RESEARCH REVIEW JOURNALS
Volume-04
Issue-06
June-2019

ISSN: 2455-3085 (Online)
RESEARCH REVIEW International Journal of Multidisciplinary
www.rrjournals.com[UGC Listed Journal]

Measuring R&D Intensity for Technological Classification of Knowledge Based Manufacturing Industries

[*1]Dr. Sivakoumar. N & [2]Dr. V. Kavida

[1]*Assistant Professor of Foreign Trade, Indira Gandhi College of Arts and Science, (Government of Puducherry), Kadirkamam, Puducherry-605 009 (India)*
[2]*Associate Professor, Department of Commerce, School of Management, Pondicherry University, Puducherry-605 014 (India)*

ARTICLE DETAILS

Article History
Published Online: 10 June 2019

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

[*]**Corresponding Author**
Email: sivakoumarn[at]gmail.com

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 is based on the Research & Development (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.

1. 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 under taken 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 Research & Development (R&D) intensity of the firms representing seven industries, which are 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.

2. 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 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.

3. 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)

High Technology Industries	
1	Aircraft and spacecraft
2	Pharmaceuticals
3	Office accounting and computing machinery
4	Radio, TV and Communications equipment
5	Medical, Precision and Optical instrument
Medium High Technology Industries	
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
Medium Low Technology Industries	
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
Low Technology Industries	
16	Manufacturing - recycling
17	Wood, pulp, paper products, printing and publishing
18	Food products, beverages and tobacco
19	Textiles, textile products, leather and footwear

4. 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:

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

5. 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.

6. Classification of Knowledge based Manufacturing Industries of India

Kumar & Pradhan (2003a), Kumar & Pradhan (2003b) were the pioneering studies in presenting a 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)

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

Kumar & Pradhan (2003a,b) and Kumar & Pradhan (2003b).

7. Research Framework

Since, OECD Classification is the only available 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 seven industries in India, in conformity with the OECD classification. These seven knowledge based manufacturing industries in India are: 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.

8. 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

	Proportion of Sample = n/N		
Industry	**n**	**N**	**n/N**
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
TOTAL	**235**	**606**	**38.77**

n = sample from COSPI; N = population in COSPI

9. Results

The R&D intensity of 235 firms representing seven industries viz., 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. The R&D intensity of the seven knowledge based manufacturing industries in India are rubber & plastic products industry 0.37 percent; non-ferrous metals industry0.24 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.

Table – 4: R&D Intensity of Knowledge based Manufacturing Industries in India

Industry	**India**
Rubber & Plastic products	0.37
Non-ferrous metals	0.24
Textiles, Leather & Footwear	0.23
Wood, Paper and Paper Products	0.20
Food, Beverages and Tobacco products	0.18
Ferrous metals	0.17
Refined Petroleum Products	0.09

10. 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 knowledge based manufacturing industries, standardization of the same across countries have not been under taken 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 evaluation the R&D intensity of the firms representing 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 in India and found that the all these industries spend less than 1 percent of their revenue for R&D.

References

1. Aboody, D. and Lev, B. The Value Relevance of Intangibles: The Case of Software Capitalization. Journal of Accounting Research. 36 (supplement): 1998: 161-191.
2. Aggarwal, A.. Strategic approach to Strengthening the International Competitiveness in the knowledge based industries: The Indian pharmaceutical industry. Research and Information System for Developing Countries, RIS- DP #80:2004. (Available at www.ris.org.in).
3. Dahlman, C., and Utz, A. India and the Knowledge Economy: Leveraging Strenths and Opportunities, Overview, Wasington D C: The World Bank 2005.
4. Ding, Y., Stolowy, H. and Tenehaus, M. R&D productivity: An exploratory international study. Review of Accounting and Finance, Vol. 6 No. 1 2007:86-101.
5. Drucker, P. The Age of Discontinuity: Guidelines to Our changing Society. New York: Harper and Row 1969.
6. Drucker, P.F. The coming of the New Organization. Harvard Business Review, Vol. 66(1), 1998:3-11.
7. Fama, Eugene F., and Kenneth R. French. Industry costs of equity. Journal of Financial Economics 43. 1997: 153–193.
8. Griliches, Z. Market value, R&D and patents. Economics Letters, Vol. 7, 1981: 183-187.
9. Hatzichronoglou, T. Revision of the High Technology Sector and Product Classification. OECD Science, Technology and Industry Working Papers, 1997/02, OECD Publishing 1997. Available at http://dx.doi.org/10.1787/134337307632
10. Kumar N. and Pradhan, J.P. Export performance of Indian enterprises in the Knowledge Based Industries: Recent Trends, Patterns and Implications. Research and Information System for Developing Countries (RIS), Discussion Paper, No- 42, New Delhi 2003.
11. Kumar, N., and Pradhan, J. P. (2003). Export competitiveness in the knowledge-based industries: a firm-level analysis of Indian manufacturing. Research and Information System for Developing Countries (RIS), Discussion Paper, No- 43. New Delhi.
12. Lev, B. and Sougiannis, T. The capitalization, amortization, and value-relevance of R&D. Journal of Accounting and Economics, Vol. 21, 1996:107-138.
13. Machlup, F. The Production and Distribution of Knowledge in the United States. Princeton University Press, Princeton, NJ 1962.
14. Mashelkar, R. A. Economics of knowledge. Excerpts from the 16th Dr.C.D. Deshmukh Memorial Lecture at the International Centre, New Delhi, India.1999. Available at http://www.ias.ac.in/currsci/jul25/articles14.htm.
15. Mukerjee. Centre for Development Studies Trivandrum. MPRA Paper No. 35694 :2009. Available at http://mpra.ub.uni-muenchen.de/35694/.
16. Naik, P. K., and Narayanan, K., and Padhi, P. *R&D intensity and market valuation of firm: S study of R&D incurring manufacturing firms in India.* MPRA paper 37299. 2012 Available at: https://mpra.ub.uni-muenchen.de/id/eprint/37299.
17. Organisation for Economic Co-operation and Development (OECD) Measuring What People Know: Human Capital Accounting for the Knowledge Economy. Paris: OECD 1996.
18. Pavitt , K. Sectoral Patterns of Technical Change: Towards a Taxonomy '. Research Policy 13 : 1984: 343 – 73 .
19. Shaban, M. Intellectual Capital and Corporate Performance: An Empirical Analysis of BSE 500 Companies in India (Unpublished Doctoral Thesis), Pondicherry University, Pondicherry, India, 2014. Available at Ananda Rangapillai Library, Pondicherry University 2015.

