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Product Market Competition and R&D:

A Firm level Study of Indian Manufacturing Industry

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Dissertation Submitted in the partial fulfillment of the requirements for the degree of Master of Philosophy in Applied Economics of the Jawaharlal Nehru University

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M.Phil Programme in Applied Economics

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I hereby affirm that the work for this dissertation, 'Product Market Competition and R&D: A Firm level study of Indian Manufacturing Industry ' being submitted as a part of the requirements of the MPhil Programme in Applied Economics of the Jawaharlal Nehru University, was carried out entirely by myself. I also affirm that it was not part of any other programme of the study and has not been submitted to any other University for the award of any degree.

June 25, 2007

Prabhu Dass. G

Certified that this study is the bona fide work of Prabhu Dass. G, carried out under our supervision at the Centre for Development Studies.

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ABSTRACT OF THE DISSERTATION

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Technological progress is considered as the engine of long run economic growth. It is also one important source of competitiveness of firms. Therefore in the modern world policies measures have been put in place to encourage deliberate investments to generate technological progress. Investment in R&D particularly by manufacturing firms is one of the important sources of technological progress. A number of studies examine the factors determining firms' decision to invest in R&D. Among the various determinants the impact of market structure in which the firm operates is one of the highly debated issues in the literature. From our review of theoretical and empirical literature it is not clear whether or not a competitive market structure promotes R&D investment by firms. However, the recent changes in the policy regime in developing countries particularly in India tries to increase the competitive pressure on domestic industry in order to improve the pace of technological progress. Against this background the present study examines the impact of product market competition on firms' decision to invest in R&D in Indian manufacturing industry.

Our analysis shows that the government spending on R&D has come down and there has been a substantial increase in the private sector R&D spending in the post reform period both in terms of spending and intensity. In our analysis, we examined market structure in terms of extent of product market competition using Lerner index. The findings suggest that for majority of the industry groups there was a marginal increase in the competition, but for only a few industries there is substantial change in product market competition over time since 1991, which can be attributed to liberal policy regime of the Government. And some industries, the degree of market power has not changed. Hence the series of measures introduced to increase competition in the industrial sector has resulted in inducing some degree of competition in majority of the industries.

In our analysis of the impact of product market competition on R&D we used econometric methodology and firm level panel data for the period 1995-2004. In this we examined the impact of product market competition on the probability of firms investing in R&D, using a Probit regression. For capturing the technological opportunity and appropriability conditions, we used Pavitt Sectoral classification of industries and estimated the determinants of R&D for each sector separately namely 1) Supplier dominated 2) Scale intensive 3) Specialised suppliers and 4) Science based. From the estimation we could see that as the Lerner index increases, the probability to do R&D also increases, but after certain level it is decreasing in three sectors i.e., Supplier dominated, Scale intensive and Science based. For Specialised suppliers sector we don't get significant result. This finding of an inverted U shaped relationship between product market competition and R&D lies in tandem with the new theoretical argument, which states that too little and too much competition is not conducive for innovation effort of firms. Therefore, the study finds that Schumpeterian hypothesis that a monopoly market structure is conducive for innovation effort of firms does not hold in Indian manufacturing sector.

CONTENTS

Chapter 4: Conclusion

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Technological change is central to the process of economic development. It refers to improvements in the transformation of inputs into outputs, including improvements in the quality of output (Fransman 1986). The ability to understand, exploit and adapt to a rapidly changing technological environment is seen as a key factor in improving the standards of living. Hence, in the modern world policy measures have been put in place to encourage deliberate investments to generate technological progress. Investment in R&D, particularly by the manufacturing firms, is one of the important sources of technological change. R&D invested in producing new products allows firms to gain market shares, while process R&D allows firms to reduce their production costs. The role of research and development in economic growth has been examined extensively in the literature for several decades[1].

It is thus viewed that technological change is the product of deliberate R&D activity for product or process improvement. R&D activity contributes to economic growth by methods, which either improves quality of factor inputs - labour and capital or increases the efficiency with which these factors are used. Hence investment in R&D is definitely a sign of development of new technology and also one of the indicators of technological adoption. There are many factors, which affect the R&D activity of firms in an economy, and of the various other determinants, the type of market structure that promotes R&D is a much-debated issue in the literature. Economists differ in terms of the type of market structure that promotes R&D effort of firms. Schumpeter (1942) is most often cited as the originator of the view that small firms operating in competitive markets may not be as dynamically efficient as a larger firm operating in a more concentrated market. Schumpeter argued that monopolistic power in the existing product market might be a pre condition for innovation and anticipated market power in new products may provide essential incentives to innovate (Baldwin and Scott 1987). The Schumpeterian hypothesis asserts that the possession of accumulated monopoly rewards, the prospects of additional rewards in the future and the security attending market power are

[1] Innovation activity can be quantified either in terms of the inputs used or in terms of output generated from the economic activity. Conventional input measures are R&D expenditure; R&D manpower and the output measures are Patents and new products. For the present analysis R&D expenditure as a percentage of sales is used as proxy for innovation effort.

prerequisites for undertaking the risks and uncertainties of innovation effort of firms (Markham 1965). The essence of Schumpeter's argument is that innovation is an activity fraught with uncertainty, and that large-scale R&D may not be attractive unless some sort of insurance is available to the potential entrepreneur i.e. firms with greater market power can more easily appropriate the returns from innovation and hence have better incentives to innovate (Symeonidis 1996). But there have been arguments supporting and disagreeing with Schumpeter[2] and this led to the long-standing and much debated hypothesis that more concentrated industries are more conducive for R&D. Arrow (1962) argued that under certain conditions, there is greater incentive for doing R&D, when industries are competitive than when monopolized. Still at empirical level there has been inconclusive evidence on the effect of market structure on innovation effort of firms as market structure's influence on R&D may be dependent on industry specific factors like barriers to entry, technological appropriability and technological opportunity[3].

This chapter focuses on the survey of literature that has made contributions to the link between market structure and innovation effort of firms[4]. The important question that is raised in the literature is what kind of market structure induces firms to undertake R&D investment. Incentives associated with outperforming rivals can encourage firms to innovate and in some cases, may be tempted of supra-normal returns that may encourage firms to do R&D.

1.1 R&D and Market structure: theory and evidence

Various studies in this area empirically test the Schumpeterian hypothesis by exploring the causal link between market structure and research and development. It is argued that a highly concentrated market structure protects the dominant firms from competitive pressures and enables them to appropriate the fruits of their R&D effort. But a certain viewpoint is also prevalent which says that the presence of market power with concentration enables the firms to reap profits without necessary being innovative (Kathuria 1989).

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[2] For a detailed review see Symeonidis (1996).

[3] Technological opportunity is the potential for technological progress in general or specific field and technological appropriability is capturing and protecting the competitive advantages of new and improved products or production processes. The role of these two industry specific characteristics in determination of R&D activity of firms is well explained in third chapter of this study.

[4] For an intense review of literature on the relationship between market structure and innovation see Kamien and Schwartz (1975).

Dhalokia (2004) surveys the literature on market structure and innovation by keeping the basic argument that monopoly has implications on innovation that are far reaching in terms of optimal social output. The result of literature survey done by the author is that monopoly power definitely seems to have a strong impact on innovations in the product market, by providing significant rewards to inventors, having quicker innovation procedures, possessing ability and resources to create barriers to entry in the market.

Dasgupta and Stiglitz (1980) address the issue of market structure and R&D investment of firms and bring a fundamental change to the Schumpeterian argument. The authors argue that except in the short run, both market structure and innovation effort are endogenous and they depend on factors such as technological opportunity, the nature of capital market i.e. market rate of interest and the ability of firms to access external capital for funding their research and development. Unlike in Schumpeterian argument, which considers the degree of competition and nature of innovation effort as a causal one, the authors build a model in which both are considered endogenous. Industrial concentration and research intensity are simultaneously determined in their model and market structure, to a large extent, is determined by the conditions for innovation effort. They conclude by saying that a pure monopolist may not have sufficient incentive to undertake R&D activity and to engage in risky ventures and since competitive markets encourage firms to engage in risky research projects and pressure from competition may speed up the research and development activities of firms.

There are other studies, which articulate the various ways in which market structure and innovation behaviour interact. Kamien and Schwartz (1982) bring out different dimensions of the relationship between market power and innovation effort of firms. Various issues like innovation and anticipation of market power and innovation and possession of market power is dealt by the authors in detail. If a firm has a monopoly power over its present products and subsequently controls over the channels of distribution then it can extend it to new output. The authors clarify Schumpeter's analysis by saying that a monopoly firm can easily respond to its rival's innovations more quickly and it is able to finance its risky projects internally. But they also caution that monopoly power can act as a major disincentive to innovation because a firm

having monopoly profits has less incentive to seek additional returns through innovation. They review the empirical literatures available and come to the conclusion that rivalry in R&D may be related to the industry concentration ratio. But the authors find little support to the standard hypothesis that R&D activity increases with monopoly power and the study revealed an inconclusiveness of the relationship between market structure and innovation activity. In this work a new hypothesis emerges from their analysis, i.e. a market structure intermediate between monopoly and perfect competition would promote the highest rate of innovation.

Findings from earlier studies on the sign of linear relationship between market concentration and R&D were mixed, with the majority pointing to a positive relationship. Some recent studies have found an "inverted U" relation, i.e., a positive relationship between concentration and R&D to a certain level of concentration but a negative relationship beyond that. Scherer (1967) finds a non-linear inverted U relationship between market structure and innovation. He notes that innovation effort (measured by total number of technical engineers and natural scientists as a proportion of total employment) increases with market concentration (measured by four firm concentration ratio) up to certain point, after which it decreases[5]. Aghion (2003) finds inverted U shaped relationship between product market competition and innovations, at the industry level and at the firm level. However, there are studies, which find that the relation between market concentration and R&D intensity disappears when inter-industry differences are controlled for (Levin *et al.*, 1985). The Schumpeterian hypothesis on market structure and innovation has gone through lot of empirical validation over the years by different scholars. Some of the selected empirical works, which test the relationship between market structure and innovation, is summarized below.

[5] Quoting Scherer "technology vigor appears to increase with concentration mainly at relatively low levels of concentration. When the concentration ratio exceeds 50 or 55 percent, additional market power is not conducive to more vigorous technological efforts and may be downright stultifying" (PP: 530 1964).

Table 1.1: Selected review of studies on market structure and Innovation.

Study	Data and Period	Methodology	Variables	Results/inference
Horowitz (1962)	Two data sets for research activity and two data sets for industrial concentration covering 18 two-digit industries and 29 two and three digit industries for the period 1959.	The correlations are obtained between industries ranked with respect to size of firm and industrial concentration, and ranked in accordance with the various measures of research expenditure	Four firm concentration ratio is used as a index for market concentration and research expenditure as a proxy for innovation	The author finds that in more concentrated industries firms are likely to maintain high research intensities[6].
Hamberg (1964)	Two data sets are used in the analysis. One for research intensity[7] and the other for industrial concentration for the year 1958.	Cross-section data and ordinary least square technique is used to test the relationship between innovation effort and concentration	Research expenditure is used a indicator for innovation which is used as dependent variable and Weighted average concentration index is used as a indicator for market concentration and is used as independent variable.	Positive but weak relationship between Market concentration and R&D[8].
Williamson (1965)	Data used from Mansfield for two time points - 1919-1938 and 1939 - 1958	Panel data analysis using OLS technique. Both linear and double log model is used.	Innovations introduced by four largest firm in the industry is taken as independent variable and four firm concentration ratio as independent variable	Negative and significant relationship between market structure and innovation.
Jadlow (1981)	A sample of 20 therapeutic drug markets for the time period 1963-1973.	Panel data analysis using OLS technique	Innovation counts [9] is used as the dependent variable and 4 firm concentration ratio is used as independent variable.	Positive relationship between market structure and innovation

6 Research intensity is research and development expenditure as a proportion of sales.

7 Research intensity is R&D expenditure/sales

8Quoting Hamberg "Hence though positive association between R&D intensity and industrial concentration apparently exists, it must be described as weak, as must also be the case for industrial concentration as a stimulus to R&D, both in absolute and relative terms." (PP: 75, 1964)

[9] Each market's rate of innovation has been measured by counting the total number of innovations introduced in that market during the 1963-1973 time period. All New Chemical Entities are treated as innovations by the author and are weighted by second year dollar sales so as to reflect each new product economic importance to society.

Mukhopadhyay (1985)	Concentration and R&D data of 4, 8 and 20 firms from 1963-77.	Panel data analysis for 304 industries.	Changes in four and eight firm concentration ratio are taken as dependent variable and R&D intensity is taken as independent variable.	Negative relationship between market structure and Innovation.
Levin et al (1985)	Survey data on R&D appropriability and Technological opportunity for the year 1984.	Cross-section data using OLS and Two State Least Square estimation.	R&D intensity is taken as dependent variable and Four firm concentration ratio is taken as independent variable.	Inverted 'U' relationship between market structure and Innovation.
Geroski (1990)	Data on 4378 innovations introduced in UK, 1945-83.	Panel data analysis for two time points i.e., 1970-74 and 1975-79 using Tobit and OLS technique	Innovation output as dependent variable and concentration index as independent variable.	Negative significant relationship between market structure and innovation
Gayle (2001)	Firm level data for 4800 U.S manufacturing firms over the period 1965 to 1995.	Panel data analysis using three separate simultaneous equations.	Citation-weighted patent count for innovation output as dependent variable, and market concentration measured by Herfindahl index,	Positive relationship between market structure and innovation.[10]
Raider (1998)	Three data sets used for analysis including the Yale survey data providing information on innovations since 1970.	Cross section analysis using OLS technique	R&D intensity is used as dependent variable and four firm concentration ratio as one of the independent variable	Inverted 'U' relationship between market concentration and innovation activity[11].
Chang-Yang lee (2005)	Data on R&D and market concentration on 426 Korean industries for 1983 from Yale survey data.	Cross section analysis	Log of R&D intensity dependent variable and four firms concentration ratio and Herfindahl index as independent variables.	Inverted 'U' relationship between market concentration and innovation activity.

10 The study also provides some new insights on innovation effort by claiming that on average successful innovation is more powerful than advertising at increasing a firm's market share. Even though the paper finds empirical support for the Schumpeterian hypothesis, the results can only be interpreted as on average relationships. If the analysis were done for industries individually for evidence of the Schumpeterian hypotheses, various Industries specific characteristics would have got included.

11 When the author uses simple OLS technique the coefficients report an inverted U nature of the association between concentration and innovation activity. But when the analysis was made by accommodating network constraints the results demonstrated different picture i.e. concentrated industries facing extreme downstream and upstream competition devote a greater proportion of their resources to research and development and experience higher rates of innovation, indicating that extremity is a positive motivator for innovation activity

From the review of above literature, which empirically examines the relationship between market structure and innovation, a few inferences can be made. Three main results seem to have emerged from the survey of empirical studies. The results can be grouped into three. First, there is evidence of a positive relationship between R&D and concentration in general, although it may be weak. A concentrated market structure or monopoly is more conducive for innovation as firms with greater market power can easily appropriate the returns from innovations and hence have better incentive to innovate and firms with greater market power can finance their own research and development activities from their own profits. Second, there is even less evidence of a negative relationship between innovation and market structure. Third, the relationship between market structure and innovation is found to be of inverted 'U' shaped i.e. too much or too little competition is not suitable for innovation effort of firms. The logic behind this argument is that firms compare the expected profit of pre and post-innovation rents. Hence if competition increases, firms might escape competition by innovating. The positive effect of competition on innovation and R&D is strongest in levelled industries characterized by neck-to-neck firms with similar technological level[12]. However, if competition is intense, firms may not be able to appropriate their returns from innovation, i.e. the negative Schumpeterian effect of competition on R&D dominates the escape competition effect. Hence the above two forces give rise to inverted U shaped relationship between product market competition and R&D (Poldahl and Tingvall 2005).

A variety of measures have been used in the empirical literature for measuring innovation activity. Measures of innovation inputs included in the analysis are research and development expenditure and R&D personnel. Measures of innovation output include number of patents and number of significant innovations. The studies have basically used cross section data, panel data and case study approach.

From the above review of the studies, one of the major problems is its inconclusiveness and ambiguity on the relationship between market structure and innovation. There is lack of adequate consensus with regard to the results of the analysis. The diverging results could probably be explained by measurement problems associated with

[12] If an industry is characterized by neck-to-neck firms with similar technology, the gain due to an innovation is high. Instead of sharing the technological lead with its competitors, firms will now be the single front technology firm. Hence product market competition will boost firm R&D.

conceptualizing innovation and market concentration or because of paucity of data and empirical procedures used in the estimation. From the survey of the empirical literature we can see that market structure alone does not induce R&D activity; industry specific characteristics such as technological opportunity and appropriability also explain the variance in R&D intensity along with market structure variables (Geroski 1990).

In India too, many scholars have empirically tested the relationship between market structure and innovation. The Indian studies, similar to the developed country studies give, mixed results. An important work in this regard is Desai (1982). In this work the author tries to explore the relationship between market structure and innovation activities of firms in Indian industry keeping Schumpeterian hypothesis (relationship between firms' size, market structure and innovation) in background. The key argument of the paper is that it is oligopolistic type of market structure with equal firm size distribution, where competition is more prevalent between few firms, which are conducive for innovation. He further argues that large firms seek new technology only if technology makes a significant difference to their competitive position and this it does mostly in a highly integrated short tailed market.

The author classifies the industry structure into long tailed i.e. existence of small number of large firms and large number of small firms and short tailed i.e. the oligopolistic type, where small firms are few or absent. The methodology used by the author for classifying the market structure is the H index and E index of inequality. For capturing investment in technology the author took three variables - research and development expenditure, import of technology and foreign subsidiaries. The author finds that in most industries apart from vehicle industry, the HHI index was low, the size distribution was highly skewed and the industry structure was long tailed. And size distribution of firms was less skewed in short tailed (oligopolistic) industries. With regard to research and development intensity, short tailed industries were more R&D intensive, as R&D is scale related. These industries (Short-tailed) are technology - intensive industries. And the proportion of firms doing R&D was lower and highly variable in long-tailed industry. With regard to technology imports too the author gives a similar picture where technology imports, unassociated with in house R&D are likely to be the highly dominated by a large number of medium sized firms, which are too small to do R&D - industries with low concentration. The author believes that technology imports tend to create oligopolistic market structures, R&D reinforces the competitive advantage of large

firms and concludes that neither the long tailed market structure (large number of firms), which is common in India, is not especially conducive for technological progress, nor the government-established monopoly firms. The analysis would have been more influential if firm level data to capture firm level characteristics affecting innovation activity had been used with more appropriate statistical technique to understand the effect of market structure on innovation effort of firms in Indian industry.

Table 1.2: Selected review of Indian studies on market structure and Innovation

Study	Period	Methodology	Variables	Results/inference
Subrahmanian (1971)	1968	Case study of Chemical industry and analysis using correlation and OLS regression technique.	R&D intensity is used as dependent variable and concentration index is used as independent variables.	Does not provide any conclusive evidence on the relationship between market structure and innovation to support Schumpeterian hypothesis
Vijayabhaskar (1991)	1980-90	Time series analysis.	R&D growth as dependent variable and concentration growth as independent variable	Negative relation between market structure and innovation effort of firms.[13]
Subodh (2002)	1992-97	Time series data for two industries and analysis using Probit estimation.	R&D intensity is taken as dependent variable and market concentration dummy as independent variable	Negative relationship between market structure and innovation effort for Pharma firms and positive relationship for electronic firms.
Das (2002)	1982-98	Panel data analysis	R&D expenditure is the dependent variable and four firm concentration ratio is the independent variable[14]	Only for transport industry market structure has positive effect on innovation effort of firms, for rest of the industry the relationship is not evident as the variables are not significant.

[13] The author finds that research intensity decreases with increasing concentration. As the period of analysis is between 1980-90, it was not possible for the study to capture the picture of the relationship between market concentration and innovation activity in the pro-market oriented economy.

[14] The author also uses dummy variable to show the structural break and other economic variables like technological opportunity is not considered for analysis.

The Indian literature on the issue of market structure and innovation has also yielded results, which are indefinite. Only Subrahmanian (1971) and Subodh (2002) among Indian literature use estimation techniques to test the effect of market structure on innovation effort of firms, but their analysis too have data limitations and estimation problems. As majority of the studies try to confine their analysis to the pre-reform period, change in the trend and pattern of market structure and innovation effort of firms in the post reform context is not captured.

1.2 Problem of the study

In the present study we try to test the effect of market structure on innovation effort of firms. Even though this has been tested empirically by several scholars, results produced are ambiguous either because of lack of proper statistical data or data non-availability. In India, economic reforms- pro-market oriented industrial, technology; trade and other major economic policies- have been initiated since 1991 in place of earlier policies based on command planning and discretionary controls of government. A proper empirical understanding of this issue is required in the post reform scenario as one of the basic objectives of the government behind the paradigm shift in the policy-framework probably was to increase the competitive pressure on domestic industry in order to improve the pace of technological progress. Therefore, the present study examines whether the government's pro-market economic reforms have helped in raising the R&D activity, a major source of innovation, of firms, by creating a favourable environment for innovation. We have also examined the non-linear effect of market structure on R&D. Market structure is analysed through the extent of product market competition using Lerner index and innovation effort of firms is measured through R&D expenditure[15].

Keeping these issues in the background, the study tries to examine the following objectives:

1. To analyse the trends and pattern in research and development expenditure of manufacturing firms in India.

2. To analyse the trends in product market competition across manufacturing industries in the post reform period.

3. To empirically examine the impact of product market competition on firms decision to invest in R&D and examine their inter sectoral variation.

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[15] As majority of the studies use R&D expenditure to measure innovation effort of firms, we too use the same indicator in present study to measure innovation.

1.3 Chapter Scheme

The present study is divided into four chapters. Chapter one reviews the theoretical and empirical literature on market structure and innovation. In the second chapter we examine the trends and patterns in R&D expenditure and product market competition. Third chapter estimates the relationship between product market competition and the probability to do R&D by firms. Fourth chapter concludes the study.

1.4 Data Source

For the present study we have used pooled firm level dataset (combining cross section and time series data from Centre for Monitoring Indian Economy (CMIE) database PROWESS. We have also used other data source like DST (Dept. of Science and Technology) dataset for getting the macro R&D data. Detailed description of data and methodology used in the study will be provided in the subsequent chapters.

CHAPTER 2

R&D AND PRODUCT MARKET COMPETITION: TRENDS AND PATTERNS

2.1 Introduction

This chapter examines the trends and patterns in R&D investment and product market competition in Indian industry. This chapter is divided into five sections. Section one deals with India's pre and post reform industrial policy. In second section we try to examine India's R&D policy in the pre and post reform period and analyse the trends and patterns in R&D investment. Third section analyses the trends and pattern in product market competition indicating whether there has been a change in product market competition in India since reforms. Section five examines the relationship between R&D intensity and Lerner index and summarizes the major findings of the chapter.

2.2 India's industrial policy in pre and post reform period

Before analysing the trends in competition and R&D investment, it would be significant to understand various policy measures undertaken by government before and after reforms. From a controlled regime the manufacturing sector has moved to a pro market oriented one. Throughout 1960s and 1970s Indian industry was highly regulated and protected as the formal manufacturing sectors were subject to licensing requirements and capacity controls. Controls on imports and tariffs protected Indian industry from foreign competition. In a process that arguably began in the 1980s, but gained prominence after 1991, Indian industry was progressively deregulated and exposed to domestic and foreign competition[16]. And one of the basic objectives behind this shift in policy was to strengthen competitiveness in Indian Industry. A series of measures to deregulate the financial sector and to provide access to foreign technology were also introduced from the early nineties to facilitate the entry of more firms in the industry.

To get an overview of the reforms policies it would be significant to analyse the industrial policy prevailing prior to the launching of the reforms (Table 2.1). The industries were either a state monopoly or subject to strict industrial licensing.

[16] See Joshi and Little (1997) , Athreye and Kapur (2003)

Industrialisation was thus under centralised investment planning and gave more emphasis to basic and heavy industries under public sector. The direct involvement of the state in economic development resulted in the heavily regulated markets, the policy of self-reliance in industrialization resulted in a restrictive trade policy regime which gave emphasis to import-substitution thus hampering efficiency and export performance. Import requirements of basic and heavy industries put further pressure on balance of payments, resulting in more restrictive controls on imports of commodities and capital and perpetual shortage of foreign exchange in the face of non-expanding exports (Bhagawati and Desai 1970). These inward looking policies made Indian industrial sector internationally uncompetitive and trade protection compounded the problem of technical inefficiency because of a regulatory regime. The government of India started relaxing its regulations and controls over the industrial sector since mid-eighties and introduced comprehensive measures of market-friendly reform policies in the nineties. These policy measures have tried to undo some of the problems by bringing in less protective and more market friendly measures.

The Indian approach towards liberalization resulted in the adoption of a number of pro - market oriented policies (See Table 2.1 and 2.2 in appendix - I). In a broader context reform policies like abolishing of license raj, opening of industries to private as well as foreign players, were basically aimed at increasing competition. Reforms measures adopted in the external sector include partial substitution of some quantitative restrictions by tariffs in the 80s and the abolition of all Quantitative Restrictions in the nineties. The significant shift in policy regime towards more market-oriented economy was intended to promote competition and enhance efficiency.

2.3 India's R&D scenario in pre and post reform period

Investment in R&D expenditure is one of the indicators of technological adoption growth. R&D yields new products, improves the quality of life, and new processes, enabling firms to reduce costs of production and become more competitive. Maintaining or increasing the R&D effort is essential if we are to increase the rate of productivity growth and improve living standards. Having examined the Industrial policy of India in the pre and post reform scenario; it would be significant to look into India's R&D scenario for both the periods. In the pre-reforms era, most of the R&D in India was undertaken by the government both for defence research and for the generation of the

public stock of knowledge. The R&D activity by private firms in the pre-reforms era was very marginal (Patibandla 2006). Forbes (2001) examines the R&D situation of India in the pre and post reform period[17] and found that bulk of the R&D activity was devoted to "development", which meant developing local suppliers of raw materials and components, developing substitutes where the exact product was not available and developing local manufacturing process. Indigenisation was the core strategy of firms in Indian industry. Even though much effort was spent on enhancing domestic technological capability, the important issue was whether this effort was useful in the production of globally competitive products. The expansion and diversification in the industrial base during the pre-reform period was mainly owing to increasing factor inputs, particularly increasing public investment; factor productivity, which grew at a negligible rate of 0.2 percent, did not contribute significantly to industrial growth (Ahluwalia 1991).

In the post-reform scenario the focus changed the technology profile of Indian industries (Aggarwal 2001). One of the indicators of increased technological activity in the post-reforms era is the technical collaboration between local firms and foreign firms. It is found that technical collaborations are the largest in the capital goods industries, followed by basic goods and consumer non-durable goods during this period (see Table 2.3)

Of the various policy initiatives of the Government to harness the innovation activities of firms, key are increasing the supply of technically trained human resource, providing fiscal incentives for encouraging R&D activities, improving the technological infrastructure and last but not the least increasing the level of protection of Intellectual Property Rights (Mani 2007).

[17] The author claims that the R&D effort of Indian companies in the pre-reform scenario could be divided into three – basic research which absorbed 2 -3 % of corporate R&D, development around 30-40% and the rest of the corporate R&D was spent on operational investigations i.e. the problem of raw material supply, manufacturing problems and customer problems

Table 2.3: Industry-wise breakdown of foreign collaboration approvals in India (August 1991 to March 20002)

Industry	Number of approvals	
	Technical	Financial
Basic goods	1517	1942
Power	21	246
Oil refinery	111	144
Capital goods	3237	3301
Electrical equipment	893	768
Electronics	158	327
Transportation	562	610
Intermediate goods	251	560
Consumer non-durables	1387	2976
Pharmaceuticals	236	247
Textiles	151	576
Food products	134	613
Consumer durable goods	37	122
Passenger cars	6	65
Services	571	5601
Computer software	86	2267
Telecommunications	126	675
Financial services	8	406
Total	7000	14502

Source: Economic and Political Weekly (2002) as quoted in Patiblanda (2006)

Table 2.4: Major Indian policy initiatives to encourage innovation

Year	Policy Initiative
1958	Scientific Policy Resolution
1970	Indian Patents Act
1983	Technology Policy Statement
1985	R&D Cess Act
1988	Venture Capital Guidelines Announced
1995	Technology Development Board Act
1996	CSIR 2001: Vision and Strategy Announced Securities and Exchange Board of India (Venture Capital Funds) Regulations, 1996
1999	The first amendment to the Indian Patents Act (IPA) 1970: to put in place a mechanism for accepting product patent applications covering pharmaceutical and agricultural chemicals from January 1, 1995 (better known as the mail-box provisions) and to provide exclusive marketing rights if certain conditions are fulfilled
2000	New Millennium Indian Technology Leadership Announced
2002	The second amendment to the IPA to bring it in conformity with all the relevant provisions included in the TRIPS Agreement, barring a solitary exception. This exception viz., introduction of product patents in the area of chemicals, pharmaceuticals, agricultural chemicals and food.
2003	New S&T policies announced
2005	The third amendment to the IPA extending product patents to chemicals, pharmaceuticals, agricultural chemicals and food.

Source: Mani (2007)

Policy measures in the post-reform scenario aimed at improving the international competitiveness and technological up gradation of Indian industries (See Table 2.4), and whether they were able to increase the R&D profile of firms is an important question to analyse. Given this background, this chapter tries to examine two objectives, first to analyse the trends and patterns of R&D activity of firms in Indian manufacturing industry and second to assess the degree of imperfection in Indian manufacturing industry since 1991.

2.4 Trends in R&D expenditure

This section analyses the trends in R&D investment of firms in Indian industry. We begin the analysis with a short sketch of the trends in national R&D spending during pre and post reform scenario by examining the trends in R&D/GNP ratio. Our aim is to capture the changing profile of the R&D spending and to examine whether there has been an increasing role of private sector in R&D activity.

Table 2.5: National Expenditure on Research & Development in relation to Gross National Product

Year	R&D Expenditure	GNP	R&D as a % of GNP
1985-86	2068.78	248118	0.83
1986-87	2435.4	276453	0.88
1987-88	2853.07	313374	0.91
1988-89	3347.26	373995	0.90
1989-90	3725.74	432289	0.86
1990-91	3974.17	503409	0.79
1991-92	4512.81	579009	0.78
1992-93	5004.6	661576	0.76
1993-94	6073.02	769265	0.79
1994-95	6622.44	903975	0.73
1995-96	7483.88	1059787	0.71
1996-97	8913.61	1230464	0.72
1997-98	10611.34	1376943	0.77
1998-99	12901.54	1583110	0.81

Source: Calculated from DST Research and Development Statistics 2001

Table 2.5 shows the share of R&D expenditure in GNP in India. Not only it is less than one percentage, there has been a marginal decrease in this average share of R&D expenditure in the post-reform period. From this initial analysis one may be tempted to conclude that the pro-market oriented reform policies of the Government have not increased the overall R&D activity in the country. But from an aggregate analysis we cannot come to such a conclusion. To get a more detailed picture of the R&D activity we need to analyse the trends in allocation of National R&D expenditure by sector.

Table 2.6: National Expenditure on Research and Development by sector

Year	Sector			
	Central sector (%)	State sector (%)	Government sector (%)	Private sector (%)
1980-81	76.33	7.80	84.13	15.87
1985-86	79.95	7.87	87.82	12.18
1990-91	76.95	9.21	86.16	13.84
1993-94	74.58	9.25	83.82	16.18
1994-95	71.13	8.96	80.08	19.92
1995-96	69.48	8.78	78.26	21.74
1996-97	64.26	9.59	73.85	26.15
1997-98	64.88	8.73	73.62	22.98
1998-99	67.48	7.96	75.44	21.63
1999-00*	67.27	7.80	75.07	22.30
2000-01*	67.02	7.65	74.67	22.98

*Estimated

Source: DST Research and Development Statistics 2001

From table 2.6 we can see that in the post-reform period there was a change in the pattern of R&D activity. The private sector began to play an increasing role in the aggregate R&D expenditure. Its share in total R&D expenditure has increased from 15.87% in 1980-81 to 22.98% in 2000-01. On the other hand, even through it constitutes a major part of national R&D expenditure, the relative share of Government sector in aggregate R&D expenditure has declined over the years since reforms. Therefore, even though as seen from Table 2.5 the national R&D expenditure as a percentage of GNP may show declining trend, the increasing participation of private sector in the R&D activity is an indicator that the pro-market oriented reform policies have had positive influence on the private sector R&D spending.

Table 2.7: Industrial Sector R&D expenditure - constant price (Rs Lakhs)

Year	Industrial Sector - R&D expenditure
1985-86	92802.91
1986-87	101511.4
1987-88	105376.8
1988-89	123383.2
1989-90	135433.8
1990-91	130981
Growth rate 7.35	
1991-92	133887
1992-93	148251.6
1993-94	152534.8
1994-95	158093.4
1995-96	171973.8
1996-97	221791.5
1997-98	217356.4
1998-99	232640.3
Growth rate 8.58	

Source: Calculated from data collected and compiled by DST

Table 2.7 presents the growth rates of industrial sector R&D expenditure. The actual R&D expenditure increased from Rs. 92802.91 lakhs in 1985-86 to Rs. 232640.3 in 1998-99. The annual growth rate of industrial R&D expenditure in the post-reform (8.58%) period is more compared to pre-reform period (7.35%). Even though the growth rate in the aggregate industrial R&D expenditure is increasing over the years, one cannot make out the dispersion across sectors. Here we analyse the trends in the break-up of industrial R&D expenditure.

Table 2.8: Shares of Public and Private Sectors in Total Industrial R&D expenditure

Year	Public Sector share	Private sector share
1985-86	44.08	55.92
1986-87	44.70	55.30
1987-88	48.18	51.82
1988-89	45.03	54.97
1989-90	45.70	54.30
1990-91	42.98	57.02
1991-92	43.20	56.80
1992-93	38.06	61.94
1993-94	35.59	64.41
1994-95	23.92	76.08
1995-96	20.81	79.19
1996-97	18.03	81.97
1997-98	18.11	81.89
1998-99	18.92	81.08
1999-00	17.84	82.16
2000-01	16.81	83.19

Source: Computed from DST data on R&D statistics

The share of public sector has drastically decreased during the post reform period compared to pre-reform period i.e. from 44.08% to 16.81% (see Table 2.8). But the private sector share has been showing an increasing trend over the periods and its increase has been phenomenal since reforms. There are evidences of more private sector participation in industrial R&D. But the new policy environment has definitely led to the increased participation of the private sector in R&D activity in India. Therefore, keeping the broad picture of national R&D expenditure in background, an attempt is made to analyse the R&D expenditure of firms in Indian manufacturing industry.

Table 2.9: Trends in R&D expenditure [18]

Industry groups	1995		2004	
	% of firms investing in R&D	Total firms	% of firms investing in R&D	Total firms
15	9.02	133	17.68	181
17	13.61	169	20.10	199
20	27.27	55	17.39	69
24	38.52	405	48.05	512
25	15.04	113	28.80	125
26	28.24	85	39.76	83
27	19.25	161	16.24	197
29	39.26	135	47.26	146
31	43.75	96	43.85	130
34	35.14	111	45.70	151
Total	28.16	1463	34.91	1793

Source: Computed from CMIE prowess database

The trends in R&D behaviour of firms has been analysed during a time period when Indian Economy is considered to be operating in more liberal policy regime from 1995 (Balakrishnan *et al* 2006). The R&D spending for firms in the 10 industry groups is given in table 2.9[19]. We can see that, even though, a small percentage of firms are engaged in R&D activity (35%) in 2004, it has improved since 1995 (28%). In 2004 the top three industrial groups in terms of R&D spending were Manufacture of chemical and chemical products (48.05%), Manufacture of machinery and equipment (47.26%) and Manufacture of Motor Vehicles Travellers and Semi-Trailers. Compared to 1995, even though there are inter-industry groups variations, the R&D spending increased in all the industry groups except two i.e. Manufacture of wood and wood products (27% to 17%) and Manufacture of basic metals (19% to 16%). Clearly the R&D spending firms are

[18] The name of major two digit NIC- industry groups is given in Appendix of the last chapter.

[19] Our sample consists only of those product groups where the number of firms is greater than or equal to 50.

higher in 2004 when compared to 1995. This is suggestive of the rising interest of firms on investing in R&D activities in the aftermath of the pro market oriented reform and trade policies initiated in 1991. This picture is more evident when we look at the total spending on R&D by the top ten firms in India (see Table 2.10). The outcome of increased technological activity by large Indian firms is that some of them have emerged as world-class players (Forbes 2002).

Table 2.10 R&D expenditure by the large Indian companies

Firm	1998-99 (Rs. Million)	1992-93 (Rs. Million)
Reliance Industries	751	24
Mahindra & Mahindra	414	33
Ranbaxy	523	84
Eicher Ltd	222	40
Wockhardt Ltd	156	33
Indian Oil Corporation	772	185
Crompton Greaves	217	54
Hindustan lever	373	113
TELCO	1000	308
Ashok Leyland	217	94
Bajaj Auto	315	144
Indian Telephone Industries	338	212
Bharat Heavy Electricals	527	430
Steel Authority of India	483	395
Oil and Natural Gas Corporation	250	221
Bharat Electronics	661	705
DRL	212	31

Source: Forbes (2002) as quoted in Patiblanda (2006)

Table 2.11 R&D intensity

Industry groups	R&D sales ratio>=2					
	1995			2004		
	No of firms having R&D intensity >=2	(1) as a % of (3)	Total R&D firms	No of firms having R&D intensity >=2	(4) as a % of (6)	Total R&D firms
	(1)	(2)	(3)	(4)	(5)	(6)
15	0	0.00	12	0	0.00	32
17	2	8.70	23	0	0.00	40
20	0	0.00	15	0	0.00	12
24	26	16.67	156	54	21.95	246
25	1	5.88	17	0	0.00	36
26	1	4.17	24	1	3.03	33
27	2	6.45	31	0	0.00	32
29	4	7.55	53	4	5.80	69
31	5	11.90	42	10	17.54	57
34	3	7.69	39	6	8.70	69
Total	44	10.68	412	75	10.98	683

Source: Computed from CMIE prowess database

As the analysis of the spending of the R&D expenditure of firms in the manufacturing industry, may give only a partial picture of the R&D activity in India, the R&D intensity i.e. the ratio of R&D expenditure to sales is analysed in table 2.11. A higher R&D intensity represents a higher R&D activity. We can see that less than 11% of the R&D spending firms are having R&D intensity more than 2%[20]. The situation has remained almost same in 2005 when compared to 1995, even though there is a very marginal increase. The percentage of firms engaging in R&D activity having intensity greater than or equal to 2 % has increased slightly from 10.68% to 10.98 %. Also there is inter-industry difference in R&D intensity. Chemicals and chemical products (54%), Electrical machinery (10%) and Manufacture of motor vehicles form the major industry groups with R&D intensity greater than or equal to 2%. The number of R&D spending firms has also increased from 412 in 1995 to 683 in 2004.

From the above analysis, we could see that there is a shift in the pattern of R&D spending in India during reforms. There is a decline in Government investment in R&D expenditure and there has been a simultaneous increase in the participation of private sector. This shift in R&D behaviour of Indian industry might also be reflecting the changes in product market competition that are brought about during the post-reform period. Now having analysed the trends and patterns in R&D investment of firms, we would like to focus on our next objective of this chapter i.e. to analyse the trends in product market competition.

2.5 Product market competition and market structure

Market structure and competition in an industry can have one to one relationship as structural features of an industry strongly influence the competitive behaviour of its member firms (Collins and Preston, 1969). The line of reasoning for this argument given by the authors is that the structural variables explain the inter-industry differences in price-cost margin, which explains the competition in the market. For example if an industry is close to monopolistic market structure, higher will be the price-cost margin, as few firms control a high proportion of the industrial output and vice-versa. They also note that in a monopoly market structure price-cost margins are wider than under competition and conclude that there is positive relationship between price-cost margin and concentration or higher concentration brings about higher monopoly profits. Hence,

[20]The international norm of R&D intensity is 2%, which can be used as a benchmark (http://www.hindu.com/biz/2004/01/12/stories/2004011200471600.htm)

by analysing the degree of market power we can get the extent of product market competition or the type of market structure. Deodhar and Pandey (2006) state that an appropriate measure of degree of market power is the distance between price (P) and marginal cost (MC). Therefore, in this section the trends in market structure is analysed through the extent of product market competition which is measured through examining the trends in price-cost margins or levels of market power of firms i.e. ability of the firm to price its product above the marginal cost.

There are empirical studies, which look at the extent of competition in Indian industry by analysing the market power of firms (Goldar and Aggarwal 2004, Balakrishnan *et al* 2006). The study by Goldar and Aggarwal (2004) conclude that the lowering of tariff rates and removal of quantitative restrictions on imports of manufactures had a significant pro-competitive effect on Indian industries. Balakrishanan *et al* (2006) using firm level data empirically examined whether the reform policies introduced in 1991 have reduced the market power of firms. The study concludes that there is no evidence of a reduction in market power. Since the existing empirical literature does not give conclusive evidence on the extent of product market competition in Indian manufacturing industry, there is further need to examine the same.

The degree of market power can be well captured through Lerner index. Conventional measures of market structure like Herfindahl index or concentration ratios, also indicators of product market competition, but may not reveal the degree of competition in the market unless adjusted for imports. Another issue is that in the context of globalisation, for many firms, the final good market may be located in both the home country and abroad while the R&D activity may be concentrated to one country. Hence, competition on foreign market may affect the R&D performed in the home market. One of the advantages with Lerner index is that the degree of market power of firms can be gauged without the need to measure the extent of competition from foreign markets. Therefore, for measuring the extent of product market competition and also in the estimation of relationship between product market competition and R&D, Lerner index is preferred to Herfindahl index or concentration ratios. The index is a measure proposed by economist Lerner (1934) to measure monopoly power. When Perfect competition exists, P=MC and Lerner index assumes value zero. When P>MC indicating

some degree of monopoly power, the index becomes positive and varies between zero and one. The closer the index is to the value of one, the more monopoly power the firm is said to possess.

Lerner index is calculated as

$$L = \frac{P - MC}{P}$$

This can be measured directly if the data on marginal cost of the firms are available, but unfortunately the data on marginal cost is rarely available, so we use average cost instead of marginal cost[21]. The Lerner index is measured as

$$L = \frac{P.Q - AC.Q}{P.Q} = \frac{P - AC}{P}$$

Our indicator of product market competition is one minus Lerner index. A value 1 indicates absence of market power, and values below one indicate some degree of market power.

$$1 - L$$

$$\frac{P}{P} - \left(\frac{P - AC}{P}\right)$$

$$0 < \frac{AC}{P} \leq 1$$

$$L_{ijt} = \frac{Sales_{ijt} - Cost\ \ of\ \ Production_{ijt}}{Sales_{ijt}}$$

Where $Sales_{ijt}$ includes sales of the i^{th} firm of j^{th} industry at t^{th} time, $Cost\ of\ Production_{ijt}$, which includes raw material expenses, energy expenses, operating expenses and depreciation of i^{th} firm of j^{th} industry at t^{th} time.

$$L_{jt} = \frac{\sum_{i=1}^{n} L_{ijt}}{n}$$

[21] There are studies which state that average cost can be used instead of marginal cost while calculating the Lerner index under the assumption that AC ≈ MC (Aghion 2003)

The index was then averaged across firms. For constructing the Lerner index we have used the firm level data from Centre for monitoring Indian Economy (CMIE) database PROWESS. Firms with missing values on sales, cost of production and firms having no constant data have been removed from the analysis. The final sample for analysis consisted of around 23000 observations. Our industry code is measured at the four-digit NIC code. From four digit we aggregated the Lerner index into two digit industry groups[22]. The index analysing the trends in degree of product market competition is given in table 2.12.

Table 2.12: Trends in Lerner index

Industry groups/Year	1992	1994	1996	1998	2000	2002	2004
15	0.69	0.73	0.75	0.75	0.75	0.77	0.79
16	0.45	0.51	0.59	0.63	0.62	0.64	0.66
17	0.80	0.80	0.81	0.80	0.82	0.83	0.82
18	0.74	0.73	0.77	0.77	0.79	0.81	0.80
19	0.81	0.77	0.79	0.79	0.78	0.81	0.81
20	0.76	0.78	0.75	0.80	0.81	0.78	0.80
21	0.70	0.72	0.79	0.76	0.75	0.78	0.77
22	0.80	0.77	0.76	0.67	0.71	0.80	0.80
23	0.70	0.75	0.72	0.67	0.73	0.76	0.76
24	0.72	0.71	0.72	0.72	0.73	0.73	0.73
25	0.69	0.70	0.72	0.72	0.72	0.75	0.76
26	0.62	0.64	0.63	0.67	0.67	0.68	0.70
27	0.79	0.78	0.76	0.79	0.80	0.81	0.80
28	0.76	0.77	0.75	0.75	0.76	0.79	0.77
29	0.72	0.72	0.72	0.74	0.75	0.75	0.73
30	0.71	0.68	0.74	0.75	0.80	0.79	0.81
31	0.72	0.69	0.72	0.74	0.75	0.74	0.76
33	0.73	0.71	0.74	0.74	0.73	0.75	0.73
34	0.71	0.70	0.70	0.71	0.72	0.72	0.71
35	0.78	0.76	0.75	0.76	0.76	0.75	0.78
36	0.74	0.77	0.83	0.82	0.80	0.80	0.82

Source: author's computations

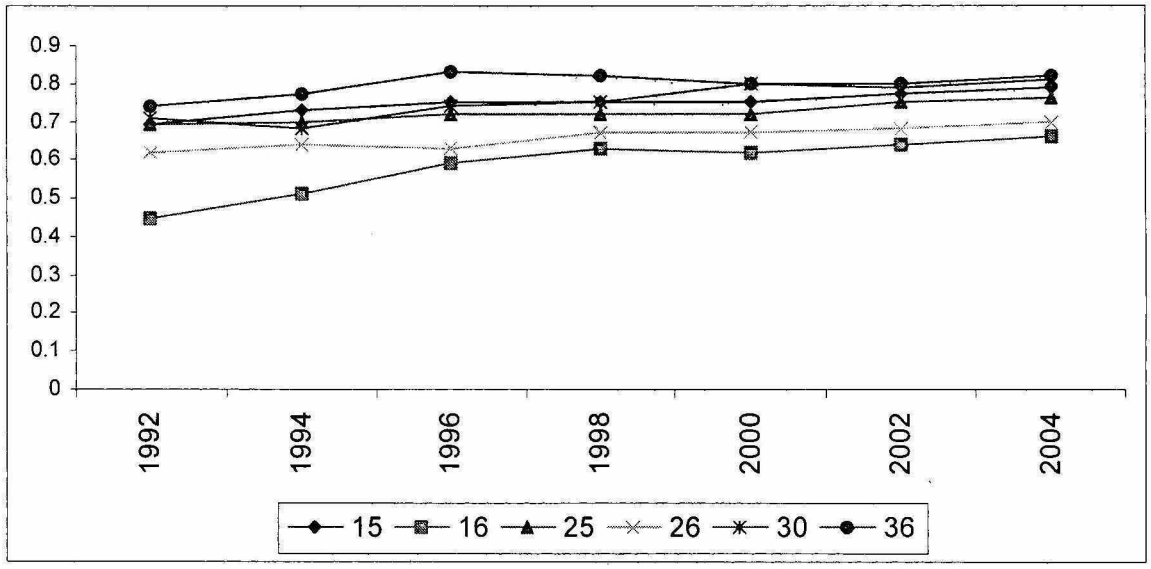
2.6 Trends in Lerner Index

The industries where Lerner index has increased are manufacture of food products and beverages, manufacture of tobacco products, manufacture of rubber products and plastics, manufacture of Other Non-Metallic Mineral Products, manufacture of Office Accounting and Computing Machinery, manufacturing of furniture etc. For eight product groups there was marginal increase in the Lerner index i.e. for manufacture of textiles, manufacture of wearing

[22] Aghion (2003) state that as Lerner index is taken to be constant within industries, it can be averaged across all firms in the industry.

apparels, manufacture of wood products, manufacture of paper products, manufacture of coke products, manufacture of basic metals, manufacture of electric machinery, manufacture of radio and television equipment. But for eight product groups the level of competition remained same. These product groups are tanning of leather, printing media, manufacture of chemical and chemical products, manufacture of fabricated metal products, manufacture of machinery and equipment, manufacture of medical equipments, manufacture of motor vehicles, and manufacture of other transport equipment. For industry groups where there has been a substantial increase in competition is shown in the below chart.

Fig 2.1 Product groups which show decrease in Lerner index



From the above analysis, it can be concluded that for majority of the industry groups there was a marginal increase in Lerner index, indicating an increase in the competitive pressure. However for few industries there is substantial change in product market competition, which may be due to liberal policy regime of the government. Though competition has not changed in some industries, analysis confirms that the series of measures introduced to increase competition has resulted in lowering the level of market power in majority of the industries with some degree of imperfection in the market structure.

2.7 Relationship between product market competition and R&D intensity

Having analysed the trends in R&D expenditure and product market competition, it would be significant to see the relationship between the two. The theoretical and empirical findings on the effect of product market competition or market structure on R&D investment of firms is given in the introductory chapter. There are no conclusive

findings on the kind of product market competition affecting the R&D investment of firms. This motivates us to revisit the "Schumpeterian hypothesis"[23] on market structure and R&D activity. Before estimating the effect of product market competition on the R&D activity by firms, it would be significant to analyse the relationship between the two. For measuring R&D activity we have used R&D intensity and for measuring product market competition, Lerner index is used. We have done a spearman rank correlation to examine the relationship between the two and the analysis is done for two time points - 1995 and 2005 (see table 2.13).

Table 2.13 showing correlations between Lerner index and R&D intensity (1995)

Correlations	1995	2004
Pearson Correlation Coefficient	.064*	.098*
Number of observations	1617	2006

* Correlation is significant at the 0.5evel (2-tailed).

The relationship between Lerner index and R&D intensity for the year 1995 is positive and significant. The same picture emerges when we examine the correlation between Lerner index and R&D intensity for the year 2004. However from a descriptive analysis it would not be appropriate to conclude regarding the effect of product market competition on R&D investment of firms. A more rigorous analysis is required in determining the kind of product market competition more conducive for R&D activity of firms. An understanding of the influences that motivate innovation, and channel its direction, is necessary if government intervention is to be successful in increasing the production of useful innovation in specific areas (Rosenberg 1972).

2.8 Summary

In this chapter an attempt was made to examine the trends and patterns of R&D investment and product market competition in Indian manufacturing industry. It is evident from the analysis that the state played a major role in nurturing R&D activity in the economy. This is confirmed by the dominant share of government expenditure in overall R&D expenditure. But in the post reform period, the private sector R&D has increased and the government's share decreased. Even though there are inter-industry variations in R&D investment, the overall investment in R&D by industrial sector in

[23] The hypothesis has been explained in the first chapter of this study.

India has increased. This indicates that the change in the industrial and innovation policy has improved the progress of R&D in industrial sector. We also have made an attempt to analyse whether such a pattern is also reflected in product market competition. Analysis shows that market has become more competitive in majority of the industries though with inter-industry differences. Also in this chapter an attempt was made to examine the relationship between product market competition and R&D intensity. It was found that there exist a positive relationship between product market competition and R&D intensity. Against the above background the next chapter analyses the effect of product market competition and other determinants of R&D activity on the probability to invest in R&D by firms.

APPENDIX - I

Table 2.1: Key changes in India's industrial policy regime, 1950-1980

Industries (Development and Regulation) Act, 1951	Specified the Schedule I industries where licenses were required for firms with fixed investment above a certain level of investment or import content of investment above a certain level
Companies Act, 1951	Restrictions on the operation of managing agencies, which affected the operation of many British companies in India.
Industrial Policy Resolution, 1956	Articulated the role of public investment in planned development and specified: Schedule A industries reserved exclusively for state enterprises Schedule B industries where further expansion would be by state enterprises
Corporate Tax Policies, 1957-1991	Specified rates of corporate tax on companies incorporated outside India. These were usually between 15-20% higher than the rates applied to large Indian companies during this period.
Monopolies and Restrictive Trade Practices Act, 1969	All applications for a license from companies belonging to a list of big business houses and subsidiaries of foreign companies were to be referred to a 'MRTP Commission' which invited objections and held public hearings before granting a license for production.
Industrial Policy Notification, 1973	Made licensing mandatory for all industries above certain investment limits Specified industry Schedules IV and V, there licensing was mandatory for all firms irrespective of size Small scale industry reservation introduced for some industries. Small was defined based on an investment limit.
Industrial Policy Statement, 1973	Specified the criteria and list of Appendix I of 'core' industries to which large business houses and foreign firms were to be confined. Main criteria for being an Appendix 1 industry were that of local non-availability or domination of a sector by a single foreign firm. Schedule A industries from IPR, 1956 could not figure in the Appendix 1 list.
Foreign Exchange Regulation Act, 1973	Foreign companies operating in India were required to educe their share in equity capital to below 40%. Exceptions were decided on a discretionary basis if: The company was engaged in 'core' activities (as defined in IPS, 1973) The company was using sophisticated technology or Met certain export commitments.
Industrial Policy Resolution 1977	Expanded the scope of reservations of particular lines of business activity for production in the small-scale industrial sector. Small industry concessions would be lost if firm grew to a certain 'large' size.

Table 2.2: Key changes in India's industrial policy regime, 1980-1999

Policy announcements, 1985	Business houses were not restricted to Appendix 1 industries as long as they moved to industrially backward regions Minimum asset limit defining business houses was raised from Rs. 200 million to Rs. 1 billion.
Amendment to MRTP Act, 1985	A company could be referred to the MRTP commission only if it showed assets greater than Rs. 1 billion.
New Industrial Policy 1991	Abolished licensing for all except 18 industries. Large companies no longer needed MRTP approval for capacity expansions Number of industries reserved for the public sector in Schedule A (IPR1951), cut down from 17 to 8; Schedule B was abolished altogether. Small firms were allowed to offer upto 24% of shareholding to large enterprises. Limits on foreign equity holdings were raised from 40 to 51% in a wide range of industries and foreign exchange outflows as dividends were balanced by export earnings. EXIM scrips (import entitlements linked to export earnings) were introduced and were freely tradable and could be used for all categories of imports. Actual user requirements for import of capital goods, raw materials and components under OGL were removed. Royalty limits increased to encourage technology imports.
Policy announcements, 1992-99	Number of industries requiring licensing steadily decreased. By 1998 the number of industries requiring compulsory licensing was down to 9. Oil exploration and Minerals were removed from list of reserved industries for the public sector, bringing the number of Schedule A industries down to 6. Infrastructure industries like basic telecom and power opened to private ownership (including foreign ownership). Small scale industry reservations decreased: 15 items including ready-made garments are removed from reserved list. Investment limit for defining a firm as small scale raised from Rs. 7.5 million to Rs. 30 million. Pricing of coal, drugs and pharmaceuticals de-regulated.
Tariff reductions, 1992-99	Peak tariffs reduced to 110% in 1992 and gradually brought down to 40% in 1998. List of freely importable goods expanded Reform of structure of tariffs.

Source: Athreya and Kapur 2003

CHAPTER 3

PRODUCT MARKET COMPETITION AND R&D INVESTMENT

3.1 Introduction

In this chapter we examine the effect of product market competition on R&D investment in the case of Indian manufacturing industry. Specifically we analyse the effect of product market competition on the probability of investing in R&D. Here we capture the non-linear relationship between product market competition and R&D. Further we also examine the intersectoral variation in the effect of product market competition. For this we use firm level panel data. The chapter is organised into four sections, including this introduction. Next section deals with the methodology, data and construction of variables. The third one discusses the results and the last one concludes the chapter.

3.2 Methodology, data and construction of variables.

We use econometric methodology to examine the effect of product market competition on R&D investment. Here the effect of product market competition on the probability of investing in R&D has been examined. For this we use a pooled Probit estimation. In this model, the dependent variable takes value one if the firm is making investment in R&D, otherwise zero. We use two set of variables as determinants of probability of investing in R&D. The first set consists of variables of our interest, namely Lerner index (LER) and its square (LER^2) to capture the product market competition and its non-linear effect. The second set includes other determinants of R&D investment. These include (1) firm's size (SAL), (2) rate of profit of the firm (ROP), (3) advertisement intensity (ADVINT), (4) age of the firm (AOF), (5) A dummy variable if the firm has foreign equity participation (FDID) (6) disembodied technology import intensity (FTP), (7) capital goods import intensity (CGI) and (8) export intensity of the firm (EXPINT). The selection of control variables is based on the previous studies in Indian context[24]. The Probit regression model for i^{th} firm in t^{th} year is given below.

[24]See Subrahmanian (1971), Kumar and Aggarwal (2000) Kumar and Sidharthan (1997), Pradhan (2003), Parameshwaran M (2007).

$Prob\ (Y_{it} = 1) = F(\beta' \boldsymbol{x}_{it})$

where $F(.)$ is the standard normal distribution function and $\boldsymbol{x}$ is the vector of explanatory variables and β is its coefficient vector. β'x is defined as follows.

$$\beta'x = \beta_0 + \beta_1 SAL_{it} + \beta_2 LER_{it} + \beta_4 LER^2_{it} + \beta_5 ROP_{it} + \beta_6 AOF_{it} + \beta_7 FDID_{it} + \beta_8 ADVINT_{it} + \beta_9 CGI_{it} + \beta_{10} FTP_{it} + \beta_{11} EXPINT_{it} + \lambda Z_{it} + \varepsilon_{it}$$

where Z includes a set of industry specific dummy variables to capture the industry specific variation and λ is its coefficient vector[25].

3.3 Data

The study uses firm level panel data, covering the whole manufacturing industry, for the period 1995-96 to 2004-05 obtained from the electronic database of Centre for Monitoring Indian Economy, PROWESS. The study thus covers a period during which Indian industry was operating in a more liberal policy regime (Balakrishnan *et al* 2006). The panel is unbalanced and consists of 18159 observations on 2520 firms divided into 99 four-digit industries of National Industrial Classification (NIC), 1998.

3.4 Construction of variables

In this sub-section we explain the construction variables and their possible relationship with the probability of investing in R&D.

(1) Firm Size (*SAL*)

Size of the firm has generally been posited as a determinant of R&D investment in the literature focussing on Schumpeterian hypothesis. The Schumpeterian hypothesis postulates a positive relationship between firm size and innovation effort of firms. Larger firms can have greater internal resources to devote to R&D compared to the small firms and consequently are more involved in-house R&D[26]. As resource base and scale economies are positively related to firm size, large firms are better able to fund the risky R&D ventures than small firms. The present study uses sales of the firm to proxy its size.

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[25] A similar approach can be seen in Chang-Yang Lee (2005).

[26] For an excellent review of literature on firm size and R&D see Symeonidis (1996).

(2) Product market competition *(LER)*

As we have already discussed in the introduction chapter product market competition and R&D investment is expected to have a non-linear relationship. Lerner index has been used to measure the product market competition and, as we have noted above, its square term is included to capture the non-linearity. It may be noted that construction of Lerner index and its advantages over other measure of competition are discussed in the previous chapter.

(3) Profit (*ROP*)

Profit is expected to encourage investment in R&D, as the risk associated with R&D is high, firms may be unwilling to fund their R&D with borrowed funds (Kumar and Aggarwal 2000). So profits can be one of the key sources of internal finance available with the firm and a higher rate of profit may indicate an internal generation of funds, which may favour R&D activity. Higher profit margin is likely to induce firm to undertake R&D and spent more as a percentage of sales, *ceterus paribus*. The present study uses rate of profit, which is defined as the ratio of profit after tax to sales, to capture the effect of profit on R&D investment.

(4) Advertisement Intensity (*ADVINT*)

The relationship between advertising intensity and the probability to do R&D can be of complementary or a substituting type. Both are incurred for strengthening the competitive position of firms (Andras and Srinivasan 2003). A firm may invest in advertisement to appropriate the returns from R&D by increasing its market share; or it may incur only advertisement expenditure and not R&D to gain market share. In the former case, the relationship between advertisement intensity and R&D can be complementary, but in the latter case the relationship between the two can be of supplementing type as both are spent from a firm's sales revenue. Advertisement intensity is measured as the ratio of advertisement expenditure to sales of the firm.

(5) Age of the firm (*AOF*)

Age of the firm can have significant impact on the probability to do R&D by firms, as innovation is a result of accumulated learning process. Past experience of firms can have positive impact on their decision on investment in R&D as older firms benefit from accumulated technological learning and better ways of adapting to new products (Pradhan 2003). Hence we too expect a positive relationship between age of the firm and decision to invest in R&D activity.

(6) Foreign collaboration (*FDID*)

Type of ownership (domestic or foreign) of a firm can have significant impact on its R&D behaviour. Foreign affiliation can have either positive or negative impact on the decision to invest in R&D. Foreign affiliates can have lower R&D compared to local firms on account of captive access to resources of their parent companies (Kumar and Aggarwal 2000). On the other hand, it can have a positive influence, if technology, which is sourced from the parent firm, needs to be adapted to suit local factor prices, usage pattern and so on (Parameswaran 2007). In the present study, we have used a dummy variable (FDID) to distinguish between domestic company and foreign company. The variable takes value one if 10 percentage of the firm's equity is held by foreign company, 0 otherwise.

(7) Technology Imports (*CG, FTP*)

Imports of technology by a firm can be in embodied form through capital goods and disembodied form by paying royalty or lumpsum payments. Technology imports can have positive or negative relationship with the probability to invest in R&D. Import of technology can positively affect the in-house R&D of firms if the foreign technology requires further R&D on the part of importing firm to absorb, adapt and assimilate imported knowledge to local conditions. Imports of technology can have negative impact when it substitutes in-house R&D. The relationship between foreign technology payment and the probability to do R&D depends on the nature of domestic R&D capability of firms. We use two variables to capture the impact of imported technology. First one, namely disembodied technology import intensity (FTP), capture the effect of disembodied technology import and the second one is the capital goods import intensity (CG) to capture the effect of embodied technology import intensity. FTP is defined, as the ratio of foreign technology payment to firm's sales and CG is the ratio of expenditure on imported capital goods to its sales.

(8) Export Intensity (*EXPINT*)

R&D performance of firms may also depend upon whether the firm is export oriented or not. Export enables the firm to produce on a large scale, which allows it spread the fixed R&D costs over a large scale of output. This reduces the per unit R&D cost and thereby increases the rate of return from R&D investment. Therefore, export is expected to encourage R&D investment. We use export intensity of the firm to capture the effect of export, which is defined as the ratio of export to sales.

3.5 Sectoral classification of Industries

Empirical literature testing the relationship between product market competition and innovation points out certain issues. Among them the most significant is the industry-specific characteristics that may be correlated with concentration, which may affect the innovation capabilities of firms.[27] Industries differ widely to the degree to which they engage in R&D[28] investment i.e. the probability to engage in R&D may be more in some industries compared with others. The empirical literature, however, has found that the market structure's effect on innovation may be dependent upon inter-sectoral variations, such as technological opportunities (potential for technological progress in general or within a particular field[29]), appropriability conditions (capturing and protecting the competitive advantages of new and improved products or production processes), and firm specific technological expertise including absorptive capacity for exogenous technological knowledge, accumulated technological expertise from learning-by-doing and entry conditions. We noted in the last chapter that there are inter-industry variations in R&D investment.

But a precise measurement of capturing varying technological opportunities across industries has not yet been found (Kumar and Sidharthan 1997). Most of the studies[30] have used industrial dummies to capture technological opportunities faced by firms and one of the main limitations in using dummies to capture technological opportunity is that in addition to technological opportunities, they can also represent other industry

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[27] See Symeonidis (1996)
[28] In the last chapter we noted that there are inter-industry differences in R&D expenditure.
[29] See Olsson (2004)
[30] See Scherer (1965)

specific characteristics. To overcome this limitation and to account for the inter-sectoral differences in technological opportunity and appropriability the present study classifies the industries into four sectors using Pavitt (1984) taxonomy. These four sectors are (1) Supplier dominated industries, (2) Scale intensive industries (3) Specialised suppliers, and (4) Science based industries. The industries included in each of the sectors are given in the Table 3.1. Supplier Dominated industries are generally small, with weak in-house R&D and engineering capabilities, and largely non-technical means of appropriation. Technological trajectories are therefore defined in terms of cutting costs, with suppliers as a source of new technology, mostly in production. These industries can make only a minor contribution to their process or product technology. Firms in the Scale intensive industries are relatively big and make a relatively large contribution to the innovations in their principal sectors of activity. In contrast the main focus of firms in specialized suppliers is on product innovations for use in other sectors. These firms are often relatively small. Customers are an important trigger for (or source of) product innovation. In Science based firms, the main sources of technology are the R&D activities of firms in the sector, based on rapid development of the underlying sciences. These firms are relatively big, and produce a relatively high proportion of process as well as product innovations made in their principal sector of activity (Pavitt 1984). These four categories of industries can also be viewed as representing classes of technological opportunity. This is an important feature of the environment of a firm that we need to control for, since the opportunity for R&D-based innovations depends on the state of knowledge in relevant fields of science and technology (Scherer 1965).

Table 3.1 Sectoral classifications of industries

Category of Firm	Description	4 digit NIC codes
Supplier dominated	Textiles Clothing Leather Printing Fibres Wood and furniture Paper	1711, 1712, 1721, 1722, 1723, 1729, 1730, 1810, 1820, 1911, 1912, 1920, 2211, 2212, 2213, 2219, 2221, 2222, 2230, 2010, 2021, 2022, 2023, 2029, 3610, 3691, 3693, 3694, 3699, 2101, 2102, 2109.
Scale intensive	Food Beverage and tobacco Oil Rubber and plastics Building materials, Earthen ware, glass Metals Metal products Means of transport	1511, 1512, 1513, 1514, 1520, 1531, 1532, 1533, 1541, 1542, 1543, 1544, 1549, 1551, 1552, 1553, 1554, 1600, 2511, 2519, 2520, 2610, 2691, 2692, 2693, 2694, 2695, 2696, 2699, 2710, 2720, 2731, 2732, 2811, 2812, 2813, 2891, 2892, 2893, 2899, 3410, 3420, 3430, 3511, 3512, 3520, 3530, 3591, 3592, 3599.
Specialised suppliers	Machinery Instruments Optical goods Remaining	2911, 2912, 2913, 2914, 2915, 2919, 2921, 2922, 2923, 2924, 2925, 2926, 2927, 2929, 2930, 3311, 3312, 3313, 3320, 3330, 3000, 3710, 3720.
Science-based	Chemicals Electrical goods	2411, 2412, 2413, 2421, 2422, 2423, 2424, 2429, 2430, 3110, 3120, 3130, 3140, 3150, 3190, 3210, 3220, 3230.

Table 3.2 Summary measures of variables

Variable	Mean	Std. Dev.
Sales	192.73	737.10
Lerner	0.25	0.06
Lerner square	0.07	0.03
Capital goods import	0.04	2.31
Foreign technology payments	0.002	0.12
Rate of profit	0.01	0.46
Advertisement intensity	0.01	0.05
Age of firm	19.30	59.44
Export intensity	12.70	43.24
No of firms having foreign investment	415	
No. of firms	2520	
No. of Observations	18159	

3.6 Estimation and Result

We estimate the Probit model using maximum likelihood method. There may be some variables in our model, which are not strictly exogenous. For example variables like sales, export intensity may be endogenous in the model as current year investment in R&D can affect the future profit or export of firms. There can be a lag effect of R&D on variables like export or profit. Hence, we use pooled (cross section of data combined with time series data) Probit regression model, which can control for simultaneous relationship in model i.e. the binary estimation can account for variables which may not be strictly exogenous (Wooldridge 2002, pp: 405)[31].

As the estimated coefficients of the Probit model are not the marginal effect of the variables, we also compute estimate their marginal effect. The marginal effect allows us to find the change in the probability of investing in R&D due to a point change in the explanatory variable. Marginal effects of all variables except that of Lerner index are estimated using the following expression.

$$Marginal\ effect\ (ME_i)\ of\ i^{th}\ variable = f(\boldsymbol{X\beta})\beta_i$$

Where β_i is the coefficient of i_{th} explanatory variable and $f(.)$ is the density function of normal distribution.

Marginal effect of Lerner index is computed using the following expression.

$$Marginal\ Effect\ of\ Lerner\ Index\ = f(\boldsymbol{X\beta})(\beta_1 + 2\beta_2 L)$$

It is clear from the above expressions that the marginal effect of variable would vary from one observation to another, therefore, we estimated the marginal effect of a variable and their standard errors for each observation and their averages are reported. However, in the case of Lerner index, marginal effects can vary from one observation to another not only in magnitude but in terms of sign also, as average is not a good representation of their effect. Therefore, in this case we also consider the distribution of the marginal effects and test statistic (z) while drawing inference.

The estimated coefficients and their marginal effects are respectively reported in Table 3.3 and Table 3.4.

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[31] For the detailed description of the properties of Pooled Probit estimation, see Wooldridge, 2002.

Table 3.3: Coefficient estimates of Probit model

Variables	Supplier Dominated	Scale Intensive	Specialised Suppliers	Science based
SAL	.0025* (15.65)	.00065* (17.46)	.0022* (11.84)	.00089* (13.81)
LER	14.17* (2.50)	8.59* (7.46)	26.61* (3.45)	24.64* (5.30)
LER^2	-26.49* (-2.05)	-13.99* (-6.95)	-53.92* (-3.63)	-38.82* (-4.43)
ADVINT	4.17 (1.93)	4.60* (5.67)	7.74* (3.78)	5.52* (6.76)
ROP	.55 (1.67)	.21 (1.85)	.47* (2.05)	.54* (3.43)
AOF	.0005 (1.12)	.00047* (2.54)	.00096 (1.82)	.000072 (0.29)
FDID	.57* (4.43)	.46* (9.24)	.16* (2.63)	.53* (9.41)
FTP	41.65* (3.84)	.29 (0.65)	3.91 (1.29)	3.35 (1.28)
CGI	-.054 (-0.39)	-.077 (-0.89)	-2.51* (-2.53)	-1.11* (-2.79)
EXPINT	1.42 (1.60)	-.64 (-0.57)	2.14* (3.32)	2.61 (4.17)
Pseudo R^2	.1636	0.13	0.13	0.092
Number of observations	3110	7421	1865	5736

Figures in brackets are 'z' values

*Significant at 5 % level

In all the regressions industry specific dummies were included.

Table 3.4: Estimated marginal effects of Probit regression

Variables	Supplier Dominated	Scale Intensive	Specialised Suppliers	Science based
SAL	.00057* (15.65)	.0002* (17.46)	.00087* (11.84)	.00034* (13.81)
LER	.61* (2.74)	.22* (2.35)	-.40 (-.77249)	1.35* (4.13)
ADVINT	.93 (1.93)	1.44* (5.67)	3.06* (3.78)	2.16* (6.76)
ROP	0.12 (1.67)	0.07 (1.85)	.18* (2.05)	.21* (3.43)
AOF	.0001 (1.12)	.00014* (2.54)	.00038 (1.82)	.000028 (0.29)
FDID	.16* (4.43)	0.16* (9.24)	.06* (2.63)	.21* (9.41)
FTP	9.28* (3.84)	.09 (0.65)	1.54 (1.29)	1.31 (1.28)
CGI	-.01 (-0.39)	-.024 (-0.89)	-.99* (-2.53)	-.43* (-2.79)
EXPINT	.31 (1.60)	-.20 (-0.57)	.84* (3.32)	1.02* (4.17)

Figures in brackets are 'z' values
*Significant at 5 % level
In all the regressions industry specific dummies were included.

First we discuss the effect of control variables. In all the four sectors, the coefficients of firm size proxied by sales (*SAL*) are positive and significant. This result is in line with the Schumpeterian hypothesis on firm size and R&D investment. The estimated marginal effect of advertisement intensity (*ADVINT*) on the probability to do R&D is positive and significant for all the sectors except in Supplier dominated sector. It may be suggesting that firms in these sectors are using advertisement as a complementary strategy along with R&D to strengthen their competitive position in the market. Rate of profit (*ROP*) is having a positive and significant impact on the probability to invest in R&D only in Specialised suppliers and Science based sector. This result suggests that internal resource generation of firms significantly increases the R&D activity of firms in Specialised suppliers and science based sectors. Age of the firm is having positive and significant effect only in scale intensive firms.

Foreign equity participation (*FDID*) is positive and significant in all the sectors. This may be indicating that the technology, which is sourced from the parent firm, needs to be adapted to suit local factor prices, usage pattern and so on. Therefore, firms are increasing their technology capability through R&D investment.

Disembodied technology import intensity (*FTP*) is significant only in the Supplier dominated sector. This tends to confirm that imports of knowledge have been followed by further technological effort by firms in this sector, particularly because of their low technological capability they have to undertake in-house R&D activity in order to absorb imported technology. In the rest of the sector, this variable is not significant. Therefore, it may be concluded that in sectors where technological capability is low, import of technology is encouraging in-house R&D investment.

Capital good import intensity is found to have significant negative effect in Specialised suppliers and Science based sectors. Export intensity (*EXPINT*) is positive and significant only in Specialised suppliers and Science based sectors.

Lerner index is positive and significant and its square is negative and significant in all the sectors. Thus, the result is suggesting a non-linear relationship between product market competition and R&D investment. As we have already mentioned above, as the sign and statistical significance of marginal effects of Lerner index vary from one observation to another, to draw inference, we also look at the distribution of the marginal effects and their test statistic. Table 3.5 presents the distribution of the marginal effects of the Lerner index.

Table 3.5: Distribution of marginal effects

Supplier dominated

Lerner	Marginal effects		Test statistic (z)		Total observations (%)
	<0 (%)	>0 (%)	z<-1.96 (%)	z>1.96 (%)	
0-.25	0.00	100.00	0	87.14	92.75
.25-.50	70.80	29.20	3.98	0.00	7.25
.50-.75	0.00	0.00	0.00	0.00	0.00
.75-1	0.00	0.00	0.00	0.00	0.00
Total					100

Scale intensive

Lerner	Marginal effects		Test statistic (z)		Total observations (%)
	<0 (%)	>0 (%)	z<-1.96 (%)	z>1.96 (%)	
0-.25	0.00	100	0.00	99.74	45.97
.25-.50	33.88	66.12	24.48	36.65	53.28
.50-.75	52	4	87.5	7.14	.75
.75-1	0.00	0.00	0.00	0.00	0.00
Total					100.00

Specialised suppliers

Lerner	Marginal effects		Test statistic (z)		Total observations (%)
	<0 (%)	>0 (%)	z<-1.96 (%)	z>1.96 (%)	
0-.25	23.32	76.68	0	39.19	43.91
.25-.50	100.00	0.00	99.47	0.00	56.09
.50-.75	0.00	0.00	0.00	0.00	0.00
.75-1	0.00	0.00	0.00	0.00	0.00
Total					100.00

Science based

Lerner	Marginal effects		Test statistic (z)		Total observations (%)
	<0 (%)	>0 (%)	z<-1.96 (%)	z>1.96 (%)	
0-.25	0.00	100.00	0.00	99.47	34.70
.25-.50	8.88	91.12	1.84	53.69	65.30
.50-.75	0.00	0.00	0.00	0.00	0.00
.75-1	0.00	0.00	0.00	0.00	0.00
Total					100.00

In Supplier dominated sector, at a lower level of Lerner index (less than 0.25) 100 per cent of the marginal effects are positive and 87 per cent are significant. In the next quarter of the Lerner index, 71 per cent are negative but majority of the marginal effects are not significant. In Scale intensive sector 100 percent are positive and 99 % are significant at lower level of Lerner index. In the second quarter 66 % are positive and 37% are significant. Here also 38 % of the marginal effects are negative and 24% are significant. In the third quarter 52% of the marginal effects are negative and 88 % are significant. In Specialised supplier sector 76 percent of marginal effects are positive and 39 percent are significant at lower level of Lerner index (less than 0.25). In next quarter, 100 percent of the marginal effects are negative and 99 percent are significant. In Science based sector at lower level of Lerner index, 100 percentage of the marginal effects are positive and 99 % are significant and in the next level 91 % of marginal effects are positive and 54 % are significant. Also, in this level 9 % of the marginal effects are negative but again majority of them are not significant. From the above analysis we can see that at lower level of Lerner index majority of marginal effects are positive and significant. At higher level of Lerner index marginal effects are either negatively significant or insignificant. From the above analysis we can infer that at lower level of Lerner index the probability to do R&D by firms is high. But at a higher level, the probability to invest in R&D by firms is lower or gets adversely affected.

To get further insights into the relationship between Lerner index and probability of investing in R&D, we computed its marginal effect keeping all the variables, except Lerner index at their mean values. These estimates are plotted against Lerner index in Figure 3.1, 3.2, 3.2, and 3.4. The figures show that in all the sectors except in Specialised supplier sector the inverted U shaped pattern is visible, which more so in Science based sector. This result may be supporting the inverted U shaped relationship between product market competition and R&D investment as argued by Aghion (2003), i.e. in extreme case of market structure, monopoly, the returns from R&D is dependent on the monopolist technological leadership and he has no incentive to invest in R&D to gain market share. However, firms find it difficult to appropriate returns from their innovation effort and hence has lower incentive to innovate in the case of perfect competition. Hence our empirical results may be supporting the hypothesis of Aghion (2003). This finding points towards the fact that a market structure intermediate

between monopoly and prefect competition is more conducive for R&D effort of firms. This relationship can be observed in industries like automobiles, where an oligopoly kind of market structure prevails i.e. the market is controlled by few firms like Bajaj, Honda Motors, Mahindra, Telco, Premier, Hindustan Motors, Maruti etc. and it is an industry where lot of technological progress is happening (Narayanan 2004). Hence competition among a few in an industry promotes innovation and technological progress in an industry.

3.7 Summary and Conclusion

In this chapter an attempt was made to examine the effect product market competition on the probability to invest in R&D. It examines the effect of product market competition or the kind of market structure on the R&D effort of firms. To account for the technological opportunity and appropriability conditions, we used Pavitt's sectoral classification of industries and estimated the determinants of R&D for each sector separately, using Probit regression model. From the estimation we could see that as the degree of market power increases, the probability to do R&D increases to a certain level and then it is decreasing in all the three sectors i.e. Supplier dominated, Scale intensive and Science based The average marginal effect of Lerner on R&D is not significant in Specialised supplier sector. This finding of an inverted U shaped relationship between product market competition and R&D lies in tandem with the new theoretical argument, which states that too little and too much competition are not conducive for innovation effort of firms.

Fig 3.1 Marginal effects of Lerner Index

Supplier dominated

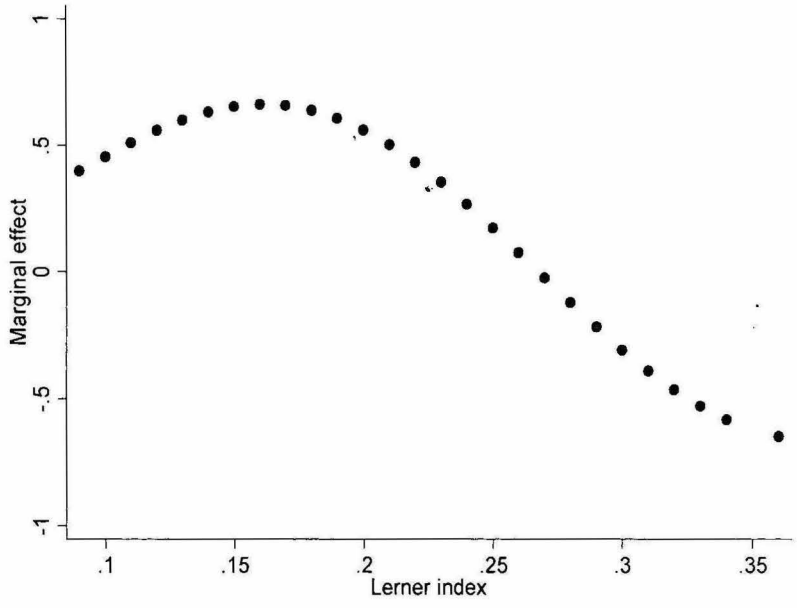


Fig 3.2 Scale intensive

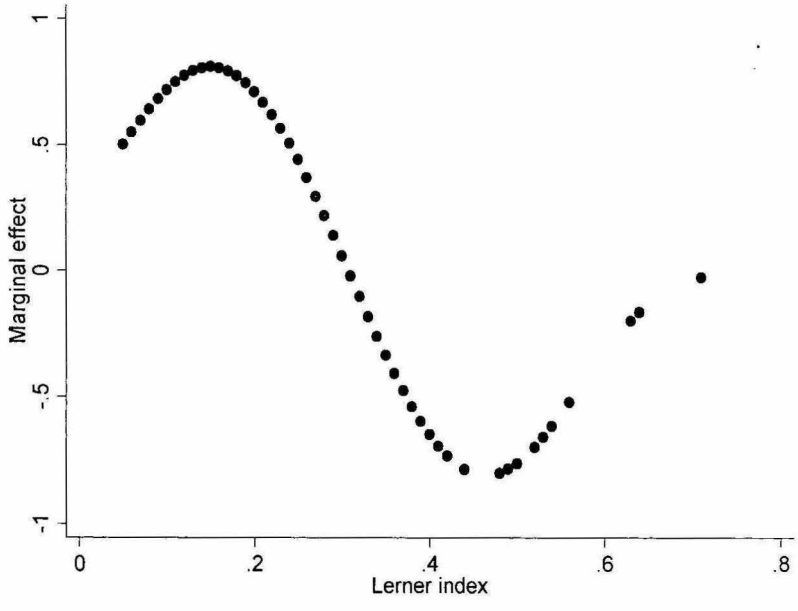


Fig 3.3 Specialised suppliers

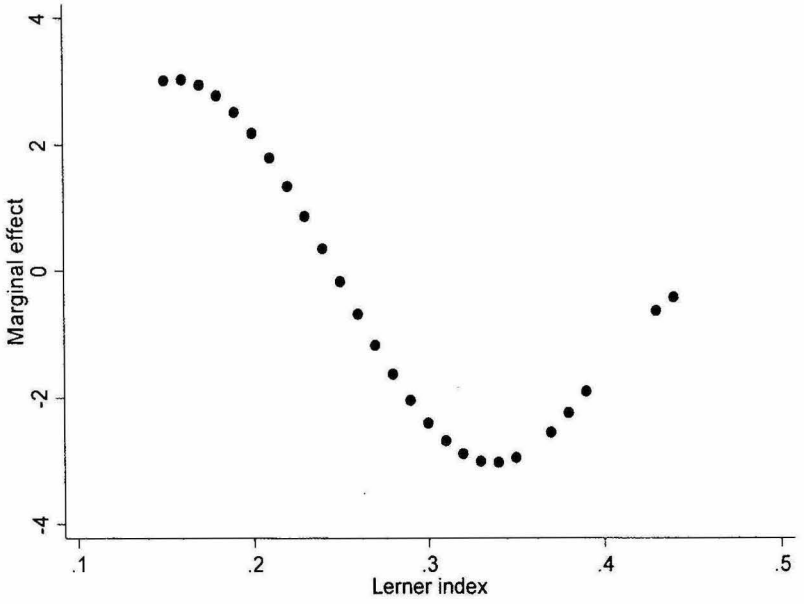
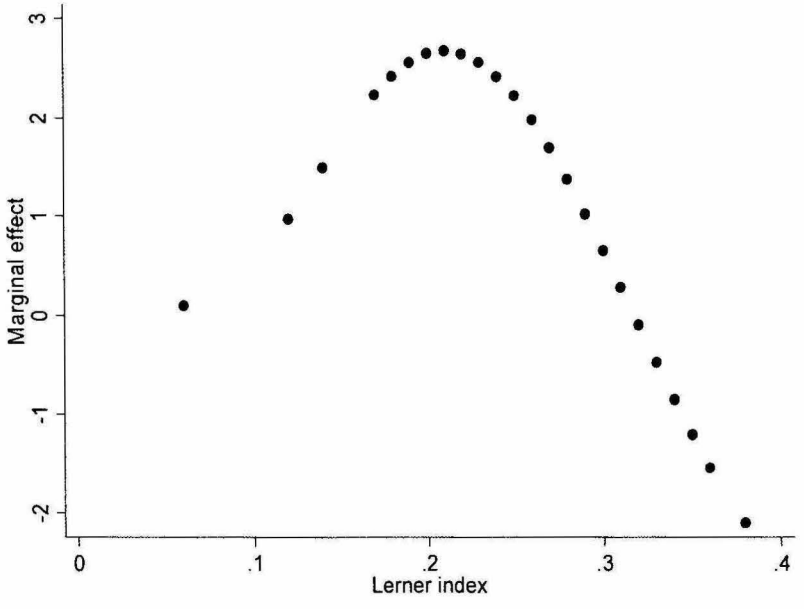


Fig 3.4 Science based



CHAPTER 4

SUMMARY AND CONCLUSION

4.1 Context of the study

This study examined the effect of product market competition on R&D effort of Indian manufacturing firms. Research and development, an input to innovation, is considered as an engine of growth, as it can determine the prospect of an industry. Hence the various factors, which determine the R&D investment decision of a firm, also become crucial to analyse. Among the key determinants of R&D, the kind of market structure, conducive for R&D investment becomes significant issue to examine. Chapter one of the study reviews the literature both international and Indian, testing the market structure R&D[32] relationship. Three kinds of results emerge from the review. First is the positive effect of market structure on R&D effort of firms. Second, there is less evidence of a negative effect of market structure on R&D. Third, the relationship between market structure and R&D is inverted 'U' shaped. The logic of this finding is that too much and too little competition is not conducive for R&D activity of firms. If there is too much competition the incentive to do R&D decreases as firms' may not be able to appropriate their returns from investing in R&D and too less competition makes firms lethargic and reduces its incentive to invest in R&D (Aghion 2003, Chang-Yang Lee 2005). Hence in this study we also empirically tested the existence of a non-linear relationship between market structure captured by the extent of product market competition and the probability of investing in R&D.

4.2 Empirical results of the study

Before estimating the effect of product market competition on R&D investment, we examined in the second chapter, the trend and patterns in R&D expenditure and product market competition during the liberalisation phase. This provided a background for further analysis. The chapter also examined the industrial and innovation policies of the government in the pre and post reform scenario.

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[32] As most of the studies have used R&D expenditure as an indicator for innovation effort of firms, we too use the same.

Lerner index was used to measure the extent of product market competition and R&D expenditure was used to examine the innovation effort of firms. We first analysed the trends and patterns in R&D investment. We could see that in the post-reform period there was a change in the pattern of R&D activity. The private sector began to play an increasing role in the aggregate R&D expenditure with inter-industry differences[33] and the relative share of government sector declined over the years. Also during this period there were changes in product market competition. The study shows that competition has increased marginally or remained stable in majority of the industries. The analysis was done for 28 two-digit product groups.

Having examined the relationship between product market competition and R&D intensity, the effect of product market competition on the probability to undertake R&D investment by firms was analysed using Probit estimation, controlling for other key determinants of R&D investment in the fourth chapter. An attempt was made to answer the following question. What is the impact of product market competition on the R&D investment decisions of firms? For capturing the non-linear effect of product market competition on R&D, a square term of Lerner index was also included in the estimation. Also to capture for the industry specific characteristics in the form of technological opportunity and appropriability, the industries were divided into four categories using Pavitt's taxonomy. The four categories are Supplier dominated, Scale intensive, Specialised suppliers and Science based.

The results from the analysis suggested that firm size was found to be positively influencing the probability to do R&D in all four sectors, supporting the Schumpeterian hypothesis that larger the size of the firm more would be the innovation. Advertisement intensity is also positively affecting the probability to do R&D by firms in all the sectors except in Supplier dominated sector. This result suggests that for gaining competitive position in the market, firms in these sectors may be using advertisement as a complementary strategy along with research and development. Profit is another significant variable, which is having a positive effect on the probability to invest in R&D, but only in Specialised suppliers, and Science based sectors. Firms in these sectors are using internal resources to finance their R&D activities. Age of the firm is having

[33] In almost all the industry groups in the R&D investment has increased in the post-reform period.

positive and significant effect only in Scale intensive firms, suggesting that only in this sector past accumulated experience is being used by firms to generate knowledge through R&D. Foreign equity participation is positively affecting the probability to do R&D by firms in all the sectors. This result indicates that firms are increasing their technological capability through R&D investment to adapt foreign technology, which is sourced from parent firm.

Disembodied technology import intensity is significant only in the Supplier dominated sector indicating the fact that in sectors where technological capability of firms is low, import of technology is encouraging in-house R&D investment. Capital good import intensity is found to have significant negative effect in Specialised supplier and Science based sectors. Export intensity is positive and significant only in Specialised suppliers and Science based sectors.

Regarding the impact of product market competition on the probability to do R&D by firms, we could also observe an inverted 'U' shaped relationship in all the sectors except Specialised suppliers. The effect of product market competition on the probability to do R&D in Specialised suppliers sector was not significant. Therefore, the findings of the study indicate that too much and too little competition is not conducive for R&D investment of firms. In extreme case of market structure, monopoly, the returns from R&D is dependent on the monopolist technological leadership and he has no incentive to invest in R&D to gain market share. And in the case of perfect competition, firms find it difficult to appropriate returns from their innovation effort and hence have lower incentive to innovate. A market structure intermediate between perfect competition and monopoly is suited for R&D investment in Indian manufacturing industry. This result may be supporting the inverted U shaped relationship between product market competition and R&D investment as argued by Aghion (2003) and Chang lee (2005).

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APPENDIX - II

National Industrial Classification 1998 - 4 digit, 3 digit and 2 digit.

Division 15: Manufacture of Food Products and Beverages		
151		Production, processing and preservation of meat, fish, fruit vegetables, oil and fats.
	1511	Production, processing and preservation of meat and meat products
	1512	Processing and preserving of fish and fish products [fishing and processing of the catch aboard the fisher boats are classified in class 0500 whereas activities of vessels engaged only processing and preserving are classified under this class]
	1513	Processing and preserving of fruit and vegetables
	1514	Manufacture of vegetables and animal oils and fats [Wet corn milling and production of corn oil is classified in class 1532 and treatment of oils and fats by chemical processing is classified in class 2429]
152	1520	Manufacture of dairy products [production of raw milk is classified in class 0121]
153		Manufacture of grain mill products, starches and starch products, and prepared animals feeds
	1531	Manufacture of grain mill products [Manufacture of potato flour and meal is classified in class 1513. Production of corn oil is classified in Class 1532]
	1532	Manufacture of starches and starch products
	1533	Manufacture of prepared animal feeds
154		Manufacture of other food products
	1541	Manufacture of bakery products
	1542	Manufacture of sugar [manufacture of glucose and other sugars from starches is classified in class 1532]
	1543	Manufacture of cocoa, chocolate and sugar confectionery
	1544	Manufacture of macaroni, noodles, conscious and similar farinaceous products
	1549	Manufacture of other food products n.e.c.
155		Manufacture of beverages
	1551	Distilling, rectifying and blending of spirits; ethyl alcohol production from fermented materials
	1552	Manufacture of wines
	1553	Manufacture of malt liquors and malt
	1554	Manufacture of soft drinks; production of mineral waters

Division 16: Manufacture of Tobacco Products		
160	1600	Manufacture of tobacco products [tobacco related products are also included while preliminary processing of tobacco leaves is classified in class 0111]
Division: 17: Manufacture of Textiles		
171		Spinning, weaving and finishing of textiles.
	1711	Preparation and spinning of textile fiber including weaving of textiles.
	1712	Finishing of textile. (This class includes finishing of textiles of Class 1711 by operations such as bleaching, dyeing, calendering, napping, shrinking or printing. No distinction is to be made between these activities carried out on a fee or contract basis or by purchasing the material and selling the finished products).
172		Manufacture of other textiles
	1721	Manufacture of made-up textile articles, except apparel
	1722	Manufacture of carpet and rugs [manufacture of linoleum and other hard surface floor coverings is classified in class 3699]
	1723	Manufacture of cordage, rope, twine and netting
	1729	Manufacture of other textiles n.e.c.
173	1730	Manufacture of knitted and crocheted fabrics and articles
Division : 18 : Manufacture of Wearing Apparel; Dressing and Dyeing of Fur		
181	1810	Manufacture of wearing apparel, except fur apparel [this class includes manufacture of wearing apparel made of material not made in the same unit. Both regular and contract activities are included]
182	1820	Dressing and dyeing of fur; manufacture of articles of fur
Division 19: Tanning and Dressing of Leather; Manufacture of Luggage, Handbags		
191		Tanning and dressing of leather, manufacture of luggage handbags, saddlery & harness.
	1911	Tanning and dressing of leather
	1912	Manufacture of luggage, handbags, and the like, saddlery and harness
192	1920	Manufacture of footwear
Division 20:Manufacture of Wood and of Products of Wood and Cork, Except		
201	2010	Saw milling and planing of wood
202		Manufacture of products of wood, cork, straw and plaiting materials
	2021	Manufacture of veneer sheets; manufacture of plywood, laminboard, particle board and other panels and boards
	2022	Manufacture of builders' carpentry and joinery
	2023	Manufacturing of wooden containers
	2029	Manufacture of other products of wood, manufacture of articles of cork, straw and plaiting materials

Division 21: Manufacture of Paper and Paper Products		
210		Manufacture of paper and paper product
	2101	Manufacture of pulp, paper and paper board
	2102	Manufacture of corrugated paper and paperboard and of containers of paper and paperboard
	2109	Manufacture of other articles of paper and paperboard
Division 22: Publishing, Printing and Reproduction of Recorded Media		
221		Publishing [This group includes publishing whether or not connected with publishing. Publishing involves financial, technical, artistic, legal and marketing activities, among others but not predominantly]
	2211	Publishing of books, brochures, musical books and other publications.
	2212	Publishing of newspapers, journals and periodicals (includes periodicals of technical or general contents, trade journals, comics etc.)
	2213	Publishing of recorded media [includes publishing of records and other recorded audio media]
	2219	Other publishing [includes publishing of photos and postcards, time-tables, forms, posters or other printed matters.]
222		Printing and service activities related to printing
	2221	Printing [includes printing of newspapers, magazines, periodicals, journals and other material for others on a fee or contract basis]
	2222	Service activities related to printing
223	2230	Reproduction of recorded media [This class includes reproduction of records, audio, video and computer tapes from master copies, reproduction of floppy, hard or compact disks, reproduction of non-customised software and film duplicating]
Division 23: Manufacture of Coke, Refined Petroleum Products and Nuclear Fuel		
231	2310	Manufacture of coke oven products [This class includes the operation of coke ovens chiefly for the production of coke or semi-coke from hard coal and lignite, retort carbon and residual products such as coal tar or pitch. Agglomeration of coke. Distillation of coal tar is classified in class 2411.]
232	2320	Manufacture of refined petroleum products
233	2330	Processing of nuclear fuel [includes extraction of uranium metal from pitchblende or other uranium bearing ores; manufacture of alloys, dispersions or mixtures of natural uranium or its compounds; manufacture of enriched uranium and its compounds; plutonium and its compounds; uranium depleted in U 235 and its compounds; other radioactive elements, isotopes or compounds; and, non-irradiated fuel elements for use in nuclear reactors]

Division 24: Manufacture of Chemicals and Chemical, Products		
241		Manufacture of basic chemicals
	2411	Manufacture of basic chemicals except fertilizers and nitrogen compounds
	2412	Manufacture of fertilizers and nitrogen compounds
	2413	Manufacture of plastics in primary forms and of synthetic rubber.
242		Manufacture of other chemical products
	2421	Manufacture of pesticides and other agro chemical products
	2422	Manufacture of paints, varnishes and similar coatings, printing ink and mastics
	2423	Manufacture of pharmaceuticals, medicinal chemicals and botanical products
	2424	Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations
	2429	Manufacture of other chemical product n.e.c.
243	2430	Manufacture of man-made fibers [This class includes manufacture of artificial or synthetic filament and non-filament fibers.]
Division 25: Manufacture of Rubber and Plastic Products		
251		Manufacture of rubber products
	2511	Manufacture of rubber tyres and tubes; retreading and rebuilding of rubber tyres
	2519	Manufacture of other rubber products
252	2520	Manufacture of plastic products
Division 26: Manufacture of Other Non-Metallic Mineral Products		
261	2610	Manufacture of glass and glass products
269		Manufacture of non-metallic mineral products n.e.c.
	2691	Manufacture of non-structural non-refractory ceramic ware
	2692	Manufacture of refractory ceramic products
	2693	Manufacture of structural non-refractory clay and ceramic products
	2694	Manufacture of cement, lime and plaster
	2695	Manufacture of articles of concrete, cement and plaster
	2696	Cutting, shaping and finishing of stone [includes cutting, shaping and finishing stone for use in construction in cemeteries, on roads, as roofing and in other applications]
	2699	Manufacture of other non-metallic mineral products n.e.c.
Division 27: Manufacture of Basic Metals		
271	2710	Manufacture of Basic Iron & Steel
272	2720	Manufacture of basic-precious and non-ferrous metals
273		Casting of metals [This group includes casting finished or semi-finished products producing a variety of goods, all characteristic of other activity classes]
	2731	Casting of iron and steel
	2732	Casting of non-ferrous metals

Division 28: Manufacture of Fabricated Metal Products, Except Machinery and		
281		Manufacture of structural metal products, tanks, reservoirs and steam generators
	2811	Manufacture of structural metal products
	2812	Manufacture of tanks, reservoirs and containers of metal [includes manufacture of containers of metal for compressed or liquified gas. Also includes manufacture of central heating boilers and radiators. Manufacture of reservoirs, tanks and similar containers of types normally installed as fixtures for storage or manufacturing use of metal, whether or not fitted with tops, closures, or lined with materials other than iron, steel or aluminum]
	2813	Manufacture of steam generators, except central heating hot water boilers
289		Manufacture of other fabricated metal products; metal working service activities
	2891	Forging, pressing, stamping and roll-forming of metal; powder metallurgy
	2892	Treatment and coating of metals; general mechanical engineering on a fee or contract basis
	2893	Manufacture of cutlery, hand tools and general hardware
	2899	Manufacture of other fabricated metal products n.e.c :
Division 29 : Manufacture of Machinery and Equipment N.E.C.		
291		Manufacture of general purpose machinery
	2911	Manufacture of engines and turbines, except aircraft, vehicle and cycle engines
	2912	Manufacture of pumps, compressors, taps and valves: [hydraulic power engines an motors; pumps for liquids whether or not fitted with measuring devices, including hand pumps and pumps designed for fitting to internal-combustion piston engines etc.; air or vaccum pumps, air or other gas compressors; taps, cocks, valves and similar appliances for pipes, boilers shells, tanks, vats or the like including pressure reducing valves and thermostatically controlled valve].
	2913	Manufacture of bearings, gears, gearing and driving elements: [ball and roller bearings including their parts; mechanical power transmission equipment of any material. (shafts, and cranks; bearings housings; gears and gearing including friction gears; gear boxes and other variable speed drivers; clutches, including automatic centrifugal clutches and compressed air clutches; fly wheels and shaft couplings); and articulated link chain]
	2914	Manufacture of ovens, furnaces and furnace burners
	2915	Manufacture of lifting and handling equipment :[machines for mechanical handling of materials, gods of people other than over-the-road vehicles; pulley tackle and hoists; winches and capstans;

		jacks; derricks; cranes, including cable cranes, mobile lifting frames, straddle carriers; works tucks whether or not fitted with a crane or other lifting or handling equipment, such as are found in the factories, warehouses, dock areas. station platforms etc.; lifts, elevators, liquid elevators, conveyors, teleferics; and parts of these equipment]
	2919	Manufacture of other general purpose machinery
292		Manufacture of special purpose machinery
	2921	Manufacture of agricultural and forestry machinery
	2922	Manufacture of machine-tools
	2923	Manufacture of machinery for metallurgy: converters, ingot moulds, ladles and casting machines; metal rolling mills and rolls for such mills.
	2924	Manufacture of machinery for mining, quarrying and construction
	2925	Manufacture of machinery for food, beverage and tobacco processing
	2926	Manufacture of machinery for textile, apparel and leather production [This class includes manufacture of machines for preparing textile fibers, spinning machines, weaving machines (looms) auxiliary machinery, machinery for washing, bleaching, dyeing, dressing, finishing, sewing machines, machinery for preparing tanning, hides, skin or leather and machinery for making or repairing of foot wears etc.]
	2927	Manufacture of weapons and ammunition [includes tanks and other fighting vehicles; heavy weapons, artillery, mobile guns; small arms such as light machine guns, rifles; air or gas guns and pistols; firearms which fire blank cartridges, signal flares, captive bolts and other non-projected firing pistols etc.]
	2929	Manufacture of other special purpose machinery
293	2930	Manufacture of domestic appliances, n.e.c.
Division 30: Manufacture of Office, Accounting and Computing Machinery		
300	3000	Manufacture of office, accounting and computing machinery
Division 31: Manufacture of Electrical Machinery and Apparatus N.E.C.		
311	3110	Manufacture of electric motors, generators and transformers
312	3120	Manufacture of electricity distribution and control apparatus: [electrical apparatus for switching or protecting electrical circuits (e.g. switches, fuses, voltage limiters, surge suppressors, junction boxes etc.) for a voltage exceeding 1000 volts; similar apparatus (including relays, sockets etc.) for a voltage not exceeding 1000 volts; boards, panels, consoles, cabinets and other bases equipped with two or more of the above apparatus for electricity control or distribution of electricity including power capacitors.]

313	3130	Manufacture of insulated wire and cable : [insulated (including enamelled or anodized) wire, cable (including coaxial cable) and other insulated conductors; insulated strip as is used in large capacity machines or control equipment; and optical fibre cables]
314	3140	Manufacture of accumulators, primary cells and primary batteries
315	3150	Manufacture of electric lamps and lighting equipment
319	3190	Manufacture of other electrical equipment n.e.c.
321	3210	Manufacture of electronic valves and tubes and other electronic components
322	3220	Manufacture of television and radio transmitters and apparatus for line telephony and line telegraphy
323	3230	Manufacture of television and radio receivers, sound or video recording or reproducing apparatus, and associated goods
Division 33: Manufacture of Medical, Precision and Optical Instruments, Watches		
331		Manufacture of medical appliances and instruments and appliances for measuring, checking, testing, navigating and other purposes except optical instruments
	3311	Manufacture of medical and surgical equipment and orthopedic appliances
	3312	Manufacture of instruments and appliances for measuring, checking, testing, navigating and other purposes except industrial process control equipment
	3313	Manufacture of industrial process control equipment: [apparatus used for automatic continuous measurement and control of variables such as temperature, pressure, viscosity and the like of materials or products as they are being manufactured or otherwise processed]
	3320	Manufacture of optical instruments and photographic equipment
333	3330	Manufacture of watches and clocks
Division 34: Manufacture of Motor Vehicles Travelers and Semi-Trailers		
341	3410	Manufacture of motor vehicles
342	3420	Manufacture of bodies (coach work) for motor vehicles; manufacture of trailers and semi-trailers
343	3430	Manufacture of parts and accessories for motor vehicles and their engines [brakes, gear boxes, axles, road wheels, suspension shock absorbers, radiators, silencers, exhaust pipes, clutches, steering wheels, steering columns and steering boxes and other parts and accessories n.e.c.]
Division 35: Manufacture of Other Transport Equipment		
351		Building and repair of ships & boats
	3511	Building and repairing of ships [This class includes ship building and repairing (other than yachts and other vessels for pleasure or sports) and the construction and repair of floating structures, whether or not used in freight/passenger carriage]
	3512	Building and repairing of pleasure and sporting boats

352	3520	Manufacture of railway and tramway locomotives and rolling stock
353	3530	Manufacture of aircraft and spacecraft
359		Manufacture of transport equipment n.e.c.
	3591	Manufacture of motorcycles
	3592	Manufacture of bicycles and invalid carriages
	3599	Manufacture of other transport equipment n.e.c.
Division 36: Manufacture of Furniture; Manufacturing N.E.C.		
361	3610	Manufacture of furniture
369		Manufacturing n.e.c.
	3691	Manufacture of jewellery and related articles
	3693	Manufacture of sports goods
	3694	Manufacture of games and toys
	3699	Other manufacturing n.e.c.
Division 37: Recycling		
371	3710	Recycling of metal waste and scrap
372	3720	Recycling of non-metal waste and scrap