

# Technological Classification of Knowledge Based Manufacturing Industries: A Comparison between India and OECD countries

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## Abstract

Industries are generally classified into different groups on some parameter in order to compare the performance between the groups of homogeneous units, be it firms or industries. Many empirical research studies in the area of innovation management, knowledge management and intellectual capital are undertaken on some industries, without any rationale for the choice of the industry. Developing a framework for undertaking research studies in knowledge based industries would help the researchers to focus more on strategies, models and developing metrics for innovation, intellectual capital and knowledge management. OECD Classification is the only available classification for knowledge based manufacturing industries and this classification is based on the R&D intensity of firms. Therefore an attempt is made in this study to develop a framework for industrial classification of knowledge based manufacturing industries in India on the lines of OECD classification and compare the R&D intensity of Indian industries with OECD countries to assess the technological level the Indian manufacturing industries.

**Keywords:** R&D Intensity, Industrial Classification; Knowledge based Industries

## Introduction:

Industries are generally classified into different groups on some parameter in order to compare the performance between the groups of homogeneous units, be it firms or industries. Though some Standard Industrial Classification (SIC) like Fama and French (1997) and Pavitt's Taxonomy (1984) are widely used in economic and management research, industrial classification for knowledge

based manufacturing industries is yet to come. Since, OECD Classification is the only available classification for knowledge based manufacturing industries, standardization of the same across countries have not been undertaken by the researchers. This research study is an attempt in this direction. As, OECD classification is based on the R&D intensity of firms representing the respective industries, this study undertook to evaluate the R&D intensity of the firms representing fourteen knowledge based industries in India, which are pharmaceutical industry, electronics industry, transport (automobiles – vehicles) industry, non-electrical industry, electrical machinery industry, transport (automobiles – equipments) industry, chemicals (excluding pharmaceuticals) industry, rubber & plastic products industry, non-ferrous metals industry, textiles, leather & footwear industry, wood, paper & paper products industry, foods, beverages and tobacco products industry, ferrous metals industry and refined petroleum industry.

## Evolution of Knowledge based Industries in Knowledge Economy:

Fritz Machlup is credited to have originally conceptualized the idea of knowledge economy. Machlup (1962) observed that knowledge as anything that is known by somebody and producing knowledge means not only discovering, inventing, designing and planning, but also disseminating and communicating. Peter Drucker popularized the term knowledge economy in his book, *The Age of Discontinuity: Guidelines to Our Changing Society*. Drucker (1969) introduced the term knowledge economy as a new element in the inventive process. He observed that knowledge has

actually become the primary industry, the industry that supplies the economy the essential and central resources of production. He further observed that knowledge is now the main cost, the main investment, the main product of an advanced economy and the livelihood of the largest group in the population. Recognizing the growing prominence of knowledge in the production process, Drucker (1998) stated that knowledge is now becoming *one* factor of production, sidelining both capital and labor. Knowledge economy is a phrase often used, but sparsely defined. Though there is no generic definition of knowledge economy, Organization for Economic Co-operation and Development (OECD) had made the first attempt to define it as economies ‘those which are directly based on the production, distribution and use of knowledge and information’ (OECD, 1996). Machlup (1962) was the pioneer in classifying knowledge production and distribution in an economy. He identified the sectors with heavy concentration of knowledge assets and classified knowledge production into six major sectors: education, R&D, artistic creation, communications media, information services and information technologies. He showed that these account for the largest sectoral share of GDP and employment in an economy. The knowledge based industries are those industries which are involved in knowledge production and distribution. Since, R&D, artistic creation, information communication technology is widely used in production of goods and services, a new genre of industries have arisen, where knowledge is both an input and output. The knowledge based industries are considered to be the backbone of knowledge economy. Mashelkar (1999) attempts to explain knowledge based industries as those industries where technology overrides the traditional factors of production viz. land, labor and capital. Since the source of technology is rooted in knowledge, the industries that will have knowledge as its core resource are categorized as knowledge industries. The emphasis in these industries is not on physical or tangible assets but on intangible knowledge assets.

**R&D intensity as the basis for classification of Knowledge based Manufacturing Industries:**

The Organization for Economic Co-operation and Development (OECD) has been the pioneer in classifying industries as knowledge based industries. The classification has been based on the R&D intensity of these industries. The R&D intensity comprises of direct intensity – a measure of production of technology and indirect intensity – a measure of use of technology. Though these indicators were calculated over a long period (1973-1992), the final classification was constructed for 1980 and 1990 data. Accordingly

the manufacturing industries were classified as, i) high technology industry, ii) medium high technology industry, iii) medium high technology industry and iv) low technology industry (Hatzichronoglou, 1997). The OECD technology classification is widely used in innovation research with a focus on knowledge economy. Kumar & Pradhan (2003a), Kumar & Pradhan (2003b), Agarwal (2004), Mukerjee (2009) Naik et al (2013) and Majid (2015) have used OECD technology classification in the context of research related knowledge based manufacturing and technology intensity of manufacturing industries of India. The widely used OECD technology classification is as follows:

**Table – 1: OECD Technology Classification of Manufacturing Industries (Based on OECD Science, Technology and Industry Scoreboard, 2011)**

<b>High Technology Industries</b>	
1	Aircraft and spacecraft
2	Pharmaceuticals
3	Office accounting and computing machinery
4	Radio, TV and Communications equipment
5	Medical, Precision and Optical instrument
<b>Medium High Technology Industries</b>	
6	Electrical machinery and apparatus
7	Motor vehicles, trailers and semi-trailers
8	Chemicals excluding pharmaceuticals
9	Railroad equipments and transport equipments
10	Machinery and equipment

<b>Medium Low Technology Industries</b>	
11	Building and repairing of ships and boats
12	Rubber and plastics products
13	Coke, refined petroleum products and nuclear fuel
14	Other non-metallic mineral products
15	Basic metals and fabricated metal products
<b>Low Technology Industries</b>	
16	Manufacturing – recycling
17	Wood, pulp, paper products, printing and publishing
18	Food products, beverages and tobacco
19	Textiles, textile products, leather and footwear

**R&D Intensity as Indicator of Technological level of Firms:**

The level of R&D activities of firms or a nation has been considered as a reliable indicator of the willingness and desire to create or develop technological capabilities. The analogy between R&D and technological capabilities has been highlighted in neo-classical theories. Schumpeter (1942) has explicitly linked R&D with technological capabilities of firms. Research and Development (R&D) intensity is a popular measure used in innovation literature to gauge the technological capabilities of firms. It is a ratio widely used in innovation literature to gauge the innovation related activities of firms. It is used to measure the magnitude of R&D activities of firms. Further it used as an indicator for measuring the technology intensity of firms for technology based classification. The OECD has been using this measure to classify the manufacturing industries based on their technological capabilities. Griliches (1981), CIMA (2003), Lev & Sougiannis (1996), Aboody & Lev (2001), Ding et al.(2007), Agarwal (2004), Naik et al. (2012) have used R&D intensity as a proxy for technological capabilities of firms.

It is measured by:

$$\frac{R\&D\ Expenses}{Value\ Added}$$

**R&D ‘spending’ in India:**

Dahlman and Utz (2005) observe that India has to consciously make a transition to shifting labor from low productivity in agriculture and other informal service activities to more productive sectors and knowledge based activities. It exhorts that India has to leverage its strengths to become a leader in knowledge creation and use. It further notes with concern that though, India has attracted more than 100 R&D units of multinational corporations, its own R&D performance is very dismal. It observes that in India some 70 percent of R&D is still performed by state and central governments and only 27 percent of R&D is conducted by corporate enterprises (private sector 22 percent and public sector enterprises 5 percent) and nearly 3 percent of R&D is conducted by universities and higher education institutions. On the contrary, in OECD nearly 50 to 60 percent of R&D comes from private enterprises. This study has identified the following as four pillars for the knowledge economy of India: i) strengthening the economic and institutional regime; ii) developing educated and skilled workers; iii) creating an efficient innovation system and iv) building a dynamic information infrastructure.

**Classification of Knowledge based Manufacturing Industries of India:**

Kumar & Pradhan (2003a), Kumar & Pradhan (2003b) were the pioneering studies in presenting the classification of knowledge based manufacturing industries for India. These studies observe that knowledge-intensive products are not only high value adding in nature but also contain technological efforts on the parts of the producers and generate knowledge spillovers for rest of the economy. The main competitive advantage in these products lie in advanced and fast changing technologies with high R&D investments, high skills and complex learning process. The low technology products tend to be low value adding, have slower growing market, offer limited learning potential, smaller scope for technological up gradation and less intra-industry and inter-industry spillovers. Further the high technology industries are faster growing and also have a higher value addition than matured low technology industries. Technology or knowledge intensive industries may also have intra-industry and inter-industry externalities vital for economic growth. These studies however categorized Indian manufacturing industry based on technology on the lines of OECD.

**Table - 2: Technology Classification of Manufacturing Industries of India (Based on OECD Technology Classification, 2001)**

<b>High Technology Industries</b>	
1	Pharmaceuticals
2	Electronics
<b>Medium High Technology Industries</b>	
3	Chemicals excluding Pharmaceuticals
4	Electrical machinery
5	Non-electrical machinery
6	Transport Equipments
<b>Medium Low Technology Industries</b>	
7	Rubber and Plastic products
8	Other non-metallic mineral products
9	Cement & glass
10	Basic metal and metal products
<b>Low Technology Industries</b>	
11	Food, beverages and tobacco products
12	Textile leather and footwear
13	Wood, paper and paper products

\* Kumar & Pradhan (2003a,b) & Kumar & Pradhan (2003b).

**Research Framework:**

Since, OECD Classification is the only available classification for knowledge based manufacturing industries, standardization of the same across countries have not been under taken by the researchers. Therefore this research study is an attempt in this direction. As OECD classification is based on the R&D intensity of firms representing the respective industries, this study undertook to evaluate the R&D intensity of the firms representing fourteen industries in India, in conformity with the OECD classification. These fourteen knowledge based manufacturing industries in India are: pharmaceutical industry, electronics industry, transport (automobiles – vehicles) industry, non-electrical industry, electrical machinery industry, transport (automobiles – equipments) industry, chemicals (excluding pharmaceuticals) industry, rubber & plastic products industry, non-ferrous metals industry, textiles, leather & footwear industry, wood, paper & paper products industry, foods, beverages and tobacco products industry, ferrous metals industry and refined petroleum industry.

**Sample size and Source of Data:**

The data was sourced from PROWESS, the electronic database of Centre for Monitoring Indian Economy (CMIE). The CMIE Overall Share Price Index (COSPI) is a total returns index of all firms in India where trading took place on at least 66% of days in last six months. It reflects the equity market of 2800 firms. The firms listed in COSPI Manufacturing Index were chosen for the study. The study period covers a decade, from 2003 to 2013. The study period assumes significance as it would help to review the impact of transition from soft intellectual property regime to TRIPs compliant strong intellectual property regime. The sample was chosen based on the availability of data for R&D expenses as follows:

**Table - 3: Sample Selection of Firms**

Industry	Proportion of Sample = n/N		
	n	N	n/N
Pharmaceuticals	92	150	61.33
Electronics	23	53	43.40
Electrical Machinery	21	50	42.00
Transport (Automobiles) Vehicles	14	19	73.68
Chemicals excluding Pharmaceuticals	51	96	53.13
Transport (Automobiles) Equipments	52	82	63.41
Non-electrical Machinery	46	71	64.79

Rubber and Plastic Products	32	86	37.21
Refined Petroleum Products	17	17	100.00
Non-Ferrous Metals	15	36	41.67
Ferrous Metals	38	171	22.22
Wood, Paper and Paper Products	19	52	36.54
Food, Beverages and Tobacco Products	57	58	98.28
Textiles, Leather and Footwear	57	186	30.65
<b>TOTAL</b>	<b>534</b>	<b>1127</b>	<b>47.38</b>

n = sample from COSPI; N = population in COSPI

**Comparison of R&D Intensity of Knowledge based Manufacturing Industries of India and OECD Countries:**

The R&D intensity of 534 firms representing the fourteen industries viz., pharmaceutical industry, electronics industry, electrical machinery industry, transport (automobiles – vehicles) industry, chemicals (excluding pharmaceuticals) industry, rubber & plastic products industry, non-ferrous metals industry, textiles, leather & footwear industry, wood, paper & paper products industry, foods, beverages and tobacco products industry, ferrous metals industry and refined petroleum industry was computed for the entire study period i.e., for 10 years and their averages are calculated and presented in the following table. Further, R&D intensity of these fourteen industries representing the OECD countries were computed from the OECD Stan indicators and presented for comparing with the Indian industries. The R&D intensity of the fourteen knowledge based industries in India are: pharmaceutical industry 2.61 percent; electronics industry 2.06 percent; transport (automobiles – vehicles) industry 0.80 percent, non-electrical industry 0.63 percent; electrical machinery industry 0.61 percent; transport (automobiles – equipments) industry 0.58 percent; chemicals (excluding pharmaceuticals) industry 0.44; rubber & plastic products industry 0.37 percent; non-ferrous metals industry 0.24 percent; textiles, leather & footwear industry 0.23; wood, paper & paper products industry 0.20 percent; foods, beverages and tobacco products industry 0.18 percent; ferrous metals industry 0.17 percent and refined petroleum industry 0.09 percent. Whereas the R&D intensity of the fourteen knowledge based industries in OECD Countries are: pharmaceutical industry 10.5 percent; electronics industry 8.6 percent; transport (automobiles – vehicles) industry 3.5 percent, non-electrical industry 2.1 percent; electrical machinery industry 3.9 percent; transport (automobiles –

equipments) industry 2.9 percent; chemicals (excluding pharmaceuticals) industry 3.1 percent; rubber & plastic products industry 0.9 percent; non-ferrous metals industry 0.9 percent; textiles, leather & footwear industry 0.3; wood, paper & paper products industry 0.3 percent; foods, beverages and tobacco products industry 0.3 percent; ferrous metals industry 0.6 percent and refined petroleum industry 0.9 percent. The results show that the R&D intensity of knowledge based manufacturing industries in India is much lower than the knowledge based manufacturing industries of OECD. But, the ranking of fourteen knowledge based industries in India is almost similar to the ranking of the fourteen knowledge based industries in OECD countries.

**Table - 4: Comparison of Knowledge based Manufacturing Industry of India with OECD**

Industry	R&D Intensity (in Percent) Rank	
	India	OECD*
Pharmaceuticals	2.61	10.5
Electronics	2.06	8.6
Transport (Automobiles) Vehicles	0.80	3.5
Non-electrical machinery	0.63	2.1
Electrical machinery	0.61	3.9
Transport (Automobiles) Equipments	0.58	2.9
Chemicals excluding Pharmaceuticals	0.44	3.1
Rubber & Plastic products	0.37	0.9
Non-ferrous metals	0.24	0.9
Textiles, Leather & Footwear	0.23	0.3
Wood, Paper and Paper Products	0.20	0.3
Food, Beverages and Tobacco products	0.18	0.3
Ferrous metals	0.17	0.6
Refined Petroleum Products	0.09	0.9

\*Source: Computed from OECD STAN Indicators

**Conclusion**

Industries are generally classified into different groups on some parameter in order to compare the performance between the groups of homogeneous units, be it firms or industries. Though some Standard Industrial Classification (SIC) like Fama and French (1997) and Pavitt’s Taxonomy (1984) are widely used in economic and management research, industrial classification for knowledge based manufacturing industries is yet to come. Since, OECD Classification is the only available classification is only available classification for

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