CHAPTER 5

IMPACT OF GLOBALISATION ON INDIA’S TECHNOLOGY REGIME: A QUANTITATIVE EXPLORATION FOR INDIA’S ORGANISED MANUFACTURING INDUSTRIES
5.1. Introduction

Manufacturing may be defined as the process of converting raw materials, components, or parts into finished goods that meet a customer's expectations or specifications. Normally a man-machine setup is employed under manufacturing with the division of labour at the core of the production level in a large scale framework. As per Webster’s II New University Dictionary, Houghton Mifflin, Boston, (1984), manufacturing is the making or processing (raw material) into a finished product especially by a large-scale industrial production with industrial machines.

The management cycle of industrial process involves the following steps: estimating → planning → scheduling → execution → evaluation. To what extent a manufacturing organisation will be able to place it at the helm of the competitive environment depends on all elements of the manufacturing system to satisfy the needs and wants of its customers in a timely and effective manner.

The manufacturing production system is classified into mass production, batch production and jobbing shop production. In mass production the volume of output is large, labour skill needed is low and intensity of specialized equipment and tooling is high. A batch process is one which does not involve sufficient volume from a single product rather the common components are made in volume and used to form products as needed. The jobbing shop system provides facility that is capable of producing a wide variety of products in very small volumes. The production facility is general purpose and flexible enough to meet a variety of needs. With the improvement in the application of technology and knowledge in the production another system has been developed, i.e., assembly line or flow shop production in which discrete parts are put together to make a finished product. It is a high volume operation that produces products that are very similar in features and performance. In this case, items are produced in a continuous manner with usually only one possible routing and it requires high automation.
In all categories of the manufacturing production the innovative R&D efforts deserve significant role. Nelson and Winter (1982), in this regard, mentioned “the innovative R&D efforts of the firms in the industry take advantage, as it were, of new technological opportunities that have been created elsewhere. Greater R&D expenditure within the industry means that latent productivity is tracked more smoothly, but aside from that the path of best-practice productivity is unlikely to be much higher than it is when industry R&D expenditures are less”. It was also explained by them how the average productivity could be geared up. The superior techniques, defining ‘best practice’ temporarily, result from innovative R&D efforts. As the number of innovator becomes larger relative to the industry, the larger the immediate effect of such a technical change on industry average productivity and ‘when a new technique is imitated, the larger the imitator relative to the industry, the larger the impact on industry average productivity of each successive imitation of the new technique’ (ibid). Not only R&D efforts seem to play the pivotal role in the epoch of structural change in the manufacturing system ushered through the process of globalisation but there are other factors to be considered – new goods, new methods of production or shipment of products, new markets, new forms of industrial organisation, technologies used elsewhere-are also to considered and all these together constitute the technology regime within which the manufacturing process takes place.

The manufacturing process in India covers all manufacturing, processing and repair & maintenance services units irrespective of their employment size, investment and location. The organised sector refers to that portion of manufacturing activity which is formally registered with the state governments. The registered manufacturing sector includes all factories covered under sections 2m (i) and 2m (ii) of the Indian Factories Act (IFA), 1948 which refers to the factories employing 10 or more workers and using power or those employing 20 or more workers but not using power on any day of the preceding 12 months (for the entire country except the states of Arunachal Pradesh, Mizoram, and Sikkim and Union Territory of Lakshadweep). It also includes Bidi and Cigar establishments registered under Bidi and Cigar Workers (Condition of Employment) Act, 1966 with the same employment and use of power criteria as mentioned above. All electricity undertakings engaged in generation,
transmission and distribution of electricity registered with the Central Electricity Authority (CEA) were covered under ASI irrespective of their employment size, until 1997-98. Since 1998-99, the electricity units registered with the CEA and the departmental units such as railway workshops, RTC workshops, GOVT. MINTS, sanitary, water supply, gas storage, etc. are not covered under ASI.

It is worth taking into account that prior to the 1980s manufacturing was dominated by large, vertically integrated firms (for example, GM, GE, IBM, DEC, Fujitsu and Hitachi) that produced most parts and components within their country and firm boundaries using proprietary architecture. Today industries have increasingly become vertically segmented, with each segment managed by a different company, perhaps in a different country. Each stage in the value chain involves significant competition and the value and market power lie in the standards that create intellectual property-based monopolies (Intel chips and Windows, operating systems, for example). This has led to a growing proportion of international trade occurring in components and other intermediate goods, resulting in the growing integration of world markets, with an increased service component (for example, logistics and customs clearance) in the production of the final product. The new strategic weapon for assemblers (Dell, GM and Nokia) is supply chain management¹.

From 1950s to the ‘80s the Indian manufacturing sector was guided by protectionist industrial and trade policies which assigned the state the central role in making investment decisions.

It is true that the policy framework indulging in state-led import substitution had helped to create a diversified manufacturing sector; however, the industrial stagnation since the mid-1960s bolstered some tentative steps towards liberalizing these regimes in the late 1970s and early 1980s.

The liberalization of the economy has opened new windows of opportunity for manufacturing sector. Progressively the success of manufacturing industries depends on innovations, research and development. It is decisive not only to remain competitive but also, significant advantages can be gained by developing
and commercializing new technologies which have been made available with the entry of MNCs and increasing flow of FDI.

The study made by Trivedi, Lakshmanan, Jain and Gupta(2011) explained the relative position of six major industry groups of the organised sector in India for the period 1980-81 to 2003-04, namely, Food and Beverages, Chemical and Chemical Products, Leather and Leather Products, Metal and Metal Products, Machinery and Transport equipment and Textile and Textile Products. It was observed that ‘metal’ and ‘machinery and transport equipment’ industries, each, accounted for about one-fifth of Gross Value Added in the organized manufacturing sector. This was followed by Chemical industry which accounted for 13% of Gross Value Added. However, in terms of job provision Textiles and Food industries together accounted for about 38 per cent of jobs in the organized manufacturing sector. Leather industry has been the least important industry from the chosen industries.

Global value chain (GVC) is defined as the internationalisation of the production processes, whereby firms located in different countries participate in the different stages of the production process. CYGNUS (2005) pointed out that factors such as internationalisation of the production process across the countries, movement towards low efficient and low cost locations, increase in inter-dependency of countries collectively resulted in the emergence of Global Value Chain (GVC) that ultimately led to changing scenario of Indian manufacturing industry like:

- Functions which earlier fell under manufacturing domain like R&D, design development, marketing and customer support are being largely outsourced and are considered as service activity, once they are outsourced.

- The outsourcing of parts of manufacturing activity is mainly to make the operations economical while there is a growth in trade.

Moreover, it was pointed out that for the success of the Textiles, Pharmaceuticals and Automobiles, among others, investment in R&D, market diversity, focus on specialized areas of operation, global perspectives and knowledge, upward movement along the value chain, and In-house expertise to developing and absorbing the technology should be accorded with high priority.
Technological capabilities can best be described in terms of three levels: the basic level involves the ability to operate and maintain a new production plant based on imported technology, the intermediate level consists of the ability to duplicate and adapt the design for an imported plant and technique elsewhere in the country or abroad, while an advanced level involves a capability to undertake new designs and to develop new production systems and components (UNIDO, 2005). Indian manufacturing firms, mostly, have been operating at the basic or intermediate level of technological capabilities (ibid.)

In the present chapter, in an aggregated perspective, the impact of globalisation on India’s technology regime is studied. For this, how far and to what extent the R&D intensity of the manufacturing industries were influenced by different variables are examined since the R&D intensity measures the technological innovation and the technology adaptive capability of the industries and these, in turn, best serve the nature of technology regime. The study considers the following industries: Automobiles, Cement, Chemicals, Electronics, Software, Telecommunication, Personal Care, Pharmaceuticals, Engineering, Textiles, Refineries, Steel, Food Processing and Electric Equipment. Before embarking upon any empirical exercise, the nature of the industries and their technology status deserve analysis.

5.2 Indian Manufacturing Industries

5.2.1 Automobiles

Indian automobile industry started functioning within a protected environment and this continued for a long time. On the one hand, there were fewer firms in the market giving rise to an oligopolistic structure and on the other; the firms mostly depended on the import of technology for the growth. This resulted in little motivation for diversification and technology upgradation. Since the mid-eighties the deregulation and partial liberalisation led to introduction of new models of motor vehicles which, in turn, caused structural transformation of the industry. Technological upgradation was fostered through import of technology and the competence of recipient depended on the level of accumulated technological capability through learning –by- doing and in-house R&D efforts (Narayanan,
Following liberalisation in the 1990s, the Indian automotive industry transfigured into a relatively high-growth and dynamic one following the buoyant rise of the automotive industry. There has been a rapid spurt of production, investment and exports. Between 1996-97 and 2004-2005 auto-component production rose annually by about 18% while investment increased at an annual rate of 15%. During the span of nine-years, exports in the auto-components sector also grew sharply, at an average annual rate of 42% in the mid-to late 1990s, rising about 5 times from a modest value of US$ 291 million in 1996-97 to about US$ 1400 million in 2004-5 (Parhi,2008).

UNIDO (ibid.) observed that 'Indian companies had no longer been restricting themselves to component manufacturing. They were focusing on using their expertise in CAD/CAM and in designing and engineering capabilities by entering into designing and development of components for new product'. The report also stated that India’s strengths include designing to lower costs or designing more quickly. Firms in India lowered manufacturing costs by using design changes to optimize inputs. For example, the steering system of the Maruti Alto was redesigned so that its weight was lowered by 15 per cent. Through redesign, the stabilizer bar for another Indian car was reduced in weight by 40 per cent and in cost by 10 per cent. Faster design development reduced development costs and lead times. For instance, Indian suppliers designed system within six months for an automotive OEM, after the OEM had tried to develop a similar system with suppliers in other LCCs for over four years with no success.

5.2.2. Cement

The cement industry in India, among other energy intensive industries, has been identified as energy-intensive industry. Over the period 1973-1993, the real value of output increased by an average of 8.7% per annum showing second highest growth in the group of energy-intensive industries. At present the Indian cement industry produces 13 different varieties of cement employing three different process types- wet, semi-dry, and dry processes. As of 1997, the 86% of production was done in dry processes. During the period 2002-03 to 2006-07, the demand for cement increased without significant addition of capacity and as a result the capacity utilization level reached 100% in 2006-07.There was a
marked change in the product-mix during 2000-01 to 2008-09 towards Pozzalana Portland Cement (PPC) shrinking the share of Ordinary Portland Cement (OPC). Since 2005-06 all players in the cement industry started embarking upon the capacity expansion programmes and as in March, 2009 the country had an installed capacity of around 209 million tones\(^3\). It was reported that the companies with lower costs, stronger capital structures, and a diversified portfolio of plants and markets would be better placed to ride out the pressures in the medium term. Therefore the scope of further technological orientation in the industry cannot be ruled out.

5.2.3. Chemicals

As the contribution to the global Chemical industry by Asia has been growing India emerges as the focus for the chemical companies worldwide. In terms of volume India is the third-largest producer of chemicals in Asia\(^4\). The industry manufactures a wide spectrum of products spanning Basic, Speciality and Knowledge segments. While R&D remained a universal imperative for the industry its purpose and nature varied across segments. The focus of the basic chemical sector should focus on process innovation and product development and strengthen their competitiveness through improvements based on performance and quality of products. Firms in the knowledge based chemical sector should focus on R&D with the objective of achieving product leadership and process innovations.\(^5\)

During the highly protected environment Indian Chemical industry did not have to face completion and as such the firms in the industry used to operate in small scale. With liberalisation as the entry of MNCs in the industry took place the industry was under competitive pressure and it required investing more in upgrading technology. Nevertheless the industry did not register much headway towards escalation of spending in R&D as compared to other global players.

Six major chemicals produced in India are Methanol, Aniline, Alkyle Amines and its derivatives like Formaldehyde, Acetic Acid and Phenol and these contribute to nearly two third of Indian basic organic chemical industry. The balance one third
of the organic chemical consumption in the country is accounted for by other wide variety of chemicals.

At the industry level the Indian chemical industry is characterised by high domestic demand potential, high degree of fragmentation and small scale of operations, limited emphasis on export due to attention on domestic demand and small scale of operations, low cost competitiveness resulting from high cost of power, import duties, taxes and cost of capital and scant attention to R&D. R&D in the sector could be undertaken in respect of product development, process innovation, equipments for production and research related to application and safe use of chemicals.

5.2.4. Electronics

The electronics industry was set off around 1965 with an orientation towards space and defense technologies. Subsequently, the developments of consumer electronics, mainly transistor radios, black and white TV, calculator and other audio products took off. Colour Televisions soon followed. The year 1985 witnessed the Computers and Telephone Exchanges which were succeeded by Digital Exchanges in 1988.

The electronics industry in India constitutes just 0.7 % of the global electronics industry. India is an exporter of vast range of electronic components.

Until the 1970s the industry was highly protected. The slow growth of the electronics industry and its devolution of technology began to receive the attention of Indian policy makers by the late 1970s. Since 1983, the electronics policy started advocating liberalization. The first measures announced in 1983 were concerned with reducing input costs through the lowering of import duties and local taxes and encouraging economies of scale by removing some of the restrictions on the entry of large firms. A number of ambitious plans for setting up high-tech production facilities for integrated circuits (ICs) and electronic switching components were also announced, although some aspects of the policy fluctuated, particularly those related to import restrictions and duties. With liberalisation, the industry began to grow and embraced a diversified product line. In the pre-liberalization period the industry was characterized by high
production costs and obsolete product designs. In the post-liberalization era a sharp increase in the number of manufacturers who largely offer state-of-the-art designs\(^8\) was noticed. During the pre liberalisation period, the strong emphasis placed on self-reliance required manufacturers to use local, and often out-dated, designs while the import restrictions in effect required that components be purchased locally. Many of these were high priced and of poor quality. The liberal electronics policy removed this obstacle by simply allowing the import of Completely Knocked-Down kits (CKDs)/ Semi-Knocked-Down kits (SKDs) for local assembly. Alam (1990) criticised the liberalisation policy on the ground that the ‘policy of liberalization had some very serious negative repercussions. In particular, it created conditions where innovation became extremely unattractive. Instead of attaining production efficiency and technological superiority, manufacturers found it more profitable to minimize in-house value added by assembling imported kits. There was little incentive to carry out R&D and design activities and in fact, often the only requirement for success in the marketplace was the ability to identify and obtain components at the lowest price. Even those firms which developed a certain level of technological competence found that they could not compete with imports and were forced to abandon their in-house design activities in favour of imported designs and CKDs/SKDs\(^8\).

5.2.5. Software

The Indian software industry has exhibited commendable success. For the last thirty years it has been growing at the rate 30 % annually. The Indian software industry has grown from a mere US $ 150 million in 1991-92 to a staggering US $ 5.7 billion (including over $4 billion worth of software exports) in 1999-2000. No other Indian industry has performed so well against the global competition. The annual growth rate of India’s software exports has been consistently over 50 % since 1991. The IT and Software industry is a major economy player in India. Mainly based on IT software and facilities such as system integration, software experiments, custom application development and maintenance (CADM), Network and IT services and solutions; the country's IT-BPO industry expanded by 12% during fiscal year 2009, and attained aggregate returns of US$71.6 Billion. The IT industry in India had an increase of about US$7 billion in the
2008/2009 i.e. US$47.3 billion against US$40.9 billion in the previous financial year.

NASSCOM-Deloitte study showed that the contribution of the IT/ITES industry to the GDP of India had gone up to a share of 5% in 2007 from the meager 1.2% in 1998. Revenues from the Industry have been put at US$64 billion and its growth rate stood at 33% in the Fiscal Year ended 2008.

Software is usually classified by type of use and by customization. Types of software by usage:

1. System-level software: programs that manage the internal operations of the computer, such as operating system software, driver software, virus scan software and utilities.

2. Tools software: programs that help applications to work better, such as database management software.

3. Applications: programs that deliver solutions to the end-user, such as word processing software and financial accounting software.

Types of software by customization:

Software is either (1) written for general use and replicated in its original form across many users, or, (2) written for a specific user. The former is termed a software product or package. The latter is termed custom software.

While the System-level software is the most complex as it manages the interfaces with both hardware and higher level software; applications software is the least complex. Nowadays, all system level software are products. Since variations in needs appear most at the stage of applications, most customized software is applications software.

Major software and IT industry players in India include, Tata Consultancy Services, Wipro Limited, Infosys, HCL Technologies, Tech Mahindra, Patni Computer Systems, i-flex solutions, Mphasis, L&T Infotech and IBM India. There are numerous software companies in the country but the above are the top
companies that offer IT and software services. Software exports from India have increased and account for about 60% of India's total software revenue. This has been boosted by the domestic software market that depends on the sale of software packages and products, earning revenue for the country. About 40% of the domestic software market is made of products while more than 80% of software exports earnings are generated by services like custom software development and consultancy services.

The NASSCOM-BCG Innovation Report 2007 stated that the Indian IT-ITES industry has evolved through three distinct phases: Phase 1 was typically an export-led growth driven by factor arbitrage for relatively commoditised services like application development and management. The Indian IT-ITES firms invested little in R&D and consequently created little intellectual property assets. During phase 2, the Indian IT-ITES firms gained domain experience and developed a reputation for superior delivery and hence were able to capture value in the market. During phase 3 (current phase), the firms are moving into higher value services like IT consulting, systems integration, engineering services, contract R&D, etc.

The report made it explicitly clear that the industry being at an inflection point needs to differentiate itself by creating new sources of competitive advantage through sustained innovation. The customers who are becoming more knowledgeable and demanding want to move from pure factor arbitrage predicated vendor services to partnerships which deliver business value and productivity gains through innovation. The current innovation footprint of the Indian IT-ITES industry is heavily skewed away from market-facing and breakthrough innovation efforts and is focusing predominantly on sustaining, and some enhancing, innovations on inputs and business processes. The report confirmed that while sustaining innovations are important, only a significant shift towards more market-facing breakthrough and enhancing innovations will provide the necessary revenue impetus in the medium to long-term. According to the report the following areas of innovation can address this need:

a) Penetrating new customer segments in intellectual asset-intensive service lines like engineering and R&D services
b) Creating IP in emerging technology areas and

c) Technical innovations to own standards for next generation of technologies.

5.2.6. Telecommunication

The Indian telecom sector was entirely under government ownership until 1984, when the private sector was allowed in telecommunication equipment manufacturing only. In order to concretise its earlier efforts towards developing R&D in the sector the government set up an autonomous body – Centre for Development of Telematics(C-DOT) in 1984 to develop state-of-the-art telecommunication technology. The objective was to meet the growing needs of the Indian telecommunication network. The actual evolution of the industry started after the Government separated the Department of Post and Telegraph in 1985 by setting up the Department of Posts and the Department of Telecommunications (DoT).

The entire evolution of the telecom industry can be classified into three distinct phases: Phase I- Pre- Liberalisation Era (1980-89), Phase II- Post Liberalisation Era (1990-99) and Phase III- Post 2000.

The Telegraph Act, 1985, empowered the government to hold monopoly on all types of communications until the liberalisation started in the 1990s after which the Indian telecom market has become one of the most liberalised markets in the world with private participation in almost all of its segments. The New Telecom Policy (NTP-99) provided the much needed impetus to the growth of this industry and set the trend for liberalisation in the industry.

The three major technological innovations that have taken place in the Electronics, Telecommunications & IT are:

i. Innovations in digitalization, computerization, and miniaturization

ii. Innovations in the Internet, Mobile communications, Packet based Next Generation Networks (NGN) leading to convergence of services.
iii. Innovations related to ICT as a generic technology to redesign and rationalize production, administration and transaction processes and to create new processes and products to create the information society.\(^9\)

The successful innovation and digitalisation of technology had been an outcome of indigenisation of technology in the 1990s which kept the prices of telecom imports low since there was always a competing Indian product. Moreover, the Indian R&D and manufacturing segments gained self-confidence as a sequel to it.

R&D intensity in the telecom industry has been negligible. In 2005-06 out of the total R&D spending by the public sector the share of the telecom industry was 3.04\%, out of the expenditure by the private sector it was 1.57\% and that of the industrial sector it stood at 1.83\%.

In order to beef up R&D infrastructure in the telecom sector and bridge the digital divide, cellular operators, top academic institutes and the Government of India together set up the Telecom Centres of Excellence (COEs).

Seven Centres of Excellences in various field of Telecom have been set up with the support of Government and the participation of private/public telecom operators as sponsors, at the selected academic institutions of India. To support Research & development in the country and promoting Start-ups focused on technology and innovation, a weighted deduction of 150\% of expenditure incurred on in-house R&D is introduced under the Income Tax Act. In addition to the existing scheme for funding various R&D projects have been funded through new scheme like Support International Patent Protection in Electronics & IT (SIP-EIT), Multiplier Grants Scheme (MGS).

The government has initiated the setting up of an Open Technology Center through NIC aimed at giving effective direction to the country on Open Technology in the areas of Open Source Solutions, (OSS), Open Standard, Open Processes, Open Hardware specifications and Open Course-ware. This initiative will act as a National Knowledge facility providing synergy to the overall components of Open Technology globally.
5.2.7. Food Processing

Food processing involves any type of value addition to agricultural or horticultural produce and also includes processes such as grading, sorting, and packaging which enhance shelf life of food products. Vital linkages and synergies between industry and agriculture are ensured through food processing. In terms of production, consumption, export and growth prospects the Food Processing Industry in India is one of the largest sectors. The government has announced fiscal reliefs and incentives, to encourage commercialization and value addition to agricultural produce, for minimizing pre/post harvest wastage, generating employment and export growth. India's food processing sector covers a wide range of products fruit and vegetables; meat and poultry; milk and milk products, alcoholic beverages, fisheries, plantation, grain processing and other consumer product groups like confectionery, chocolates and cocoa products, Soya-based products, mineral water, high protein foods etc.

Indian food processing industry is widely recognized as a 'sunrise industry' having huge potential for uplifting agricultural economy, creation of large scale processed food manufacturing and food chain facilities, and the resultant generation of employment and export earnings. The industry is estimated to be worth around US$ 67 billion and employing about 13 million people directly and about 35 million people indirectly.

In terms of this industry India has certain advantages being one of the largest producer of food in the world, having diverse raw material base suitable for food processing companies, 50 per cent of household expenditure by Indians being on food items and having the proximity of India to markets in Europe and Far East, South East and West Asia. The opportunities open to the economy in terms of the industry are that the country has the processable varieties of crop, contract farming, investments in infrastructure through Public Private partnership (PPP), Mega Food parks, Integrated cold chain and Food safety Management Systems.

Two nodal agencies, Agricultural & Processed food products Export Development Authority (APEDA) and Marine Products Export Development
Authority (MPEDA), were formed for promoting exports from India. MPEDA is responsible for overseeing all fish and fishery product exports; APEDA, on the other hand, holds responsibility for the exports of other processed food products.

UNIDO (2005) enumerated the following market features that determine the types of technologies and processing equipments required by India: first, the technologies for food processing in India are not at par with the global standards despite having the capability of design, development and construction of process plant machinery matching international standards, secondly, there are many units producing jam, jelly, pickles marketed locally which are in the tiny and cottage sector and do not adhere to F.P.O quality standards. Also, they are reluctant to adopt new capital intensive technologies. Thirdly, there is a lack of in-house quality control and testing facilities in conformity with the international standards posing critical bottleneck in exports of products as nontariff barriers lead to stringent food import norms in developed countries and lastly, poor infrastructure facilities such as irregular power supply, high inland transportation cost and lack of cold chain facilities etc. Lastly, there is lack of adequate storage facilities and adequate infrastructure to facilitate the transportation and marketing of processed food products. This continues to impede the development of large scale processing in India.

Some of the technological trends in agro/food processing sector in India include:

Food extrusion Technology: The technology has been fully absorbed and adapted to suit Indian conditions. The technology is used especially in case of meat products.

Cold Chain Technology: The task of cold chain is to minimize damages to raw materials from farm to factory. India is now beginning to build the necessary cold chain infrastructure. The metro cities in India already have a well-connected cold chain. However, cost effective technologies are still required to grow food processing sector.

Food preservation technologies: The increasing demand for high quality processed foods is driving industrial houses to adopt novel preservation techniques. These are aimed at increasing the shelf life of products and also at
preserving the nutritional value of foods up to the point of consumption. The emerging food preservation technologies include Hurdle preservation, Ohmic heating, Ultra high pressure processing, Irradiation, modified atmosphere packaging and high –intensity pulsed electric fields, anti-microbial enzymes and active packaging.

In addition to these technologies, research in non-thermal food preservation processes is being pursued in many university and industry R&D laboratories (ibid).

India would need food processing technologies and equipment in the following areas- processed meat, especially poultry, soft/fruit drinks, ready-to-eat/serve snacks, value-added dairy products, specialty processing equipment for bakery and confectionery items, and thermo-processing. New and used slaughter line equipment, dairy equipment, sausage casing/sausage making equipment, meat tenderizing equipment, pizza making machines, mixing tanks, and snack food making machinery are some major items in demand in India (ibid).

Innovation and new product launches are the key priorities for the companies in the food processing industry in the developed countries. However, given the nascent stage of the food processing industry in India, spending on R&D has been significantly low even for large companies in the organised sector\textsuperscript{10}, e.g., the R&D spending of some of India’s prominent companies in the industry are as follows:

a) Dabur - Rs. 1.24 Crores (USD 0.25 Million) or 0.06% of the gross turnover

b) Britannia Industries Limited - Rs. 3.47 Crores (0.70 Million) or 0.133% of the gross turnover.

Global organizations however spend significantly on R&D:

a) Nestle - CHF 1.97 billion or 1.80% of the gross turnover

b) Unilever - Euro 927 million or 2.29 % of the gross turnover.
Hence, both on an absolute basis as well as on a percentage basis, Indian companies have been spending lower on R&D compared to their global peers.

The industry is reported to have starved of appropriate technologies affordable to self-employed entrepreneurs, micro enterprises and small-scale sector processing units. During the last one and half decade the players existing in the government funded R&D system have miserably failed the industry and their blind pursuit of useless patents and income generation by any means has pushed the industry in a miserable state.

The food processing sector is a high priority sector that is poised to grow significantly in the next 10-15 years. However, the technological capabilities and technology adoption in Indian organizations is very low. India would require extensive technology development and import initiatives to realise its goals of being a export powerhouse and improving efficiencies in food sector (UNIDO, 2005).

5.2.8. Refinery

Indian refining industry has emerged as a major global player. For the last few years, the country emerged as a refinery hub and the refining capacity has exceeded the demand. According to the Ministry of Petroleum and Natural Gas, Government of India, the country’s refining capacity has increased from a modest 62 Million Metric Tonnes Per Annum (MMTPA) in 1998 to 215.066 MMTPA at present, comprising of 22 refineries - 17 under Public Sector, 3 under private sector and 2 in Joint Venture (JV). During 2011-12, two new JV refineries of 6 MMTPA and 15 MMTPA were commissioned in Bina, Madhya Pradesh and Bathinda, Punjab.

During the XII Five Year Plan there has been an increase of 50.600 MMPTA capacities of the eleven companies altogether in the refinery sector.

Crude oil contains hydrocarbons that vary in their boiling point. Refining is a process in which crude oil is heated in a vacuum until it evaporates and then allowed to rise up a column. Different hydrocarbons liquefy at different temperatures and can be collected at various heights in the distillation column.
The principal products, with their approximate boiling points, are petroleum gas (20°C), naphtha (40°C), petrol (70°C), kerosene and jet fuel (120°C), diesel (200°C), lubricant (300°C), and furnace oil (370°C); solid petroleum coke collects at the bottom after the liquid fractions are removed\textsuperscript{11}.

Report of the Working Group on Petroleum & Natural Gas Sector for the XI Plan (2007-2012)\textit{(Ministry of Petroleum & Natural Gas, November, 2006)} pointed out the following features of R&D to be accomplished in regard to the refining sector:

(a) In order to be a catalyst in the entire development cycle, R&D policy for petroleum sector ought to be industry friendly. It must include attributes, which should effectively inculcate the culture of academia-industry interactions, export orientation, competitiveness apart from the development of human resources.

(b) R&D activities would require close interaction between industry and research organisations. Involvement of the industry was considered essential in the areas of selection/prioritisation of R&D projects, becoming the stake holder for the R&D projects, project formulation and monitoring the progress of the projects and implementation of the findings of R&D works etc.

(c) India is spending around Rs.200-250 crores on R&D efforts in the hydrocarbon sector having an annual turnover of around Rs.400,000 crores. There is an urgent need to increase expenditure in R&D, keeping in proportion to the turnover of the industry.

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(e) There is huge scope for improvement in the hydrocarbon sector through R&D. Emphasis is required to encourage a culture of R&D in the oil industry. The benefits of R&D could be multiplied by ensuring close interaction between refining industry and research institutions.
(f) Today Indian refining industry is facing new challenges which includes surplus capacity, volatile refining margins, stringent fuel specifications, emergence of alternatives such as fuel cells, hydrogen etc. Besides the need for improving energy efficiency is increasingly becoming paramount. There have been concerns over depleting crude oil resources and we ought to look at ways and means to enhance recovery rate while at the same time look at alternative energy sources.

(g) As the country takes its place in the global arena, India has to match world-class technologies and indeed turn from consumers to providers of technologies. A high oil price provides great incentive in coming up with alternatives. Further, it has been statistically proved that innovation is not prerogative of large corporation but small companies could be equally innovative. This provides scope for a comprehensive R & D program.

(h) R&D could be tackled at two levels - (a) at the level of educational institutes, universities and colleges and (b) at the industry level. To build a culture of R&D in the educational institutes, encouragement is needed to undertake basic research in the hydrocarbon sector on specified areas relating to their fields through government grants. At the corporate level, R&D thrust should be driven by business level strategy i.e. in refining - technology to upgrade heavy petroleum residue to clean fuels, alternative source of energy/technology which can replace fossil fuel, process/catalyst improvement etc. and in the upstream-improving extraction ratio, E&P evaluation etc.

5.2.9. Personal Care

The industry is divided into fabric wash, personal wash, hair care, oral cares, skin care, colored cosmetics, men’s toiletries and fragrances. The industry is characterised by low entry barrier and severe competition. Besides the large multinational players, there are some leading domestic players as well as the huge unorganized players. Notwithstanding most of the market share residing with the larger players, companies compete for the marginal market share. The major players are affected by the cheaper imports and duplicate products.
In order to meet diversified demand the industry has moved from basic products, such as soaps, shampoos and hair oils, to functional products, such as cold creams, and now to specialized products, such as sun block lotions, body exfoliating creams and skin whitening & anti-ageing products.

The Indian personal care ingredients market is currently estimated at ~$300-350 million. The relatively higher price sensitivity of the Indian personal care market has traditionally limited the role of high value personal care ingredients. This has also contributed to lower R&D spends and fewer innovations by the Indian personal care product formulation companies, few of which are backward integrated in the personal care ingredients space. However, the recent market developments and changed competitive landscape with the advent of large corporations willing to take investment decisions for a longer time horizon have contributed to changing the scenario\textsuperscript{12}.

The presence of Multinational players with international brands has been the feature of the Indian formulation segment. Local brands too are gaining a foothold in the market by innovatively developing value offerings to meet the unique needs of the Indian consumer. The development of R&D capabilities is necessary for further customizing products for Indian consumers, creating greater awareness among the burgeoning middle class and ensuring effective distribution reach to service them. It is reported that the companies that are able to develop a judicious mix of the above will be the eventual winners. The time is ripe to review one’s strategy and come up with innovative approaches to help realise the full potential of the Indian personal care sector, where the ingredients market is likely to double in the next four years.

5.2.10. Textiles

India’s Textile industry was predominantly unorganized industry even a few years back, but the scenario started changing after the economic liberalization of Indian economy in 1991. The opening up of the economy provided the much-needed thrust to the Indian textile industry and it has now successfully become one of the largest in the world. The industry contributes about 14 per cent to industrial production, 4 per cent to the country's gross domestic product (GDP)
and 17 per cent to the country’s export earnings. The industry provides direct employment to over 35 million people and is the second largest provider of employment after agriculture. It not only generates jobs in its own industry, but also opens up scopes for the other ancillary sectors.

The different segments of the industry are- Cotton Textiles, Silk Textiles, Woolen Textiles, Readymade Garments, Hand-crafted Textiles and Jute and Coir.

The expenditure on R&D by Central Ministries/Departments other than major Scientific Agencies in textiles during the years 2002-03, 2003-04, 2004-05 and 2005-06 were Rs 7910.94, 8174.44, 9090.06 and 8936 lakh respectively(Department of Science and Technology, Government of India). 

To what extent an industry acquires technology is reflected, among others, in its expenditure made on the payment of royalty. Suman & Mehra (2000) provided an empirical finding on the expenditure made by Indian firms on royalty payment. It was revealed that for the period 1990-91 to 2006-07 ‘highest investment on royalty payment has been made by Post and Telecommunication and followed by Extraction of Crude Petroleum and Natural Gas etc., Mining of Coal and Lignite etc. At next level (one fifth to one eighth expenditure) are Manufacturing of Motor Vehicles, Manufacturing of Basic Metals and Manufacturing of Food Products and Beverages. Manufacturing of Chemicals and Chemical Products is in the top 10 sectors ranking for expenses made towards Royalty payments’. The study also supplemented the analysis with the data on expenditure made by the firms on R&D. On both counts, the ranking of manufacturing of textiles did not fall within the first tenth during the same period.

5.2.11. Pharmaceuticals

According to the report on the Indian Pharmaceuticals industry India represents $6 billion of the $550 billion global pharmaceutical industry but its share is increasing at 10 % a year, compared to 7 % annual growth for the world market overall. The “organized” sector of India's pharmaceutical industry consists of 250 to 300 companies and this sector accounts for 70 % of products on the market, with the top 10 firms representing 30 %. However, the total sector is estimated at nearly 20,000 businesses, some of which are extremely small.
Approximately 75% of India's demand for medicines is met by local manufacturing. The KPMG report said that Pharmaceutical production costs are almost 50% lower in India than in Western nations, while overall R&D costs are about one-eighth and clinical trial expenses around one-tenth of Western levels.

Pradhan & Puttaswamaiah (2005) confirmed that Indian pharmaceutical industry today stands among the technologically most vibrant segments of Indian manufacturing. Since late 1960s strategic policy interventions were consciously undertaken in order to achieve self-sufficiency in drugs production, self-reliance in drugs technology and accessibility of quality drugs at reasonable prices and these culminated in enabling the industry to exhibit the growth and technological development. The same study provided a glimpse of the R&D intensity in the industry which runs as ‘R&D activity in Indian pharmaceutical industry has increased substantially in the latter half of the nineties, both in absolute amount of rupees spent and as a proportion of total turnover. The estimated R&D expenditure by the sample firms has risen from mere Rs. 8 crores in 1990 to an impressive figure of Rs. 515 crores in 2001’. The sample firms in the study were reported to have spent around 2.2% of sales in 2001 as compared to 0.2% in 1990. In terms of R&D intensity the performance of foreign firms was however observed to be contrary to the expectation when compared to domestic firms. The observed R&D intensity of domestic firms, 2.6%, was three and half times higher than that of foreign firms, which is low at 0.74%. However impressive had been the growth of R&D intensity it had been low compared to the then international level at 10-15% of sales.

In another study (Kumari, 2007), analysing the impact of liberalisation policies on technology imports in Indian Pharmaceutical Industry, it was found on the basis of estimated function that among the factors determining technology imports, it was size of firm and not growth of firm or export orientation which had been significantly determining technology imports in the pharmaceutical industry.

UNIDO (ibid.) indicated that driven by the change to a product patent regime and the opportunities offered in the international market, the mindset of Indian companies towards research has altered. Indian companies are shifting their focus to innovative research that is, developing non-infringing processes, New
Chemical Entities (NCEs), Novel Drug Delivery Systems (NDDS), Biopharmaceuticals etc. Thus Indian drug companies have started to invest more in research and development to produce their own patented formulations, or to affiliate themselves with large Western pharmaceutical companies and become outsourcing centres for some of those firms’ activities, such as clinical trials. The better-financed companies are already attempting to develop their own drugs—to become innovators instead of just copiers. This is an expensive process, and will not yield results quickly, if ever. As an alternative, Indian firms are expanding their overseas sales of existing generic drugs. To that end, some have already established production facilities and equipment that meet regulatory standards in the US and elsewhere. Some Indian companies have also begun purchasing foreign pharmaceutical firms to improve their access to overseas markets and develop new profit streams. Finally, Indian firms have begun collaborating with Western drug companies on back-office clinical trials and other research-oriented activities, which Indian companies can often perform at a fraction of the developed-country cost.

5.2.12. Steel

Within the energy intensive industries the iron and steel sector holds a considerable share. In 1993 it accounted for 46.5% of value of output within the energy intensive industries and for 7.8% in the manufacturing sector. Production in the iron and steel sector has been increasing over the last 20 years. Over the period 1973-1993 real value of output increased by an average of 7.6% p.a. Following the fertilizer and cement industry, iron and steel shows third highest growth in the group of energy intensive industries. The growth of real value of output was stable at around 7.8% during the pre liberalization period (1973-1985) and decreased significantly to 6.2% in the following period of economic liberalization (1985-91).

In 1991, as the liberalization process culminated, real value of output growth increased substantially by 10.2% until 1993. The economic liberalisation of the 90s witnessed the entry of several large integrated steel plants in the realm of private sector (Essar Steel, JSW Ispat Steel and JSW Steel). The country experienced rapid growth in steel making capacity mainly owing to two factors -
new players streaming in to join the race and modernisation and expansion of existing plants. During this period, a large number of coal based sponge iron plants and electric induction furnace based steel making plants came into existence. As a result of this production capacity of steel increased from 21 MT (crude steel) in 1990-91 to over 78 MT in 2010-11.

India has abundance of iron ore, many other raw materials for iron making, and cheap labour. It has the fourth largest iron ore reserves (10.3 billion tonnes) after Russia, Brazil, and Australia. It has the third largest pool of technical manpower next to United States and erstwhile USSR. In spite of these advantages, it could not adopt the advancement of technology satisfactorily. After independence in 1947, five major integrated steel plants were set up under public sector during late ‘50s and early ‘60s. The total saleable steel production, which was only 0.9 million ton per annum (mtpa) in 1947, raised to nearly 19 MT pa in 1997-98.

Between the fifties and the seventies, large integrated steel plants were set up in the public sector at Bhilai (BSP), Durgapur (DSP), Rourkela (RSP) and Bokaro (BSL), and Steel Authority of India (SAIL) came into being as the largest steel producer in the country. Plants like Rourkela Steel Plant (RSP) adopted the state-of-the-art technologies of the time, namely LD steel making. Another Greenfield public sector plant i.e. Visakhapatnam Steel Plant (VSP) was set up in the 90s, which incorporated a few modern technologies and practices of the day.

In 2010, India produced 68.32 MT crude steel and was ranked the fourth largest steel producer in the world, after China, Japan and the US. The industry is growing fast at the rate of 9-10 % and such a growth rate is considered necessary to sustain the economic development of the country. Per capita steel consumption in India is low at 55 kg as against the world average of 200 kg. This justifies the need for a rapid increase in capacity and production of steel in the years to come.

There are two main process routes for steelmaking - the "primary or integrated route" based on Blast furnace (BF) and Basic oxygen furnace (BOF)/LD
Converter using iron ore as the basic raw material and the Electric Arc Furnace (EAF) route using steel scrap as basic raw material with or without sponge iron.

In India, steel is produced adopting three main process routes - Basic Oxygen Furnace (BOF), Electric Arc Furnace (EAF) and Electric Induction Furnace (EIF).

Since the 1990s far reaching changes have been observed in the industry. The new units brought in new technologies to this industry. Existing units in both private and public sectors have undertaken extensive programs of modernisation, expansion and debottlenecking. It is worth mentioning that the new age entrepreneurs have shown a rare foresight in embracing state-of-the-art technologies and have innovated with alternate and mixed routes of production in keeping with the exigencies of raw material availability. Industry experts believe that a second push to the Indian steel industry must come from within through focused efforts to enhance efficiency in all areas of operation - from mining of raw materials to finishing of the final products. In this context attention should be paid to the R&D upheld by the industry. Moreover, at the advent of liberalisation in 1991 managing the technological change in steel industry had become an essential task for the Indian economy especially so for being rapidly industrialised economy.

Indian companies put less emphasis on R&D expenditure. Except a very few companies, the overall focus on R&D is too low. As for example, in 1997-98, companies like Tata Steel and Reliance spent only 0.14% and 0.29% of their sales value respectively on R&D. Out of large Indian companies only just a few spent a good amount (e.g., Ranbaxy 3.88%, TELCO 2.03%) in 1997-98. The in-house research facilities in most of the large integrated steel plants are not properly organised. Many of them started their R&D activities late.

According to a source of the Ministry of Steel, Government of India, of late several large steel plants have been setup in the country and they are gradually setting up relevant infrastructure for pursuing in house R&D to address their technological problems. However, most of these R&D projects have been limited to day to day problems of the company and are mainly directed towards incremental development. As such initiatives towards disruptive R&D for
development of path breaking technology is limited. Investment in research and
development in Indian steel industry in general has been limited. Actual
investment varies in the range of 0.15-0.25% of the sales turnover.

5.2.13. Engineering

Of the overall Indian manufacturing sector engineering is the largest part. By the
early 1970’s, India had achieved the capacity to produce almost all verities of
engineering goods needed domestically. The setting up of public sector
enterprises (PSE) like Hindustan Machine Tools (HMT), Heavy Engineering
Corporation (HEC), Bharat Earth Movers Ltd. (BEML), Bharat Heavy Electricals
Ltd. (BHEL) Bharat Heavy Plates & Vessels (BHPV) etc. were aimed at
achieving self sufficiency in the promotion of engineering goods. These
industries further facilitated the development of other major sectors like fertiliser
plants, railways, defense establishments etc.

The engineering sector consists of two segments- heavy engineering and light
engineering. Heavy engineering segment forms the majority of the engineering
sector in India. In the year 2003-04, out of the total engineering production of
US$ 22 billion, the heavy engineering market contributed over 80 per cent with
the light engineering segment accounting for the remaining.

After liberalisation, as competition broke out, Indian firms were compelled to
develop improved capabilities and this, in turn, made them more competitive. In
order to cope up with global market requirements, the companies under
engineering sector, besides diversifying their manufacturing range, concentrated
on quality improvement. The Indian engineering industry has emerged as a
dynamic sector in the country’s industrial economy and has made the country
self reliant in key areas. The total production of the Indian engineering industry
was approximately US$ 22 billion in 2004. The engineering sector exports stood
at US $ 6.6 billion in 2001-02 and imports at US $ 4.9 billion the same year.
Indian engineering manufacturing sector employs over 4 million skilled and semi-
skilled workers\textsuperscript{15}.

Over the years following liberalisation, the engineering industry has been able to
develop advanced manufacturing technology. Nevertheless UNIDO (\textit{ibid.})
reveals that though Indian manufacturing industry has mastered standard techniques it has remained dependent for highly expensive and complicated technologies.

5.2.14 Electric Equipment

A healthy and robust electrical equipment industry is necessary for the transmission and distribution of electricity and this encompasses the entire value chain in transmission, distribution and generation of power. Therefore, such industry is of strategic importance for the economy.

The Indian electrical equipment industry comprises of two segments - generation equipment (boilers, turbines, generators) and transmission & distribution (T&D) and allied equipment like transformers, cables, transmission lines, switchgears, capacitors, energy meters, instrument transformers, surge arrestors, stamping and lamination, insulators, insulating material, industrial electronics, indicating instruments, winding wires, etc.

The industry is 10.51% of the manufacturing sector in terms of value and 1.46% of the GDP. It also provides direct and indirect employment to 1.5 million people and over 5 million across the entire value chain

In order to pursue the government’s move towards capacity enhancement in power generation, transmission and distribution in the 10th, 11th and 12th Plans, the domestic electrical equipment manufacturing industry has made huge investments in doubling and, in some cases, even tripling its production capacity. Though the industry has developed full potential to meet the growing demand the built-up capacity remains underutilized across several products due to sluggish domestic demand and a surge in imports of electrical equipment in recent years.

There is slow pace of absorption of new technology by domestic manufacturers of electrical equipment, and also user industries, and low investment in research & development (R&D). According to estimates, less than 1% of the annual turnover of the industry is invested in R&D.
All the three segments of the power sector, viz. generation, transmission and distribution are interdependent on each other. Indian Electrical Equipment Industry: Mission Plan 2012-2022, Department of Heavy Industry Ministry of Heavy Industries & Public Enterprises, Government of India stated that of late, equipment manufacturers are gearing up in accordance with the future plans of NTPC in the generation sector and PGCIL in the transmission sector. At present, equipment manufacturers are able to meet the demands of the generation, transmission and distribution sectors. However, the lack of a system or platform to regularly inform the entire industry on developments taking place in thermal/hydro/nuclear generation and transmission sectors is resulting in inability to update the products for the future.

The Mission Plan also informs that the large companies in the US, Europe, South Korea, China, etc. spend more than 4-5% on R&D, which is much higher than Indian companies, which spend less than 1% on an average. The Plan has not been optimistic regarding the R&D done in the industry as it stated that considering the scale of operation of the global majors, actual spending by Indian companies on R&D is too small. In fact, many Indian companies do not spend on R&D at all. That the industry has been much more concerned with day-to-day problems, turnover, profit, etc. instead of giving importance to innovation in manufacturing process was also reported in the Plan. Therefore, in this section an empirical probe will be conducted to discern the impact of liberalisation on India’s technology regime from the perspective of the manufacturing industries.

5.3. Database and the construction of variables

Capitaline Corporate Database was used to obtain data on R&D expenditure made by manufacturing industries in India. The Capitaline Corporate Database analyse companies with the most accurate, transparent financials in the market place covering 230000 companies with over 2500 unique financial data items and 300 industry-specific items. The industries taken into account were Automobile, Cement, Chemicals, Food Processing, Electric Equipment, Electronics, Engineering, Personal Care, Pharmaceuticals, Refineries, Software, Steel, Telecommunications and Textiles. These industries, as has been
discussed in the preceding sections, are important in terms of their strategic importance, contribution to the GDP of the country, export earnings and role as provider of employment opportunities. Capitaline provides firm-level as well as industry level data.

For Automobiles, the items included were LCVS/HCVS, Motorcycles / Mopeds, Passenger Cars, Scooters And 3-Wheelers, And Tractors.

Cement included Major - North India., Major - South India, Mini - North India, Mini - South India, Cement Products.

Among Chemicals were included Alcohol-Based, Benzene-Based, Calcium Carbonate, Gelatin, Inorganic – Large, Inorganic - Medium / Small, Maleic Anhydride / Phthalic Anhydride, Organic – Large, Organic - Medium / Small, Pentaerythritol / Formaldehyde, Plasticizers, Speciality – Large, - Speciality - Medium / Small

Electric Equipment included General – Large, General - Medium / Small, Gensets / Turbines, Switchgears/Relays/Circuits and Transformers.

Electronics involved Capacitors, Compact Discs, Hard Ferrites, Instrumentation And Process, Control, Others, PCBs, Picture Tubes - B &Amp; W, Picture Tubes – Colour, - Picture Tubes - Glass Shells, Power Devices / Equipment, Soft Ferrites, TV / Audio / VCR / VCP.


Food - processing involved Rice, Atta / Rava / Sooji, Egg Powder, Fruit Processing and Mushrooms and also Spices / Pickles, Food And Dairy Products - Indian – Large, Food And Dairy Products - Indian - Medium / Small, Food And Dairy Products – Multinational.

Personal Care industry included Indian – Large, Indian - Medium /Small and Multinational.
Software included Large, Medium and Small.

Steel involved Large, Medium / Small, Pig Iron, - Rolling, Seamless Tubes, Sponge Iron, Tubes / Pipe steel – Wires.

Telecommunications included Equipment – Large, Equipment - Medium / Small and Service Provider.


Through screening of the database, the data were obtained for the period 1996-2009 relating to the following variables pertaining to the industries- sales turnover, R&D expenditure, foreign exchange earnings, exports (f.o.b.), imports of raw materials, spares and finished goods (c.i.f.), payments of royalty and technical fees and import of capital goods, all in Rs. crores.

R&D intensity (RDI) is defined as R&D expenditure as proportion of sales turnover, outward orientation-1(OOR-1) is the earnings in foreign exchange as proportion of sales turnover, outward orientation-2(OOR-2) is exports (f.o.b.) as proportion of sales turnover, imports of spares, raw materials and finished goods together as proportion of sales turnover is import intensity (IIT), payments of royalty and technical fees as proportion of sales turnover is the import of disembodied technology intensity (DTI) and import of capital goods as proportion of sales turnover is the import of embodied technology intensity (ETI) and TECHIM is the technology import intensity which is the sum of embodied and disembodied technology import as proportion of sales.
It has already been explained that the two crucial components of technology regime, namely, technological opportunity and cumulativeness of learning could best be represented by the R&D intensity and it is necessary to discern which factors are responsible for influencing this intensity at the level of industry in the Indian manufacturing sector.

**Industry Size:**

That the firm size matters in carrying out R&D or innovation was acknowledged by Schumpeter (1950) much before. While addressing the advantages of ‘monopoly level of organisation’ he referred to the innovation ‘capability advantages’ of large firm size stemming from economies of scale in R&D and management, greater capabilities for risk spreading, finance, and so on (Nelson & Winter, *ibid.*). Nelson and Winter (*ibid.*) have justified a positive effect of firm size because larger firms are better able to appropriate returns from their innovative activity. The empirical studies, however, yielded mixed results, e.g. Cohen, Levin & Mowery (1987) found that the size of the firm as a whole, though not the size of the business unit, had a significant but small positive effect on the R & D intensity of business units. In this study industry size has been taken as an explanatory variable influencing RDI. The annual sales turnover (transformed into logarithm) is taken as the size of the industry.

**Technology Imports:**

Technology import has been considered to be a crucial factor determining RDI and in a country like India the import of technology is an important source of technology acquisition. The evidence in the case of India has supported the ‘complementarity’ hypothesis, that is, technology imports were followed up by further technological effort for adaptation and absorption of imported knowledge (Kumar & Agarwal, 2005). Technology import consists of both embodied and disembodied technology imports- while the former is represented by the import of capital goods, the latter implies royalty, technical and license fees paid abroad. Both these imports are expressed as proportion of sales implying the embodied technology import intensity (ETI) and disembodied technology import intensity (DTI).
**Outward Orientation:**

It has been observed empirically that the industries which are outward oriented are possessed with the incentive to pursue R&D. Outward orientation implies export intensity and foreign exchange earnings by making overseas investment and licensing activity of Indian enterprises by providing technological inputs. Export by the Indian industries (f.o.b) as proportion of sales is denoted by the OOR-2 and foreign exchange earnings as proportion of sales is represented by OOR-1.

### 5.4. Trend of the variables

Compound annual growth rates were calculated for the variables during the period 1996-2009 which was shown in Table 5.4. It was observed that SIZE registered highest growth in software industries and next to it, were Telecommunications, Refineries, Food Processing, Engineering, Electric Equipment, Pharmaceuticals, Steel, Electronics, Cement, Automobiles, Personal Care, Chemicals and Textiles.

Table 5.1 showed the trend of RDI of the Indian manufacturing industries. It was revealed that the highest RDI in the Automobile sector stood for the year 1998, though in the years 2005, 2008 and in 2009 it was better, however, that could not reach near the figure 38.47 achieved in 1998. The figures higher than average were found during the period 1996-2001. In the case of the Cement industry higher than average were the figures for the years 1996, 2006, 2007 and 2009. In the case of the Chemicals industry four years exhibited higher than average-1996, 1998, 2002 and 2003. Food Processing industry exhibited higher than average values for five years, Electric Equipment industry seven years, Electronics industry five years, in the case of Engineering industry only one year exhibited higher than average values, in the case of personal care products producing industry five years, in the case of the Pharmaceuticals industry six years, in the case of the Refineries industry five years, Software industry showed higher than average values for nine years, in the case of the Steel industry six years, in the case of the Telecommunications industry nine years and the Textiles industry exhibited higher than averages RDI only four years.
Regarding the growth of RDI it was revealed from Table 5.4 that the Steel industry achieved the highest rank followed by Software, Pharmaceuticals, Automobiles, Personal Care, Electric Equipment, Food Processing and Chemicals. Negative growth rates were observed in the Telecommunications, Electronics, Engineering, Textiles, Refineries and Cement industries.

Positive growth rates were achieved by the Telecommunications, Electric Equipment, Automobiles and Pharmaceuticals industries in respect of embodied technology import intensity. Negative growth of disembodied technology import was observed in the Engineering, Textiles, Steel, Food Processing, Chemicals and in Refineries and the industries like Software, Personal Care, Automobiles, Electronics and Pharmaceuticals achieved two digit figures in respect of the disembodied technology import intensity with Software experiencing the highest rate of 19.56%. Other than Food Processing, Cement and Telecommunications, others achieved positive growth rates of OOR-1 and Personal Care, Software and Cement industries experienced negative rates of the variable OOR-2.

Table 5.2 showed the trend of embodied technology import as proportion of sales by the manufacturing industries. Except the Telecommunications industry, other industries could not be marked with moderate figures.

Regarding the disembodied technology import intensity (DTI), Table 5.3 showed that Automobiles achieved highest rate in 1999 and it was 4.59%, thereafter the figures dropped and a slight improvement was observed in the years 2000 and 2008 but that, too fell short of what was achieved in 1999. Other than this, no other industries were found to have contributed significantly to the import of disembodied technology import, at least, as proportion of their sales.

In spite of these observations it could not be concluded that the industries, taken into account in this study, were devoid of inclining towards the import of technology, for a good number of industries the CAGR of DTI was positive and sound. Even for ETI the growth rate was positive for Telecommunications, Pharmaceuticals, Automobiles and Electric Equipment. That is, the Indian manufacturing industries, mostly, had been prone to the import of technology; however, as proportion of their sales the figures were not satisfactory.
5.5. Methodology

Methodology of this section consisted of two parts. In the first part, the influence of SIZE and ETI and DTI on RDI of the industries was explored in elasticity terms. While carrying out this exercise log linear model was applied as in this situation this model is recognised as the most suitable model and this was discussed under Model 1.

Model 1

The following regression equation was fitted:

\[ \text{LGRDI} = \alpha + \beta_1 \text{LGSIZE} + \beta_2 \text{LGETI} + \beta_3 \text{LGDTI} + \epsilon \ldots (i) \]

where \( \text{LGRDI}, \text{LGETI} \) and \( \text{LGDTI} \) were \( RDI, \text{ETI} \) and \( \text{DTI} \) transformed into log values and \( \epsilon \) was the error term.

On the basis of the industry-level data obtained from the Capitaline Corporate Database equation (i) was fitted and the analysis of regression equation was shown in Table 5.5.

In the second part, in order to capture the influence of outward orientation along with the influence of size of the industry and the import of technology import on \( RDI \) a multiple regression analysis was done taking \( RDI \) as the dependent variable and \( \text{ETI}, \text{DTI}, \text{SIZE}, \text{OOR1} \) and \( \text{OOR2} \) as the explanatory variables and this analysis was made in Model 2.

Model 2

The following regression equation was fitted:

\[ \text{RDI} = \alpha + \beta_1 \text{ETI} + \beta_2 \text{DTI} + \beta_3 \text{OOR1} + \beta_4 \text{OOR2} + \beta_5 \text{SIZE} + \epsilon \ldots (ii) \]

where the variables had usual interpretation except that \( \text{SIZE} \) was considered as sales turnover of the industry transformed into logarithm and \( \epsilon \) was the error term.

Data were obtained from the Capitaline Corporate Database. The analysis of regression equation was shown in Table 5.7.
5.5.1. *Empirical findings of Model 1*

It was observed that the estimated coefficient of LGSIZE appeared significant in the cases of Cement, Electronics, Pharmaceuticals, Software and Steel industries. Embodied Technology Import Intensity had significant impact on R&D intensity in the Chemicals, Electric Equipment, Automobiles and Steel industries and the impact of Disembodied Technology Import Intensity appeared significant in the case of Chemicals, Electronics, Automobiles, Food Processing, Refineries, Software and Steel industries.

From the estimated coefficients it was reasonable to compute different elasticities-

\[ e_1: \text{elasticity of RDI with respect to SIZE (}\delta \log \text{RDI}/\delta \log \text{SIZE}) \]

\[ e_2: \text{elasticity of RDI with respect to ETI (}\delta \log \text{RDI}/\delta \log \text{ETI}) \]

\[ e_3: \text{elasticity of RDI with respect to DTI (}\delta \log \text{RDI}/\delta \log \text{DTI}) \]

Table 5.6 showed these elasticity values. In the case of Cement industry, \( e_1, e_2 \) and \( e_3 \) were inelastic and \( e_1 \) and \( e_2 \) were negative while \( e_3 \) was positive. Chemical industry showed positive \( e_1 \) and \( e_2 \) and negative \( e_3 \) and all these values were less than one. Electric Equipment industry witnessed positive \( e_2 \) and \( e_3 \) but showed negative \( e_1 \) and all these values were inelastic. Electronics industry disclosed negative values in the cases of \( e_1 \) and \( e_2 \) but positive in the case of \( e_3 \). However, all these values were inelastic. Engineering industry yielded negative \( e_1 \), negative \( e_2 \) and positive \( e_3 \) and all these values were inelastic. Automobiles industry revealed positive values in the cases of \( e_1 \) and \( e_3 \) and negative value in the case of \( e_2 \) and all these values were inelastic. Pharmaceuticals industry showed positive values in the cases of \( e_1 \) and \( e_2 \) but negative value in the case of \( e_3 \) and all these values were inelastic. Similar was the findings in the case of Food Processing and Personal Care industries. Refineries industry disclosed positive value in the case of only \( e_3 \), Software showed positive value in case of only \( e_1 \) and \( e_1 \) was highly elastic and so also was the value of \( e_3 \), though, it was negative. Steel disclosed positive values in the cases of \( e_1, e_3 \) and \( e_1 \) was elastic. Telecommunications and Textiles
industries yielded negative values in the cases of $e_1$ and $e_3$ and positive values in the case of $e_2$. Thus SIZE had positive effects upon RDI in the cases of industries engaged in producing chemicals, automobiles, pharmaceuticals, food processing, personal care, software and steel.

5.5.2. Empirical findings of Model 2

The impact of DTI on RDI was significant in the Cement industry. The impacts of ETI, OOR-2 and SIZE were negative upon RDI while the impact of OOR-1 was positive. In the Chemicals industries the influences of ETI, OOR-1 and SIZE were positive but that of DTI and OOR-2 were negative. In Electric Equipment industry ETI cast significant positive effect upon RDI. In this industry the impact of DTI and OOR-2 were positive. Only SIZE cast significant impact in the Electronics industry, however, the impact was negative. In this industry, DTI and OOR-1 showed positive impact on RDI. Engineering industry showed positive impacts of only DTI and OOR-2 on RDI. In the Pharmaceuticals industry, the impact of ETI, OOR1 and SIZE were significant. However, in this industry, other than SIZE and ETI, the coefficient of OOR 1 was negative implying that change in OOR 1 caused for reduction in RDI. The Food Processing industry exhibited positive impact of ETI and OOR-2 on RDI. ETI, DTI and OOR-1 had positive influence on RDI in the Personal Care products producing industry. In the Refinery industry, the impact of DTI was significant and the coefficient of DTI was positive implying that the change in DTI resulted in the increase in RDI. In Software industry, except OOR-1 the other variables had negative impact on RDI. In the case of Telecommunications, the impact of OOR 1 was significant; however, coefficient was negative implying that change in OOR 1 caused for reduction in RDI. Lastly, ETI came up with significant impact in the Textiles industry. In this industry, also, DTI, OOR 1 and OOR 2 cast significant impact. While estimated coefficients of DTI and OOR2 were negative in sign that of ETI and OOR 1 were positive. Table 5.8 summarised these empirical findings.

It was revealed that SIZE had significant impact on RDI in the Electronics and Pharmaceuticals industries. OOR-2 showed significant impact on RDI in the Textiles industry only. OOR-1 impacted significantly in the Pharmaceuticals, Telecommunications and Textiles industries. DTI exhibited significant impact on
RDI in the Cement, Refineries and Textiles industries and ETI had significant influence in the Electric Equipment, Pharmaceuticals and Textiles industries.

5.6. Concluding observations

SIZE had considerable impact only for the Electronics and Pharmaceuticals industries. The CAGR of SIZE for these industries had been 13.71% and 14.28% which were moderate compared to others. For the other industries though the CAGR of SIZE had been considerable this could not create impact on technological innovation and adoption. This implies that industries growing bigger did not render undertaking R&D seriously.

Import of technology - embodied and disembodied- played appreciable role in influencing R&D for the Cement, Electric Equipment, Pharmaceuticals, Refineries and Textiles and these industries constituted less than 50% of the sample size in this study. From the values of elasticities of RDI with respect to ETI and DTI the same observations were made. Therefore ‘import and adapt’ principle was not effective in the case of Indian manufacturing industries.

Outward Orientation in the form of exports (f. o. b) had a positive impact on RDI in the case of Textiles and negative influence for Pharmaceuticals and Telecommunications. For Pharmaceuticals, import of embodied technology influenced R&D implying that the industry’s import of technology was adopted through incurring R&D and this was supplemented by the growing size of the industry. Refineries imported technological knowledge and for effective use of that knowledge the industry had to rely on R&D. Contrarily for Textiles, import of this knowledge provided a relief and the industry’s R&D experienced negative impact after this import of knowledge. However, import of technology in embodied form was supplemented by incurring R&D expenditure, i.e. the imported technology was adopted by the industry through R&D.

The implication for the Outward Orientation appearing not so strong a variable to influence the technological innovation of the Indian manufacturing industries accords with the observation made in the Science and Technology Policy 2003 of the Government of India “Indian exports today derive their comparative
advantage through resource and labour rather than through the power of technological innovation”.

Technological innovation in manufacturing occurs in two forms: new inventions provide a leap forward in technology and the other form of innovation comes from the steady improvement in products and manufacturing processes within major technology life cycles (National Manufacturing Competitiveness Council, 2006). Though this improvement involves ‘many less dramatic innovations’ collectively these innovations have a significant effect (ibid). The empirical observations from the Model 2 do not conform to this. Out of the 14 industries considered in the study very few undertake R&D seriously and though liberalisation has widened the scope of importing technology and exports of goods, industries, in India, have taken little advantage of this. One reason would be that technological innovation and acquisition of new knowledge and its adoption require calibration of policies and reconfiguration of competencies (ibid). However, these appear to be difficult in view of capacity constraints and economic, social and political complexities.

While making any discussion on competitiveness of the industries emphasis is placed on to identify to what extent these industries are able to take advantage of low labour costs, technology intensive exports, increasing productivity but seldom is it questioned how far the changing character of technology regime affects the performance of the industrial sector. This happens in the case of Indian manufacturing sector also. The technology regime under which the Indian manufacturing industries have been performing has undergone a pragmatic change after unshackling of the various controls and barriers but the industries are still devoid of clinging to the frequency of technological opportunity and cumulativeness of learning-the two building blocks of technology regime. This is an important reason for the industries not becoming competitive and unless these issues are taken care of it is hard to make any dent in the global competition of which technological superiority is an important factor.
Notes

1 The Second Summit on Indian Manufacturing Competitiveness was held in Hyderabad, India, in August 2006, and organized by Deloitte Research, the Indian School of Business, New York University, and Purdue University with support from the National Science Foundation.


3 op.cit

4 Indian Chemical Industry, XII th Five Year Plan.


10 PUBLIC ENTERPRISES, GOVERNMENT POLICY AND IMPACT ON COMPETITION INDIAN PETROLEUM INDUSTRY. Final Report Prepared for
the Competition Commission of India, January 2009. Indicus Analytics, New Delhi.

11 Chemical Weekly October 6, 2009


14 The Economic Times, Calcutta 1999, August 10

15 UNIDO (2005)


17 op.cit
References


Table 5.1 R&D intensity of Indian Manufacturing Industries: 1996-2009

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CAGR: Compound Annual Growth Rate; RDI: Research and Development (R&D) Intensity

Source: Capitaline Data Base, Mumbai, 2009.
Table 5.2 Embodied Technology Import Intensity of Indian Manufacturing Industries: 1996-2009

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Table 5.3 Disembodied Technology Import Intensity of Indian Manufacturing Industries: 1996-2009

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<td>0.09</td>
<td>0.00</td>
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<td>0.13</td>
<td>0.03</td>
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<td>0.14</td>
<td>0.55</td>
<td>0.09</td>
<td>0.06</td>
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<td>0.11</td>
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<td>0.07</td>
<td>0.00</td>
<td>0.36</td>
<td>0.15</td>
<td>0.18</td>
<td>0.65</td>
<td>0.14</td>
<td>0.06</td>
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<td>0.18</td>
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<td>0.00</td>
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<td>0.21</td>
<td>0.67</td>
<td>0.23</td>
<td>0.18</td>
<td>1.19</td>
<td>0.14</td>
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<td>0.04</td>
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<td>0.07</td>
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<td>0.42</td>
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<td>0.60</td>
<td>0.20</td>
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<td>0.12</td>
<td>0.08</td>
<td>0.05</td>
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<td>2007</td>
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<td>0.07</td>
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<td>0.00</td>
<td>0.37</td>
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<td>0.28</td>
<td>0.98</td>
<td>0.60</td>
<td>0.44</td>
<td>1.38</td>
<td>0.16</td>
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<td>0.10</td>
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<td>2008</td>
<td>3.87</td>
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<td>0.11</td>
<td>0.01</td>
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<td>0.38</td>
<td>0.38</td>
<td>3.07</td>
<td>0.66</td>
<td>0.29</td>
<td>2.02</td>
<td>0.12</td>
<td>0.14</td>
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<td>2009</td>
<td>1.58</td>
<td>0.10</td>
<td>0.18</td>
<td>0.02</td>
<td>0.29</td>
<td>0.50</td>
<td>0.31</td>
<td>0.66</td>
<td>0.64</td>
<td>0.12</td>
<td>2.67</td>
<td>0.18</td>
<td>0.13</td>
<td>0.07</td>
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</table>

CAGR: Compound Annual Growth Rate

Source: Capitaline Data Base, Mumbai, 2009.
Table 5.4 Compound Annual Growth rates of selected variables of Indian Manufacturing industries: 1996-2009

<table>
<thead>
<tr>
<th>Industries</th>
<th>Variables</th>
<th>Sales</th>
<th>RDI</th>
<th>ETI</th>
<th>DTI</th>
<th>OOR-1</th>
<th>OOR-2</th>
<th>IIT</th>
<th>TECHIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automobiles</td>
<td>12.67%</td>
<td>8.56%</td>
<td>1.01%</td>
<td>14.72%</td>
<td>7.07%</td>
<td>25.00%</td>
<td>-1.42%</td>
<td>3.88%</td>
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</tr>
<tr>
<td>Cement</td>
<td>13.33%</td>
<td>-16.33%</td>
<td>-3.11%</td>
<td>1.01%</td>
<td>-1.93%</td>
<td>-2.50%</td>
<td>2.39%</td>
<td>-2.95%</td>
<td></td>
</tr>
<tr>
<td>Chemicals</td>
<td>9.08%</td>
<td>1.47%</td>
<td>-12.37%</td>
<td>-9.46%</td>
<td>4.48%</td>
<td>5.43%</td>
<td>3.59%</td>
<td>-11.57%</td>
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</tr>
<tr>
<td>Electric Equipment</td>
<td>16.08%</td>
<td>3.15%</td>
<td>5.33%</td>
<td>1.26%</td>
<td>7.46%</td>
<td>9.00%</td>
<td>2.23%</td>
<td>4.50%</td>
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</tr>
<tr>
<td>Electronics</td>
<td>13.71%</td>
<td>-0.28%</td>
<td>-8.19%</td>
<td>11.80%</td>
<td>9.39%</td>
<td>5.89%</td>
<td>4.49%</td>
<td>-5.41%</td>
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</tr>
<tr>
<td>Engineering</td>
<td>18.47%</td>
<td>-0.50%</td>
<td>-1.36%</td>
<td>-3.56%</td>
<td>6.14%</td>
<td>5.69%</td>
<td>7.34%</td>
<td>-1.73%</td>
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<tr>
<td>Food Processing</td>
<td>19.87%</td>
<td>1.92%</td>
<td>-4.00%</td>
<td>-9.15%</td>
<td>-1.81%</td>
<td>0.25%</td>
<td>-4.78%</td>
<td>-4.33%</td>
<td></td>
</tr>
<tr>
<td>Personal Care</td>
<td>10.12%</td>
<td>3.33%</td>
<td>-2.89%</td>
<td>18.29%</td>
<td>0.10%</td>
<td>-0.64%</td>
<td>8.24%</td>
<td>6.17%</td>
<td></td>
</tr>
<tr>
<td>Pharmaceuticals</td>
<td>14.28%</td>
<td>9.49%</td>
<td>0.66%</td>
<td>10.26%</td>
<td>6.07%</td>
<td>5.80%</td>
<td>-0.23%</td>
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</tr>
<tr>
<td>Refineries</td>
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<td>-6.94%</td>
<td>-17.13%</td>
<td>14.35%</td>
<td>15.28%</td>
<td>6.68%</td>
<td>-9.45%</td>
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</tr>
<tr>
<td>Software</td>
<td>34.01%</td>
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<td>-3.20%</td>
<td>19.56%</td>
<td>9.39%</td>
<td>-0.89%</td>
<td>-23.21%</td>
<td>4.62%</td>
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</tr>
<tr>
<td>Steel</td>
<td>13.98%</td>
<td>37.98%</td>
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<td>-7.12%</td>
<td>5.53%</td>
<td>7.12%</td>
<td>5.52%</td>
<td>-1.16%</td>
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</tr>
<tr>
<td>Telecommunications</td>
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<td>15.40%</td>
<td>0.57%</td>
<td>-13.62%</td>
<td>10.72%</td>
<td>-1.59%</td>
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</tr>
<tr>
<td>Textiles</td>
<td>7.28%</td>
<td>-7.39%</td>
<td>-5.13%</td>
<td>-6.14%</td>
<td>3.09%</td>
<td>3.25%</td>
<td>0.36%</td>
<td>-5.15%</td>
<td></td>
</tr>
</tbody>
</table>

RDI: R&D expenditure as %age of sales  
ETI: Import of capital goods as %age of sales  
DTI: Payment of royalties, etc. abroad as %age of sales  
IIT: Import of finished goods and raw materials as %age of sales  
TECHIM: Total of Import of capital goods and Payment of royalties, etc. abroad as %age of sales  

Source: Capitaline Data Base, Mumbai, 2009.
Table 5.5 Analysis of Regression Estimates of the Manufacturing Industries (Model 1)

<table>
<thead>
<tr>
<th>Industries</th>
<th>R</th>
<th>R²</th>
<th>Adj.R²</th>
<th>S.E.</th>
<th>F-statistic</th>
<th>Durbin- Watson ‘d’ statistic</th>
<th>Constant (t-value)</th>
<th>β₁ (t-value)</th>
<th>β₂ (t-value)</th>
<th>β₃ (t-value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement</td>
<td>0.816</td>
<td>0.666</td>
<td>0.566</td>
<td>0.77598</td>
<td>6.653</td>
<td>2.086</td>
<td>17.280 (4.642)</td>
<td>-0.652 (-3.376)</td>
<td>-0.049 (-0.209)</td>
<td>0.396 (1.650)</td>
</tr>
<tr>
<td>Chemicals</td>
<td>0.639</td>
<td>0.409</td>
<td>0.231</td>
<td>0.38117</td>
<td>2.305</td>
<td>1.955</td>
<td>-0.608 (-0.213)</td>
<td>0.350 (1.250)</td>
<td>0.816 (2.263)</td>
<td>-0.699 (-1.951)</td>
</tr>
<tr>
<td>Electric Equipment</td>
<td>0.706</td>
<td>0.706</td>
<td>0.3480</td>
<td>0.24594</td>
<td>3.310</td>
<td>1.743</td>
<td>4.980 (3.379)</td>
<td>-0.311 (1.022)</td>
<td>0.939 (0.829)</td>
<td>0.410 (2.223)</td>
</tr>
<tr>
<td>Electronics</td>
<td>0.657</td>
<td>0.432</td>
<td>0.262</td>
<td>0.40880</td>
<td>2.536</td>
<td>2.789</td>
<td>10.953 (3.432)</td>
<td>-0.837 (-2.069)</td>
<td>-0.636 (-2.069)</td>
<td>0.645 (2.223)</td>
</tr>
<tr>
<td>Engineering</td>
<td>0.348</td>
<td>0.121</td>
<td>-0.143</td>
<td>0.57704</td>
<td>0.459</td>
<td>1.814</td>
<td>5.472 (2.122)</td>
<td>-0.216 (0.711)</td>
<td>-0.483 (0.711)</td>
<td>0.502 (0.748)</td>
</tr>
<tr>
<td>Automobiles</td>
<td>0.705</td>
<td>0.497</td>
<td>0.3460</td>
<td>0.46155</td>
<td>3.295</td>
<td>2.380</td>
<td>-0.052 (-0.018)</td>
<td>0.253 (1.013)</td>
<td>-0.448 (-1.838)</td>
<td>0.457 (1.815)</td>
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<tr>
<td>Pharmaceuticals</td>
<td>0.900</td>
<td>0.809</td>
<td>0.752</td>
<td>0.30894</td>
<td>14.140</td>
<td>2.199</td>
<td>-5.756 (-2.528)</td>
<td>0.895 (4.976)</td>
<td>0.251 (1.350)</td>
<td>-0.207 (-0.970)</td>
</tr>
<tr>
<td>Food Processing</td>
<td>0.764</td>
<td>0.583</td>
<td>0.458</td>
<td>0.31798</td>
<td>4.666</td>
<td>1.690</td>
<td>0.006 (0.007)</td>
<td>0.126 (0.518)</td>
<td>0.291 (1.314)</td>
<td>-0.651 (-2.800)</td>
</tr>
<tr>
<td>Personal care</td>
<td>0.178</td>
<td>0.032</td>
<td>-0.259</td>
<td>0.68344</td>
<td>0.109</td>
<td>1.958</td>
<td>-0.059 (-0.148)</td>
<td>0.175 (0.558)</td>
<td>0.028 (0.087)</td>
<td>-0.013 (-0.040)</td>
</tr>
<tr>
<td>Refineries</td>
<td>0.765</td>
<td>0.586</td>
<td>0.462</td>
<td>0.47056</td>
<td>4.714</td>
<td>1.643</td>
<td>0.088 (0.037)</td>
<td>-0.075 (-0.316)</td>
<td>-0.277 (-1.233)</td>
<td>0.789 (3.322)</td>
</tr>
<tr>
<td>Software</td>
<td>0.887</td>
<td>0.787</td>
<td>0.723</td>
<td>0.37394</td>
<td>12.306</td>
<td>1.019</td>
<td>-8.219 (-3.677)</td>
<td>2.195 (5.630)</td>
<td>-0.065 (-0.413)</td>
<td>-1.740 (-4.438)</td>
</tr>
<tr>
<td>Steel</td>
<td>0.957</td>
<td>0.916</td>
<td>0.890</td>
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<td>36.162</td>
<td>2.695</td>
<td>-33.526 (-7.588)</td>
<td>1.199 (6.981)</td>
<td>-0.494 (-2.978)</td>
<td>0.432 (1.964)</td>
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<tr>
<td>Telecommunications</td>
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<td>0.304</td>
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<td>1.14876</td>
<td>1.456</td>
<td>2.344</td>
<td>1.007 (0.197)</td>
<td>-0.029 (-0.046)</td>
<td>0.580 (0.917)</td>
<td>-0.091 (-0.296)</td>
</tr>
<tr>
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<td>0.59043</td>
<td>1.311</td>
<td>2.423</td>
<td>4.521 (0.591)</td>
<td>-0.162 (-0.419)</td>
<td>0.552 (1.564)</td>
<td>-0.622 (-1.479)</td>
</tr>
</tbody>
</table>

Source: Capitaline Corporate Database, 2009. Mumbai
### Table 5.6 Values of Elasticities of India’s Manufacturing Industries

<table>
<thead>
<tr>
<th>Industry</th>
<th>$e_1$</th>
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<th>$e_3$</th>
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</thead>
<tbody>
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<td>-0.652</td>
<td>-0.049</td>
<td>0.396</td>
</tr>
<tr>
<td>Chemicals</td>
<td>0.350</td>
<td>0.816</td>
<td>-0.699</td>
</tr>
<tr>
<td>Electric Equipment</td>
<td>-0.311</td>
<td>0.693</td>
<td>0.210</td>
</tr>
<tr>
<td>Electronics</td>
<td>-0.837</td>
<td>-0.636</td>
<td>0.645</td>
</tr>
<tr>
<td>Engineering</td>
<td>-0.216</td>
<td>-0.483</td>
<td>0.502</td>
</tr>
<tr>
<td>Automobiles</td>
<td>0.253</td>
<td>-0.448</td>
<td>0.457</td>
</tr>
<tr>
<td>Pharmaceuticals</td>
<td>0.895</td>
<td>0.251</td>
<td>-0.207</td>
</tr>
<tr>
<td>Food Processing</td>
<td>0.126</td>
<td>0.291</td>
<td>-0.651</td>
</tr>
<tr>
<td>Personal care</td>
<td>0.175</td>
<td>0.028</td>
<td>-0.013</td>
</tr>
<tr>
<td>Refineries</td>
<td>-0.075</td>
<td>-0.277</td>
<td>0.789</td>
</tr>
<tr>
<td>Software</td>
<td>2.195</td>
<td>-0.065</td>
<td>-1.740</td>
</tr>
<tr>
<td>Steel</td>
<td>1.199</td>
<td>-0.494</td>
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<tr>
<td>Telecommunications</td>
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<td>0.580</td>
<td>-0.091</td>
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<tr>
<td>Textiles</td>
<td>-0.162</td>
<td>0.552</td>
<td>-0.622</td>
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**Source:** Computed from Table 5.5 by using the elasticity formula.
<table>
<thead>
<tr>
<th>Industries</th>
<th>Estimated Values</th>
<th>R</th>
<th>R²</th>
<th>Adj.R²</th>
<th>S.E.</th>
<th>F statistic</th>
<th>Durbin- Watson 'd' statistic</th>
<th>Constant (t-value)</th>
<th>β₁ (t-value)</th>
<th>β₂ (t-value)</th>
<th>β₃ (t-value)</th>
<th>β₄ (t-value)</th>
<th>β₅ (t-value)</th>
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<tbody>
<tr>
<td>Cement</td>
<td>0.678</td>
<td>0.460</td>
<td>0.123</td>
<td>26.8285</td>
<td>1.363</td>
<td>3.139</td>
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<tr>
<td>Chemicals</td>
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<td>-1.186 (0.705)</td>
<td>0.007 (0.012)</td>
<td>-0.059 (-0.032)</td>
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<tr>
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<tr>
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<td>0.636 (0.897)</td>
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<tr>
<td>Automobiles</td>
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<td>0.421</td>
<td>0.059</td>
<td>8.53876</td>
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<td>2.313</td>
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<td>-5.205 (-0.525)</td>
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<td>0.884</td>
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<td>45.58879</td>
<td>12.206</td>
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<td>2.937 (0.791)</td>
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<td>0.553</td>
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<td>0.390 (0.767)</td>
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Source: Capitaline Corporate Database, 2009. Mumbai
Table 5.8 Summary of the Empirical Findings of Regression Analysis of Model 2

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Source: Table 5.7