MARKET CONCENTRATION FIRM SIZE AND INNOVATIVE ACTIVITY:

An Analysis of Selected Indian Industries Under Economic Liberalisation

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I, hereby affirm that the research for this dissertation titled *"Market Concentration Firm Size and Innovative Activity: An Analysis of Selected Indian Industries Under Economic Liberalisation"* being submitted to the Jawaharlal Nehru University for the award of the Degree of Master of Philosophy in Applied Economics, was carried out entirely by me at the Centre for Development Studies, Thiruvananthapuram.

Thiruvananthapuram **Subodh.K.**

Certified that this dissertation is the bonafide work of Subodh.K, and has not been considered for the award of any other degree by any other university.

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Chapter 1

INTRODUCTION

Since the 1940's economists have come to recognise the role of innovative activity in firm's productivity growth particularly in the competitive market economies. The competitive environment in such economies acts as a major inducement mechanism for firms to constantly upgrade their technology through Research and Development (R&D). Even in less developed countries, innovative activity is increasingly becoming an important factor of growth and survival of firms. The role of technology has assumed added significance in the context of globalisation wherein the survival of firms depends mainly on international competitiveness.

Technological change in the developing countries, however, did not receive due attention as compared to the developed economies. Technological activity in the developing countries mainly consists of import of technology generated by the developed nations and adapting it to their local conditions. The technology policy prior to liberalisation in India mainly focussed on development of in-house R&D. Therefore technology purchase by firms was not an easy option. There were a number of restrictions on industrial licensing, imports of technology and technology embodying inputs and on foreign direct investment. While there were additional taxes on technological import, number of incentives was provided to firms, which had recognised R&D units. With economic liberalisation, there has been a shift in focus wherein technology import, both embodied and dis- embodied, became an easy option for the firms. It is hoped that the ongoing wave of globalisation would enhance flow of technology into the country and help building the much-needed technological capability. However Kumar and Siddharthan (1997) argues;

"While it is true that developing countries can benefit from the global pool of technologies and knowledge by several channels of transfer and diffusion and not reinvent themselves, literature has emphasised the need for some capability of their own even to be able effectively to employ technologies available abroad in the process of their development" (1997,p.2).

Problem of the Study

Having identified technological change as a major source of growth in the developed country context, the process of technological change has been subjected to intense study. There were studies, which tried to examine the nature of the process by which economic resources were transformed into technological advances. Related issues like whether such process exhibits increasing, decreasing or constant returns to scale and the involvement of significant spill over effects were also addressed.

The most conducive market environment for innovative activity also became a subject of interest ever since the pioneering work of Schumpeter (1942). Schumpeter hypothesised that firm size and market concentration induces innovative activity. Since then the hypotheses have been tested exhaustively in the developed country context[1]. Kamien and Schwartz (1982) summarised some of the important issues of concern on market structure and technological change for the economists in the developed countries. "What is the nature of the market for technical advances? Will the competitive marketplace allocate resources so that the mix and timing of the technological advances will be efficient? Is there a market structure most conducive for technical advance? If so, is it sustainable? What is the effect of technological advance on market structure?" (1982, p.12).

1 A detailed discussion on the Schumpeterian hypotheses and the review of the empirical literature on the test of Schumpeterian hypotheses in the developed country context are given in chapter 2.

In the Indian context the studies relating to market structure and innovative activity attained importance only in the 1970s. Since then there have been numerous attempts to empirically verify the Schumpetrian hypotheses in India. Most of these studies, however, pertain to the import substituting policy environment. Moreover, these studies generally conceptualised innovative activity only in terms of in-house R&D. Given the liberal policy environment, it is important that innovative activity is understood in terms of both technology import and in house R&D. In addition to the conceptual issues, there are a number of methodological issues that need to be taken care of[2]. In this context there arises a number of issues in terms of the relationship between firm size, market structure and innovative activity. How do the dynamic policy changes in the economy in the period of liberalisation affect the market structure innovative activity relationship? How have the firm- specific, industry-specific and product-specific characteristics of the firms influenced innovative activity? In the era of liberalisation, what are the factors that affect the decision to do innovative activity and the intensity of innovative activity? Another important issue for analysis would be whether there are significant inter-industry differences in the relationship between market structure and innovative activity after liberalisation.

Based on the above issues, the current study tries to look into the relationship between market concentration, firm size and innovative activity for two industries of the manufacturing sector, drugs and pharmaceuticals and electronics. These two industries are chosen on the basis of their high technology intensive nature[3].

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2 See chapter 3 for a discussion of the methodological issues.

3 The specific reasons for the choice of the two industries viz.: Drugs and Pharmaceuticals and Electronics are provided in Chapter 3.

The specific objectives of the current study are to analyse;

- The firm level relationship between market concentration, firm size and the decision to do innovative activity.
- The factors influencing the intensity of innovative activity at the firm level.

Data Sources

The present study calls for detailed firm level data on a number of variables. This study made use of "Prowess", a computerised database prepared by the Centre for Monitoring Indian Economy which gives firm level data on a number of financial and other variables such as R&D expenditure, exports, technology imports, dividends, profits and sales. This database is prepared from the balance sheet and director's report of all public limited companies. Data have also been collected from the `Markets and Market Shares' and `Financial Aggregates of Industries' published by the Centre for Monitoring Indian Economy. The period of analysis is for six years starting from 1992-'93 (henceforth 1992) to 1997-98 (henceforth 1997).

Chapter Scheme

The study is organised in four chapters including introduction. A review of the relevant empirical literature on the relationship between market structure and innovative activity is given in Chapter 2. The review is done against the backdrop of the Schumpeterian hypotheses and highlights the relevance of the current study in the present day context, and sets the background for an analytical frame for the study. The third chapter empirically tests the relationship between the size and market structure variables on the decision to innovate and the intensity of innovative activity for two industries of the Indian manufacturing sector, viz. Drugs and pharmaceuticals and Electronics. Chapter 4 summarises the major findings and presents the concluding observations.

Chapter 2

REVIEW OF LITERATURE AND ANALYTICAL FRAMEWORK

Introduction

Notwithstanding the general consensus on the positive role that technology plays in fostering economic efficiency and growth, economists differed in terms of their views on the type of economic structure that promotes innovation and technological progress. To begin with, it was Schumpeter (1942) who considered that the introduction of new methods of production and new commodities is hardly conceivable with perfect competition. Conceptualising innovation as a process comprising of new product, new process, new market, new organisation and new raw material, Schumpeter underlined the key role of the monopoly power in bringing about innovation. However the neo-classical school has held a diametrically opposite view. To them, a competitive market structure is likely to be superior in terms of promoting innovation. Arrow (1962) has theoretically articulated this argument. It was shown that under particular conditions, there is greater incentive for R&D when industries are competitive rather than monopolised. Arrow concluded that the incentive to invent is less under monopolistic than under competitive conditions, but even in the latter case it will be less than what is socially desirable. However Dasgupta and Stiglitz (1980) have criticised Arrow on the grounds that he took market structure as given or exogenous and that he failed to take into account the innovation possibility frontier open to firms in an industry. They developed a microeconomic model in which market structures are endogenous and the technology possibility frontier specifically influenced strategies involved in market competition. They found that high research intensity and high level of concentration go hand in hand. Industrial concentration and research intensity are advantage may be derived from patents that cannot be easily circumvented, development of expertise that cannot be easily duplicated, realisation of extraordinary profits that are available for additional R&D, development of a favourable reputation and a loyal consumer base.

Kamien and Schwartz (1982) have further articulated the manifold ways in which market concentration and innovative behaviour interacts. The first is between innovation and anticipation of monopoly power and the concomitant monopoly profits. The second source of interaction is between innovation and possession of monopoly power. A firm that has monopoly power for the present products can simply extend it to their new products, thanks to its command over channels of distribution or through its true identity. The possession of monopoly power and the associated monopoly profits may also enable the firms to respond more quickly to innovations of rivals than it would other wise. Another source of interaction between possession of monopoly power and innovation is alleged to be through the necessity to finance innovation internally. A firm realising extraordinary profits is presumably in a better position to undertake internal financing than a firm with normal profits. Another advantage for possession of monopoly power is that the firms can hire the most innovative people.

Schumpeter, however cautioned that monopoly power, sometimes, could act as a major disincentive to innovation. There can be a possibility wherein the firm with monopoly profit has less incentive or hunger for additional profits through innovation than a firm with normal profit or a new entrant. So the question that remains to be answered is; although monopoly power is advantageous to innovation, how much monopoly power is optimal? Moreover, as pointed out by Usher (1964) and Arrow (1962), as these firms already reap monopoly profits, they would rather make as much profits as possible from the present product instead of trying to get into a new market. For a new firm, there is only one option, if they are to enjoy monopoly power.

Other than this, factors like technological opportunity and market opportunity are perceived to have considerable influence on the level of technological activity. If the firms find that the returns from undertaking research in a specific area were greater than investing in another area, then the incentive to innovate would differ in these industries. Similarly, if the market demand structure calls for changes in the nature of the product produced, then firms catering to this market would be forced to react to these expectations or face the risk of being overtaken by rival improvements.

The Empirical Evidence

The empirical studies on Schumpeterian hypothesis in the developed countries have mixed results to offer. The initial studies of Mansfield (1967) Scherer (1965), Horowitz (1964) and Hamberg (1964) got a positive but weak link between market concentration and R&D activity. Studies by Williamson (1965), Bozeman and Link (1983) and Mukhopadhyay (1985) found a negative relationship between concentration and R&D activity. Scherer (1967), for the first time, observed a non-linear (inverted U) relationship between R&D intensity and market concentration. Taking data from the Census of Population, Scherer found that R&D employment as a proportion of total employment increased with concentration[1] up to a certain point and then decreased. Later studies by Levin (1985) and Scott (1984) also got the same non-linear relationship using Federal Trade Commission data.

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1 Scherer here used four firm concentration ratios as a proxy for market concentration.

Braga and Willmore (1991), for a sample of 4,342 establishments in Brazil, found an inverted 'U' shaped relationship. This implied that the extent of concentration (measured in terms of Herfindahl Index) affected the likelihood of a firm having a specific programme of product development positively up to an extent beyond which it affected the likelihood adversely.

Phillips (1966, 1971) was the first to propose that there could be causality between market concentration and R&D as success breeds success. Taking the case of aircraft market in America, he concluded that not only concentration could affect innovative activity, but also vice-versa. Thereafter studies by Farber (1981), Connolly and Hirschey (1984) Levin and Reiss (1984) studied the market structure and R&D activity relationship treating both variables as endogenous to avoid the simultaneity problem. Levin (1981) established a model in that form, where distributed lag model of past R&D investment, rather the current R&D intensity appeared on the right hand side of the concentration equation.

The study by Nelson and Winter (1982) used simulation models to explain a positive relationship between market concentration and innovative activity. They found that market structure and innovative activity are jointly determined by basic factors such as demand conditions, technological opportunities, government appropriability and nature of capital markets.

Geroski (1989, 1990, 1991) and Acs and Audretch (1991) studied the relationship between market concentration and innovative activity, when entry was also considered. Then they found that concentration had a modest negative relationship with R&D intensity in the presence of entry. Shrieves (1978), Comanor (1967) and Angelmar (1985) concluded that market structure-innovative activity relationship was affected by other factors like technological opportunity, product differentiation, and entry barriers.

It was Scherer (1980) who found that when inter-industry differences (due to technological opportunities) are taken into account, the correlation between R&D and other explanatory variables tend to become weaker and statistically insignificant. Later Shrieves (1978), Jaffe (1990), Levin and Reiss (1984), Cohen (1987), Levin (1985), Cohen and Levinthal (1989) and Geroski (1990) also used technology opportunity as a major variable to explain the relationship between market structure and innovative activity.

The studies in the developed country context on the relationship between market concentration and innovative activity did not give a positive relationship as envisaged by Schumpeter. When some studies gave a weak positive link, many others gave a negative relationship between market concentration and innovative activity. The major argument of these studies was that market concentration alone did not affect the innovative activity, but was supplemented by other factors like technological opportunity, appropriability and barriers to entry. The empirical studies also identified technological opportunity and appropriability as important variables affecting innovative activity apart from firm size and market concentration.

In India, the relationship between market concentration and innovative activity was empirically tested mainly in the eighties. Like the developed country context, the studies in the Indian context also gave mixed results on the relationship between market structure and innovative activity[2]. Desai (1984) analysed the relationship between market structure and technological

2 For more detailed surveys on market structure innovative activity relationship in the Indian context refer Kathuria (1989) Kumar and Siddharthan (1997).

change on the basis of statistical correlation as well as a series of case studies of different industries. He calculated Herfindahl indices of concentration for 42 industries based on Centre for Monitoring Indian Economy data for 1978-79, as also an `E' index[3] of inequality. He found that market structures with few firms from two to six, were more conducive to adoption of new technology by firms. Desai held that the long tailed market structure, (number of firms is large) common in India was not especially conducive to technological progress: nor are the monopoly firms set up by the government in high technology industries.

Desai concluded that whilst technology imports on their own tended to create oligopolistic market structures, R&D reinforced the competitive advantage of large firms. But the leakage of technology within the country had led to the emergence of many small firms, and they had appreciably increased their market shares. Due to inadequate firm level data, the analysis was limited to the level of industry. This could have constrained the analysis by not getting firm level characteristics affecting the innovative activity.

In a comprehensive coverage of Industrial R&D in India, Kumar (1987) analysed 1143 companies in 43 manufacturing industries, based on RBI data from 1976-77 to 1980-81. He explored the Schumpetrian hypothesis, the role of market structure using a four firm concentration ratio. He aggregated the company level data to get the industrial level data. The author controlled for technological opportunity by introducing proxy variables such as capital intensity, skill intensity, dummy variables for engineering, chemical, consumer and consumer convenience goods, and also brought in advertising intensity. The result showed that the market structure variable, (the four firm concentration ratio) attained a modest level (10%) of

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3 E- measure of inequality refers to the Gini coefficient.

significance with negative sign. The Neo-Schumpeterian expectation of a positive relationship between the seller concentration and R&D intensity was therefore contradicted for Indian Industry. The observed inverse relationship was explained by the presence of entry barriers. The government policy protected firms from both domestic as well as foreign competition, through its industrial licensing policy. Tariffs, non-tariff barriers and exchange controls had shielded the competition from abroad. The existing firms, therefore, faced hardly any actual or potential threat from potential competition. The principal motivation for firms to pursue innovative activity was to acquire monopoly power with the accompanying quasi-rents. He therefore, argued that in the absence of any threat of potential competition, high concentration did not provide any motivation for innovation. Capital intensity, a proxy variable for technological opportunity did show significance, but a negative relationship. It suggested that capital intensive industries did not offer technological opportunities. The other variables that denoted technological opportunity did not show any significance[4].

Vijaya Bhaskar (1991) took off from the earlier studies and tried to explore the association of changes in concentration levels with the industry performance in terms of growth of output and innovative activity in the eighties. His logic was that as the liberalisation measures relaxed the barriers to entry, the behaviour of firms faced with the threat of possible entry would be different. The results showed that low intensity industries benefited from high concentration levels, as the correlation coefficients were positive and significant (for both periods). However for the high intensity industries, the inverse held good, especially in the post liberalised period. The author concluded that high concentration or a monopolistic market structure was hardly conducive to the innovative activity in industries where they really matter. The research intensity

4 Kumar (1987) Siddharthan (1988), Fikkert (1993) Kumar and Saqib (1996) have taken care of appropriability and technological opportunity in their studies.

decreased with growing concentration levels. There was no positive correlation between concentration and innovativeness as envisaged by the proponents of liberalisation. However, the period of analysis was from 1980 to 1990. The liberalisation of the economy rigorously took place in India only after 1990's and the conclusions of the study therefore could not have got a clear picture of the relationship between market concentration and R&D activity. The author also did not consider any form of technology import as a measure of innovative activity. Data limitations confined the study to industry level analysis.

Prasad (1999) got a negative relationship between in house R&D and market concentration proxied by market shares for chemical and industrial machinery firms contradicting the Schumpeterian Hypothesis. This firm level study conducted in the late 1990's did not consider technology import as a significant measure of innovative activity, although chemicals and industrial machinery firms were found to be technology import intensive after liberalisation in India.

Kumar and Saqib (1996) found that both market concentration variables proxied by four firm concentration ratio and profit margin were negative, but not significant. This was the case for both the probit and tobit models to analyse the probability and intensity of doing In-house R&D.

Section 2

Firm Size and Innovative Activity

Although identified by Schumpeter, the firm size innovative activity hypothesis was fully developed by Galbraith (1952). The hypothesis said that large firms are more than proportionately innovative than small firms. In other words, in a mature capitalist economy, large firms generate a proportionately larger share of society's technological advances.

There are a few advantages for the larger firms to go for more innovative activity. One claim is that capital market imperfections confer an advantage on large firms in securing finance for risky R&D projects, because size is associated with the availability and stability of internally generated funds. A second claim is that there are scale economies associated with industrial R&D. Another advantage is that the returns from R&D are higher where the innovator has a large volume of sales over which to spread the fixed costs of innovation. Finally R&D is said to be productive in the large firms as a result of complementarities between R&D and other manufacturing activities that may be better developed with larger firms. The researchers are more productive when they have more colleagues with whom they can interact. A large group permits division of labour. Another possible advantage for a large firm over a small one in research and development is in its superior ability to exploit the output of its research efforts. Based on these arguments, the hypothesis that large firms generate more innovation is developed.

Empirical Evidence

The hypothesis relating to firm size and innovative activity has been empirically tested both in the developed and developing countries including India. The size of firm was alternately measured by number of employees, capital assets and the sales volume and the R&D intensity by R&D expenditure, scientific personnel engaged in R&D, patents received and sales associated with the new products introduced. However, there has not been any consensus on what exactly is the relationship between firm size and innovative activity. In the developed country context, the firm size was measured as the sales volume, the assets or the number of employees. Some of the studies by Comanor (1967), Horowitz (1962) and Hamberg (1966) found a weak positive link between firm size and innovative activity. All the above studies used linear regression analysis or correlation to arrive at the respective conclusion. These studies, except Comanor (1967) did not control for the industry effects[5] and later a study by Baldwin and Scott (1987) found that omission of such industry effects are likely to bias the estimates of the effects of firm size on innovative activity.

It was Scherer (1965) who first found a negative relationship between firm size and innovative activity. With a sample of 448 firms from the 500 largest in 1955, Scherer regressed R&D employment with firm size to check for non- linearities. He found that the firm size increased more than proportionately with innovative activity up to a threshold level for the smaller firms. R&D employment intensity tended to decrease among the larger firms.

Grabowski (1968) empirically tested the firm size and R&D intensity relationship using regression analysis, taking size and square of size for the chemical and drug firms. He found that research intensity for drug firms increased initially but then declined over most of the relevant range of firm size. But in the case of chemical firms, the research intensity increased proportionately with firm size[6].

Mueller (1967), Kelly (1970) and Loab and Lin (1977) found that research intensity was not

5 These studies used crude measures to control for industry effects.

6 Further data examination by Grabowski himself suggested that the observed relationship between firm size and R&D intensity in the two industries were due to other factors affecting R&D intensity.

positively related to the size of firms. While Mueller found a negative relationship, Kelly got no relationship at all. The study by Loab and Lin analysing a 1961-72 time series data relating sales to R&D expenditures for six major pharmaceutical manufacturers got a non- linear relationship. Small firms were more research intensive in the case of Shrieves (1978) and Rosenberg (1976).

The eighties saw the use of more comprehensive data to study the firm-size- R&D relationship. Bound et al (1984) used a sample of American firms to study the relationship between firm size and R&D intensity and found that R&D intensity declined slightly with size among the smallest firms and then rises with size among the very largest firms. Cohen et al (1987) using data from the Federal Trade Commission's (FTC) line of business programme, and after taking care of industry effects, firm size did not have any relationship with R&D intensity.

The studies on the relationship between firm size and innovative activity used R&D intensity, an innovative input as a proxy for innovative activity. Fischer and Temin (1973) argued that the empirical analysis should be done between firm size and R&D output as proxy for innovative activity. They found that the elasticity of R&D with respect to size in excess of one does not necessarily imply an elasticity of innovative output with respect to size more than one.

There are studies by Pavitt (1987) Acs and Audretsch (1990, 1991), which showed a 'U' shaped relationship between R&D intensity and firm size. These studies showed that very small firms and very large firms had proportionately higher R&D intensities and the pattern of relationship varied across industries.

The studies on the relationship between firm size and R&D activity in the developed country context are not in tune with the positive relationship as envisaged by Schumpeter. The general conclusion of the studies was that the research intensity (R&D/ Size) rises up to a certain firm size followed by a constant or declining research intensity. Some studies also found a negative relationship between firm size and innovative activity. Hence, the empirical studies have not been able to reach a consensus in supporting the Schumpeterian hypothesis that large firm size leads to more innovation. The studies also come to a conclusion that firm size alone cannot affect R&D intensity and other variables like technological opportunity and appropriability have influence on R&D intensity.

The first attempt in India to empirically verify this Schumpeterian hypothesis was made by Subrahmanian (1971a). He found no evidence in the Indian chemical industry to suggest a positive relationship between R&D intensity and firm size, or between R&D intensity and relative firm size (used to indicate market power). The major problem with this analysis was that factors other than firm size were not considered for analysis. In a subsequent study with the same data set Subrahmanian (1971b) did consider other variables such as profits, retained earnings, depreciation, gross investment and lagged R&D expenditure, and found absolute R&D expenditure is positively related to firm size as well as on lagged R&D and depreciation.

Lall (1983) in another econometric study of R&D activity in 100 engineering firms found that R&D intensity was positively influenced by size, age and technical absorptive capacity (proxied by percentage of total wages and salaries paid to employees earning more than Rs. 3000 per month) of the firms. Lall attributed this to the fact that the largest firms tended to be more diversified, more technologically complex and could afford more investment in R&D activities. However Lall did not have a quadratic term to check for non-linearities. Katrak (1985) found that the elasticity of R&D expenditure with respect to sales was less than unity for a cross-sectional data at the industrial level and his result contradicted the results of Lall[7].

Siddharthan (1988) argued that the relationship between the size of firm, and its conduct and performance is seldom linear as tested in earlier works. He used published data from 166 manufacturing firms (both private and public firms) for the year 1983-84, and found a 'U' shaped non-linear relationship between R&D intensity and sales turnover taken as a proxy for size. The turning point occurred at a sales level of Rs.600 million. The non-linearity was mainly because the nature and type of R&D activity between the large and small firms were different and not strictly comparable. He found that for the smaller firms, R&D expenditure increases more slowly than the increase in size, but for the very large ones, it increases faster than the increase in size. He tested this relationship for the industries like electronics, machinery, textiles and chemicals. Except for chemicals, where he got a negative relationship, in all other industries, he got the non-linear relationship between R&D intensity and firm size. However, in this study only firms, which did some in house R&D, were considered for analysis. If firms, which did not do R&D, were also included, it would have reduced the sample selection bias and the result would have been different. Deolalikar and Evenson (1989) analysed the determinants of inventive activity proxied by the average (per firm) number of patents granted to the nationals in India. They found a negative relationship between innovative activity and firm size[8].

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7 Kathuria (1989) argued that Katrak did not employ any variable, which controlled for technological opportunity and the study was based on industrial data unlike Lall's. However Katrak (1989) again got a negative relationship between firm size and in house R&D.

8 A problem with this study could be that the analysis based on patents data need not give reliable results and moreover India had a weak patent regime.

Katrak (1990) studied the relationship between firm size and R&D activity for the electrical and electronics and the industrial machinery firms and found that increase in firm size did not lead to more than proportionate increase in R&D expenditure. Katrak (1994) was of the opinion that the influence of enterprise size on technological effort depended on the industries concerned and the methodology used. Katrak studied whether larger enterprises had a proportionately higher output of in house R&D based products. This was studied using a multiple regression analysis using R&D based products as the dependent variable and the total value of the enterprises' total sales as a proxy to the size of the firm. The multiple regression analysis found that the R&D based products share reduced as the enterprise size increased. The author assumed that this result could be due to the effect of government policies. The industrial licensing policies (the data was for 1987) could have adversely affected the large-scale enterprises, which may have discouraged the R&D based production in these enterprises.

Identifying the importance of technology imports as a major component of innovative activity, Siddharthan and Krishna (1994) showed that size was a positive and significant variable in determining technology imports for firms belonging to six broad industry groups, except in electrical and electronic goods and automobiles industries. Basant (1996) tried to study the technological strategies of large-scale enterprises in Indian Industry. He studied 438 Industrial machinery firms and 651 chemical firms for the year 1974-84, compiled from the annual reports of the public limited companies. The study using multinomial logit model found that a large firm size improved the profitability /utility of being technologically active (undertake own R&D, technology import, or both) relative to the reference state of not doing anything. This was true of both the chemical as well as the machinery industry. But it was found in the chemical industry that the choice of performing only R&D was positively affected by firm size[9].

Kumar and Saqib (1996) approached the problem using a probit and tobit model. They found from the probit model that firm size was positive and the quadratic term of firm size was negative, with both being significant. This meant that the probability of doing R&D increased up to a certain point and then declined. The tobit model showed that firm size increased with R&D intensity in a linear fashion with the quadratic term being insignificant.

Subrahmanian (1996) and Prasad (1999) got evidence of a positive and significant relationship between firm size and in house R&D for post liberalisation data belonging to chemicals and electrical machinery. However both these studies considered only R&D intensity and did not consider technology import an important measure of innovative activity.

The Empirical studies on firm-size and innovative activity relationship in the Indian context also showed wide differences in the results as in the developed country context. The results mostly got a negative relationship between the two, but there were also studies, which showed a positive relationship. However, Siddharthan (1988) got a U shaped relationship between firm size and in house R&D activity, while Kumar and Saqib (1996) got an inverted U shaped relationship between the two.

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9 However the author himself agreed that there was heterogeneity among industry groups, especially in chemicals.The firms are classified on the basis of their principal products and data limitations did not permit a detailed analysis of their levels of diversification. Given the heterogenous nature of the sample firms the empirical exercise undertaken could not be a conclusive one.

Section 3

Towards an Analytical Framework

As is evident from the discussion so far made, there is a vast body of literature, in the developed countries and in India, which empirically explored the Schumpeterian hypotheses. However, there is hardly any consensus as regards the results of analysis. The divergence in the results could probably be explained in terms of the measurement problems associated with the concept of innovation and market concentration on the one hand and empirical procedures adopted in estimation.

Schumpeter conceptualised innovation as a process involving the introduction of new products, new processes, new markets, new raw material and new organisation. However, the studies, both in the developed and developing countries, have considered only R&D expenditure, R&D employment or patents as a proxy for innovation. Such narrow measure of innovation could hardly represent the concept of innovation as used by Schumpeter. All the measures of innovation used in the empirical studies have their own problems. Patent statistics, a common measure used to proxy innovation in developed countries, according to Kamien and Schwartz (1982), has the following problems:

1) Patents are used for major as well as minor innovations. Giving equal weights for both is inappropriate.
2) Many patented products and processes are never commercialised.
3) Many innovations are never patented.

The input measures of innovation (R&D employment and R&D expenditure) were also widely used in the studies in the developed country context. Scientists and research support staff are at the core of the research organisation and are directly involved in the conduct of research. Time units spent on research must be identified in this case and is always difficult. Kuznets (1962) called for a study of specialised human capabilities to measure inventive capacity of personnel. The exact time units, mental effort and human ability measures are beyond the scope of economics (Rajeswari, 1992). Thus the personnel measure of research effort fails to be a complete measure of its own. Research expenditure is the most important quantifiable measure of research effort, which is used, in empirical studies. It is a logical and direct measure, but still can be an incomplete measure. Thus the diverse and incomplete measurement of innovation could be one of the reasons for the observed divergence in the results of empirical studies.

The measurement of concentration is yet another problem faced by researchers. It is not possible for a single concentration measure to capture all the components of market structure. The most commonly used index in the empirical studies in the developed and Indian context is the K-firm concentration index, defined as the cumulative share of the Kth firm. Its popularity is mainly due to the easy availability of data and ease of computation. The choice of K is of course, arbitrary. Conventionally, in the developed economies K takes the value between 3 to 8. The problem with the measure is that it does not disclose any information on firms ranked after K.

A more comprehensive measure of market concentration is the Hirschman-Herfindahl Index. It is defined as the sum of the squared shares of `n' firms. The advantage is that it takes into account the shares of all the firms in the market. At the same time, the squaring up of the values means that the smaller firms contribute less than proportionately to the value of the index. This is a valid approach, as the entry of a number of small firms with minuscule market share would hardly affect the market power of the top firms. But a pre-requisite for this index is that, information on the market shares of all the firms should be available, which restricts its use.

A problem common to the two measures discussed above is that they are static in nature and do not capture the movements in concentration levels when the top firms keep on changing their ranks over the years. This is an obvious defect as the intensity of competition depends largely upon the ability of the top firms to maintain their position (Vijaya Bhaskar, 1991). Still most of the empirical studies have taken a four firm concentration ratio or the Herfindahl index, as they are easy to compute and serves the purpose with little defects, which are usually ignored. However, these incomplete measures of concentration could probably have resulted in diverse results in the empirical studies verifying the market concentration-innovative activity relationship.

The problem deepens when it comes to the proxy used for innovation in the empirical studies in the Indian context. All the studies have taken mostly R&D expenditure as a proxy for innovation. The studies have assumed that innovation in the developed countries and in India are the same, which is not true. It has been argued that in India, the R&D activity was mainly informal with more adaptive R&D activity. Deolalikar and Evenson came to the conclusion that " One short coming of most studies on inventive activity in India is that they limit themselves to formal inventive activity, often of the type that takes place in established laboratories and results in patents. A large majority of innovative activities among Indian firms takes place on the shop floor. Often such activities play a more important role than formal R&D in the technological development of the firm". (1990, p.244)

Kumar and Siddharthan (1997) also found that the difficulty in capturing informal innovative activity and the diverse measurements used to denote innovative activity are the reasons why the empirical studies in India on market structure and innovative activity gave contradicting results.

The studies in the Indian context also missed technology purchase, another important component of innovative effort in India. Given the fact that technology imports to India increased significantly during the 1980's and the failure to incorporate technology import appears to be a serious problem that needs to be corrected. Kumar and Siddharthan (1997) argued that "R&D expenditures only partially represented expenditures on technology, as expenditures on technology purchases- which could be substantial, especially in the developing countries are not covered, although the two could be related in some cases". (1997, p.55).

Technology purchase became a more important component of innovative activity especially after liberalisation of the nineties. It can be hypothesized that apart from large firms doing more in house R&D they also resort to more technology purchase than smaller firms for the following reasons; The larger firms are expected to have better knowledge of world market, more production experience, marketing experience compared to smaller firms. Thus a large firm is hypothesized to have a more than proportional increase in technology purchase compared to the smaller firms. It has also been argued that the in technology licensing agreements, the foreign firms have a preference for larger firms (Evenson & Joseph, 1997).

The inter-industry specificities or technological opportunities could play a major role in determining the relationship between innovation and firm size and innovation and market concentration[10]. Very few studies in India have taken care of inter-industry differences in the Indian context. Kumar (1987) understood the importance of inter-industry differences in the sample he took and introduced industry dummies to control for technological opportunity. The problem with industry dummies was that in addition to technological opportunities, they also represented other industry characteristics. Kumar and Saqib (1996) when he analysed the probability and intensity of firms that do R&D, also used industry dummies to counter the inter industry differences. According to them, the inter-industry differences in the opportunities of product and process innovations played an important role. The opportunities for adaptation varied across industries, depending upon many factors. They included the maturity of technology, the gap between local and global standards, the degree of monopolistic hold over technology and the nature of intellectual property protection and the need for such adaptation arising from different local conditions. Kumar and Saqib used a total of nine industry dummies to capture inter industry specificities for a total sample of 291 manufacturing firms and found that technological opportunity was very high in chemicals and drug industries.

The best way to capture the inter-industry differences in the sample is to test the hypothesis in different industries separately. Siddharthan (1988) attempted this in four industries, apart from pooling the whole sample and testing the hypothesis. So the inter industry specificities are an important determinant of research effort and they should be taken care of to get a reliable relationship between market structure and innovative activity.

[10] It was seen from the empirical studies that verified the Schumpetrian hypotheses in the developed country context that apart from market concentration and firm size, technological opportunity and appropriability were significant variables, which affected innovative activity.

After a detailed critical survey of studies in India, Kathuria (1989) concluded; "This strand of the technology literature of India, following in the mould of its Developed Countries counterpart, suffers from the same limitations as the latter but to an even greater degree, partly because of data limitations. In addition, most of the studies have used industry rather than firm-level data, which tends to wash out the effect of firm level variables such as size, technical capacity, age and so on." (1989, p. M120)

Goldar (1997) has looked into the methodologies adopted by the studies in the Indian context on innovative activity. He was of the opinion that most of the Indian studies were cross sectional studies and had the problems of heteroscedasticity. He suggested that the Ordinary Least Squares method used in some of these studies could not be a suitable method when variables like export orientation was related to innovative activity. This was due to the simultaneity problem between these variables. The author's observations on the methodologies of the studies relating to innovative activity in India was that " It should be noted that in many firms the R&D ratio in the sample is negligible or zero. If such firms are included in the sample to estimate the regression equation, estimation problems will be caused by the fact that the dependent variable has a lower bound. If such firms are excluded, the results get affected due to the sample selection bias. An appropriate solution for tackling this problem is to use a tobit model, as has been done by Kumar and Saqib (1996)". (Goldar, 1997, p.95)

The studies in the Indian context, as seen above, tested the Schumpeterian hypotheses in the context of liberalisation mostly using a cross-section of firms or industries. The economic liberalisation in India is characterised by rapid policy changes over the years. The cross-sectional studies undertaken in this context may not be sufficient to capture the actual market structure -

innovative activity relationship. A longer period of analysis could have given better insights on the relationship between market structure and innovative activity.

In this context there arises a number of issues, which warrants the need for a detailed study of the relationship between market structure and innovative activity in the context of economic liberalisation. The study based on firm level data should include technology purchase as a major source of innovative effort apart from in house R&D, especially after liberalisation in India. The market structure innovative activity relationship should be studied by taking care of technological opportunity and appropriability conditions apart from firm size and market concentration. The study also should include a longer period of analysis to take care of the dynamic policy changes in the context of liberalisation. More over, there is the scope for substantial methodological improvements by using the probit and tobit estimates instead of OLS.

Chapter 3

MARKET CONCENTRATION FIRM SIZE AND INNOVATIVE ACTIVITY

Introduction

The previous chapter highlighted the conceptual and methodological problems associated with the literature on the market concentration, firm size and innovative activity. The need for redefining the concept of innovation to capture the actual process that takes place in the developing countries like India has to be underlined. While technology import has been generally considered as an important aspect of the innovation process in most of the developing countries, including India, the existing literature on innovation seems to have underplayed its role. There is need to provide due importance to technological opportunity of industries as well as the appropriability conditions. A longer period of analysis, based on firm level data may be more appropriate, especially when the period of analysis is marked by flux in the policy environment. In addition to conceptual refinement and changes, there is also scope for improvement in the method of estimation as well.

Against this background, the present chapter tries to test the Schumpeterian hypotheses in the context of economic liberalisation in India by taking case of two industries, viz. drugs and pharmaceuticals and electronics. The selection of these two industries is justified on the following grounds; these industries are considered as technology intensive not only in terms of in house R&D but also in terms of technology import. While Drugs and Pharmaceutical industries have attained great importance after liberalisation contributing to the maximum patents registered from India (Prasad and Bhat, 1993), numerous studies[1] have identified electronics industry as technology intensive. The studies by Prasad (1999) and Emmanuel (1999) have empirically found that these two Industries are the most technology intensive in terms of in-house R&D and technology import respectively after liberalisation.

The chapter is organised in five sections. The first section presents the issues methods and hypotheses to be tested. The second section deals with the sample frame and the construction of variables used in the analysis. The estimated results are analysed and interpreted in the third section and the last section gives the concluding observations.

Section 1

Issues, Methods and Hypotheses

As stated earlier, innovative behaviour of Indian firms in the present study is measured in terms of their total expenditure on technology import and in-house R&D. Given the fact that a large number of firms are not investing in innovation, the first question that arises is, what is the probability of the firm engaging in innovative activities and what are the factors that influence its decision to engage in innovative activities. This issue following Kumar and Saqib (1996) has been approached using a probit model. Having analysed the decision to invest in innovation,the second question that arises is the intensity of innovative activity. This has been analysed using a tobit model. Drawing from the existing literature it has been hypothesised that a number of firm specific, industries specific and product specific factors shape the decision to invest in innovation

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1 The technological intensity of electronics industry in India after liberalisation has been discussed in detail by Joseph (1997) and Joseph and Subrahmanian (1994).

and the intensity of innovative activity. What follows is a brief account of the theoretical base for incorporating these variables and their expected relationship.

Firm Size

Firm size is expected to have a positive influence on the decision and intensity of doing in-house R&D and technology purchase. Larger firms are able to reap more internal profits and devote funds to take risks compared to smaller firms and do more in-house R&D and technology purchase than the smaller firms. The larger firms are preferred by the technology-exporting firms due to the high royalty and lump sum payments paid by them, which may not be really possible by the smaller firms. Large firms also get the benefit in the economies of the marketing, production, and also less uncertainty in information. Lall (1983) first found the positive influence of size on in house R&D in India. However the studies later (Subrahmanian1971a, Katrak 1985, 1989,1990) in the pre liberalisation regime have not got a positive relation between firm size and R&D[2]. In this era of liberalisation, it is assumed that the large firms are able to avail the above-mentioned benefits and thereby a positive relationship between firm size and innovative activity are assumed in the current study.

Some studies in India have shown a non-linear relationship between firm size and in house R&D. Siddharthan (1988) has found that the firm size first decreased with in-house R&D and then increased, showing a U shaped relation. Kumar and Saqib (1996) found an inverted U shaped relationship where the firm size increased upto a certain extent and thereafter it declined.

2 However Subrahmanian (1996) got a positive relationship between firm size and R&D activity using data from RBI.

Therefore a quadratic term of the firm size is also used in the model to test for any non-linearities between firm size and innovative activity.

Market Concentration

The relationship between market concentration and innovative activity has also been tested in the developed and developing country context. The consensus in the developed country context studies was that market concentration had only a weak positive relationship with innovative activity. However in India, Kumar (1987) got a negative relationship between market concentration and R&D intensity. His argument was that the lack of competitive pressures in the Indian industries retarded the innovative activity due to the strong policy barriers to entry by the new firms. This is not the case in the era of liberalisation where the firms are freer to do technological activity and therefore in the current study market concentration is hypothesised to have a positive relationship with the decision to do and the intensity of innovative activity.

A Dummy variable is used to differentiate the firms, which has high market shares as compared to firms with lower market shares for both the industries. The top eight firms having the highest market shares in each year for each industry is assigned value one and the other firms, the value Zero. This measure of concentration is a better measure to capture market concentration as compared to the conventional measures like four firm concentration ratio and Herfindahl index as mentioned in the earlier chapter.

Kumar and Saqib (1996) argued that the profit margins enjoyed by the firms could also indicate the competitive environment it faces. Profit margin is expected to have a positive impact on the innovative activity as it helps to generate more internal funds. However Geroski (1990) has pointed out the simultaneity bias involved in the profitability-R&D relationship as more R&D could also lead to more profits. However in India, studies by Siddharthan and Dasgupta (1983) and Kumar (1990) have not found any significant influence of R&D intensity on profit margins.

Appropriability

Other things being equal, a firm having a greater part of production chain in-house would have better knowledge generated by the innovative activity. This argument was put forward by Arrow (1962) where he argued that more than the sales; appropriability is better achieved by the internal application of knowledge. Therefore a firm having higher value added to sales will have more chance of investing in innovative activity. The value added to sales differs from industry to industry and the current study takes care of that, as it is industry specific.

Experience

It is hypothesised that a firm with a longer experience is expected to invest more in innovative activity. The older firms are able to get advantages due to the accumulated learning and the better ways of adapting to a new product. Thus, firms with experience are expected to have a positive association with the decision and intensity to do innovative activity. For the current study, the age of the firms are taken as a proxy for experience and the firms with longer age are expected to have a positive influence on innovative activity, both in the decision to do and in the intensity.

Product Market Factor

Studies by Philips (1966) and Comanor (1967) in the developed country context and Kumar (1987) and Siddharthan and Krishna (1994) have identified the chance of doing in house R&D and technology import to be more in industries where products are differentiable. The firms spend on in-house R&D and technology import to counter the threat of competitors by the introduction of new products and improvements in the already available product. Advertisement intensity of the firms is used as a proxy here for the product differentiation and it is hypothesised that there is a positive association between innovative activity and the advertisement intensity.

Export Orientation

It can be hypothesised that firms with export orientation are able to invest more in-house R&D and technology import in the context of liberalisation. The firms are now in a position to get access to international markets and to compete with foreign firms; they spend more on in-house R&D and technology import. Moreover, the liberalisation has widened the market that the cost of doing innovative activity is less when compared to the pre-liberalised regime of controls. Braga and Willmore (1991) found that there was a positive significant relationship between exports as a ratio to sales and the probability of doing in-house R&D in Brazil. The export orientation of firms is posited to be positively affecting the decision and intensity of In house R&D and Technology import of the firms.

Foreign Control Dummy

A dummy variable is introduced to see whether the firms having some permanent foreign collaboration is influencing the probability and intensity of doing in-house R&D and technology import. It can be hypothesised that firms with foreign collaboration are more likely to spend more on innovative activity. Since the shares of foreign equity in the total equity are not available, the import dividends paid in foreign currency abroad are used as a proxy for measuring foreign collaboration. Siddharthan and Krishna (1994) had found out that this variable had positively and significantly affected the technology imports for the firms in drugs and pharmaceutical industry. Therefore in this study the dummy variable takes the value one for all firms which pays import dividends in foreign currency and zero otherwise.

Section 2

The Data and the Construction of Variables

The data for the study have been exclusively collected from the corporate firm level database, Prowess, published by the Centre for Monitoring Indian Economy[3]. The data have been collected for a period of six years from 1992 to 1997. The study is industry specific and the firms are pooled for analysis. The sample consisted of 626-pooled observations, for the electronics industry sample and 534-pooled observations for the drugs and pharmaceutical industry[4].

Variable Construction

In the case of probit model, the dependent variable is a binary (0,1) depending on whether or not the firms undertake any R&D and technology import. The probit estimates give the

3 The credibility of this data base is established by a comparative analysis of the R&D data provided by different agencies. See Appendix for details.

4 Data on 105 drugs and pharmaceutical firms and 111 electronics firms for six years were considered for the study.

conditional probability of an individual firm investing in innovative activity for the given values of the explanatory variables. The dependent variable in this model is PROBRDIMP (refer table 3.1). It takes a value one if the firms undertake either in-house R&D and technology import or both and zero otherwise. In house R&D is proxied by the total R&D expenditure to sales. The technology import is captured by the royalty payments, which is a regular flow of income abroad for the technology purchase. The data on both the measures of in house R&D and technology import are collected from the prowess database.

The probit model used to test the above relationships for the two industries can be written as

$$PROBRDIMP^{*} = b0 + b1\ SALES + b2\ SALES2 + b3\ DCR4 + b4\ PROFIT + b\ 5ADS + b6\ VALUE + b7\ EXPINT + b8\ AGE + b9\ DFOR$$

Here the dependent variable is a latent variable, which cannot be observed. Hence a dummy variable which is observed is used and is defined by

$$PROBRDIMP = 1 \text{ if } PROBRDIMP^{*}>0;$$
$$= 0 \text{ otherwise.}$$

The intensity of doing innovative activity [RDIMPINT] is analysed using a tobit model. This model is used to analyse the intensity of spending on innovative activity when a large number of firms are not reporting any innovative activity. Here the dependent variable, RDIMPINT for the tobit model for each industry is equal to zero when the firm do not report either any R&D activity or technology import and to the R&D intensity and technology import intensity for other firms.

The tobit model is defined as follows[5]:

RDIMPINT = b0 + b1 SALES + b2 SALES2 + b3 DCR4 + b4 PROFIT + b5 ADS + b6 VALUE + b7 EXPINT + b8 AGE + b9 DFOR

if RDIMPINT > 0; and

RDIMPINT = 0; otherwise.

The following table 3.1 gives details of the variables used in the study, which includes the code used and the definitions of the variables.

The data on sales in the study is taken for a period of six years from 1992 to 1997, and hence there is the necessity of deflating it to standardise the variable. For both the industries, sales are deflated with the wholesale price index of the respective industries from 1992 to 1997 taking 1981-82 as the base year. Since all other variables are standardised by dividing them with sales, there is no need for deflating those variables.

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[5] For a detailed analysis on the probit and tobit models refer Maddala (1983), Greene (1993) and on the use of these models in the studies on R&D in the Indian context refer Kumar and Saqib (1996)

Table 3.1

Variable Construction and Coding.

Variable	Code	Definition
R&D intensity + Technology import Intensity	RDIMPINT	Ratio of R&D and Technology import to sales
Probability of doing in house R&D + Technology import.	PROBRDIMP	It takes a value 1 for firms doing both R&D and Technology import and 0 otherwise.
Sales	SALES	Value of sales in Rs.Crores deflated by the wholesale price index of the corresponding industry group for the period 1992 to 1997.
$Sales^2$	SALES2	Square of sales
Market concentration Dummy	DCR4	It takes a value one for firms, which have the top eight market shares each year and zero otherwise.
Advertisement intensity	ADS	Ratio of advertisement expenditure to sales
Profit margin	PROFIT	Ratio of gross profit to sales
Appropriability	VALUE	Ratio of gross value added to sales
Export intensity	EXPINT	Ratio of exports to sales
Experience	AGE	The age of the firm
Foreign control dummy	DFOR	It takes a value 1 for firms which pays dividends in foreign currency and zero otherwise.

The table 3.2 gives the summary statistics of the variables used in the study for the two industries drugs and pharmaceuticals and electronics. This highlights the inter- firm differences of the variables and the nature of variables used in the sample. The correlation matrix of the variables used in the study for the two industries showed that there was no presence of any multicollinearity among variables used in the model. The problem of heteroscedasticity has also been avoided as all the variables have been standardised by taking a ratio of these variables with sales.

Table 3.2

Summary statistics of the variables used in the model for the two industries Drugs and Pharmaceuticals & Electronics

	Drugs and Pharmaceuticals				**Electronics**			
VARIABLE	MEAN	SD	MIN	MAX	MEAN	SD	MIN	MAX
RDIMPINT	.008	.014	0	.107	.012	.046	0	.62
SALES	59.5	78.2	.21	446.3	72.2	150.8	.O5	977.1
PROFIT	.005	.29	-.05	.69	.05	.37	-.005	.45
VALUE	.212	.102	-.28	.79	.27	.19	-1	.89
ADS	.011	.02	0	.13	.011	.023	0	.438
EXPINT	.116	.187	0	.98	.05	.117	0	.86
AGE	25.11	19.14	1	85	16.97	13.7	1	68

Note: *Here SD means Standard Deviation.*

Section 3

Empirical Findings

Relationship Between Market Structure Variables and Decision to Do Innovative Activity

The probit estimates for the two industries viz. Drugs and Pharmaceuticals and Electronics on the relationship between market structure variables and the decision to do innovative activity shows some interesting results. (see table 3.3)

The estimation of the probit models for both industries show that there is a non-linear relationship between firm size and innovative activity. The variable sales is positively significant and the variable sales2 is negatively significant. This shows that firm size only influences the decision to do innovative activity upto a certain point and thereafter it declines. Thus an inverted U relationship is found between the firm size and the decision to do innovative activity for both the industries. Siddharthan (1988) had got a 'U' shaped relationship between firm size and in house R&D. This implies that with liberalisation, small firms are more induced to undertake more R&D and technology import as compared to the larger firms. It may be noted that Kumar and Saqib (1996) got a similar inverted U shaped relationship between firm size and In-house R&D for the manufacturing sector as a whole.

Table 3.3

Probit estimates on the decision to do innovative activity for the Drugs and Pharmaceuticals and Electronics industry

Variable	**Drugs and Pharmaceuticals**	**Electronics**
DEPENDENT VARIABLE	RDIMPINT	RDIMPINT
INTERCEPT	-.544* (-3.89)	- .526* (-3.4303)
SALES	.012* (5.391)	.0064* (4.070)
$SALES^2$	-.00001* (-3.397)	-7.68e-06* (-3.70)
DCR4	-.562 (-1.51)	-.0037 (.013)
PROFIT	.0117 (.129)	1.004* (4.396)
ADS	6.923*** (1.793)	-.034 (-.009)
VALUE	.327 (.978)	-1.129* (-3.94)
EXPINT	.4122 (1.184)	-1.308* (-3.04)
AGE	.013* (3.015)	.005 (.996)
DFOR	.918* (.3.918)	1.45* (5.43)
R^2	0.226	0.1942
Chi^2	150.59	150.13
Log-likelihood ratio	-257.24	-311.6
No.of observations	534	626

Note:

1) Figures in Brackets show the 't' ratios.
*2) * Significant at 1% level, ** Significant at 5% level, *** Significant at 10% level.*
3) R^2 for the probit Model is Pseudo R^2

The market concentration variable did not show a positive relationship with the decision to do innovative activity as expected for both the industries. Kumar (1987) had argued that the lack of competitive pressures in the economy in the period before liberalisation was the reason of having a negative relation between market concentration and innovative activity. The present study shows that even after liberalisation, the firms with market power do not affect the decision to do innovative activity as compared to other firms. However, the variable was not significant for both the industries.

The profit margin variable, another measure of concentration showed however a positive and significant relationship with the decision to do innovative activity for the electronics industry. This upholds the hypothesis that in the liberalised environment, in the absence of government controls and the free entry of firms, the firms tend to do more innovative activity by generating more internal funds. In the drugs and pharmaceutical industry, the variable was insignificant highlighting the fact that profit margin and its influence on the decision to do innovative activity varied from industry to industry.

The product market factor proxied by advertisement intensity (ADS) variable showed diverse results for the two industries. It showed a positive weak significant relationship with the decision to do innovative activity for the drugs and pharmaceutical firms. Siddharthan (1988) had found that firms which spend more on advertisement had done more in-house R&D. The drugs and pharmaceutical firms mostly had heterogeneous products and the incentive to innovative activity was more when compared to firms with homogenous products. In the electronics firms, advertisement intensity showed a negative relationship with innovative activity, but it was insignificant.

The appropriability condition of the firms proxied by the value added to sales ratio showed that results were different for the two industries. A positive relationship is seen between the value added to sales ratio representing the opportunities for appropriation of innovation and the probability of doing innovative activity for the drugs and pharmaceutical firms, although not significant. Contrary to this, the electronics firms show a negative and significant relationship with the value added to sales. This invalidates our hypothesis that a greater production chain in-house has greater scope of utilising knowledge generated, and the probability of doing innovative activity is high.

The relationship with export orientation of firms and the probability of doing innovative activity showed some interesting results. Export intensity was found to be positively affecting the decision to do innovative activity in the drugs and pharmaceutical firms, although not significant. For the electronics firms, export intensity showed a negative and significant relationship with the decision to do innovative activity. This meant that contrary to the hypothesis postulated, export orientation of the electronics firms have not resulted in the probability of doing innovative activity.

The experience of the firms proxied by age and the effect of foreign control of firms had a positive and significant relationship with the probability of doing innovative activity for both industries. Therefore, there was strong evidence that firms with more production experience tended to do more innovative activity. Similarly, for the firms, which had some foreign control, the probability of undertaking innovative activity was more.

The Probit analysis clearly showed some diverse results from the previous studies. There were also considerable inter-industry differences in the factors determining the decision to do innovative activity. The inverted U shaped relation between firm size and decision to do innovative activity highlighted the role of small firms in each industry. The market power of firms did not affect the decision to do innovative activity, which was also supported by other studies like Kumar (1987), and Kumar and Saqib (1996). The variables proxying appropriability condition, export orientation and product market factor showed diverse results for the two industries. This clearly showed that technological opportunity was different for different industries.

Relationship Between the Market Structure Variables and the Intensity in the Spending on Innovative Activity

The following table 3.4 gives the maximum likelihood estimates of the tobit analysis on the market structure variables influencing the intensity of innovative activity for the drugs and pharmaceutical and electronics industries.

It was found that like the probability of doing innovative activity, sales and sales2 variables were positively and negatively significant for both the industries. This meant that firm size had an inverted U shaped relationship with the intensity of doing innovative activity. As the firm size increased the intensity of innovative activity increased up to a threshold point and thereafter it declined. Thus the hypothesis put forward by Schumpeter on a positive relationship between firm size and innovative activity is not supported by this result.

Table 3.4

Tobit estimates on the intensity of innovative activity for Drugs and pharmaceuticals and Electronics

Variable	**Drugs and Pharmaceuticals**	**Electronics**
DEPENDENT VARIABLE	RDIMPINT	RDIMPINT
INTERCEPT	-.0210* (-6.88)	-.0201** (-2.33)
SALES	.00015* (5.12)	.0001** (2.415)
$SALES^2$	-1.40e-07* (-3.26)	-1.85e-07** (-2.03)
DCR4	-.0015 (-.314)	+.004 (.318)
PROFIT	.0027 (1.193)	.087* (3.46)
ADS	.181* (3.03)	.123 (.646)
VALUE	.034* (4.71)	-.0183 (-.89)
EXPINT	.024* (3.14)	-.049*** (-1.836)
AGE	5.23e-06 (-.077)	-.001 (-.684)
DFOR	.0028 (.983)	.042* (5.531)
Log-likelihood ratio	569.34	313.23
No. of observations	534	626

Note:

1) Figures in Brackets show the 't' ratios.

*2) * Significant at 1% level, ** Significant at 5% level, *** Significant at 10% level.*

The market concentration dummy variable and its relation with the intensity of innovative activity showed some interesting results for the two industries. There was a negative but insignificant relationship between market concentration and intensity of innovative activity for the drugs and pharmaceutical firms. This showed that the degree of competitive pressures did not help in the intensity of investing on innovative activity as was seen in the probability or decision of doing innovative activity. This result confirms with the results got by studies in the pre-liberalisation period including Kumar (1987) and Kumar and Saqib (1996), where they got a negative relationship. However for the electronics firms there was a positive but insignificant relationship. Thus the relationship between market concentration and the intensity of innovative activity has differed across firms in the two industries.

The other concentration variable proxied by the profit margin also showed a positive relationship with the intensity of innovative activity. However it was significant for only the electronics industry. This meant that after liberalisation, the firms in both industries could generate internal funds to invest in-house R&D and technology import, when they had high profits.

The advertisement intensity to sales which proxies the product market factors showed a positive relationship with the intensity of innovative activity for both industries. However it was significant only in the drugs and pharmaceuticals firms. This meant that the spending on R&D and technology import by the firms was higher where the products were differentiable and were aimed at gaining an edge over competitors.

Appropriability condition of the firms for the two industries showed diverse results with its relation with innovative activity. The value added to sales was found to have a negative relationship with R&D and technology import for the electronics firms. The vertical integration of firms or the production chain in house of the firms did not influence the intensity of innovative activity. However the variable was not significant. In the case of drugs and pharmaceuticals firms, the value added to sales was found to be positively and significantly affecting the innovative activity.

The export orientation of the firms was found to be negatively and significantly affecting the intensity of innovative activity for the electronics firms. This meant that similar to the decision to do innovative activity, the export orientation of electronics firms has not significantly affected the intensity of innovative activity. However, the variable was not significant in the case of drugs and pharmaceutical firms.

The firms with some permanent foreign collaboration were found to spend more on innovative activity. This was more prominent among the electronics firms. In the case of drugs and pharmaceuticals, the variable was insignificant. The experience of the firm was found to have a positive relationship with the intensity in the spending on in house R&D, in case of electronics firms. However, it was an insignificant variable for the drugs and pharmaceuticals firms. Thus age of the firm was not a major factor affecting the intensity of innovative activity, but only had an effect in the probability of doing innovative activity.

The tobit models thus showed some interesting results. The factors, which affected the intensity of innovative activity, were different for the electronics and the drugs and pharmaceutical industries, highlighting the inter-industry differences. There was however a similar non-linear relationship between the firm sizes and innovative activity as in probit analysis for both industries. When export intensity, value added, age and advertisement intensity showed a positive significant relationship with the intensity of innovative activity for the drugs and pharmaceuticals industry, it showed a negative relationship with the electronics industry. It was also seen that foreign control variable and profit margin affected the intensity of innovative activity for the firms of electronics industry, but not for the drugs and pharmaceuticals.

Section 4

Concluding Observations

The analysis of the relationship between the market structure variables and the probability of doing and intensity of innovative activity for two Drugs ad Pharmaceuticals and Electronics industry showed that there were differences among the factors that affected the decision to do innovative activity for the two industries. For the drugs and pharmaceutical firms, firm size, profit margin, age and the foreign control dummy were significant whereas for the electronics firms the value added to sales, advertisement intensity, export intensity were also significant. The signs of these coefficients were also different for these two industries. Thus it validates the argument that the technological opportunities of the industries vary and therefore the relationship between the market structure variables and the intensity of innovative activity of different industries also vary. This argument was again validated in the intensity of spending on innovative activity. When variables like advertisement intensity, value added, export intensity were significant only for the drugs and pharmaceutical firms, foreign control dummy and age variables were significant for the electronics firms. A major conclusion from the above analysis was that the factors that were responsible for the decision to do innovative activity differed from the factors that affected the intensity of innovative activity for both the industries.

Chapter IV

SUMMARY AND CONCLUSIONS

The main focus of the present study has been an analysis of the role of market structure variables on the firms' decision to do innovative activity and the intensity of innovative activity. To test whether there are any inter industry differences in the relationship, the study was carried out by taking the case of two industries viz.: drugs and pharmaceutical and electronics. The study also examined whether the same set of firm specific, industry specific and product specific factors affect the probability of engaging in innovative activity and intensity of intensity of innovative activity for the two industries.

In order to arrive at an analytical framework for the study on market structure innovative activity relationship, a close examination of the available empirical literature in the developed and Indian context were carried out. It was found that there was hardly any consensus on the results. An attempt was made to explain this in terms of the concept of innovation used in the studies as well as the differences in the empirical procedures. It was seen that the studies mainly used R&D expenditure, R&D employment and patent statistics as the major measures of innovation. However these measures were incomplete in the way Schumpeter had defined innovation and had limitations. In the Indian context, the studies did not include technology purchase as a major component of innovative effort. It was also found that most of the studies in the Indian context used OLS method in estimating the relationship which had some inherent problems and some methodological improvements like using probit and tobit model could give better insights.

The present study was based on firm level data, which have been taken from the database, Prowess, prepared by the Centre for Monitoring Indian Economy. The selection of this database was guided by its comprehensive nature and easy accessibility as compared to the official data sources for the period after liberalisation.

For analysing the relationship between market structure variables and the probability and intensity of innovative activity a longer period of analysis (1992-1997) was taken to take care of the dynamic policy changes after liberalisation. In this analysis innovative activity has been defined as a combination of in-house R&D and technology import.

The study showed that there were significant differences in the factors affecting the decision to do innovative activity and the intensity of innovative activity for both the industries. Firm size showed a non-linear (inverted U) significant relationship with the decision and intensity of innovative activity for both the industries. This implied that in the period of liberalisation the innovative activity of firms increases with size upto a certain point and thereafter it declines. There was however an insignificant negative relationship between market concentration and the decision to do and intensity of innovative activity for both the industries. This showed that contrary to our hypothesis, the firms with market power necessarily did not do more innovative activity. The value added and the export intensity variables showed some interesting results for the two industries. When value added and export intensity were positively affecting the probability and intensity of innovative activity for the drugs and pharmaceutical industry, it showed a negative relationship with the electronics industry. This meant that in the drugs and pharmaceutical industry, in the context of liberalisation a better production chain in house was found to be significantly increasing knowledge generated and had a positive impact on the decision to do and intensity of innovative activity. This was however invalidated in the case of electronics firms. Similarly, when export orientation of firms had a positive effect on probability of doing and intensity of innovative activity for the drugs and pharmaceutical firms, it had a negative and significant effect on the electronics firms.

A similar diverse result was seen in the case of the experience variable denoted by age and the foreign collaboration dummy variable. Age of the firm was significantly affecting the decision to do innovative activity for both the industries but not the intensity of innovative activity. Similarly when firms in the drugs and pharmaceutical industry having a foreign collaboration were significantly and positively affecting the decision to innovative activity, it was insignificant for the electronics firms. Similarly when foreign collaboration helped the electronics firms to significantly affect the intensity of innovative activity, it was insignificant for the drugs and pharmaceutical firms.

It was found from the study that only firm size and advertisement intensity significantly affected the decision to do and intensity of innovative activity for the drugs and pharmaceutical industry. While age and foreign collaboration dummy was significant in the decision to do innovative activity, the appropriability condition and export intensity was significantly affecting the intensity of innovative activity. For the electronics industry, the firm size, value added, export intensity and foreign collaboration dummy were the variables which affected both the decision to do and intensity of innovative activity.

To sum up, the analysis showed that the factors that affected the relationship between market structure and the probability of doing innovative activity was different from the factors that affected the intensity of innovative activity for both the industries. This result confirms our hypothesis that there are inter-industry differences in the factors affecting innovative activity. There has not been any evidence to show that firms with higher market power and larger in size are able to do more innovative activity in the period of liberalisation.

Appendix

A NOTE ON R&D DATABASE IN INDIA AFTER LIBERALISATION

Introduction

Economic reforms in India have brought the role of market forces to the forefront. In the liberalised regime, study of the relationship between market structure and innovative activity can be dealt only with good data. Griliches (1994) pointed out that empirical studies suffer as there are still no answer to the various data difficulties and lacunae. The desired data are never available due to the measurement difficulties. The data, its collection, relevance and the constraints are necessarily to be understood before using them[1].

The following Section 1 deal with the need for a comprehensive database of R&D in India. Section 2 cites the various sources of R&D data after liberalisation. Section 3 tries to compare between the data sources after liberalisation in India to choose the best data base and Section 4 gives the concluding observations.

Section 1

Need for a Comprehensive Database on R&D in India

Kamien and Schwartz (1982) argued that the major difficulty in the empirical testing of Schumpeterian Hypotheses was defining the inputs of innovative activity.

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1 Griliches (1986) noted that it was the preparation skill of the econometric chef that caught the professional eye, not the quality of the raw materials in the meal, or the effort that went into procuring them.

One measure of inputs to innovation process was the number of workers specifically assigned to R&D. The more common measure of input was the total spending on R&D. Patent statistics formed yet another measure of innovative activity.

In the developed country context, the studies on market structure and innovative activity relationship have used all the above mentioned measures like R&D expenditure, R&D employment and Patent Statistics as proxies for innovative activity (Scherer 1980, Schmookler 1962, Comanor 1965). In the Indian context, the literature shows that R&D expenditure and R&D intensity are the major proxies for innovative activity. (Subrahmanian 1971a, Lall 1983, Katrak 1985, 1990, Siddharthan 1988).

Most of the studies, which empirically tested the Schumpeterian hypotheses on the relationship between market structure and innovative activity, were based on industry level data. A firm level analysis can only bring about clearly the relationship between market structure and innovative activity. The firm level analysis warrants the need for the availability of good data. After liberalisation, which is the period of my analysis, there are official and private data sources on R&D activity in India. There has not been any serious attempt till now to study the database on R&D in India in the context of liberalisation. Therefore this attempt will surely help to identify the major data sources for R&D activity in India, their merits and demerits and to choose the best data source for analysis.

Section 2

R&D Data Sources After Liberalisation

In this section the various sources of R&D data available after liberalisation are considered[2].

The following table A-1 gives a broad outline of the various sources of R&D data in India.

TABLE A-1

Details of R&D Data in India after Liberalisation

DATA	PUBLISHER	LEVEL OF DISAGGREGATION	YEAR TILL WHICH DATA AVAILABLE	COMMENTS
R&D Statistics in India	Department of Science and Technology	Industry level data on all industrial groups of manufacturing sector.	1995-96	Only industry level data available
R&D in Industry.	Department of Science and Technology	Firm Level data on 240 manufacturing and non-manufacturing sector firms as well as industry level data.	1994-95	Firm level data are available only for manufacturing firms with R&D expenditure more than 100 lakhs.
Directory of In House R&D	Department of Scientific and Industrial research.	All Manufacturing firms	1996	Only addresses of firms doing in house R&D registered under DSIR. No Data given.
Compendium of In House R&D Centres in India	Department of Scientific and Industrial research	Firms in Chemical and Allied Industry and Engineering Industry including Electronics.	1998	Firm Level data on R&D expenditure, sales, age, R&D manpower available. Data on all firms not given; instead around 400 firms of both industries are covered each year.
Prowess	Centre for Monitoring Indian Economy	Firms, around 6000 belonging to all industry groups in the manufacturing as well as non-manufacturing sector.	2000	Computerised database. Data on current and capital R&D expenditure available separately.

[2] Since the unpublished data source from RBI are not easily accessible, it has not been considered for analysis. However, Subrahmanian (1996) has used company level R&D expenditure data from the Annual survey of Medium and Large public limited companies published by RBI.

The Research and Development Statistics, an official data source, do not give any firm level data but presents data and analyses with supporting graphical presentations on the input and output parameters covering R&D sources by industry group, fields of science, manpower and other related areas. The R&D expenditure of state and central governments and of the various departments, along with details of the patents filed industry wise are also available. These are useful and necessary information, but for detailed empirical analysis to study the market structure innovative activity relationship, this data cannot be used.

The R&D in Industry gives both firm level as well as industry level Statistics on the R&D expenditure and R&D intensity, which are collected through National Surveys. Firm level data is available for manufacturing and non-manufacturing firms, which spend more than 100 lakhs on R&D. The data can be used for analysis where large firms are to be considered, but cannot be used in the present study on relationship between market structure and innovative activity, where firms which do less R&D are also to be involved. The firms are not classified into industrial groups which makes it difficult for more detailed analysis.

The Directory of In-house R&D gives the addresses of firms, which have in-house R&D units and which are registered under the Department of Scientific and Industrial Research. There were 1248 firms, which were in the directory in 1996. However the inconvenience here is that these firms are not classified into industry groups. Only the firms, which are registered under the DSIR, are eligible for fiscal incentives and other support measures, which make it financially attractive to start their own R&D units. This could lead the firms to under report their R&D expenditure to gain concessions from the DSIR.

The Compendium of In-house R&D Centres gives useful data on R&D in the firms, which are registered under the DSIR and included in the directory of R&D units. Although the publication comes annually, the last being in 1998, the year-to-year coverage fluctuates widely. The firms covered in one year may not be reported the next year. The details on the remaining firms may be given in the following years. Thus a balanced panel sample is always difficult to get from the data available here.

The following table A-2 gives the details on the total number of firms covered each year from 1992 to 1998.

TABLE A-2

Firm Coverage in the Compendium of in -House R&D Centres

Year	Number of Firms
1993	291
1994	491
1995	376
1996	392
1997	378
1998	398

The table above shows that in 1996, the total number of firms covered in the compendium was 392. The directory of in house R&D had 1248 firms in 1996, which meant that only 31.4 % of the total firms in the directory was covered in that year.

The data of the Compendium statistics are mainly collected by sending a questionnaire to the R&D units. Almost all the R&D units registered under DSIR are included in the compendium, but the firms need not necessarily give data on R&D expenditure and R&D manpower, which restricts its use for empirical analysis. For example there were 331 electrical and electronics firms, which were included in the Compendium of R&D units, published yearly from 1993 to 1998 and there were only 46 (14%), which reported R&D expenditure for all the years.

The following table A-3 gives an idea about the reporting of R&D expenditure in the compendium of in house R&D centres for electrical and electronics firms from 1992 to 1996.

TABLE A-3

Reporting of R&D expenditure of electrical and electronics firms in the Compendium of in-house R&D centres database

Total Number of Firms	Firms which reported no R&D expenditure	Firms which reported R&D expenditure for all years from 1992 to 1996	Firms, which reported R&D expenditure only for 1996.
331	56 (17)	46 (14)	146 (44)

Note: *Figures in brackets show percentage to total*

Thus the main problem of the compendium statistics is the inconsistent reporting of R&D expenditure by firms. For a single year, 1996, a significant 44% firms have reported R&D expenditure. Thus a cross section analysis is more suited than time series analysis based on the data available here. More over the coverage of Compendium Statistics is restricted to firms in just two industry groups, the chemical and engineering Industries.

Prowess, a computerised database published by the Centre for Monitoring Indian Economy gives data on in-house R&D for all manufacturing firms and they are also classified into major industry groups based on the product characteristics. This private data source collects the R&D data directly from the reports of the Board of Directors and not from the profit and loss account. The main advantage of prowess data is that it is available till 2000. Along with R&D expenditure, other variables like sales of firm, age of firm etc useful for analysis are available in the same database.

The main problem of Prowess is the reporting of zero for firms, which do not do R&D, and for firms, which do not report R&D. The sample firms have also decreased since 1996, which means that the sample coverage is not satisfactory in recent years (Shanta and Dennis 1999, Jojo 1999).

The following table A-4 gives the number of electronics and electrical firms reporting R&D expenditure from 1992-93 and 1997-98.

TABLE A-4

Reporting of R&D Expenditure of Electrical and Electronics firms In Prowess from 1992-93 to 1997-98.

Year	Total firms	No. of firms doing R&D
1992-93	283	65 (23)
1993-94	385	91 (23.6)
1994-95	473	120 (25.3)
1995-96	529	134 (25.4)
1996-97	523	145 (27.8)
1997-98	467	135 (30)

Note: *Figures in brackets show percentage.*

It is clear from the above table that the sample firms in the electrical and electronics industry group have declined after 1995-96. However the percentage of firms, which reported R&D expenditure, have remained the same even after 1995-96 till 1997-98. This table clearly shows that prowess database is also useful to do cross-section analysis like the Compendium statistics.

SECTION 3

Choice of the Best Database: Comparing Prowess with Compendium of In -House R&D Centres

From all the sources of R&D data cited above, it can be found that Prowess and the Compendium statistics are those which give the best firm level data. Compared to Compendium on R&D centres, Prowess has a wider sample. There were 768 manufacturing firms, which reported R&D expenditure in 1996, and out of this, 385 firms (50.3%) were present in the directory of in house R&D. Similarly there were 135 firms, which reported R&D expenditure among, electrical and electronics firms in 1996 and out of those only 64 firms were present in the directory. (See table A-5)

TABLE A-5

Comparing Prowess sample with Directory of In -House R&D units, 1996

Type of Firms	Total firms reporting R&D in Prowess in 1996	Total firms not present in the directory of in house R&D units, 1996
Manufacturing firms	768	385 (50.3)
Electrical and Electronics firms	134	70 (52.2)

Note: *Figures in brackets show percentage to total.*

The above table clearly shows that the prowess sample both in the case of manufacturing firms and electrical and electronic firms, there are higher percentage of firms, which are not registered under DSIR. So the prowess also covers firms, which are not registered under the DSIR giving a better firm coverage than the Compendium statistics, which has data of firms only registered under DSIR.

Both the prowess data and Compendium statistics showed that, for the year 1996, R&D expenditure was reported for 135 and 146 electronics and electrical firms respectively. There were 36 firms in common for both data sources, which gave data for the year 1996, and it was found that there were 30 (83 %) for which the R&D expenditure was the same for both data sources.

SECTION 4

Conclusion

Prowess and the Compendium of In-house R&D centres are the best data sources available, which give firm level data after liberalisation. Although the sample firms covered under Prowess has decreased after 1996, the percentage of firms reporting R&D has not decreased after 1996. Prowess also covers all industry groups in the manufacturing sector. Compendium of in house R&D centres is restricted to the chemical and engineering firms but gives good data on R&D expenditure, sales, R&D man power and Age of firm. It is best suited for cross-section analysis. However it was also found that prowess also is suited for cross-section analysis. From the analysis it was seen that the R&D expenditure was the same for majority of the electrical and electronics firms which were reported in both prowess and Compendium statistics. R&D statistics give firm level data on the manufacturing sector but it is unsuitable for analysis of the relationship between market structure and innovative activity in the context of liberalisation. Thus Prowess database can be considered as the best database available for a firm level study on market structure innovative activity relationship in India after economic liberalisation.

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