has also helped in catering to industry's specific needs pertaining to safety in process operations.

As far as Research Labs & Higher Education is concerned there were changes in labs governance structure & incentives. In the universities, the incentive structure has been designed in such a manner that the innovators will be rewarded handsomely. This has increased, especially in the life-science department, a focus on developing new molecules and get patents. In public labs, with the change in focus on patents, things are changing. It is two labs of CSIR, namely NCL, Pune and IICT, Hyderabad which have played a leading role in helping the Indian chemical industry to attain its present position. The details about NCL is given in Box 5. (The strength and weakness of IICT is given in Box 3.) One more leading institutions University Department of Chemical Technology, Bombay, now known as The Mumbai University Institute of Chemical Technology(MUICT) has also been working with the industry and helping it to become innovative, in addition to supplying human resources.(see box 4).

The overall result is that foreign technology imports and investment have increased. More and more R&D centers are being opened up by some MNEs . There is an increase in collaboration between industry and Indian S&T institutions. Reliance, for example, is engaged in Research and collaboration with Public lab and premier technical institutes in India and abroad. They have its representative on the board of CSIR and NCL (see Box 6). The Indian Institute of Petroelum(IIP) and Adarsh chemical have developed a process for

Box 3: Indian Institute of Chemical Technology (IICT), Hyderabad

Indian Institute of Chemical Technology, celebrating its diamond jubilee year from August 5, 2003, conducts research and offers globally competitive environmentally friendly technologies for Drugs and Pharmaceuticals, Natural Products, Chemicals, Chemical Engineering, coal, Oil & fats, Catalysts, polymers, Design engineering. It also offers knowledge based services in Analytical Testing & Characterisation, Process Upgradation/ Restandardisation, New Molecule/Product development, Process Safety studies, Design/Engineering & Project Viability studies.

The number of patents filed by the IICT in India and Overseas has been growing since 1996-97. In the year 1996-97 it filed 17patents in India and 2 overseas which has increased to 46 patents in India and 139 overseas by the year 2002-2003. It has been increasing its earning from project works- Whereas its share of external earning as a ratio of CSIR budget was just 4.5 % in the year 1996-97, it increased to 11.2% in the year 2002-2003.

The IICT completed 65 sponsored research and consultancy projects , and earned Rs 17 crore for project work from both public and private agencies during the year 2002-03. It also earned Rs 32 crore grant-in-aid from the CSIR during 2002-03. In the core scientific research area, the IICT with over 290 papers published in reputed international journals with high impact factors is also second among the CSIR labs. On the patents front, in addition to 120 overseas patents, especially in the US, Europe and other developed countries, the institute had also applied for 46 Indian patents, protecting a total of 62 inventions in a single year.

The IICT has been chosen as the nodal agency to set up Rs 24-crore Bio-technology Incubator at the Shapoorji Pallonji Biotech Park (SPBP). In the drugs/pharma areas, the IICT has designed and developed more than 50 highly potential chemical entities and herbal formulations with attractive therapeutic properties. It has assisted two small and medium enterprises (SMEs) to enter into international custom synthesis field.

Among new initiatives, it has signed a multi-client sponsored technology transfer agreement for Indoxicarb, an important agrochemical, through the Pesticide Manufacturers and Formulators Association of India (PMFAI). It also proposes to develop process technologies for industrially important chemicals from tobacco.

Another major national project being led by the IICT is the development of synthetic aviation lubricants from renewable feedstocks. The consortium includes Indian Oil Corporation (R&D), Hindustan Aeronautics Ltd (HAL), National Aerospace Laboratories (NAL), Gas Turbine Research Establishment (GTRE) and the Centre for Military Airworthiness and Certification (CEMILAC).

Source: IICT

Box 4: The Mumbai University Institute of Chemical Technology (MUICT)

The Mumbai University Institute of Chemical Technology, known earlier as UDCT, established in 1934, is the most outstanding Institute of the University of Mumbai. It enjoys a unique and prominent place amongst the premier institutes that are engaged in education, training and research in the field of Chemical Engineering, Chemical Technology and Pharmacy in India.

The genesis and growth of the MUICT is a sequel to the intense desire and support by the Indian Chemical Industry. Excellent symbiosis of academic excellence and industrial relevance has been a unique feature of MUICT. MUICT has focused on catering the needs of the industry by upgrading the modifying the highly specialized courses to produce chemical engineers and technologists of A class. Appropriate specialized and interdisciplinary courses are introduced to keep pace with the fast changing technology.

The faculty members obtain several research grants through prestigious national institutions and international collaborative research programs. International collaborative programs is a common feature in MUICT and Indo-Us, Indo-French, Indo-EU, Indo-SA, Indo-Netherlands programs were instrumental in producing several outstanding research contributions in both fundamental and applied science. Industrial consultancy is another unique feature of MUICT faculty members.

In all the department of MUICT major Research Work is undergoing.

For instance, in Chemical Engg. Division the research work going on is: Design of multi phase reactors, design of multiphase reactions, separation processes, catalysis, bioseparation, enzyme technology, environmental engg., process development, computer aided mathematical modeling and stimulations, modeling of stirred reactors, pollution control etc.,

Tech. of Intermediates and Dye-stuff Division : Synthesis of heterocyclic, carbocyclic, fluorescent compounds, synthesis and applications of high performance azo pigments, synthesis of laser dyes, process development and standardization of Intermediates, pharmaceutical intermediates, liquid crystal dyes and intermediates, environmental aspects of Dyestuff etc.,

Tech. of Oils Surfactants & Oleoresin Division : Energy efficient & eco-friendly processes in oil seeds processing & utilization , novel surfactants and speciality chemicals, edible oil & oil based products, uses of oleochemical , waxes in cosmetics etc.,

Paints & Polymer Division: Polymer recycling , blends, rheological studies, synthesis and characterization of resins, colouration & colour matching synthesis of inorganic and organic pigments, ion exchange resins etc.,

Applied Chemistry Division : Sonochemistry, microwave technology, catalysis, surface chemistry, green chemistry, solvent extraction, electro chemistry etc.

Box 5: National Chemical Laboratory(NCL)

National Chemical Laboratory(NCL) was set up in 1950 with an objective to establish a world class centre of excellence in fundamental research in chemical sciences, engineering and technology. Its widely acclaimed contributions include development of a large number of indigenous catalysts, new process technologies, commercialisation of advanced material and synthesis of drugs. The work done by NCL scientists in the area of biotechnology and plant molecular biology is of far reaching significance.

The NCL has talented force of over 600 scientists(approximately 300 scientific staff with PhD) working in its 9 divisions. Catalysts are the heart of a chemical process and of chemical technology. A constant effort is being made to consolidate its core competencies while building up new areas. For example, NCL's leadership in the areas of catalysis is mainly due to its internationally recognized strengths in zeolites, oxidation catalysts based on transition metals and homogeneous catalysts. They have many major applications in the chemical industry, especially in petroleum refining, petrochemicals and even fine chemical. Similarly, NCL has the largest interdisciplinary polymer research center in India. Encompassing polymer synthesis, compounding and processing, reaction engineering, micro encapsulation and membrane materials. It has contributed to several commercial successes in fiber reinforced plastics, polyethylene cable compounds, and polymer supports for the immobilization of polymers, high performance polyethylene cable compounds, and polymer supports for immobilisaiton of enzymes. In this area of organic chemical technology, the core strengths of NCL range from organic synthesis of complex compounds, synthesis based on homogeneous and heterogeneous catalysts, bio organic chemistry, microbial transformations and isolation useful molecules from natural products. Some recent successes include the unique synthesis of ranitidine intermediate using a zeolite catalyst, complex syntheses of ranitidine intermediate using a zeolite catalyst, complex syntheses of brassinolide, biotine, prostaglandines and vitamin B6, developing novel vinblastine and vincristine from the plant Catharanthus rosins, and two pesticidal compounds from neem, which illustrates the potent

In biotechnology, NCL has developed competencies in microbial technology, fermentation technology, plant molecular biology and tissue culture. NCL scientists have earned accolades for developing disease resistant and high yielding varieties of sugarcane, cardamom, turmeric, ginger, and eucalyptus. Tissue culture based bamboo was a path breaking work.

In the year 2003-2004 the scientists working in NCL has published the second largest number of papers in chemical sciences (~ 350), files the largest number of patents, both in India (~50) and abroad (~120) and produces the largest number of Ph.Ds in Chemical Sciences in India.

Its annual budget (2003-04) was Rs 374.2 Million (8.32 Million US$). The total amount contributed by the CSIR's is Rs. 300.6 Million (6.68 Million US$). The external earnings in the year 2003-04 has been Rs.143.2 Million (3.18 Million US$). NCL's earnings from external sources come from industry-both from Indian and foreign industry. In fact, earnings from abroad have seen a phenomenal growth in the last

Box 5 continued

Box 5 continued

decade. Today, NCL is being viewed as a global R & D partner by many leaders of industry in the world. The Foreign customers include Dupont, Nestlé, General Electric, Unilever, ICI, Cargill, Ciba Geigy, rohone Poulenc, Eastman Kodak, Akzo, and Florfric.

For nearly two decades, NCL catered to the import substitution goal of the government and contributed to the growth of indigenous chemical industry, apart from continuing basic research. 'We were mostly generating repetitive technology then. There was not much innovation or excitement', says R V Chaudhari, deputy director and scientist in the chemical engineering division. According to him, the scenario was completely changed in the 1980s under the leadership of the then director Dr. L.K Doraiswamy, who restructured the institute and strengthened the new disciplines, line catalysis, polymers, biotechnology and chemical engineering. He felt that mere import substitution was not enough, and insisted on innovation rather than repetition. It was during his time that NCL made major break through in catalysis, followed by polymers. Chemical engineering became the backbone of all technology development efforts. Then came the new economic policy and fund squeeze from the government, halting many of projects at the initial stage. But NCL could survive the crisis by turning to the industry, cashing in on the foundation and expertise it built through the eighties. The liberalization and globalization of the economy meant that foreign firms could operate freely in the Indian market, making import substitution an inviable research policy, unless the indigenous technology was truly competitive. This was precisely the understanding that propelled the transformation of NCL into its present form. Simultaneously, the research contracts from abroad brought funds.

single step oxidation of cyclohexane, involving a non-polluting catalyst, for producing adipic acid and Lummus of the US has tied up with IIP and Adarsh to scale up the process at a pilot plant near Surat. The IICT has acquired considerable expertise in Chiral synthesis, i.e. synthesising the correct mirror image of the molecule selectively. Companies like Ranbaxy, Lupin, Dr. Reddy, Cipla, SOL, Gharda, United Phosphorous, Excel and others have developed very strong engineering and process development capabilities. Specialty chemicals have become the play ground for many Indian entrepreneurs and laboratories. A Herdellia chemical with its benzene and diphenyl oxide plants competes with the giants in global market place. Indian entrepreneurs, even small and medium ones, are ready to take risks and invest in technology development(Agarwal and Gupta,1999)

In brief, Indian chemical sector has learned and developed a capability to absorb, adapt, improve and manage the latest technology. It has a number of institutions, which have created and developed new products and technology. The presence of MNEs has definitely made the innovation system more dynamic

Box 6: Industry-Academics-Public Lab Interaction: A Case study of Reliance

Reliance is India's largest and most respected company. The company has grown from a textile company to a petrochemical giants over a period of 35-40 years time. It's core competencies have been in managing and executing mega project very efficiently within the stipulated time period. They also acquired the latest technology and absorbed it. Overtime , it has started focusing on Research and development- both in house through its own R&D Centres and through strategic alliance with public laboratories and Engineering and technology Institutes. It has been working towards a continual improvements in R&D efforts in polymer sector in terms of new product development, quality enhancement, and introduction of new grades and applications along with activities for creation of intellectual property.

The R&D centre at Hazira, got major breakthroughs in polymer research and filed 4 international patents:polyolefin catalysts, high performance donors and inorganic support for polyolefin catalysts.

Collaboration with National chemical Laboratory (NCL), Pune under the Research Alliance Agreement (RAA). RIL representative inducted as "Member Expert in Research Council of National Chemical Laboratory, Pune". Research under the New Millennium Indian Technology Leadership Initiative (NMITLI) CSIR for developing break through technologies. An RIL nominee has been appointed as "Member of High Powered Committee for NMITIL".

Sponsoring and participating in various R&D efforts: IIT, Mumbai and Chennai; Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore; Vlifesciences, Pune; RG Specchem, University of Massachesetts, USA; and Polymer Institute, brno, Czech Republic. Several projects cmpleted by students at the Centre for Polymer Science and Engineering, IIT, Delhi, under the guidance of "Reliance Emeritus Professor" (Reliance Chair at IIT Delhi).

The R&D activities of the polyester sector at the 'Reliance Technology Centre' located at Patalganga. These are aimed at new product development, process technology upgradation and operations support for the stable fibres, filament yarns and PET resin businesses.

The new RTC building, housing state-of-the art analytical instruments, polymer/ fibre processing and testing facilities, was inaugurated in June 2003. The interdisciplinary R&D team: consists of 55 scientists and engineers Project in Collaboration with UDCT, Mumbai:

- Kinetic study on acetic-acid-burn in the pilot oxidation reactor.
- Kinetic study on paraxylene oxidation in the pilot oxidation reactor.
- Feasibility study of oxidation of paratoluic acid in water in pilot plant.
- Development of simulation model for acetic acid dehydration by azeotropic distillation using three different entrainers viz. Paraxylene, n-butyl acetate and n-propyl acetate.

Several new in-house designs and novel ideas were implemented during the year at the Jamnagar complex.

Source: Reliance Industries Ltd Annual Report, 2003-2004.

and has spillover effect on others in terms of improving quality, introducing new products and technology, and strengthening corporate governance. The private sector enterprise in India along with the public labs , has increased its investment in R&D. However, in comparison to the other developed countries enterprises, their investment in R&D is very low. Even the interaction between public lab and industry is limited to some big companies. In order to make the Indian chemical sector internationally competitive, there is a need to increase the interaction between the public labs, institutions of higher learning and industry. It needs to focus on appropriate context(institutional and policy environment), process(day to day operation of knowledge creation and innovation management) and structure(appropriate incentives and organization mechanism).

9. Conclusions and Recommendations

The paper aimed at examining the status of Indian chemical industry in the international context. It founds that the innovation and technological strength are the key determinants of the knowledge-based industry like Chemicals. The global chemical industry is a heterogeneous, oligopolistic and research intensive industry. As the challenges faced by the industry leaders changed overtime, they changed their strategies also. To survive and grow in the global industry like chemicals, enterprises need to be internationally competitive. Indian enterprises in the chemical industry have grown big in size and strength. They are also focusing on exports, forming strategic alliances, setting up their subsidiaries abroad to be competitive. The study leads to the following conclusions.

1. Capitalizing on Strength and Overcoming Weaknesses

India is largely self-sufficient in this crucial industrial sector. It is because of state support in terms of setting up public research labs, patent regulations and setting up institutions of higher learning to produce trained manpower and do research, and entrepreneurial skill of the country which contributed to the growth of the chemicals, petro-chemicals and pharmaceutical sector and. India has proven capability for chemical process development. A diversified manufacturing base to produce quality chemicals with vibrant downstream industries in different segments has been established. Some of the segments like Dyes, Pharma, and agrochemicals have a strong presence in export market and are showing a strength to become globally competitive.

Industry, however, will have to overcome endemic weaknesses. Majorities of the Indian chemical enterprises have comparatively small plant capacities, aging equipments / processes / technology. There is a wide dispersion of Industries, which leads to high logistics costs. There are some structural weaknesses, such as, high cost and quality of power, cost of finance, not so good infrastructure development, multiplicity of taxes and long pending labour reforms. There is need to overcome these weaknesses. The top management and entrepreneurs should develop strategic intent and global mindset to be internationally competitive. They should focus on their area of strength and learn to renew their strength to enter in to the high-growth oriented segments.

2. Preparing for the change-Observing the global Trends

In order to become internationally competitive, the industry should observe the global trend and identify the forces which are going to affect its structure and performance. the trend of globalisation has affected the chemical industry. The process of integration of the economy and different industry with the world economy is continuing. It has increased the global spread, MNCs are establishing manufacturing location closer to feed stocks or closers to alternative markets. It has increased the competition for the chemical industry.

The World Trade Organisation has been responsible for changing rule of business. The rules related to intellectual property are particularly important for the chemical industry. Strengthening of patents laws is beneficial for the innovators. The knowledge of anti-dumping rules and protection from them is essential. The environmental rules are becoming more and more stringent.

The process of consolidation in the chemical industry will continue. A lot of merger and acquisitions are taking place. Earlier there was restructuring of the chemical industry focusing on three different sector, basic chemicals, specialty chemicals and knowledge chemicals. Now, the consolidation is taking place within the segments also. The purpose of consolidation is to achieve cost advantage through enhancing capacities and adding more competency and technology strength to increase more product lines.

Though it is mentioned that the specialty and knowledge business are more focused on R&D and marketing. However, the reality is there is increased focus on cost Reduction in the sector. The trend is likely to accelerate. New measure and methods will be identified to reduce cost and add value for the stakeholders. There are number of other trends which are likely to continue: increasing focus on R&D, increasing focus on core business, Increased use of IT.

3. Identifying the Key Drivers of the Industry

There are several key drivers of the industry which need to be taken into account at the time of designing national policy for the growth of this sector: increasing the domestic demand, identifying the international market and outsourcing.

The per capita consumption in most of the product segments is much below the world average. With favourable macro factors, there still remains a huge demand potential within the country. Identifying the International Markets for the products and meeting their requirements is another drivers of the industry. For instance, the Indian pharma sector is focusing on this. Outside USA, India has the highest number of USFDA approved plants and files the largest number of drug master files (DMFs) in the world. With patent regime in the near future, Indian Pharma sector has tremendous future. Pharma sector has a tremendous opportunity due to 35 block buster drugs going off patent between 2002 & 2007. Indian Market for Biotech Services & Products at $ 75 billion – Forecast for 2010 - $ 200 billion.

With high quality products and lower production costs, Indian companies provide bright opportunities for outsourcing. The fact that India ranks 8th in the world in Innovation, 4th in the availability of competent senior managers and 1st in the availability of qualified & skilled engineers, there is little doubt that Indian Chemical Industry can be the most favorable destination for Contract research, Contract manufacturing and technical support in the near future.

4. Strengthening Dynamic Capabilities to Innovate

The results of the study suggest that to be internationally competitive, firms need to keep on strengthening their technological, operational and marketing capabilities. The expenditure on Research and development, size of the firms, operational efficiencies, use of IT etc. have emerged significant variables and are associated with the good performance of the company. The successful companies are restructuring their product portfolios. As the change is continuing, the enterprises should keep on renewing their capabilities also. It needs continuous learning.

5. Set the priorities and implement the strategies

Every region has advantage /disadvantage in terms of natural resources, traditional knowledge and talent level. It needs to set priorities and identify areas of strengths. It should then develop strength and use its competitive advantage to compete in the market. Keeping in view the above mentioned observations, the enterprises and government should set their priorities and targets and implement strategies to achieve the targets with full commitment to make the firm and industry International competitive.

- ***Shifting to products and sectors with more potentials:*** Need to Shift to products and sectors with more potentials in the domestic and international market. For instance, shift to Fine Chemicals & Specialties – Biotechnology.
- ***Strengthening Technological Competence:*** With a chain of nearly 200 national laboratories and 1300 R&D units in the industrial sector, India has a strong base for innovation. Knowledge based sectors promises great future. There should be continuous efforts on the part of the enterprises to develop the Technological Capabilities and Competence. This suggests that more and more firms should enter into technological collaboration with the MNCS and Research laboratories to purchase latest technology and know how, spend more on R&D, and bring more products in to the market.
- ***Achieve Optimum Size*** to increase competitiveness and enjoy - scale economies in manufacturing, logistics, marketing, R&D and raising finances.
- ***Provisions of Finances for innovation and restructuring:*** Changing capacity paradigm has implication on financial risk profile of companies as chemical business is capital intensive. There are two challenges: substantial funds- need innovative financing and Debt financing. This will force companies to consider cost effective alternative like acquisition and Joint Venture which involve lower cost and shorter payback. Moreover, the capacity realignments diffuse the risk of overcapacity.
- ***The strategic investment decision not on the basis of Domestic Demand:*** The WTO has changed the rule of the game. The lifting of QR on imports has increased competition. Moreover, developed countries find many areas difficult for investment such as, low technology areas where there is no entry barriers and high sensitive environmental issues involved. Further, there is an additional demand in Asia, hence, they are setting up new capacities in Developing countries. This is going to increase the competition. The market is global for most of the products. The capacity creation and expansion should be with the global mindset.
- ***Use Information technology:*** The IT has revolutionized the operation, research, marketing and communications. The ERP packages to integrate the operations of the company and integrated supply chain, CRM etc are becoming essential tools to operate in the globalized business.

- ***Develop strategy to reap Collaborative Advantages:*** Establishing linkages with the suppliers and customers, with other research institutions and laboratories, even with other manufacturers is becoming essentials. The knowledge creation and dissemination require proximity, establishing of clusters, knowledge parks, chemical parks etc. are becoming important.
- ***Managing the International Trade:*** The government need to strengthen Patent administration and should take active interest in managing international trade in WTO directed regime. Use of anti-dumping a good start to protect the industry, but India should emulate US, EC, etc with safeguard duties and other measures. Intelligence of Trends & Policies in other countries needs to be strengthened. India should also actively use non-tariff barriers where relevant.
- ***Environmental consciousness:*** To overcome the qualitative barriers posed by the developed nations, the Indian chemical industry in support with the government, and ICMA should take initiatives in the area of Cleaner Production. (Res*ponsible Care, Sustainable Development, ISO, CREP).*

Suggestions and Recommendations

The study proposes some recommendations for the corporate enterprises to make their company internationally competitive and economic policy makers for making the industry as a whole a more vibrant and competitive which can help to achieve higher growth rate of GDP.

Recommendation for Business Enterprises

1. Develop a Global Mindset and Strategic Intent

To survive and grow in global industry like chemicals, enterprises need to develop a global mind-set. Even if they plan to focus on domestic market, because of the reduction in tariff rate, there is competition from the foreign players. It is better to follow an offensive policy of going for export market and be internationally competitive.

2. Choose a Right Business Model

There are three different business models in the chemical industry: Operators, solution providers or hybrid. Operators are physical asset-intensive companies. The solution providers bring an interrelated set of assets such as intellectual property, knowledge, relationships, physical assets and products to provide differentiated, value added solutions to their customers. Hybrids are companies that successfully combine elements of both operators and solution provider models within one corporate culture. Choosing the appropriate business model, understanding and focusing on its success factors would enable chemical companies to select the right growth platform and prioritize among the many options available (see box 7).

In India, generally, companies follows a Diversified Product Portfolios**.** A wide product range insulates the manufacturer from the cyclicality in prices associated with any single product. A fair proportion of specialty chemicals in the overall product mix is also beneficial, as these, unlike bulk chemicals, cannot be considered commodities. Given the increasing linkage of the Indian chemical industry with international commodity price movements, a shift in manufacturing towards specialty chemicals would play a significant role towards cushioning the producer against adverse price movements. Given the critical role played by specialty chemicals in the end use applications, customers are less prone to shifting loyalties in the event of minor price variations. Also these chemicals typically constitute a small proportion of total manufacturing cost to the end users, leading to a lower price elasticity of demand on the part of customers.

3. Develop Technological Competence to innovate

In order to be internationally competitive, company need to be either innovator or be cost competitive. To follow either of the strategy in the chemical industry, one need to have technological capabilities. For Innovation, the focus need to be not only on developing new product/or process, but also to develop technologies(see Box 8). Specialty companies need to continually look for new innovative technologies. Two questions are integral to this strategy: How do we develop new technologies while working within a market-driven, customer- focused organization? How do we develop breakthrough products with our global customers while taking the shortest path from laboratory to market?

To develop new technologies within a market-driven, customer-focused organization, it needs to address several issues. First, it must identify a worthwhile breakthrough target. Next, it must clearly identify the right target market. Finally, it must be able to effectively scale up the chemistry. Specialty chemical companies competing in today's tough, global environment can no longer afford to devote precious resources to conducting research and developing innovative products that have no target market or that have a high potential for failure.

Box 7: Business Model for Chemical Industry

There are three different business models in the chemical industry which are being followed by the 20 top global companies: Operators, solution providers or hybrid. Operators are physical asset-intensive companies. The leading operators pursue an operational excellence philosophy, being comfortable managing. The example of the operators are Air Products, Dow, ExxonMobil. Deeper analysis showed that leader-operators also demonstrated the following critical success factors: 1) world-scale manufacturing facilities; 2)access to advantaged raw materials; 3) a leadership position(number one or two) within each of the product of a focused portfolio;4) central, standard and scalable business processes and organizational structures; 5) use of low-cost channels; 6) process-related expertise and intellectual property; and 7) excellence in capital project and risk management.

The solution providers bring an interrelated set of assets such as intellectual property, knowledge, relationships, physical assets and products to provide differentiated, value added solutions to their customers. They strive to become embedded in their customers' businesses and as such need capabilities not only to product innovation and collaboration, but also in the ability to sense and respond to end market and customer needs. Specialty chemicals many be part of the bundle of components that comprises the solution, but more commodity-oriented products may also be included in a solution where the compensation should be based more on agreed outcomes or services level rather than the volume of physical product sales.

Hybrids are companies that successfully combine elements of both operators and solution provider models within one corporate culture. There are two types of hybrids: those that manage a portfolio of separate businesses and those that have a portfolio tighly linked through vertical integration.

Source: John Aalbregtse, and David Davies(2002)

4. Size is important

Competition in the industry is price based, and global linkages are well developed. Indian manufacturers face significant competition from large-scale manufacturing capacities, particularly in China and South East Asia. The existence of global scale manufacturing capacities enables the manufacturer to derive economies of scale, leading to cost leadership. The discernible trend of mergers and acquisitions in the domestic petrochemicals sector is a reflection of the need to attain internationally competitive capacities.

5. Capacity Utilization and flexible manufacturing

While the existence of global-scale capacities affords potential benefits, the removal of operational bottlenecks leading to a high capacity utilisation enables the translation of such benefits into reality. High capacity utilisation implies lower per unit operating costs, providing the manufacturer a greater degree of pricing flexibility. Further, the per unit capital cost (a major factor in this capital intensive industry) also reduces in direct proportion to the level of capacity utilisation. The existence of facilities that can be shared across different product lines assumes particular importance for specialty chemicals, as these are typically low volume products which do not, in isolation, enable cost-efficient manufacturing operations.

Box 8: A Case of Rhodia-Working together with Customers and Researchers To Innovate

Rhodia, a technology-based and market-driven company, has been successful in tailoring specific products and customized solutions for each customer market. To work on technological breakthroughs while creating customized solutions, Rhodia has implemented laboratories that integrate basic and market-driven research. It is common for scientists on the same team to work on a market focused project funded by an individual Rhodia business (for example, Home & Personal Care or Industrial Coatings) while working on "technology-push" research (such as a new polymer or a surfactant) funded by Rhodia corporate. This vertical integration of basic and applied research is the key to shortening the time to market.

For a global specialty chemicals company, innovation is the key to future growth and profitability. For innovation, Rhodia encourages its employees to think "outside the box." As researchers, their mission is to develop innovative products while taking a path as short as possible from laboratory to market.

Developing new technologies with the global customers while taking the shortest path from laboratory to market requires approaching the task with a global mindset. 'When a customer in Asia makes a request or a customer in Europe poses a question, the response should come from whichever global site is best equipped to respond'. To be able to react in this way, Rhodia is proactively developing a network of seamless, worldwide laboratories and research centers. Scientists who are used to working together staff this global network.

Electronic tools such as e-mail, video conferencing, and the company intranet are driving connectivity and integration within Rhodia. These same electronic tools allow the Centre to work with their customers as partners on implementing innovative joint projects and on developing new technologies. Again, electronic technology is allowing us to share so many resources that our scientists can collaborate with our customer partners in virtual "elabs." This collaboration will increase the speed of new product development and break down the boundaries between customer and supplier.

This new dimension of global research and development is not only fostering closer collaboration; it also is generating tremendous opportunities for those scientists who are willing to take responsibility for driving innovation within their organizations. The key to success for Rhodia and other companies in the innovation business lies in their working together with customers and fellow researchers as partners in this exciting and challenging global environment.

Source: Mathieu Joanicot, Innovation Goes Global in Specialty Chemicals,

6.Quality and environmental norms

Quality related issues assume significance in the light of the increasing focus on exports by the Indian chemical industry. While adhering to international norms on environmental pollution would have an impact on manufacturing costs, there appears no viable alternative in the longer run. The developed countries, which are likely to remain the primary consumption centres of chemical products in the foreseeable future, are becoming increasingly resistant towards the import of environment unfriendly chemicals.

Recommendation for Government

1. Strengthening chemical innovation system

Allocation of resources for research is a serious concern for India. USA spends 2.6 % of GNP on Research, so does Germany and Japan which allocates 2.8 % of their GNP towards R & D. India spends less than 1 % of GNP on research and in absolute terms it would be around 2- 3 % of USA. The chemical and pharmaceuticals industry in USA spent 31.5 Billion USD in 1997 , out of a total R&D budget of 145 Billion USD , making it the highest spender ahead of other sectors like transportation, Telecommunications and computers.

As regards chemical research, India spends as little as 1% of the USA's budget. Technology leadership can not be achieved, even in strategic areas with such low level of expenditure on R & D. Government, Industry and Institutions have to wake up and move boldly. There is a need to promote patent literacy in view of impending WTO regulations. Further, there is need to learn how to read and write patents and when and how to patent ideas and discoveries. Competitive lines would be drawn along patent work in the future.

The government should Set Targets and Priorities, strengthen educational and research institutions, increase interactions among the institutions and industry, firms to change their strategies and intents. A formulation of Innovation policy by the government can help in this direction.

2. Availability of Finance

R&D and Development: Any investments by a corporate in Research & Development should be covered under priority sector lending and therefore allow the Corporate to have access to low cost funds. This shall promote further research in the Chemical / pharmaceutical industry and shall help in increasing the research and development activity in the Country. It is suggested that any R & D capital equipment imports should be financed at LIBOR linked rates for tenor ranging from 7 to 10 years. Any local procurement of R & D capital equipments should be financed at Bank rate for tenor for the tenor of 7 to 10 years. Government should also identify or assign the special status to some designated banks for lending for such R & D activities. This would facilitate the early disbursals at right time and at right cost.

Modernization :

Funding modernization should be given priority sector status for lending institutions. If import duties are to be brought down, the cost of funds should also not be higher as compared to international players. This would mean that the transactional cost must be brought down to 1% so that the cost of borrowing equal to international LIBOR + Cost of inflation / rupee depreciation + transactional cost of 1%.

Exports:

Industry avails the facility of Rupee Packing Credit (RPC) from banks for facilitating the exports of goods to be made by the exporters. The RPC rates should be uniform across the financial sector and be linked to more realistic parameter such as Bank Rate of 6 % or Repo Rate (daily rate published by RBI) of 4.50 % plus 75 basis point spread as applied in Foreign Currency Packing Credit (FCPC) for the particular period. This shall help the exporter to plan and have the funds at more realistic cost and consequently can price its product more competitively in the international market. RBI should advise/assist the relevant banks in arranging and managing the Foreign currency funds in such a way that it eliminates any kind of scarcity of such funds and the same is available to the exports community on demand.

An equity fund to be made available with EXIM banks and the like to participate as minority partners upto 24% on Export Oriented projects for Companies with equity capital between 5 crores and 100 crores. This would be similar to the State funded Industrial Investment Corporation rules in sponsoring more projects within the States through joint venture.

Investment:

Any investments by a corporate in Captive Power plants, effluent treatment plants etc should be considered as Infrastructure investments and consessional

funding from infrastructural development board should be made available outside the balance sheet. This shall promote further investments in captive power plants and building effluent treatment plants in our country.

3. Tariffs and Export Incentives

Catalysts for use in the chemical and petrochemical industries are product specific and are generally imported. Such catalysts are subject to peak rate of 25% basic customs duty even when there is no domestic production of such catalysts. Hence it is requested that Customs duty on identified catalysts be reduced from 25% to 10% as it would not hurt the domestic industry.

The import duty on fuels, which is one of the main feedstock in the Chemical Industry should be brought down to comparable international levels. Currently, fuel which is at 15% level makes the total energy cost in India high. There is a strong case that import duty on fuels should come down to 0-5%, and there needs to be a rationalization of duties on building blocks.

Indian exports suffer from various handicaps namely higher transaction cost, infrastructural weaknesses, outdated labour laws, fuel and port costs as compared to international players. This reduces their margin of profit. If the *tax incentive* on exports is also withdrawn it will not leave adequate resources to build financial strength to compete internationally. It is recommended that we continue with *DEPB scheme* till we remove infrastructural impediments that reduces competitiveness

4. Reducing Cost

Energy is a major input for the chemical industry. So far it has not been included while calculating DEPB and advance license norm. It is suggested that energy should be available to Indian chemical manufacturers at parity with other international player(s) atleast for exports.

Keeping in view role of M &A , cost of Mergers & Acquisitions be reduced. Stamp Duty for mergers and acquisition of businesses to be made zero, particularly in case of sick and potential units. Goodwill to be allowed for tax depreciation.

5. Setting of Chemical Parks and Knowledge Parks

The promotion and setting up of clusters should be taken on priority basis. Private participation in building the clusters and park need to be increased.

Endnotes

1 Except in some new segments, like electronic chemicals etc.,

2 Global chemical industry growth has been consistently been outpacing GDP growth by a factor of 1.5. This ratio has declined during the last few years.

3 More than 80,000 products like paints and coatings, fertilizers, pesticides, solvents, plastics, synthetic fibers and rubber, explosives and many others are building blocks at every level of production and consumption in agriculture, construction, manufacturing, and in the service sectors. For all of these reasons the performance of the chemical industry is both vital for, and very much dependent on the general economic climate of the economy (Albach *et al.*,1996).

4 In the contemporary international economy, cartels have given way to inter-oligopoly competitions among the major enterprises. These new trends, however, do not preclude strategic alliances, such joint ventures, or successful strategies of rationalization, as in the case of control of over capacity.

5 While up to the 1980s foreign investments were to a large extent confined to first world countries, in the recent decades there has been an increase in the flows towards the developing countries as well. As a matter of fact, chemical investments in these countries have become a critical strategy of the major multinational chemical firms from the advanced world, and to some extent the ability to invest in these countries has become a major factor in enhancing their competitiveness, and more generally an important element for competition in the industry. Moreover, apart from foreign direct investments in plants, the developing countries have become important areas for inflows of process licenses and engineering services. Again, the competitiveness of the chemical firms in advanced countries is often related to their ability to operate and invest in these markets, as well as on their ability to complement these investments with related technology flows through licenses or engineering services.

6 Due to this overlap and incoherent definitions of the sectors of the global chemicals market, it is difficult to present precise market segment data.

7 There is high entry barriers on account of high capital spend and stringent regulations. This segment consists of Petrochemicals and intermediates, Fertilizers, Inorganic chemicals, Other petrochemicals derivates and industrial chemicals.

8 It consists of Adhesive sealants, Catalysts, Industrial gases, Plastic additives and other products.

9 A recent study shows that the worldwide market for plant-level expenditures in the chemical industry, which totaled more than $214 billion in 2003, will reach almost $241 billion by the end of 2008, expanding at a Cumulative Annual Growth Rate (CAGR) exceeding 2 percent, according to a new study by the ARC Advisory Group. (Clayton, 2004).

10 Large firms move and locate their production plants and their R&D facilities according to the presence of these factors. The scientific and technological base plays a key role in defining competitive positions of different countries and regions in different sub-sectors, because they represent a strong incentive for large multinational companies to locate in specific national boundaries.

11 These are essentially commodities, exhibiting a high degree of price cyclicality, depending on the international demand supply dynamics prevailing at the time. The liberalization and tariff rationalization measures of the Indian Government post 1991 have induced a significant increase in domestic demand for chemical products. Simultaneously, the reduced protection to the domestic industry has made it vulnerable to movements in international prices, with viability being closely linked to cost of production and capacity utilization. While the capital-intensive nature of the industry creates entry barriers, it tends to attract high levels of investment during periods of high prices. This, in conjunction with the long gestation period of plants and irregular capacity additions leads to periodic demand supply imbalances.

12 A comparison of import and export of major chemical products with that of other manufacturing products tells us that the share of import of fertilizers and chemicals in the overall import of the country has been declining in the recent year. In terms of export, whereas the share of Drugs, pharma and fine chemicals has increased, the share of dyes/intermediates and Coal tar chemicals has declined marginally in the overall export of the country(in Appendix See tableA1).

13 This is 25% of the global chemical industry in 2002.

14 Specialty chemicals are formulated to custom specifications. Therefore, their formulations can vary from one customer to another, even within the same industry. The formulations vary with applications, functions and even with specific operational conditions. Manufacturing (formulations) technology is simple. This sector is extremely service intensive- requires technical expertise in applications engineering and customer servicing. Often, these formulations are proprietary in nature. There is high unit price realisation and margins in specialty chemicals. The minimum economic capacity is low at 2000-10000 tonnes per annum. The investment required to set up specialty unit is in the range of Rs crores to Rs 15 corers

15 Together, they represent approximately 24% by value of the specialty chemicals market. The single largest specialty chemicals segment is active pharmaceutical ingredients with a sales volume of $38.5 billion. It also shows the highest forecast annual growth rate with 6.6%. High growth rates are found in various subsegments:

16 They represents 11% of the total specialty chemicals market. Pesticides are the largest of these industries with a market share of 7.4%.

17 The maturing of markets and the more intense competitive environment have exposed key segments of the specialty chemicals industry to the cyclicality of the industrial markets they serve. Some producers have tried to counteract this trend by increasingly tailoring their products and services to the special needs of customers, but at the cost of increasing complexity in their businesses. The real effect occurs later in the cycle as raw material costs rise. Specialty chemical companies are now finding it difficult to pass on their costs in the form of price increases.

18 The globalization of suppliers, customers and competitors has increased price competition. The production processes of these chemicals have become cost driven because the products no longer have patent protection nor a unique selling position.

Usually, the largest supplier with global reach is the cost leader. Excess production capacities have led to price wars and fierce competition from producers in China and India. Ways to offset the commoditization of a specialty chemical include establishing partnerships to offer a broader product line and superior logistics capabilities, combining product offering with service and technical troubleshooting, or moving a product into a new geographic market

[19] As per the estimates of KPMG,2002, India's specialty industry segment is about 25% of the total. The Industry association also uses this figure.

[20] The Indian Fine Chemical Industry is on a growth path. Fine chemicals are driven by pharmaceutical. The herbicide and pesticides Industry also use these chemicals. Performance chemicals find applications on the basis of their specific functions in a variety of industries such as textile, petrochemicals, polymers, rubber and leather products etc.

[21] For details of research methodology and variables see the appendix 2

[22] The data has been collected from the secondary sources, companies' website and CMIE' Prowess database.

[23] Comparing the papers published and patents per million population, the figure is very low for India.

[24] The discussion in section 4 shows the increasing competitiveness of the sector, but lacking adaptiveness, product specialization and geographic effect.

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Appendix I : Quantitative Analysis Tables

Table: 1.1 Share of Chemicals and others in the total Import and Export of India

Major Products	1997-98	1998-99	1999-00	2000-01	2001-02
			Share of major Imports		
Food and allied products	4.5	6.1	5.8	3.7	4.5
Fertilizers	2.7	2.3	2.8	1.5	1.3
Fuel including POL	22.6	17.6	27.4	33.2	29.5
Capital goods	18.2	16.6	12	11	11.4
Chemicals	9.4	9	7.9	6.7	7.6
			Share of major Exports		
Gems and Jewellery	15.3	17.5	20.4	16.6	16.7
Drugs, Pharmaceutical& fine chemicals	4.2	4.3	4.5	4.3	4.7
Dyes/intermediates & Coar tar chemicals	1.7	1.4	1.6	1.4	1.3
Machinery and instruments	3.4	3.4	3.2	3.7	4
Transport equipments	2.7	2.2	2.2	2.4	2.3
Electronic goods	2.2	1.5	1.8	2.4	2.7
Cotton yarn, fabrics, made-ups etc	9.3	8.2	8.4	7.9	7
Readymade garments	11.1	13.2	12.9	12.5	11.4
Handicrafts	3.4	3.7	3.6	3.1	2.5

Source: Economic Survey: 2003-04.

Table1.2: Analysis of Variance of Basic, Knowledge and Specialty Chemical Firms

	1997					2002				
	All Firms Total 322	Basic Chemicals Cases 127	Knowledge chemicals Cases 93	Specialty Chemicals Cases 102		All Firms Total 322	Basic Chemicals Cases 127	Knowledge chemicals Cases 93	Specialty Chemicals Cases 102	
Variable	**Means**	**Means**	**Means**	**Means**	**F**	**Means**	**Means**	**Means**	**Means**	**F**
Size	1.729	1.887	1.621	1.629	4.183***	1.925	2.035	1.929	1.782	2.903**
Age	1.378	1.376	1.326	1.428	3.223**	1.378	1.376	1.326	1.428	3.223**
Foreign Equity	6.840	3.155	8.506	9.908	4.405***	6.840	3.155	8.506	9.908	4.405***
R & D	0.008	0.001	0.021	0.005	3.241**	0.006	0.001	0.016	0.004	19.243***
Tech Fee	0.001	0.001	0.001	0.002	1.600	0.001	0.001	0.001	0.002	0.806
AD Intensity	0.008	0.002	0.016	0.009	12.537***	0.007	0.002	0.014	0.008	8.081***
Marketing intensity	0.042	0.043	0.041	0.041	0.045	0.050	0.049	0.057	0.046	1.401
Labour Productivity	4.388	5.589	3.213	3.965	7.307***	2.472	2.147	2.662	2.704	0.791
Capital Intensity	2.415	1.717	1.802	3.841	0.619	1.563	2.233	1.194	1.063	1.881
Vertical Integration	0.224	0.241	0.217	0.208	0.821	0.193	0.168	0.224	0.197	4.245***
Export Intensity	0.103	0.085	0.123	0.107	1.188	0.133	0.106	0.170	0.133	2.360*
Import Intensity	0.147	0.178	0.141	0.112	3.032	0.119	0.127	0.109	0.119	0.340
ROI	0.114	0.097	0.104	0.145	5.927***	0.084	0.065	0.120	0.075	8.883***
ROS	0.091	0.108	0.078	0.083	0.307	0.068	0.038	0.113	0.063	3.569**
ROE	0.136	0.079	0.167	0.178	1.038	0.163	0.216	0.063	0.186	0.256

Note: * significant at 10%; ** significant at 5%; *** significant at 1%

Table 1.3 Result of Multinomial Regression

	1997 Dependent Variable Speciality Chemical & Basic Chemicals	Speciality Chemical & Knowledge chemicals	2002 Dependent Variable Speciality Chemical & Basic Chemicals	Speciality Chemical & Knowledge chemicals
Variable	**B**	**B**	**B**	**B**
Size	1.143***	0.568*	1.146***	0.34
Age	-0.89	-2.086***	-0.96	-2.390***
Foreign Equity	-0.01	-0.003	-0.027***	-0.01
R & D	-98.410***	20.559	-104.371***	54.704***
Tech Fee	-22.32	-4.770	-28.63	-33.87
AD Intensity	-42.843**	17.981**	-33.567**	8.48
Marketing intensity	0.87	-0.348	0.96	4.11
Labour Productivity	0.102*	-0.124	-0.145*	-0.221**
Capital Intensity	-0.03	-0.109	0.940***	0.587*
Vertical Integration	5.663***	4.503*	-2.23	-1.63
Export Intensity	-0.88	0.287	-0.33	-0.43
Import Intensity	1.05	1.617	-0.73	-1.65
ROI	-7.286**	-2.743	4.96	6.173*
ROS	-4.57	-4.676	1.72	4.14
ROE	0.111	0.372	0.01	-0.50
Constant	-0.41	1.676	-0.74	1.64

Note: * significant at 10%; ** significant at 5%; *** significant at 1%

Table 1.4 Analysis of Variance of Exporters and Non Exporters in Chemical Industry

	1997				2002			
Variable	**All Firms Total 385 Mean**	**Non Exporters Cases 120 Mean**	**Exporters Cases 265 Mean**	**F**	**Total Total 385 Mean**	**Non Exporters Cases 106 Mean**	**Exporters Cases 279 Mean**	**F**
Size	1.675	1.231	1.876	65.908***	1.846	1.298	2.054	84.837***
Age	1.363	1.285	1.399	14.120***	1.363	1.330	1.376	2.092
Foreign Equity	6.264	2.588	7.928	7.864***	6.264	2.479	7.702	6.978***
R & D	0.007	0.002	0.010	1.815	0.005	0.001	0.007	11.928***
Tech Fee	0.001	0.001	0.001	0.000	0.001	0.001	0.001	0.509
AD Intensity	0.008	0.008	0.008	0.001	0.007	0.005	0.007	0.678
Marketing intensity	0.040	0.031	0.045	7.862***	0.048	0.047	0.048	0.115
Labour Productivity	4.543	4.533	4.548	0.001	2.410	0.691	3.063	21.924***
Capital Intensity	2.296	3.970	1.538	2.390	0.191	0.154	0.206	8.374***
Vertical Integration	0.221	0.212	0.225	0.368	0.113	0.064	0.132	16.338***
Import Intensity	0.153	0.079	0.187	23.212***	1.608	2.468	1.282	4.889**
Debt Equity	19.093	6.709	24.700	0.371	21.819	1.825	29.415	0.662
ROI	0.108	0.090	0.116	4.522**	0.077	0.048	0.088	11.408***
ROS	0.089	0.044	0.109	4.343**	0.061	0.017	0.078	4.932**
ROE	0.125	0.069	0.151	1.956	0.162	0.033	0.212	1.078

Note: * significant at 10%; ** significant at 5%; *** significant at 1%

Table 1.5: Result of Logistic Regression

	1997 Dependent Variable Y=0 for Non Exporters Y=1 for Exporters	2002 Dependent Variable Y=0 for Non Exporters Y=1 for Exporters
Variable	**B**	**B**
Size	2.185***	-2.337
Size square	-0.29	10.792***
Age	0.233	-1.134*
Foreign Equity	0.0088	0.0098
R & D	44.956**	177.478***
Tech Fee	-14.6581	53.7324
AD Intensity	0.8441	1.4591
Marketing intensity	3.8714	-1.9067
Labour Productivity	-0.0255	0.0583
Capital Intensity	0.0341	0.0222
Vertical Integration	-0.3458	2.638**
Import Intensity	3.630***	1.0319
ROI	-2.9567	-0.7662
ROS	1.6357	-0.9696
ROE	0.599*	0.2798
Plastics Products	-0.6336	-1.546**
Soaps & Cosmetics	-0.7509	-0.1168
Paints & Dyes	-2.089***	-1.2157
Industrial Chemicals	-1.124*	-0.9604
Agrochem & Fertilisers	-0.5553	-0.2106
Speciality Chemicals	-1.414**	-1.488**
Petrochemicals	-1.119*	-0.934
Explosives	-5.6849	-5.1301
Constant	9.7444	2.353
-2 Log Likelihood	362.326	301.995
Goodness of Fit	494.178	345.76
Cox & Snell - R^2	0.259	0.317
Nagelkerke - R^2	0.364	0.46
Chi-Square	115.417***	145.951***
Overall	78.70%	81.46%

Note: * significant at 10%; ** significant at 5%; *** significant at 1%

Table 1.6: Result of Logistic Regression in Specialty Chemical Group

	1997 Dependent Variable Y=0 for Non Exporters Y=1 for Exporters	2002 Dependent Variable Y=0 for Non Exporters Y=1 for Exporters
Variable	**B**	**B**
Size	**2.345*** **	**2.821*** **
Age	**3.224***	**-0.7641**
Foreign Equity	**-0.071** **	**-0.011**
R & D	**360.014** **	**184.5678**
Tech Fee	**14.6624**	**379.6957**
AD Intensity	**26.9945**	**-13.761**
Marketing intensity	**41.616** **	**-5.5877**
Labour Productivity	**-0.091**	**0.002**
Capital Intensity	**0.286*** **	**1.265***
Vertical Integration	**-1.428**	**-2.4393**
Import Intensity	**0.5675**	**2.1809**
ROI	**-19.156*** **	**-11.2885**
ROS	**17.147** **	**20.691***
ROE	**2.929** **	**0.3049**
Constant	**-7.855*** **	**-3.4545**
-2 Log Likelihood	**62.599**	**59.379**
Goodness of Fit	**159.187**	**61.343**
Cox & Snell - R^2	**0.394**	**0.399**
Nagelkerke - R^2	**0.586**	**0.601**
Chi-Square	**51.006*** **	**51.922*** **
Overall	**84.31%**	**84.31%**

Note: *** significant at 10%; ** significant at 5%; *** significant at 1%**

Appendix II National Innovation System Tables

Table 2.1L National Expenditure on R&D by Sector

Sector	Central Sector	State Sector	Private Sector	Higher Education sector	Total	Private Sector share to the total	Govt & Higher Education share to the total
1985-86	1654.06	162.78	251.94	-	2068.78	12.2	87.8
1990-91	3058.27	365.92	549.98	-	3974.17	13.8	86.2
1993-94	4528.98	561.5	982.54	-	6073.02	16.2	83.8
1996-97	5727.79	855.07	2330.75	-	8913.61	26.1	73.9
1999-00*	10150.99	1177.46	3365.38	396.39	15090.22	22.3	77.7
2000-01*	11835.76	1350.56	4058.83	415.06	17660.21	23.0	77.0

Source: DST, Government of India

Table 2.2: Expenditure on Research & Development by Major Scientific Agencies

	Research and Development Expenditure							
Agency\ Year	1970-71	1980-81	1990-91	1998-99	70-71%	80-81%	90-91%	% 98-99
						% of the total R&D Expenditure		
CSIR	2155.73	6900.00	24918.80	71332.00	24.16	15.74	10.77	9.88
DRDO	1755.35	7970.00	68100.00	230020.00	19.68	18.18	29.44	31.84
DAE	2871.56	7347.81	27554.00	83670.00	32.19	16.76	11.91	11.58
Deptt of Biotechnology	-	-	4136.70	9446.88			1.79	1.31
Min of I &Tech	-	540.55	3303.04	6209.64		1.23	1.43	0.86
Ministry of Non-Con Energy Sources	-	400.44	1602.00	895.00		0.91	0.69	0.12
Deptt of Ocean Develop.	-	-	2780.35	8481.60			1.20	1.17
D S T	84.18	4063.69	11982.46	29899.51	0.94	9.27	5.18	4.14
Department of Space	-	5601.56	38622.18	151556.00		12.78	16.70	20.98
ICAR	1837.00	9744.67	27625.05	84404.06	20.59	22.23	11.94	11.68
ICMR	217.63	900.11	4454.01	8625.70	2.44	2.05	1.93	1.19
Ministry of Environ. & Forest	-	373.99	16209.27	37794.95		0.85	7.01	5.23
					0.00	0	0	0
Total	8921.45	43842.82	231287.00	722335.30	100.00	100	100	100

Source: DST, Government of India.

Table 2.3: Expenditure on R &D in Chemical Industry Groups

Industry Group	R&D Units	R&D Expenditure(Rs. Lakhs) 1994-95	1995-96	1996-97	1997-98	1998-99	R&D Expenditureas % of S.T.O. 94-95	95-96	96-97	97-98	98-99
PUBLIC SECTOR INDUSTRIES											
Fertilizers	8	1420.32	1196.24	1559.92	1769.28	1948.5	0.24	0.19	0.23	0.23	0.24
Chemicals(other than fertilizers)	16	3853.41	2362.61	2390.94	2402.57	2705.2	0.46	0.24	0.37	0.36	0.38
Photographic Raw Film & Paper	1	160.66	157.06	126.55	145.74	120	2.96	3.82	6.01	4.22	3.43
Dyestuffs	0	0.00	0.00	0	0	0	0.00	0.00	0	0	0
Drugs & Pharmaceuticals	7	578.13	484.32	444.02	463.18	490.18	0.89	1.07	1.41	1.9	1.9
Soaps, Cosmetics,Toilet Preparations	1	6.83	6.54	8.09	10.29	12.26	0.09	0.08	0.08	0.09	0.1
Glue & Gelatin	0	0.00	0.00	0	0	0	0.00	0.00	0	0	0
PRIVATE SECTOR INDUSTRIES											
Fertilizers	3	291.95	463.35	407.24	438.51	423.12	0.22	0.24	0.19	0.18	0.15
Chemicals(other than fertilizers)	153	20492.15	28553.49	16557.9	15065	16809	0.91	1.06	0.53	0.5	0.53
Photographic Raw Film & Paper	2	0.00	0.00	40.66	29.45	40.15	0.00	0.00	0.63	0.38	0.69
Dyestuffs	11	1068.54	957.56	600.43	914.38	536.71	0.21	0.16	0.72	1.04	0.63
Drugs & Pharmaceuticals	126	16002.68	19388.69	26189.5	28285.6	37260	0.41	0.40	0.63	0.62	0.76
Soaps, Cosmetics,Toilet Preparations	4	2248.58	2163.03	2525.32	2414.21	2664.2	0.56	0.48	0.37	0.3	0.27
Glue & Gelatin	5	249.55	94.47	74.52	89.63	97.24	2.39	0.59	0.01	0.02	0.02

Source: Data Collected and compiled by DST

Table : 2.4 Foreign direct Investment to India-Industry-wise

(US$Million)

Sector	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-01	2001-02	2002-03(P)
Chemicals & allied products	47	72	141	127	304	257	376	120	137	67	53
Computers	8	8	10	52	59	139	106	99	306	368	297
Engineering	70	33	132	252	730	580	428	326	273	231	262
Electrical and electronics	33	57	56	130	154	645	228	172	213	659	95
Finance	4	42	98	270	217	148	185	20	40	22	54
Food and Diary products	28	44	61	85	238	112	19	121	75	49	35
Pharmaceuticals	3	50	10	55	48	34	28	54	62	69	44
Services	2	20	93	100	15	321	368	116	226	1128	509
Others	85	79	276	348	292	720	262	553	578	395	309
Total	280	405	877	1419	2057	2956	2000	1581	1910	2988	1658

Source: RBI Bulletins.

Table 2.5: Foreign Investment Approval in Chemicals and few other selected Sectors (01/081991 to 31/05/2002)

Name of the Industry	Total	No. of Approvals Technical Collaboration (TC)	Financial Collaboration (FC)	% of total TC Approved	% of total FC Approved	Amount of FDI approved (Rs. In Millions)	% of total Amount Approved
Metallurgical	694	351	343	4.99	2.30	154036.97	5.59
Fuels	893	268	625	3.81	4.20	774067.34	27.6
Electrical	4689	1159	3530	16.47	23.71	273995.96	9.77
Telecommunications	828	127	701	1.80	4.71	562245.72	20.05
Transportation	1471	587	884	8.34	5.94	206000.56	7.35
Fertilizers	66	57	9	0.81	0.06	3254.41	0.12
Chemicals	1729	801	928	11.38	6.23	127542.74	4.55
Photographic	28	12	16	0.17	0.11	2366.87	0.08
Dye-Stuffs	22	4	18	0.06	0.12	1188.87	0.04
Drugs & Pharmaceuticals	497	240	257	3.41	1.73	29168.05	1.04
Soaps, Cosmetics & Toilet preparations	63	21	42	0.30	0.28	3784.8	0.13
Glue & Gelatin	5	1	4	0.01	0.03	19.33	0
Service Sector	999	56	943	0.80	6.33	179324.9	6.39
Miscellaneous	1938	726	1212	10.31	8.14	57116.28	2.04
Grand Total	21926	7039	14887	100	100	2804421.5	100

Source: RBI Bulletins.

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