LIBERALISATION POLICIES AND INDUSTRIAL STRUCTURE: THE PETROCHEMICAL INDUSTRY IN INDIA

USHA RAMACHANDRA

THESIS SUBMITTED TO
THE UNIVERSITY OF HYDERABAD
FOR *THE* AWARD OF THE DEGREE OF
DOCTOR OF PHILOSOPHY
IN ECONOMICS
1994

CERTIFICATE

I hereby declare that this thesis titled *'Liberalisation Policies and Industrial Structure: The Petrochemical Industry in India'* for the award of the degree of Doctor of Philosophy is entirely my own work and has not been submitted for any other degree at this or any other university.

Usha Ramachandra
(USHA RAMACHANDRA) 12 May

Enrolment No.GS 1083

We certify the above and recommend that the thesis be forwarded to the examiners for evaluation.

Geeta Gouri

Prof. Geeta Gouri,
Chairperson,
EDP Division,
Institute of Public Enterprise,
HYDERABAD 500 007.

Prof. T. Diwakar Rao,
Head, Department of Economics,
School of Social Sciences,
University of Hyderabad,
HYDERABAD 500 134.

Dean,
School of Social Sciences,
University of Hyderabad.

Acknowledgements

1 thank Prof. Geeta Gouri an Prof. T. Diwakar Rao for supervising my work. Prof. Geeta Gouri introduced me to the theoretical advances in industrial organisation and International trade and provided the much needed impetus for completing this work. Prof. T. Diwakar Rao took time off his busy schedule to look through the draft of this work.

I am grateful to the Indian Council of Social Science Research (ICSSR) for offering me a doctoral fellowship which enabled me to take up this project.

The Institute of Public Enterprise disbursed the fe1lowship promptly and offered infrastructure al support in terms of a good library , computer facilities and a space in which to work. Mr. T. L. Sankar, former Director , IPE, actively encouraged me *during my association with IPE. And the faculty and supporting staff of IPE provided a conducive atmosphere in which I could complete this dissertation. I in particular thank Prof. Mishra. Dr. Pakki Reddy, Dr. Asha Bhandarkar, Ms. Sujata Rao, Ms. Sunitha Murthy and Mr. Krishna. A special thank you to Abhijit who stayed on till after office hours and even came on holidays to assist me.*

I thank Prof. D.N. Reddy, Dr. Pradipta Chowdhury. Dr. Vatsala Narsimhan and Dr. Maddhuri from the Department of Economics, University of Hyderabad for their help and encouragement.

The staff of the university computer centre have been extremely helpful. The Library and the 2500 acres of beautiful wilderness that is the HCU campus has offered inspiration and solace.

Prof. Kadekodi, 1EG, Hew Delhi, made available to me a *mine of information on the petrochemical industry. He also introduced me to people who have worked on the industry and who offered many useful suggest ions, apart from long sought after documents. They are Prof. Sengupta & Mr. R. Mondal in the Planning Commission, Mr. A. Balakrishnan, OCC, Ms. L.B. Singh, Department of Petrochemicals, Dr. A. Masood, BICP and Mr. S. Mitra, Economic Times. I also thank the late Mr. L.H. Doshi for providing me the Kapur Committee Report which was the starting point of my industry study.*

I thank P.V. Ramana who fueled my *interest in industrial organisation and with whom I spent many pleasurable hours reading. He helped translate my ideas on firm behaviour in the petrochemical industry into mathematical models.*

Prof. R. Harshe has been more than a *guide and friend during my stay at HCU. Whenever work was at a standstill 1 could rely on his inspiring me into greater effort and per perseverance.*

It is difficult to mention all the people who have helped me in various ways during my stay at HCU. I thank Giridhar for editing the draft of this thesis and Rekha for proofreading. Many others pitched in to make my load lighter. Those who helped with the vagaries of the computer were Uma, Vasu. and Murali. 1 thank Reeba, Rama Rao and Srilata, without whose assistance the production of this thesis would have been an ardous task.

A special thanks to my parents who uncomplainingly put up with long absences from home and supported my desire to continue my studies in Hyderabad; and my sisters Shashi and Lakshmi for their support. Many members of my extended family have provided a warm and affectionate atmosphere from which I derived strength. My grandfather who instinctively understood my desire to immerse myself in books; my grandmother whose undaunting good cheer is an example to emulate; and Ravi & Putti who gave me sanctuary and support during the most trying phase of this work.

LIBERALISATION POLICIES AND INDUSTRIAL STRUCTURE:

THE PETROCHEMICAL INDUSTRY IN INDIA

Abbreviations and Acronyms

ABS	A.B.S. Resins
ACN	Acrylonitrile
AF	Acrylic Fibre
ASF	Acrylic Staple Fibre
BR	Butadiene Rubber
BTD	Butadiene
CAM	Cellulose Acetate Moulding Powder
CMIE	Centre for Monitoring Indian Economy
CPL	Caprolactum
DMT	Di-methyltetraphathalate
ED	Ethylene Dichloride
EO	Ethylene Oxide
EXIM	E:cport-Import
FERA	Foreign Exchange Regulation Act
GOI	Government of India
HDPE	High Density Polyethylene
IO	Industrial Organisation
IT	International Trade
IPCL	Indian Petrochemical Co. Ltd.
IPP	Isopropanol
LAB	Linear Alkyl Benzene
LDCs	Less Developed Countries
LDPE	Low Density Polyethylene
LLDPE	Linear Low Density Polyethylene
MEG	Mono Ethylene Glycol
MES	Minimum Economic Scales
MFM	Melamine Formaldehyde Moulding Powder
MIX	Mixed Xylene
MRTP	Monopolies and Restrictive Trade Practice;
NFY	Nylon Filament Yarn
NILP	New Industrial Licensing Policy
NIY\TC	Nylon Industrial Yarn\Tyre Cord
NOCIL	National Organic Chemicals Ltd.
NTY	Nylon Tyre Yarn
OGL	Open General Licence
ORX	Ortho Xylene
PBR	Poly Butadiene Rubber
PET	Polyethylene Terathane
PFM	P.F. Moulding Powder
PFY	Polyester Filament Yarn
PHA	Phthalic Anhydride
PM	Polymides
PMM	Polymethyl Methacrylate
POY	Polyester
PP	PrDpylene
PPFY	Polypropylene Filament Yarn
PPL	Polypropylene
PPSF	Polypropylene Staple Fibre
PRX	Paraxylene
PS	Polystyrene
PSF	Polyester Staple Fibre
PTA	Purified Terephthalic Acid
PVC	Poly Vinyl Chloride
RIL	Reliance Industries Ltd.
RTY	Rayon Tyre Yarn
SBR	Styrene Butadiene Rubber

tpa	tonnes per annum
UCIL	Union Carbide (India) Ltd.
UFM	Urea Formaldehyde Moulding Powder
VAM	Vinyl Acetate Monomer
VFY	Viscose Filament Yarn
VSF	Viscose Staple Fibre

LIST OF TABLES AND FIGURES

INTRODUCTION

India has been initiating liberalisation policies pertaining to trade and industry to reactivate a stagnating industrial sector. Since the early 1980s the state has been making way for market forces to determine resource allocation in the economy. Liberalisation policies, calling for a gradual deregulation of trade and industry coupled with a withdrawal from the public sector, aim to increase competition in a hitherto protected and regulated industrial sector with the goal of achieving efficient outcomes.

In India, the government has played a key role in shaping the structure of industry, including the petrochemical industry. Initially, government policy regulated the entry of new firms and the capacity expansion of incumbent firms; apart from providing a high level of protection. We perceive these policies as an erection of artificial entry barriers. The erosion of these barriers, in the process of liberalisation, was expected to enhance competition. The changes in the extent of competition can be gleaned from observing changes in industrial structure which *are* an outcome of liberalisation policies.

How does one examine the efficacy of liberalisation policies in an industry? Literature on industrial organisation indicates a negative correlation between the level of competition in an industry and the presence of entry barriers. There are two kinds of entry barriers in *an* industry: artificial barriers which *are* imposed by a government and natural barriers which *are* an outcome of the structural characteristics of *an* industry and the strategic behaviour of firms in that industry. Therefore, any study of emerging competition warrants an analysis of entry barriers in an industry. Such a study facilitates the examination of whether policies designed to enhance competition in an industry remove these barriers.

The petrochemical industry in India is one of the industries being liberalised in order to make it competitive. We have selected to study the petrochemical industry because of its growing importance in the industrial sector on three counts: (a) it is an emerging 'core' industry in that as a producer of intermediate goods, it has numerous -forward and significant backward linkages to other industries; (b) the end-products of petrochemical inputs are increasingly becoming a part of the consumption basket of a large section of the population; and (c) petrochemical end-products *are* increasingly becoming substitutes for natural products. Therefore, the petrochemical industry would be crucial for industrial development and growth.

Industrial structure in India has been largely determined by government policy. Policies in the pre—1iberalisation period imposed (a) entry restrictions and (b) capacity restrictions on firms through industrial licensing and the Monopolies and Restrictive Trade Practices (MRTP) Act. Liberalisation policies have removed both entry and capacity restrictions on firms in order to build up a competitive market structure, thereby removing artificial entry barriers. The removal of these restrictions have enabled farms to build up excess capacities and vertically integrate - both strategies are potentially entry deterring. The petrochemical industry (both domestic and global) is one of high fixed and sunk costs, and economies of scale. These inherent characteristics of the petrochemical industry coupled with the other natural barriers arising out of firm strategies has resulted in high concentration and the continuation of an oligopolistic industrial structure. Under these circumstances, how efficacious *are* liberalisation policies?

Our study is an attempt to test the hypothesis that while liberalisation policies attempt to remove artificial entry barriers, natural entry barriers may continue to inhibit competition in an industry. The problem is compounded by the way liberalisation is sequenced. Domestic liberalisation precedes trade liberalisation thus enabling domestic firms to take advantage of liberal domestic policies while being protected from

external competition. Given the above hypothesis, the objective of the study is to analyse how, despite liberalisation policies, the operation of natural entry barriers can be inimical to competition in an oligopolistic industry.

Chapter One sifts through the existing literature for a definition of liberalisation before elaborating on the theoretical underpinnings of competition and the role of entry barriers in defining the degree of competition. It then examines the literature on entry barriers in industrial organisation theory and international trade. The chapter concludes by outlining the methodology of the study, and the sources of data used.

Chapter Two traces the growth and development of the Indian petrochemical industry and situates it in the global context. A brief technical note to the industry is provided to facilitate an understanding of the nature of the industry. The latter part of the chapter examines the structure of the domestic industry on the basis of concentration, vertical integration and excess capacities of firms, and then outlines the nature of entry barriers in the petrochemica1 industry.

Chapter Three examines the role of government intervention which has shaped the structure of the petrochemical industry in India. In the regulated regime, the role of the government was to erect artificial entry barriers in order to 'direct' investment into areas of national priority. Liberalisation policies have sought to bring down these entry barriers to enhance competition, in the petrochemical industry. But natural entry barriers remain untouched by liberalisation policies.

The first section of Chapter Four offers three models analysing the entry deterring possibilities of excess capacities, vertical integration and concentration in an industry characterised by high fixed costs and scale economies such as the petrochemical industry in India. The first two models, set in the theoretical framework of the New Industrial Organisation, examine how firm strategies - building excess capacities and vertical integration - provide opportunities for- incumbent firms to deter

entry and thus enjoy continual market power. The third model incorporates the dimension of trade to examine the welfare implications of free entry of firms in a highly concentrated domestic market (a) under conditions of autarky, (b) with free trade and (c) with the imposition of tariffs.

The second section of the chapter offers suggestions for new forms of government intervention in the light of our analysis. Given that liberal trade and industrial policies in the petrochemical industry can counter the spirit of liberalisation, it becomes imperative to formulate policies complementary to liberalisation in order to handle market disruption problems that arise in a liberalised environment.

Chapter 1

LIBERALISATION. COMPETITION AND BARRIERS TO ENTRY

The objective of liberalisation is to induct competitive -forces into the economy. More specifically, liberalised industrial policies are targeted to increase competition and to obtain efficient outcomes in industry. In a world without market imperfections and externalities, liberalised markets would lead to a first-best Pareto optimal situation. But in a second-best world of imperfections, it becomes important to trace the implications of these liberalisation policies. Liberal industrial policies can have competitive outcomes only in the absence of entry barriers. Liberalisation policies remove artificial barriers to entry by new firms, and allow capacity expansion of incumbent firms. However, the existence of natural barriers indicates imperfect competition as reflected in the industry's structure. This chapter will review the existing literature on liberalisation, competition and barriers to entry keeping in view our case study is of the petrochemical industry.

LIBERALISATION: DEFINITION **AND** CONCEPT

Liberalisation in its broadest sense, is a shift towards decreasing government intervention in economic activity. Two significant forms of intervention have been — direct state participation in economic activity and government's regulatory role through industrial and trade policies. Liberalisation would then denote deregulation — a decrease in government role in resource allocation, production and distribution decisions in the economy and privatisation — a decrease in the government's direct participation in economic activity.

At one end of the spectrum liberalisation stands for minimum government activity [Guha 1990:1]; and at the other end a liberalised market where there are no quantitative restrictions either on buyers or sellers. Since all restrictions *are* not quantitative, liberalisation in a more general sense could be

defined as any policy action which reduces the restrictiveness of controls - either their complete removal or the replacement of a more restrictive set of controls with less restrictive ones [Kruegar 1986:16].

It is important at this point to make a distinction between liberalisation as it is understood an India as against its definition in the theoretical literature. India has had a history of myriad controls and regulation on industry especially, on the size of firms, output, location, production pattern and trade. Therefore, any relaxation of these controls constitutes liberalisation and deregulation of industry is part of this process. 'Xr\ the theoretical literature however, liberalisation is usually understood as an 'opening' up of the economy with respect to trade, both in terms of trade restrictions as well as exchanne-rate controls.

LIBERALISATION POLICIES IN INDIA

Government liberalisation policies have been structured to revitalise Indian industry by infusing it with a greater degree of competition. As opposed to earlier policies which directed investment in industry to what were understood to be 'nationally desirous' in a protected environment, liberalisation allows a manufacturer greater liberty in selecting investment levels and output patterns according to the dictates of the market. Liberalisation, by systematically deregulating industry and cutting down restrictions on trade (especially imports), aims at infusing greater competition into the industrial sector and thereby increasing growth and efficiency.

Liberalisation policies in India had a modest beginning in the late 1960s to remedy the foreign exchange and fiscal problems faced by the economy. The relative merit of the market as opposed to state directed development began gaining support on account of three problems facing the economy from the late 1960s. The first was the prolonged stagnation in the industrial sector .1

The second, an increasing inefficiency and low rates of return of the public sector as a whole into which the government had committed vast resources resulting in an internal resource crunch. The third was the recurring balance of payments crises. A conscious policy of liberalisation was advanced by policy-makers as an effective measure to counter these problems. Liberalisation was envisaged to tackle both the problems of resource mobilisation and efficiency and thereby the foreign exchange problem as well.

Policy-makers appear to have had the following two hypotheses on how liberalisation would tackle the above problems the effects of liberalisation on tackling both demand and supply-side constraints in the economy:

1. "Liberalisation of industrial and trade policies will improve industrial efficiency by:
(a) providing greater access to imported intermediate inputs, capital goods and technology:

(b> exposing domestic producers to competition, external *and* internal, and thereby force them to reduce costs, and

(c) lifting curbs on the growth and size of firms so as to exploit scale economies.

2. Improvement in efficiency and the resultant reduction in costs will stimulate domestic demand and enable India's industrial products to compete abroad, thereby relaxing demand-side constraints on industrial growth." [Goldar 1990:603

'Until 1991 there was no official policy statement setting out explicitly what the new economic policy was and what it intended to achieve. The novelty of the policy was perceived only when changes in policy and procedures relating to industrial licensing, exchange rate policy, import policy along with some observations about the need for rationalising and simplifying the systems of fiscal and administrative procedures were pieced together. 'Policies that are directed at the industrial sector can be classified into two categories: (a) domestic liberalisation and (b) trade liberalisation. This distinction is made because in the Indian context these two have not been implemented in tandem. Domestic liberalisation not only pre-dates trade liberalisation but has been more systematic.'

Domestic Liberalisation

Domestic liberalisation policies sought to redefine the contours of the state and market in favour of the market in the domestic sphere of economic activity. These policies were aimed at deregulation and privatisation. To translate these objectives into policy terms, the government formulated the following measures to facilitate capacity and output expansion and to remove procedural impediments to investment and growth of firms.

Delicensing: A number of industries (apart from the small-scale sector) were progressively delicensed by the time the New Licensing Industrial Policy [NILP] was enunciated in 1991. NILP delicensed all industries irrespective of size of investment or the ownership of the undertaking except 18 industries which still required licensing. The number of industries was later reduced to 15.

Broadbanding: Diversification in specified industries was permitted without obtaining an industrial license, initially subject to the condition that the firm did not come under the purview of Monopolies and Restrictive Trade Practices [MRTP] Act & Foreign Exchange Regulations Act [FERA]. This policy was designed to introduce some flexibility into the licensing mechanism and to enable manufacturers to utilise their capacities more efficiently and fine tune their product mix in response to market demand. This scheme commenced with the machine tools industry in 1983. and the list grew steadily. In August 1988, the government announced that the broadbanding facility would be available for companies that came under the purview of the MRTP and FERA in Appendix A. and would be subject to export obligations in respect of non- Appendix A companies. This policy measure lost its relevance due to the liberalised licensing policy in the NILP [1991].

Re-endorsement of Capacity: Licensed capacity in selected industries was increased by an additional 25% over and above the highest production level achieved during the previous five years. Also, automatic growth was allowed. This policy became redundant after the NILP [1991] when licensing was limited to a small list of industries.

Minimum Economic Scale: Minimum capacities of operation were prescribed in select industries in order to exploit economies of scale. This was with a view to increase efficiency in units that could not exploit scale, economies because of the stringent licensing laws. As on February 1990, 106 products in 14 broad industrial groups had a prescribed minimum economic scale of operation.

MRTP Constraints: In many cases, large business houses and FERA companies were excluded from taking advantage of liberalisation measures announced since the late 1970s. The more recent measures have displayed a tendency to permit liberalisation for these groups but mostly with a caveat demanding either export obligations or the promotion of industrialisation in a backward area. The most important trend however, has been the gradual removal of the MRTP constraints themselves. The turnover limit by which a company came under the purview of the MRTP Act was gradually raised from Rs 20 crs to Rs 100 crs in 1985 and soon after to Rs 500 crs, till the ceiling was completely scrapped under the NILP C 1991].

Opening up the Public Sector: Areas that were earlier under the exclusive purview of the public sector were gradually opened up to the private sector.

The policies of broadbanding, re-endorsement of capacity and the prescription of *MES* were part of the earlier liberalisation packages before the large-scale delicensing in the NILP [1991] made them redundant. Amongst these policies, the stipulation of *MES* was aimed at increasing the efficiency of industries where size was pivotal to efficiency. If firms had been constrained by small size in the pre-liberalisation period, they could expand to *MES* and beyond to obtain efficiency gains. But for the new firms, since entry had to be large-scale, the cost of entry increased creating an entry barrier. This policy thereby threw up two problematic outcomes when dealing with the question of *MES* and the anti-competitive outcomes of such a policy in terms of concentration and firm size. Industrial organisation has shown that the relationship between size of entry and the anti-competitive effect of large size is not so simple.

Minimum Economic Size and Concentration:

A rather simplistic assumption is often made that goes as follows: as entry increases, the level of concentration in a firm declines and a large *MES* is an impediment to entry.' However, as Davies [1988: 93] has shown the causality is not so simple.

Suppose an industry has sales, initially of S and a

Herfindahl index OH. The typical size of a firm in an industry is defined as :

$Z = S\sqrt{H}$ where $\sqrt{H}$ = the numbers equivalent dimension of the Herfindahl index & Z = equivalent size of the firm.

Now suppose a new firm enters the industry at size λZ where concentration in terms of the Herfindahl index is:

$$H = \sum S_i^2 / S^2$$

The post-entry concentration in terms of the Herfindahl index is:

$$H^* = \sum \frac{S_i^2 + \lambda S^2 H^2}{(S + \lambda S H)^2} = \frac{S^2(1 + \lambda^2 H)}{S^2(1 + \lambda H)^2} = \frac{H(1 + \lambda^2 H)}{(1 + \lambda H)^2}$$

It follows that $H^* > H$ if $1 + \lambda^2 H > (1 + H\lambda)^2$

i.e. if $\lambda^2 H > 2H\lambda + H^2\lambda^2$

i.e. if $\lambda > 2 + \lambda H$ or $X > 2/(1 - H)$

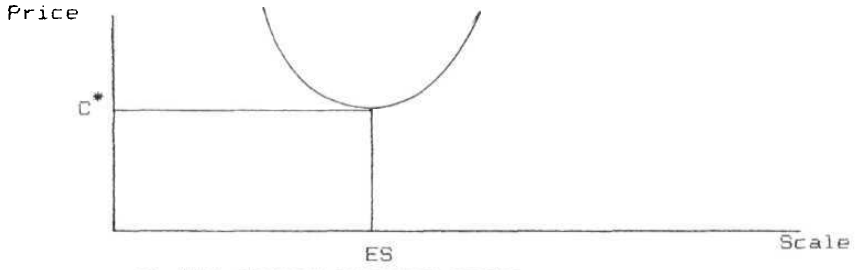
It is therefore possible that entry can increase concentration if the entrant is relatively 'large', where 'large' is made precise by X > 2/<l — OH). For instance, this is true for an entrant little more than twice the typical size in an unconcentrated industry, but larger-scale entry would be required as OH increases.

Minimum Economic Size (MES) and Firm Size:

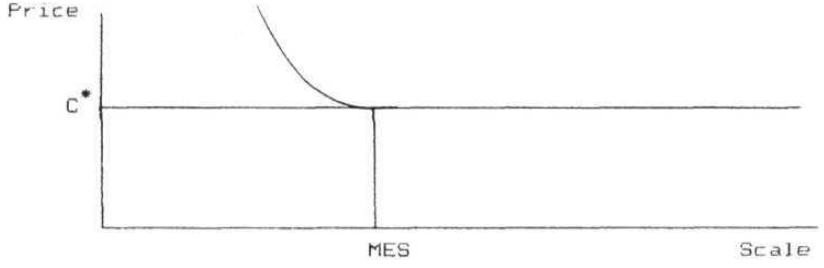
Economies of scale exist when the production cost of a single product decreases with the number of units produced. In this situation, the most efficient industrial structure would be one which could serve the entire market or at least one that is large relative to demand. However", if firms are much larger than *MES*, concentration will be greater than is strictly required by efficiency. Most firms do operate with a notion of *MES*, but in India since earlier policies had stringent rules about scales of operation without regard to *HES,* liberalisation policies had to prescribe *HES* of operation to enable firms to exploit economies of scale.[5]

The setting up of MES of operation is based on a fundamental proposition in industrial organisation that there is a minimum efficient capacity (and thereby scale of operation) that firms must operate at in order to function efficiently or at least cost. Figure 1.1 illustrates two typical average cost curves at the firm level.

Figure 1.1
Long Run Average Costs at Firm Level



a) 'U' shaped average costs



b) 'L' shaped average costs

In a competitive industry, firms have U-shaped average cost curves, where costs are minimum at C corresponding to ES (a given efficient size) that firms operate at. In a competitive market firms will compete till price - C and all firms produce at ES Csee Fig.1.1 (a)].

The number of firms that can exist in a market is definitely constrained by the size of the market. Therefore, if demand at price = C is X_c, then the market will support Xc/ES equally sized firms and this ratio will determine the level of concentration in

the industry. Therefore, given constant demand, the more concentrated an industry the larger is the efficient size relative to the market size. However, firms behave competitively because they *are* of equal size. For example, consider a market which supports only two equal-sized firms. The Herfindahl index is 0.5, which is not high. But both firms have to produce at *C* or else face entry.

However, U-shaped cost curves are *rare* and a more realistic assumption would be to have an L-shaped average cost curve such as that in Figure 1.1(b). This is especially so in the petrochemical industry where fixed costs are high and firms exhibit increasing returns to scale. Firms *are* prescribed an *MES* of operation such that at output below *MES* costs *are* higher than efficiency permits; and at output beyond *HE'S* costs are minimum and *MES* is a benchmark capacity. Therefore, anything that allows a firm to price in excess of C is an entry barrier. Let us consider the following possibilities:

(a) If p > C and output < Xc, and entry (for whatever reason) does not occur, the size of the market is deliberately reduced. The concentration in the industry becomes higher and it becomes a supply-led industry.

(b) If p > C , it becomes possible to survive in the market profitably at scales less than *MES*: in that this allows a sub-optimal sector of small-scale firms to survive and concentration is reduced.

(c) Without the competitive discipline of new entry, existing large firms may be able to increase their market shares, thus moving out along the cost curve and increasing size inequalities and concentration thereof.

The domestic liberalisation policies in India of delicensing, broadbanding, re-endorsement of capacity, removal of MRTP constraints and the opening up of the public sector were policies aimed at encouraging the entry of firms and increasing competition.1 The exception was the stipulation of *MES* that was essentially viewed as an efficiency-enhancing measure. However, its repercussions on industrial structure was much more complex. Firms required huge investments to set up capacity at *MES.* And

large investments in turn were barriers to entry. Even if entry occurs, it is likely to be subsumed by the already concentrated market, thus perpetuating the existing oligopoly. But if entry was completely deterred, existing firms would continue to operate within the dictates of an oligopoly thus further adding to increasing the anti-competitive nature of the industry.

The additional problem with *MES* was that with large-scale 'efficient' operations, firms could no longer be constrained by domestic demand and would have to be internationally competitive. Therefore, apart from policies that were directed at inducing competition within firms in the domestic industry, the government initialised a series of measures targeted at increasing the competitiveness of Indian industry by allowing them freer access to imported inputs. These measures sought to liberalise trade.

Trade Liberalisation

Trade liberalisation attempts to lower trade barriers and improve industrial efficiency through exposure to foreign competition and improved access to imported machinery and raw materials. Policies that dealt with physical restraints on imports through quantitative controls or tariffs were gradually eased through trade liberalisation measures. The policies are:

Deletion of Items on Banned List: The Export-Import [EXIM] policy contains a list of products, the imports of which are banned on account of the country having reached self-sufficiency or, a product the import of which would affect domestic capability. Any deletion of an item on this list indicates a reduction of trade barriers and consequently a reduction in protection to domestic industry.

Shift to Open General Licence (OGL): A shift from the banned or restrictive list to the OGL and a further shift from a quantitative controls to tariffs constitutes a further step towards liberalisation.

Decreasing Tariffs: A progressive lowering of tariffs on import?:, far items on the 06L list also constitutes liberalisation.

Trade barriers *are* essentially barriers to entry -for firms across countries. In India, these barriers were erected by the

government to protect domestic industry by preventing the entry of foreign firms (i.e. goods). Any shift in trade policy to decrease its restrictiveness can be termed trade liberalisation.

Trade and domestic liberalisation, implemented in tandem, are expected to increase competition in the domestic industries and compel them to compete internationally. While domestic liberalisation is expected to introduce greater competition in the domestic industry, trade liberalisation is to expose domestic industry to foreign competition. There does seem to be a consensus that domestic liberalisation should precede trade liberalisation in order to enable heavily protected industries to 'ease' themselves into competitiveness without drastically disturbing other macro-variables Csee Bhagwati 1987, Patel 1986 etc.]. However, the longer the gap between domestic and trade liberalisation, the stronger the tendency for the economy to revert to the old order of protection and regulation. What is clear however, is that liberalisation policies sought to increase the level of competition in Indian industry. Several government committees have been set up by the government to recommend policies in order to increase the efficiency of the petrochemical industry in India, through liberalisation. Competition, being central to liberalisation, warrants an examination of how it is variously constructed in mainstream economics.

COMPETITION AND INDUSTRIAL STRUCTURE

Conventional economic theory makes a case for competitive markets on the grounds of efficiency. The concept of competition which is central to mainstream economic theory, has been the pivot around which production is organised and prices and incomes are determined. In fact, "In economic life, competition is not a goal: it is a means of organizing economic activity to achieve a goal. The economic role of competition is to discipline the various participants in economic life to provide their , goods and services skillfully and cheaply " [Stigler 1968:5].

Competition, in the traditional sense, exists only when there *are* a large number of sellers and buyers and no one individual can influence prices. The economic case for competition is, therefore, made on the grounds that a competitive market system solves both the resource allocation and income distribution problems through its pricing mechanism. This pricing mechanism has an in-built process through which it maximises consumer and producer's surplus thereby taking care of the welfare problem. While the homogeneity of the product and an atomistic market structure are sufficient conditions for the existence of pure competition, an additional characteristic is the absence of barriers to entry by new firms. This was recognised by early industrial economists and emphasised repeatedly [see Bain 1954 & 1956, Scherer 1980:11 etc].

Numerous other factors *are* recognised as inhibiting the working of a competitive market, thus stamping perfect competition as first-best but ideal and ruling out its feasibility as a basis for policy prescriptions. Some of these factors are: *a)* externalities; b) economies of scale (or increasing returns to scale); c) product differentiation; and d) asymmetric information. The notion of a perfectly competitive market was thereby discarded as impractical, for policy making, and the conceptualisation of other forms of competition were formulated.

The effort to uncover the second-best competitive ideal led to the definition of the operational norms for a 'workable competition'. J.B. Clark declared that perfect competition "does. not and cannot exist and has presumably never existed" [1940:241] and went on to argue that some departures from the purely and perfectly competitive market were neither harmful nor avoidable in the long run (as was commonly supposed). He then formulated certain minimal criteria for judging the workability of competition which included the absence of entry barriers. Subsequently, conditions of entry were recognised as a crucial factor on which industrial structure and the nature of competition depended.

The vast literature on workable competition that followed was reviewed in Sosnick [1958]. Using Sosnick's general scheme, Scherer [1980:42] categorised the most commonly cited norms of workability into structural, conduct and performance criteria. The structural norms include:

(a) The number of traders should be at least as large as scale economies permit.
(b) There should be no *artificial inhibition on mobility and entry*. (Italics mine)
(c) There should be moderate and price sensitive quality differentials in the products offered.

Entry is significant not only when competition is important but efficiency too. For example, in Schwartzman [1973], the following assumptions of the competitive model underlie his conclusion relating to technical efficiency.

(1) Firms maximise profits.
(2) Firms have complete knowledge of available techniques and associated costs.
(3) Entry is costless.

It is significant to note that Schwartzman omits the usual condition of a large number of buyers and sellers common to other competitive models. Since the first two assumptions apply to monopolistic as well as to competitive firms, the assumption about entry becomes crucial. "The condition of entry and profit maximising behaviour, nevertheless, may be important for efficiency. Easy entry encourages efficiency which therefore may be higher under competition than under an alternate market structure. The condition of ease of entry, however, is not sufficient for superior efficiency, for there may be other sources of efficiency, including scale economies which favour monopolistic industry and these cannot be described without investigation..." [Schwartzman 1973:762]. Schwartzman in fact anticipates the contestability literature through his notion of entry conditions.

It is therefore clear that competition can be encouraged only when entry into an industry is not hampered by entry barriers. In other words, barriers to entry *are* essential for the existence of

non-competitive behaviour since free entry is bound to create competitive conditions.

In the literature that followed, what became clear was that the assumption about entry was crucial when examining the nature of competition in an industry. And the nature of competition determines industrial structure.\ The following table illustrates the linkages between industrial structure <as defined by the extent of competition) and the level of entry barriers:

Table 1.1
Industrial Structure and Entry Conditions

Industrial Structure Defined mainly by Market Share and Concentration	Entry Conditions
Pure Monopoly Dominant Firm Tight Oligopoly Loose Oligopoly	Ranging from high to low entry barriers
Monpolistic Competition	Free Entry
Pure Competition	Free Entry

Source : Shepherd [1979:12] Extracts of Table 4.2

The industrial or market structure is defined in terms of the extent of competition in an industry. And, what determines the extent of competition is industry-specific. A general definition would be that any characteristic of a firm that affects its price-cost margin or profitability comprises its market *or* industry structure. As Shepherd writes:

> "The field of industrial organisation has acquired an abundance of hypotheses about what constitutes market structure. Neo-classical analysis was premised on the firm's market share, atomistic or pure monopoly. Then came the Chamberlainian group of the 1930s, Bain's entry barriers of the 1950s and firm size and advertising in the 1960s" [Shepherd 1972:25].

Hay and Morris [1979:200] define the primary constituents of industrial structure as scale. concentration and product differentiation. Dichotomising each of these aspects of structure into high (x) or low (o), they obtain the following classification of possible market structures:

Table 1.2
Classification of Industrial Structures

#	Scale	Concentration	Product Differentiation
1.	x	x	
2.	x	x	o
3.	x	o	x
4.	x	o	o
5.	o	x	x
6.	o	x	o
7.	o	0	x
8.	o	o	o

Source: Hay and Morris [1979:200]

A priori, possibilities (3) to (6) in the above table can be eliminated since large scale is not consonant with low concentration or vice versa. Possibility (8) represents the structural conditions for perfect competition, while (1) is that of a monopoly. Possibility <7> represents Chamberlainian monopolistic competition and (2) represents a homogeneous oligopoly which typifies the Indian petrochemical industry.

Although an abundance of factors constituting structure make for a comprehensive study, it is obvious that the selection of the most significant determinants of market structure are industry specific. Shepherd includes the following elements based on "theory and part empirical studies..., though without unanimity" [1972:25].

(a) Market share
(b) Leading firm group
(c) Entry barriers
(d) Firm size
(e) Advertising intensity
(f) Growth rate

However entry barriers appear to be a common denominator while determining industrial structure which in turn rests on the extent and nature of competition in an industry. 'A distinction is made between entry barriers and actual entry. ' This distinction is crucial to the theories that focus upon potential competition and not actual entry as important in markets that *are* typically imperfect. Potential competition relates to conditions of entry and consequent incumbent performance as a mechanism to control power [Gilbert 19896:.

The notion of potential competition was in fact put forth by J.B. Clark. ' It was however, resurrected and developed almost a century later by the contestability theorists such as Baumol, Panzar and Willig. What it essentially propounds is that as long as entry barriers are minimal or non-existent, there is complete freedom to enter and exit. The mobility in an industry is a market disciplining factor and it is one of the essential forces of competition irrespective of industrial or market structure.

The following section discusses the different forms that entry barriers take in industry.

ENTRY BARRIERS IN INDUSTRY: ARTIFICIAL AND NATURAL

Entry is defined as a new legal entity where a new production capacity is set up. Anything that impedes this entry- is an entry barrier. Conditions of entry play a crucial role in determining the structure of an industry and has been of continuing concern to industrial organisation economists. Industrial Organisation literature is replete with definitions ot entry barriers which are paradigm-specific, and will be discussed in the next section. In this section we discuss the broad categorisation of entry barriers into artificial and natural barriers, and their implications for liberalisation policy.

There *are* two types of entry barriers in an industry artificial and natural. Artificial barriers *are* legal exclusions that arise from government constraints such as licensing, quotas,

permits, patents etc. Natural barriers *are* those that. *are* intrinsic to the nature of the industry or those that *are* a result of firm strategies. While industrial organisation literature has emphasised natural entry-barriers, it is literature on regulation of utilities that has dealt with artificial entry-barriers. In India, early industrial policy has revolved around putting up artificial entry barriers in industry. And in this context it is important to study both artificial and natural entry barriers.

Artificial entry-barriers include government policies that restrict the growth of the firm (in terms of asset limits) and licensing rules that dictate what firms should produce and where.

Natural entry-barriers *are* either intrinsic to an industry or arise out of firm strategies. Barriers that *are* intrinsic to the industry *ar&* high cost of investment (and/or positive sunk costs). For example, in an industry where scale economies are significant, output is definitely constrained by the size of the? market and that makes it 'efficient' to have only one firm. In this case, scale economies becomes a natural entry-barrier.

Natural entry-barriers that can result out of firm strategies are concentration, vertical integration and excess capacities. Natural barriers can be further classified into those that are natural to a firm and those that arise as a result of a firm's operating strategies. In Salop's [1979] terms they are `innocent' and 'strategic' entry-barriers respectively. "An innocent entry-barrier is unintentionally erected as a side effect of innocent profit maximisation. In contrast, a strategic entry barrier is purposely erected to reduce the possibility of entry" [Salop 1979:335].

Natural entry-barriers that *are* intrinsic to an industry *are?* the high cost of investment and sunk costs. These *are* significant where scale economies *are* important and confers first-mover advantages to the incumbent firm. With the existence of scale economies output is constrained by the size of the market. In this case, an efficient entrant may be deterred by an established

firm who has sunk sufficient costs to make his own exit uneconomical and entry mutually destructive.

Natural entry-barriers that arise out of firm strategies *are* industry specific and numerous. Firms may choose a variety of ways to deter entry and retain market power. Firms may hold excess capacities, integrate vertically or differentiate their products. Though these strategies *are* employed to maximise profits, they certainly constitute an entry barrier if they contribute to the strengthening of oligopolistic hold of the industry.

Trade barriers are analogous to our notion of artificial and natural entry-barriers in industry. Trade barriers are a myriad combination of government-dictated artificial and natural obstacles to trade. Government-imposed artificial barriers include tariffs, quantitative restrictions, laws on patents and controls on exchange rates. The natural barriers are the asymmetry between the technological and structural characteristics of foreign vs. domestic industries and restrictive trade practices such as dumping.

Liberalisation policies attempt to remove artificial barriers to entry. And since they are imposed by legal dictate and constitutional authority, they can also be similarly removed. Kahn [1988:116] states, "No barrier to entry is more absolute than one imposed or enforced by the sovereign power of the state. All others are potentially subject to hurdling, erosion or circumspection." On the contrary, our contention is that while artificial barriers can be easily removed, other barriers persist. The persistence of these natural barriers to entry negates the objective of building a competitive market by eroding artificial barriers. The removal of artificial barriers allows firms to behave in ways that accentuate natural barriers. Therefore, the problem of inducing competition in certain industries (such as those with economies of scale) through policy measures becomes far more complex. Industrial Organisation (*IO*) theory has attempted to unravel this complexity by focussing on entry barriers.

ENTRY BARRIERS IN INDUSTRIAL ORGANISATION LITERATURE

The most appropriate definition of industrial organisation is perhaps by Shepherd [1984:574]. He says "Industrial organisation is about the nature of the competitive process and the effects of monopoly distortions (and possible benefits) in the variety of actual markets." This definition emphasises the point that industrial organisation theory draws sustenance from the actual working of the market, the framework of any particular study not withstanding.

The entire mainstream industrial organisation literature can be categorised into four quasi-chronological perspectives:

(a) The S-C-P paradigm/ Old Industrial Organisation
<b) The Chicago School
(c) Theory of Contestable Markets
(d) The New Industrial Organisation

Industrial economics (or what is now called Industrial Organisation) came to be known as such when it branched off from the micro-theory of the firm with the work of Mason, Clark and Bain. Bain's seminal contribution to IO was instrumental in dubbing the initial phase the Structure-Conduct-Performance paradigm, now called the 'old' industrial organisation. Industrial economics evolved from new ways of looking at the firm. Orthodox neo-classical theory of the firm was based on the technical nature of the firm as represented through a production function. The departure came from a desire to analyse the economic behaviour of firms through structure, conduct and performance relationships which could be empirically supported.

The Chicago School opposed the establishment of a separate branch of economic work called Industrial Organisation. But their critique of the Old IO formed a framework which was distinct enough to be called the Chicago School. The Contestability theorists offered an alternative definition of competition and their analytical work took the Chicago School's work to its logical end.

At the same time, the 'New' Industrial Organisation grew out of the 'Old' Industrial Organisation, which was dubbed as empirically-led theory and started using game-theoretic models to analyse firm behaviour. This departure is exemplified in Tirole [1988] where he examines the firm from both the technological and contractual points of view - with special emphasis on the latter [1988:15-603. Tirole in fact blends the older (neo-classical/production function) and newer (more microanalytic/contracting) theories as complementary theories. Williamson [1990] calls this entire set of non-neoclassical work on the theory of the firm a 'nexus of treaties'.[22]

The following section will outline how entry barriers *are* analysed in Industrial Organisation theory. Our review is restricted to entry which manifests itself as a new firm where fresh production capacity is set up. An entry barrier is any impediment, intentional or unintentional, to entry. Entry can also occur by other means, like acquisitions or mergers. Such entry is not typical of firms in India. And keeping in view that our case study is that of the petrochemical industry, a homogeonous oligopoly, our review is restricted to studies in industrial organisation pertaining to entry through investment, and entry barriers in a homogeneous oligopolistic industry to prevent such entry.

S-C-P Paradigm: The Old Industrial Organisation and Entry Barriers

This phase of industrial organisation theory was synonymous with the work of J. Bain in the 1950s, and was loosely referred to as the Harvard School. Industrial economics was a marked departure from the theory of the firm, managerial economics or even price theory. This branch of economics evolved an identity of its own through the work of Mason, Clark and Bain. Bain's work stemmed from attempting to explain inter-industry difference in profits which led to his main contribution to industrial organisation theory: that of highlighting the role of entry barriers and the notion of limit pricing, both set within the

S-C-P paradigm which survives even today in various forms. The S-C-P paradigm "...established an analytical and empirical methodology which was to dominate the subject for at least 20 years." CDavies *et al* 1988:2]. The S-C-P paradigm is illustrated in Figure 1.2.

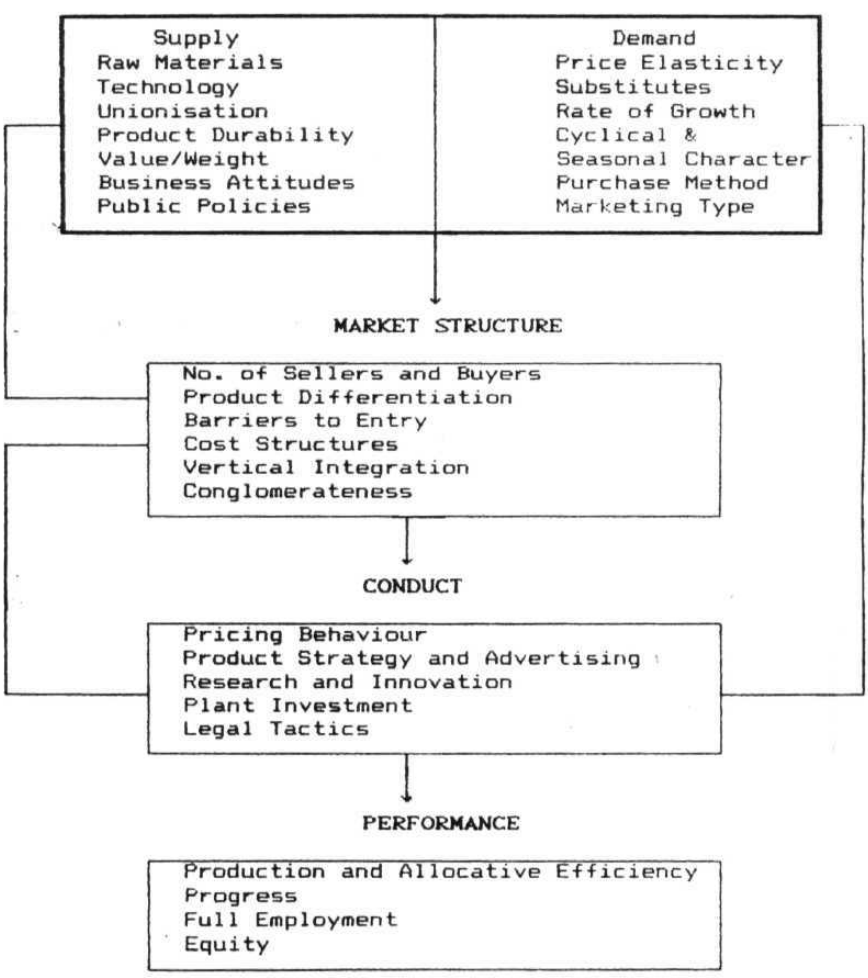
It is important to note that the S-C-P paradigm does not require a specification of market or industrial structure but can be used to analyse industries that conform to any industrial structure. Given that the pre-requisites of perfect competition do not exist, the novelty of this approach was that it could be used to analyse a situation with any degree of imperfection since market structure, conduct and performance depend on relatively stable and observable conditions. In addition, the S-C-P paradigm is structured in a form so flexible that it could be modified to form the basis for much of the empirical work that was carried out for decades to come. In fact the S-C-P paradigm "... entailed theoretical analysis of one or more of the causal links in the S-C-P trilogy which was typically subjected to empirical testing against large scale inter-industry data, increasingly with the use of econometric techniques" CDavies *et al* 1988:2].

The importance of entry barriers as a significant deterrent to competition gained currency on account of Bain's seminal work on "Barriers to New Competition" [1956].[23] In early industrial economics, inter-industry differences in profits were expected to disappear in the long run under conditions of perfect competition which implied free entry. The same outcome would also be expected under conditions of monopolistic competition. However, there was substantial empirical evidence that inter-industry differences in profitability was a persistent phenomena. Such differences were first explained in terms of a single variable, i.e. concentration. However, Bain's work showed that it was not concentration *per se* that was the root of the problem, but barriers to entry were.

Bain shifted the focus of empirical research in industrial economics away from the case study approach to the analysis of

Figure 1.2

Structure - Conduct - Performance
(A Model of Industrial Organisation **Analysis)**



Source : **Scherer,** F.M. [1980:4]

industries by using statistical tools on cross-industry-level data. He used profits as a 'litmus test' for entry barriers to substitute for real barriers since the possible outcome of entry barriers were high profit rates. This proxy has been used by many economists who have regressed profit rates on a host of industry specific variables to denote entry barriers.

In Bain's definition, barriers to entry *are* factors that make it possible for established firms in an industry to enjoy supra-normal profits without attracting new entry. Without entry barriers, firms cannot sustain long-run market power. Thus, preventing the entry of new firms was crucial to retain such power. Bain listed four sources of entry barriers:

(a) Economies of scale (e.g. Fixed Costs): Bain argued that if the minimum efficient scale is a significant proportion of the industry demand, the market makes supra-normal profits without inviting entry.

(b) Cost advantage of established firms: The established firms may own superior production techniques, learned through experience (learning by doing) or through R & D (patented or innovations). They may have accumulated capital that reduces their cost of production. They may also have foreclosed the entrant's access to crucial inputs through contracts with suppliers.

(c) Product differentiation advantages: Incumbents patent product innovations (which of course, can be seen as a cost advantage relative to the product), or they may corner the right niches in the product space and hence enjoy consumer loyalty.

(d) Absolute capital costs: Large capital requirements, in absolute terms, constitutes an entry barrier. Entrants, in this case have trouble financing their investments for two chief reasons: banks are less eager to lend to entrants who are less well known than incumbents and in case of entry, incumbents can inflict losses on entrants in the product market in order to reduce their ability to finance new investments.[2*]

Bain further categorised entry barriers in terms of incumbent behaviour in the face of an entry threat Ccited in Waterson 1984:57]:

(a) Blockaded Entry where barriers *are* such that established firms could price even at the monopoly level yet still not incur entry.

(b) Easy Entry where barriers are so small that pricing even very slightly above costs allows entry.

(c) **Ineffectively** Impeded **Entry** where pricing at a level at which no entry will occur is less profitable than maximising short run profits and allowing entry.

(d) Effectively **Impeded** Entry where pricing at the level at which no entry will occur is more profitable than maximising short run profit and allowing entry

Bain's argument that a potential entrant might be deterred if the capital requirements of entry were large in *absolute* terms did not command much respect. But the more recent contestable market theory implies that entry will be deterred if a large fraction of entry costs are sunk and, therefore, the relative importance of sunk costs **are** correlated with the absolute level of capital requirements. **Schmalensee** C19B9: 9693 in fact states the **following** as a '**stylised** fact' : *"Measures of scale economies or capital requirements tend to be negatively related to entry. In other words, both scale economies and high capital costs are potential entry deterrents."*

Bain's systematic attempt to reveal a correlation between measures of market concentration, conditions of entry and supra-normal profits revealed that in the absence of substantial barriers to entry, the correlation between profits and market concentration was weak. This revelation led to Bain's theory of limit pricing which was later modified by Sylos-Labini and **Modigliani.**

The Bain-Sylos-Labini-Modigliani Limit Pricing Model:

The essential assumptions of the Bain-Sylos-Labini-Modigliani Limit Pricing Model *are:*

(a) There *are* two periods: pre-entry (t=0) and post-entry (t=1). Entry may occur only in period 1.

(b) There is a single established firm or a co-ordinated cartel, the incumbent **(i),** and a single potential *entrant* (*e*).

(c) Consumers **are** indifferent **between** purchases from the

incumbent or the entrant and have no costs of switching supplies.

(d) Demand does not change.

(e) In period $t=1$, the incumbent can commit to an output level x_i which it must maintain at all future periods.

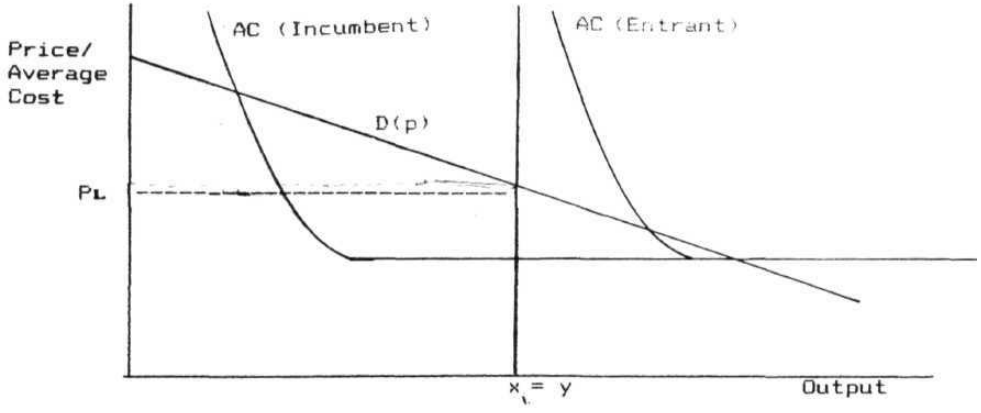
The market price is $P(x_i)$ in the first period and $P(x_i+x_e)$ in the second period, where x_e is the entrant's production. Suppressing price factors, the entrant's profit is:

$$\Pi_e(x, x_i) = P(x_i + x_e)x - C_e(x)$$

where $C_e(x)$ is the entrant's cost function. Let x be the entrant's profit-maximising output taking xi as given. The firm should enter if its maximum profits are positive and should stay out otherwise. The *limit output, Y,* is the smallest x_i for which x_e is zero (no entry). The associated *limit price* is P_L. This is illustrated graphically in the following figure.

Figure 1.3

Limit Pricing



The **incumbent** and the potential entrant have the same average cost curve, AC. The potential entrant takes the

incumbent's output as given and maximises its profit given the residual demand curve D(P) - x_i. This is shown by using x_i rather than the original axis as the ordinate for the entrant's demand and cost curves. Given xi, there is no output at which the entrant can earn a positive profit. This is the smallest output that yields everywhere negative profits for the entrant, hence $x_i = Y$. The associated price is the limit price, P_L. Limit pricing and variations thereof have been extensively discussed in the literature Csee Gilbert 1989a, 198963. While Bain emphasised the supply-side aspects of entry barriers, other economists included demand aspects too. For example, Scherer [1980:2463 states three conditions under which potential entrants expect existing firms to maintain their output in the face of sizeable new entry. In this case, price can be held persistently above the competitive level by a greater percentage margin without attracting entry. The three conditions *arei*

(a) The less elastic demand is,

(b) The higher the proportion of total industry output a firm of minimum optimal scale must produce, and

(c) The more a firm operating at less than minimum optimal is disadvantaged by high unit costs.

The early works of Bain *et al* spawned a great deal of empirical work on entry barriers. Research in the old *IO* essentially involved econometric analysis of industry specific/cross-industry data by regressing profitability on various proxies for entry barriers.

Bain's work and methodology became popular in the 1960s and 1970s as is evident from the numerous studies that followed that ran regressions to explain differences in inter-industry profits. The independent variables were picked up from the S-C-P norms depending on industry specific characteristics, data availability as well as the objectives of the study.

Bain [1956] examined 20 U.S. industries and concluded that the most significant barriers to entry were product

differentiation, economies of scale and control of patents (or scarce resources). This study was the forerunner of numerous econometric analyses which tried to unravel the relationship between structure as determined by barriers to entry, and performance as determined by profitability. The difficulty of measuring barriers to entry was somewhat surmounted by adding proxies for various sources of entry barriers to regressions of profitability on concentration. [Also see Comanor and Wilson 1967, Orr 1974 etc. which are examples of econometric work in the pattern of Bain] Other studies that investigate the relationship between size, concentration and entry include Dunne, Roberts and Samuelson [1989] [29], Bresnahan & Riess [1991] [30] and Hause & du Rietz [1984]. These papers are slight variations on Bain's schemata, but within the old *IO* paradigm.

Lieberman's study of the U.S. chemical industry explores several relationships between various determinants of market structure and their anti-competitive effects. Lieberman [1987b] investigates the factors that determine the size of new industrial plants in the U.S. chemical processing industry.

Lieberman also examined the entry deterring effects of excess capacity, where he differentiates between firms that build and maintain excess capacities for strategic and non-strategic reasons. Profit maximising firms, he says, hold non-strategic excess capacities in markets where demand is cyclical or stochastic or where plants *are* inherently lumpy or subject to economies of scale [Lieberman 1987a:238]. This point is particularly relevant in industries which require huge investments (such as the petrochemical industry) and which have other entry barriers apart from the high cost of entry such as economies of scale and the resultant excess capacities. The potency of these entry barriers may be under-cut by market growth, free-rider problems and demand-related effects but there nevertheless remains a strong incentive to deter entry on the part of the incumbent.

Strategic excess capacity may be built either to deter entry or to preempt existing rivals. The basic entry deterrence

argument is that excess capacity enables incumbents to threaten to expand output and cut prices following entry, thereby making entry unprofitable. Entry deterrence is therefore achieved by intensifying the post-entry competition anticipated by the entrant.

Capacity built by incumbents after the announcement of entry may also serve entry deterring objectives. If incumbents have a shorter construction lead time than entrants, i.e. if incumbents can expand existing facilities more rapidly than entrants, it might be as good as (but less costly than) excess capacity held in advance of a specific entry threat. Even if initial entry occurs, incumbents by responding aggressively, may be able to establish a predatory reputation sufficient to deter further entry. Empirical evidence, however, appears mixed and even contradictory. (See Lieberman [1987a][93] & Hilke [1984][94].

A third method by which firms can deter entry is by vertical integration. A firm can be described as vertically integrated if it encompasses two single output production processes in which either (1) the entire output of the 'upstream' process is employed as *part or all* of the quantity of one intermediate input into the 'downstream' process; or (2) the entire quantity of one intermediate input into the 'downstream' process is obtained from *part or all* of the output of the 'upstream' process [Perry 1989:1853. "The former is called forward integration and the latter backward integration. Silberston C19723 terms vertical integration, 'depth of production' which is partly a function of the history of the plant and partly of technical and economic considerations.

Perry [1989:1873 lists three broad determinants of vertical integration:

(a) Technological economies,
(b) Transactional economies, and
(c) Market imperfections.

Vertically integrated firms in an industry can develop incumbent power which in turn acts as an entry deterrent. While

vertical integration has theoretically been understood to deter entry, it has been difficult to establish this in an empirical fashion in the old *IO* perspective. In fact the question of whether vertical integration is an anti-competitive strategy or not, and the role it plays as an entry deterrent has been the subject of a long-standing debate.

Williamson [1971:112] points out that "Policy interest in vertical integration has been concerned mainly with the possibility that integration can be used strategically to achieve anti-competitive effects." The anti-competitive effects of vertical integration are of two types:

(a) Price discrimination, and
(b) Barriers to entry.

He also lists price discrimination and barriers to entry as one of the incentives for a firm to integrate.

While theoretically it has been well understood that vertical integration is entry deterring, it has been difficult to establish this empirically in the old *IO* perspective.

The numerous empirical studies that were conducted by picking up strands from the S-C-P paradigm, and testing hypotheses on their relationship using econometric tools, did not develop into a generalised framework for analysis. Nor were the results consistent, partly because the studies were too relationship and industry-specific. The two main shortcomings of these inter-industry studies were: (a) the limitations of data and <b> the difficulty of using cross-section data to identify key structural parameters [see Schmalensee 1988]. Economists reacted to these shortcomings by reverting to industry specific analysis (rather like the pre-Bainian case studies approach) while using econometric tools. So much so that "...there was a growing unease at what some would call catholic and others call *ad hoc* theorising behind the new empirical work. This gave rise to an approach which is perhaps most appropriately described as 'empirically driven theory'. By this we mean research with an ultimate

empirical objective, but based on explicit theoretical-model building designed to establish a formal relationship between the variables concerned : the theoretical model is then used to guide the specification of estimating equations." CDavies *et al* 1988:6] This in turn led to the use of mathematical modelling using game theoretical principles to partial equilibrium analysis in microeconomics to formulate new models of entry-deterring strategies.

In the late 1970s, this movement towards empirically motivated theory was joined by mathematically trained economists and led to what Davies *et al* call the 'New industrial organisation'. But parallel to the development of the S-C-P paradigm was the work of the Chicago School which is best defined by their differences with the old *IO*.

The Chicago School

A major voice of dissent against the development of industrial organisation as a separate branch of economics has been by proponents of what can be loosely termed the Chicago School. The root of the Chicago School's criticism has been that industrial organisation rests on nothing but the basics of neo-classical price theory. Stigler in fact declared that "...there is no such thing as industrial organisation" [1968:1] and went on to say that what was considered industrial organisation was precisely that content of economic theory - price or resource allocation theory - now given the 'infelicitous' name of microeconomics. He, nevertheless, conceded that there were two somewhat 'honourable' reasons for industrial organisation to branch off from traditional microeconomics. That the formality of economic theory did not allow for studies that dealt with the details of empirical measurements and industrial organisation took on the chores of dealing with pubic policy questions, in particular those proposed by anti-trust laws and public regulation which traditional economic theory did not deal with. Nevertheless, he stated that much of industrial organisation

literature has been "so non-theoretical or even anti-theoretical, that few economic theorists were attracted to it." [1968:1]

Both Bain and Scherer were anxious to relate their work to policy issues and "given the underlying assumptions of the paradigm, it carries the undeniable presumption against monopoly power and big business" CDavies *et al* 1988:43. This must have been anathema to the Chicago School economists since the gist of their critique revolves around the Harvardians' benign view of the market. This view rests on a conviction that inter-industry differences in market shares and profits can be explained solely by differences in efficiency. The Chicago School does not reject the concept of barriers to entry but believes that they play a minor role [Gilbert 19896:1123.

The salient features of the Chicago School can be summarised as follows CGilbert 19896:1133:

(a) Gains from incumbency should be modest and temporary.

(b) Strategic behaviour of established firms influencing the conditions of entry should be minimal.

(c) Industry structure and profits should reflect cost differences and not accidents of history that determine the order of entry of the firm.

(d> Market concentration should not, by itself be a determinant of price.

Stigler, a staunch proponent of the Chicago School, defines a barrier to entry as "a cost of producing (at some or every rate of output) which must be borne by a firm which seeks to enter an industry but is not borne by firms already in the industry" [Stigler 1968:67]. Essentially, this means that the different conditions that entrants and incumbents face in an industry is in itself an entry barrier. As Gilbert [1989a:476] points out, Stiglerian barriers to entry do not exclude demand considerations. For example, consumer loyalties affect the costs that a new firm must incur in order to reach a particular level of sales. To the extent that the new firm has to overcome more consumer resistance

than the established firm, the entrant would experience a Stiglerian barrier to entry.

Stigler's definition of an entry barrier is akin to the notion of sunk costs in contestability. The entrant has to ensure that expected revenue will be sufficient to compensate for the risk of losing irreversible investment. If production exhibits increasing returns to scale, an 'efficient' market structure calls for a single firm. This in turn calls for large plants where the Minimum Economic Scale (*MES*) is large. But large *MES* does not automatically imply that entry barriers *are* high. Caves, Khalizadeh and Porter [1975] (cited in Schmalensee [1988:968]) argue that even if *MES* is large relative to the market, small-scale entry may be attractive unless the cost penalty for operation at sub-optimal scale is substantial.

The main contention of the Chicago School is that anything that increases the efficiency of a firm is not a barrier to entry. In fact, in their parlance, concentration, excess capacities (as a result of scale economies) or vertical integration cannot be entry barriers if they are the outcomes of efficiency. As Shepherd remarks, "The Chicago School regards all elements of market power (internal and external) as small and/or short lived. Any existing market power is held to reflect economies of scale; therefore it is justified by efficiency" CShepherd 1984:575].

Demsetz, a strong proponent of the Chicago School in fact declares that economies of scale and concentration *are* not barriers to entry but arise out of efficiency on the part of incumbents. He attributes even informational and reputational advantages of early entrants as part of the costs of doing business and not barriers to entry [Demsetz 1982].

Demsetz alleges that the previous studies of Bain, Stigler, and others of that genre have presented too narrow a view of barriers to entry, a view that focuses on the cost of producing the *physical* output of an existing firm. Defining barriers to entry thus, Demsetz claims, not only diverts attention from other

types of barriers but also hides the value judgment implicit in the notion of barriers. He says that these early studies either ignore or treat the costs as 'unproductive' that must be incurred "to create and to maintain a good reputation, to bear risks of innovation and to build a scale of operations appropriate to the economical servicing of consumer demands, and it tends to neglect the incentives that will face future decision-makers as a result of today's policy. Licenses, trademarks, copyright, patent, entitlement to the fruits of past investment including the investment in an honourable long history, and the right to reduce price may or may mot be desirable, depending on how these implications are valued" [Demsetz 1982:573.

The Chicago School's view that even vertical integration is not an entry barrier is exemplified by Stigler. He points out "...there is no reason to expect that vertical integration has any monopolistic implications as long as every stage of production is competitive" [1968:3033. In this case, the value of transaction costs as an entry barrier loses its validity since vertical integration merely substitutes internal organisation for market exchange.

Bork supports the view that vertical integration is an outcome of sound business acumen. He argues that "In general, if greater than competitive profits are to be made in an industry, entry should occur whether the entrant has to come in both levels at once or not. I know of no theory of imperfection in the capital market which would lead suppliers of capital to avoid areas of higher return to seek areas of lower return" [1969:148].

The Chicago school disregards the existence of entry barriers as insignificant and if at all they exist, as temporary. This view was further polished by economists who went on to re-define the notion of perfect competition giving birth to the theory of contestable markets.

Contestability, Sunk Costs and Barriers to Entry

The contestable market theory has sought to provide an alternative to the unrealistic notion of perfect competition in traditional industrial organisation literature. This theory branched off from the Chicago School approach to take the 'pro-market' view to its logical end and, further, to argue that potential entry was sufficient to discipline all markets including natural monopolies. "Contestability is merely a broader ideal, a benchmark of wider applicability than is perfect competition" [Baumol 1982:1]. Its proponents Baumol, Panzer and Willig call it the "uprising in the theory of industrial structure", "a new theory of industrial organisation" which offers "a unifying analytical structure to the subject area, and ... useful insights for empirical work and for the formulation of policy" CBaumol 1982:13.

What the theory of contestable markets states is as follows: If there are no sunk costs, and if there exists at least one potential entrant who could produce exactly the same products as the incumbent, and if the equilibrium concept is such that the entrant can undercut the incumbent for long enough to enable the entrant to sell his desired output, then we have what is known as a perfectly contestable market CBaumol 1982]. The core of the theory states that even if there are substantial economies of scale and/or economies of scope, or other traditional market deficiencies - provided there are no sunk costs - there can be no exploitation of monopoly power as pricing in excess of average cost would result in under-cutting entry. It is the ability to withdraw costlessly that encourages entry and ensures that incumbents act competitively in the first place.

A perfectly contestable market is therefore an illustration of a market without barriers to entry or exit. There is no product differentiation and no cost advantages. There is no uncertainty and no switching costs, and learning economies are non-existent. Production may exhibit increasing returns to scale,

but firms do not incur any costs that are not perfectly reversible in the event of exit from the market i.e. absence of sunk costs. The entry conditions in such a market *ar&:*

(a) Free and without limit,
(b) Absolute, and
(c) Perfectly reversible [see Shepherd 1980:573].

Baumol and Willig, the proponents of contestability theory de-fine an entry barrier as "anything that requires an expenditure by a new entrant into an industry, but that imposes no equivalent cost upon an incumbent" [Baumol & Willig 1981:408, cited in Gilbert 1989a:476]. And, in a contestable market of costless entry and exit, there *are* no entry barriers. Since sunk costs *are* the crux of determining whether or not a market is contestable, competitive conditions can exist in any industry where sunk costs are zero. This definition precludes all other barriers to entry including scale economies.

For the contestability theorists the absence of sunk costs is important on two counts. Firstly in a contestable market without sunk costs, the entry option can be exercised at no cost. A potential rival can consider a hit and run entry without concern about irreversible investments. It pays a potential rival to enter the market if he anticipated any positive profits. Secondly, with no sunk costs and with identical technologies, the incumbent firm and a potential entrant bear the same cost at each level of output. There is no strategic asymmetry between an entrant and an established firm because each faces exactly the same cost and revenue functions.

The absence of barriers to entry and exit therefore provides a convenient benchmark to ascertain the consequences of barriers to competition. Baumol, Panzar and Willig show that if a market is perfectly contestable and if an equilibrium exists, then price equals marginal cost for any product produced in positive amounts by two or more firms. If only one firm exists in a perfectly contestable equilibrium, total revenues will exactly equal total production costs.

Contestability theorists make two controversial claims:

(a) That their notion of contestability avoids ex *posts*-oligopolistic interactions compared to earlier studies in *IO* theory, and

<b> that perfect contestability theory yields a useful benchmark even when the conditions for perfect contestability are not satisfied.

Brock contests the robustness of these claims and says that the rules of the game are not specified and therefore such claims have to be viewed with caution [Brock 1983].

When sunk costs are zero, the potential entrant enforces competitive conditions, regardless of industrial structure including monopolies. But the higher the sunk costs, the greater the risk assumed by entrants. Entry is less attractive because the entry barrier too is high. This notion of potential competition being a market disciplinarian hinges upon the absence of sunk costs. As Dasgupta & Stiglitz point out "...if there are even small sunk costs, potential competition may not be effective in ensuring either that profits go to zero or that efficient outcomes obtain" [1988:571].

A contestable market characterised by 'ultra free' entry, as Shepherd [1984:572] terms it, provides efficient outcomes in all markets i.e. markets with varying degrees of imperfection. These firms are efficient in that they make zero profits, offer Ramsey optimal prices. create an efficient production and market structure, and avoid cross subsidies in pricing. Shepherd [1984] not only questions the semantics of the term contestability, but is sharply critical of the realism of the assumptions about the nature of competition and chary of the empirical issues in measuring and testing ultra free entry.

A contestable market allows for scale economies as long as they are not sunk. The greater the proportion of costs that is non-recoverable on exit, the quicker and more aggressively is the incumbent able to respond. And the greater is the premium over

cost that the incumbent can earn before the potential entrant is willing to risk entry CDavies *et al* 1988:38]. Therefore contestable market theory targets potential entry as a primary determinant of market structure and performance.

The contestability theory which took-off from the Chicago School was one of the two developments in Industrial Organisation theory. The other was the 'new' Industrial Organisation which broadly recognised the Bainian barriers to entry as important, but was increasingly dissatisfied with the empirical work and empirically driven theory of the 'old' industrial organisation. And that inter-industry analysis had outlived its usefulness in analysing industries. The 'new' *IO* economists began the use of game theoretic tools to explain firm strategies in clearly defined industries.

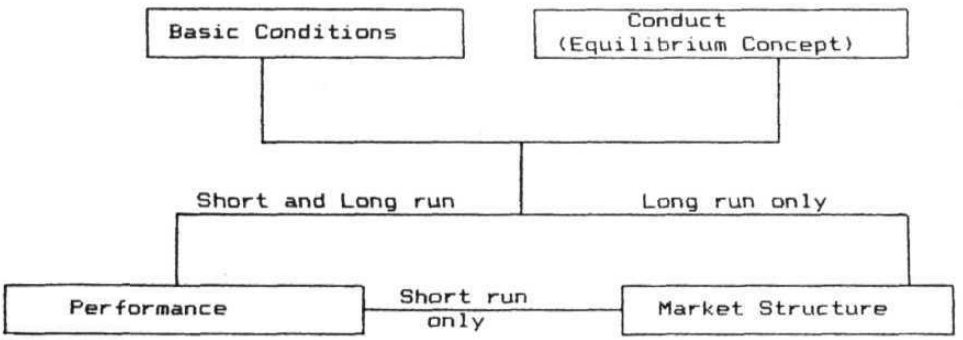
The New Industrial Organisation and Entry Barriers

Competition and entry barriers continue to be the recurring theme of Industrial Organisation. These concepts were however analysed in a more rigorous fashion that allowed for game theoretic tools to analyse strategic firm behaviour in models of imperfect competition. This is reflected from the 1970s, when a growing volume of work in industrial organisation was done by mathematically trained economists who were interested in the theoretical problems of industrial organisation but not necessarily in the specification of econometric work. Davies *et al* [1988] call this strand of work the 'New Industrial Organisation' and defend this distinction on the ground that "the rigour of the New Industrial Organisation compared with the Catholicism of earlier years is sufficiently different in emphasis to warrant some sort of distinctive label". The roots of the New Industrial Organisation lie in the works of Cournot, Bertrand, von Stackelberg and Schelling.

The distinction between the old and new *IO* was essentially that of methodology. The methodology of the new *IO* primarily involves defining the basic initial conditions and the problem,

determining the equilibrium strategy followed by the players in the game (Cournot, Bertrand or Nash) and then working out long or short-term strategies [see Figure 1.43.

Figure 1.4
The 'New Industrial Organisation'



Source : Davies *et al* [1988:7].

In contrast to Fig. 1.2, Fig. 1.4 clearly illustrates that the conduct of firms is specified through an equilibrium concept where both the initial conditions and mode of conduct are exogenous and there is no feedback. And market structure is treated as more centrally endogenous.

Models of entry deterrence in the new *IO* formulate post-entry strategies and moves in order to trace back the implications for entry deterrence. (In contrast, the theory of perfectly contestable markets finds post-entry conditions irrelevant and strategic entry deterrence impossible.) While the Old Industrial Organisation picked up causal strands in the S-C-P paradigm and tested them using econometric techniques, the new *IO* builds mathematical models of firm behaviour which *are* as yet, not amenable to testing using firm or industry specific data. However, the new *IO* uses many of the concepts of the old *IO* and injects a measure of analytical rigour into them.

Economists of the new *IO* use game theoretic approaches for analysing situations in contrast to the econometric analysis of the earlier theorists working in the old *IO.* Their analysis involves chalking out and comparing the equilibrium strategies followed by firms in the pre and post-entry period based on the information available about the industry. The equilibrium conditions could be Cournot, Bertrand or Nash. These equilibria are:

Cournot Equilibrium: The output rates chosen by the firms constitute an equilibrium if, given the outputs chosen by rivals, no firm can improve its profits by altering its output.

Bertrand Equilibrium: The prices chosen by firms constitute a Bertrand Equilibrium if, given the prices chosen by rivals, no firm cam improve its profits by altering its prices.

Nash Equilibrium: Each firm optimises its profits given the strategy of rivals.

Depending on the specificities of the model, the notion of Stackelberg leadership could be imposed to analyse the post-entry game. In a Stackelberg equilibrium, one firm (the leader) moves first, and the second firm (the follower) moves next. The follower chooses a strategy, taking the leader's choice as given. However, the Stackelberg leader anticipates the follower's choice and take this into account when making a decision.

After setting out the problem in this way, the long-run and short-run strategies of the firms *are* worked out. The greatest advantage of this method is perhaps, the systematic way the problem is set out and analysed. As Schmalensee puts it, "Perhaps the greatest merit of the game theoretic approach is that it disciplines theoretical discussion by, in effect, forcing theorists to specify and then abide by the rules of the games they analyse" [Schmalensee 1988:646].

Entry deterrence literature in the new industrial organisation can be categorised in terms of the following three attributes to entry:

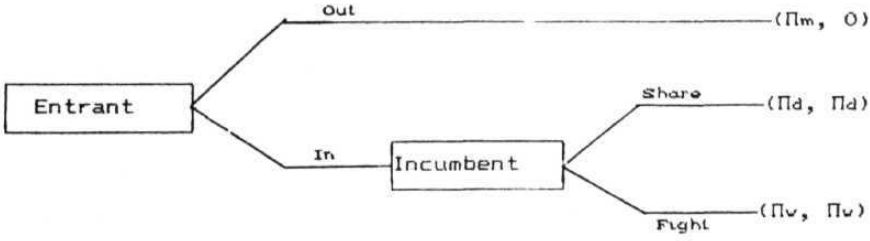
(a) When information is *asymmetrical,*

(b) When incumbents make commitments (usually of capacity) in advance of entry, and
(c) When entrants are uncertain about an incumbent's objectives

Models based on industry specific characteristics are then built, the underlying premise being information asymmetry, commitment or uncertainty. Some models also superimpose a behavioural condition of reputation-building on the part of the incumbent. An incumbent may behave aggressively (and thereby irrationally); the incumbent's predatory actions are designed to eliminate entrants when they appear; by building a reputation for such credible threats, the incumbent could serve to deter the more sophisticated entrants.

Analysis of this sort led to a variety of two-period entry deterrence models with a single established firm (a monopoly) and a potential entrant. If there were more than one incumbent, the models would assume some sort of a collusive behaviour which liken the collusive oligopoly to a monopoly. This would enable the players to act in a duopoly game (in case of entry) which is amenable to detailed analysis. This basic framework of analysis enabled economists to examine the entry-deterring strategies of incumbents who used various entry barriers such as high cost of entry, excess capacity, concentration, vertical integration etc. to deter potential entrants. The following is typically reduced form of two-stage game between an incumbent monopolist and a prospective entrant.

Figure 1.5
The Entry Game



Source: Dixit [1982:3]

In the first stage, the entrant has to make the entry decision. If he stays out, the incumbent earns monopoly profits (Π_m). If entry occurs, the incumbent decides whether to fight a price war resulting in Π_v to each player or share the market with Π_d to each duopolist. In Figure 1.5, each end-node represents a pay-off, the first component being the incumbents. It is assumed that $\Pi_m > \Pi_d > 0 > \Pi_v$. i.e. a duopoly is profitable but not as much as a monopoly while a price war is mutually destructive. Most entry games are modifications of the above model suited to the specificity of the study. The basic entry-deterring model works out post and pre-entry conditions, compares the two and makes conjectures about the entry-deterring strategy of the incumbent. And many modifications can be made to the above basic model depending on industry-specific basic conditions and the specificities of the game to be researched.

There is extensive literature analysing how an incumbent monopolist might invest pre-emptively in order to deter all future entry. We discuss those papers where firms invest (a) to expand capacity for the same product and <b> create capacity in a neighbouring product i.e. to integrate vertically. These two forms of capacity commitments are relevant for the Indian petrochemical industry.

Studies of capacity expansions and entry deterrence *are* based on the basic idea that a firm's capital investment is inflexible downwards, so that by investing pre-emptively, the incumbent monopolist commits himself to a higher capital stock and thus to a lower (short-run) marginal cost function, at least over an ascribed output range. The lowered marginal cost makes the incumbent a tougher competitor in any future interaction, thereby reducing expected profits from entry. Studies by Spence [1977], Dixit [1979, 1980], Eaton & Lipsey [1980, 1981], and Gilbert & Harris [1984] are representative of this genre of writing. The new *IO* uses many of the concepts of the old *IO* and presents them in a rigorous analytical manner. Dixit s work [1979 & 1980]

provides a fine example as he translates Bain's categorisation of entry barriers into the vocabulary of the new *IO*.

We will develop in detail Dixit's work, not only because it provides for alternative approaches but is seminal for understanding increasing to scales industries such as the petrochemical industry. Before doing so we shall briefly survey one of the earliest studies in the new *IO*, examining entry deterrent possibilities of excess capacity, by Spence [19773. He argues that entry is deterred in an industry when existing firms have enough capacity to make entry unprofitable. The resulting excess capacity is an effective entry deterrent partly because it is irreversible and represents pre-emptive commitments to the industry. Of course the presence of excess capacity, given output levels, results in higher costs than *are* necessary. It also results in higher prices and lower levels of output than those implied by various forms of the limit price model. The post-entry game, therefore, involves leadership by the established firm. The incumbent's threat of producing at a level equal to the pre-entry capacity is believed by the prospective entrant and entry is thereby deterred.

In the Spence model, existing firms choose capacity in a strategic way designed to discourage entry. "This strategic purpose is realised by holding 'excess' capacity in the pre-entry period. This excess capacity permits existing firms to expand output and reduce price when entry is threatened, thereby reducing the prospective profits of the new entrant who operates on the residual demand curve to zero. Given that capacity is selected in this entry forestalling manner, existing firms choose pre-entry price and quantity so as to maximise profits" [1977:534-35].

Entry barriers in Spence's model *are* a "combination of structural and technological factors on the one hand, and obstacles that are put in place by the existing industry on the other" [1977:543]. He stresses on the latter which involves the irreversibility of investment which is important on two counts: (a) that such a commitment would constitute a credible threat and

(b) there is no need to set sub-optimally a relatively flexible instrument like the price, since that can be adjusted within the time horizon required for entry to take place. He discards the view that the mere threat of entry is a resource-improving measure.

Detailed studies on competition and entry barriers in the new *IO* framework is that of Dixit. Dixit [1979 & 1980] draws attention to the critical roles of expected post-entry competition in deciding the extent to which economies of scale and excess capacities can be a barrier to entry. (Ironically, it appears that the more competitive the post-entry game is expected to be, the greater will be the entry barrier.) Dixit formulates three scenarios. If entry takes place:

(a) The incumbent firm acts as a Stackelberg leader and the entrant is the follower CDixit 1979];

(b) Both the firms act as Nash players CDixit 19803; and

(c) The entrant becomes a Stackelberg leader and the incumbent is the follower CDixit 19803.

Whereas in Dixit C19793 the incumbent firm has a clear first mover advantage, Dixit [1980] explores the possibilities of limited leadership.

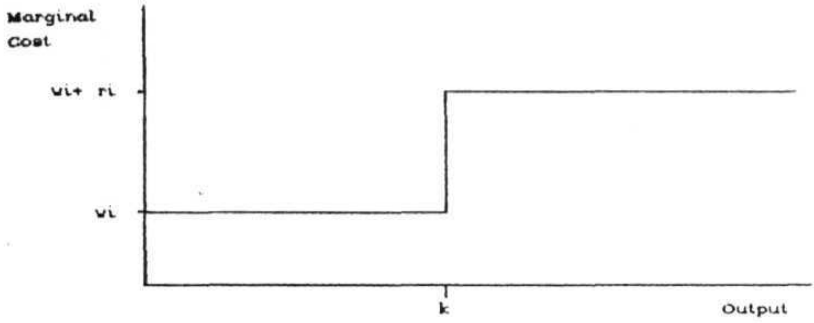
Dixit [1979] analyses a model of duopoly where scale economies are introduced into the model via fixed costs. Leadership by one "established" firm may yield an outcome in which the second is inactive, but entry prevention is not a prior constraint. Dixit discusses a case where the incumbent firm's strategy is to threaten a sufficiently large output in the event of entry while maintaining enough capacity to make that threat credible. He uses linear demand and cost functions and assumes Cournot competition.** While demand functions *are* the usual ones, cost functions *are* defined as follows:

$$C_i = f_i + w_i x_i + r_i k_i$$

where x_i = output
k_i = capacity &
toi. + r_i = v_i = marginal cost of expanding output and capacity together.

The following figure illustrates the above cost function.

Figure 1.6
Marginal Cost Function with Sunk Costs



The **incumbent** firm <1) can threaten a post-entry output of *hi* while producing xi (≤ *hi)* so long as entry does not occur. For firm 2, the relevant quantity is **Ki:** it will stay out if *hi* > **Bi** where **Bi** is the incumbent's limit output at which entry can be prevented because the entrant has a certain fixed cost. Dixit then defines the four possible outcomes in terms of Bainian entry barriers and shows how the strategy of excess capacity can enlarge the zone where entry is effectively impeded at the expense of the zone where it is allowed to occur. Allowing excess capacity to be held introduces a second way of barring entry that is preferable over a portion of the range.

Dixit **[1980]** analysis the entry game in a case **where** the incumbent incurs a sunk cost. There is one incumbent, one potential competitor and two periods: *before* and *after* entry. Entry occurs only in the second period. If entry occurs, the two firms behave as Cournot competitors. The entire game rests on the premise the ' *Strategic entry deterrence requires an inter temporal linkage between actions that the incumbent may take prior to entry and the probability or extent of subsequent entry.'* **[Gilbert** 1989a: 4883

In Dixit's model, the inter-linkage is achieved by allowing for capital expenditures that, once made, become irreversible or sunk in the next period. This enables the incumbent firm to commit to an output it cannot otherwise sustain as an equilibrium if its first-period expenditure were reversible. The incumbent is able to turn a liability (irreversibility of capital investment) into a key asset that makes entry deterrence feasible.

In an extension of the above model, Dixit considers a possibility where the entrant acquires the role of quantity leadership i.e. Firm E chooses a point on Firm I's reaction function to maximise its own profit. But Firm I, by its initial capacity commitment, can decide on a reaction function to present to the entrant.

In the models of Dixit credible entry deterrence is an example of the indirect effects of a barrier to exit where sunk costs affect the behaviour of established firms. With Cournot competition, sunk costs make an incumbent firm more aggressive. If capital investments were recoverable, the opportunity cost of capital would be an additional component of the firm's marginal cost function and the firm's reaction function would shift to the left. The firm would produce less at every level of rival output and perhaps exit the market, making entry more profitable.

The Dixit's models were the forerunner of many models of that genre. Fudenberg and Tirole [1983] analyse how an early entrant in a market can exploit his headstart by strategic investment. They study the investment game in the no-discounting case and arrive at an equilibrium which shows that the follower firm is forever deterred from investing. Capital is sunk only to the extent that it is embodied in a durable investment. Eaton and Lipsey [1980] argue that the entry deterrence property of capital depends critically on its durability and this aspect of capital has been largely ignored. They charge that the works of Dixit [1979, 1980] & Spence [1977] amongst others of that genre deal with, what they call, the atemporal aspect of capital as a barrier to entry. A monopolist strategically commits a quantity of

capital which is sufficient to produce a negative flow of profits to a new entrant. The durability of capital is a constraint on a firm's ability to exploit a sunk cost barrier to entry. When capital wears out, an established firm and an entrant *are* on a level playing field (provided all of the firm's capital wears out at the same time, which seems rather unlikely).

Strategic decisions with respect to capital durability *are* examined by Eaton and Lipsey £19803 in two models. In the first model capital decays exponentially, and in the second model, capital decays only with use. Specific capital is a natural vehicle for commitment to the market and commitment is valuable to the firm since it inhibits entry. Accordingly, a profit maximising firm will choose the specifications of capital, so that marginal cost is equal to a positive marginal value in inhibiting entry. This choice will often result in specific capital that is 'too durable' or 'too soon replaced' or 'too well maintained' relative to the unconstrained cost-minimising solution.

Markets with increasing returns to scale in investment where competition occurs over both the amount and the timing of new capital construction are examined in Gilbert and Harris [1984]. They develop a theory of competition in markets with indivisible and irreversible investments. The consequences of competition depend on the strategies and information available to the competitors. If firms act as Nash competitors with binding contracts, revenues will exceed costs for any number of firms, and otherwise identical firms will earn different profits. In the absence of binding contracts, competition over the timing of investment can completely dissipate profits in a sub game perfect equilibrium with two or more firms.

The underlying assumption of many capacity commitment models is what Malueg & Schwartz [1991] term the *mimicking principle*. The mimicking option implies that the incumbent makes the same investment decision that an entrant would make and thereby deter entry. For example, if the entrant was planning to enter with capacity k, the incumbent could hope to deter entry by expanding

by capacity k. In Eaton & Lipsey [1980] the incumbent deters entry by building a new plant sufficiently in advance before the old one needs to be replaced. The mimicking option exists in their model because, by assumption, the market cannot support two independently operated plants. Thus, by adding the plant the entrant would have added, the incumbent deters entry. In Gilbert & Harris [1984] the mimicking option arises because the incumbent and the entrant would use the added plant identically (i.e. to capacity) in any subsequent output interaction. So if allowing one entrant suffices to deter further entry, duplicating that entrant's investment will suffice to deter it.

Another aspect of barriers to entry that came into prominence was of vertical integration through capacity creation in neighbouring products. Vertical integration has long been known to provide integrating firms with greater profits. Schmalensee [1973] investigates the implications of vertical integration by successive monopolists for costs, prices and welfare in the case of a monopolist who produces an intermediate good and integrates forwards into the competitive customer industry. He assumes that the intermediate-good monopolist must sell his output of final products at a price equal to the average cost of the producers he does not control. Since the monopolist has an incentive to acquire these independent producers, he may well not want to sell at this price. Under some conditions, it would be in the monopolist's interest to engage in a price squeeze, whereby he charges the independent producer q and sells his own production for less than $M(q)$, in order to purchase the fixed assets of the independent producers on favourable terms.

In his vertical integration model Schmalensee [1973] investigates the case of a monopolist in an intermediate industry who integrates forwards. He assumes forward integration of firms "...from concentrated markets to unconcentrated industries because it is generally profitable." C1973:4493 On the other hand, given the presence of monopoly power in the market for the intermediate good involved, such an integration, he says, is not necessarily a

bad thing. Complete integration will lower the average social cost of producing the final product, and it may well lower its price also. Even if the price of the final product rises because of integration, the Marshallian measure of welfare too may increase.

The vertical integration of successive oligopolists has been demonstrated by Greenhut and Ohta [1979] as mutually profitable, since industry output increases and product price is lower. This implies in general to oligopolistic industries in which fixed proportions apply to successive stages of production. The welfare gain stemming from vertical integration is further shown to hold not only in the case of a Cournot oligopoly but also a Stackelberg oligopoly. Greenhut & Ohta therefore recommend that industries characterised by oligopoly and fixed proportions in successive stages should be allowed to integrate without concern over 'arbitrary' concentration ratios.

The view that a monopolist producing an intermediate product and selling to a competitive industry has a profit incentive to integrate forward, has also been supported by Vernon and Graham [1971]. They say this is not true only in a special case when production in the customer industry is characterized by fixed coefficients. They show graphically and verbally that attempting to capture monopoly profits by pricing an intermediate good above cost leads to substitute away from it and, thus, to inefficient production at the next stage. A monopolist can avoid this inefficiency and thus increase his profit by integrating forward.

This review of literature on the entry , deterrence possibilities of investment by incumbent firms has dealt with two strands in *IO* theory: first, the question of how the creation of excess capacity by incumbent firms can deter entry; and second, how vertical integration is an entry barrier.

In the 1980s, the models of the new *IO* attracted trade theorists which resulted in a synthesis of trade and industrial organisation theory. The concept of the firm was replaced by the

nation to overcome the geographical restrictions of the domestic market. Once the stage was set, domestic and foreign firms could play the 'industry game' using the rules of the new industrial organisation, with the added complexities of trade. This branch of economics came to be known as the New International Trade Theory (IT) and gained currency predominantly through the works of Krugman [1979, 19903, Helpman [1984], Caves [1980], and Ethier [1982&].

THE NEW INTERNATIONAL TRADE THEORY

The theory of comparative advantage enunciated by Ricardo in 1817 has been the fundamental underpinning of economists' argument of the gains from trade for nearly 200 years. His theory gave rise to the traditional constant returns and perfect competition models of international trade. These models sought to explain differences in export performance in terms of factor endowments - the most popular being the Heckscher-Ohlin theory and its numerous variations. The only exception to the traditional gains from trade theory was the infant industry argument for protection; in fact, the only case where a departure from the free trade norm was grudgingly accepted by trade theorists.

A major departure came in the late 1970s with the possibility that trade might arise for reasons other than exogenous differences in factor endowments, technology, or tastes. These theories arose from a desire to provide a satisfactory explanation for intra-industry trade that was globally prevalent. The New International Trade (IT) pointed out that economies of scale that characterised imperfect competition could generate international trade and that too in the absence of cost differences. In other words, trade was simply a way of extending the market and exploiting scale economies [Krugman 1979:4793.

/Trade theory and industrial organisation theory were increasingly combined to offer explanations of cases where economies of scale had led to arbitrary specialisation in products that were produced in monopolistically competitive conditions.

This major departure from mainstream trade theory sought to provide a theoretical justification for government intervention in trade on two counts: a) for strategic reasons and b) on account of externalities. As a result of which, while "free trade is not passé, it is an idea that has irretrievably lost its innocence", [Krugman 1987:313].

The crux of the new *IT* theory is its incorporation of scale economies to formal models. Traditional trade theory avoided the problem of scale economies because firstly, it was incompatible with the perfect competition assumption of the early trade models and secondly, it was awkward to model. It was the revolution in industrial organisation theory, particularly the use of game theoretic oligopoly models which were incorporated by trade theorists that helped to overcome this problem. In fact, international trade theory was remoulded into the image of industrial organisation by superimposing government interactions onto the firm strategies. Therefore international trade theory became not so much competition amongst nations, but competition amongst firms where governments were interested players and makers of trade policies [see Dixit 19873.

It was recognised very early that scale economies were not 'compatible' with traditional trade models which propagated free trade. Frank Graham argued that economies of scale in production provided a rationale for protection on the grounds that protection raises the sales of domestic firms and thus allows them to slide down their average cost curves. [The new trade theorists in fact point out that it is economies of scale that leads to specialisation which drives trade in the modern world. In an increasing returns industry, one can envisage a scenario whereby a few efficient manufacturers are adequate to cater to the world market. In such a case, an individual country that protects such an industry can raise the scale of that industry (domestically) sufficiently to reap a net benefit and even lower prices to domestic consumers. Regarding such a situation, there is much debate in the new *IT* about 'optimal' trade policy.[Although the

case for free trade appears stronger, evidence shows that an individual country acting alone may have reasons not to adopt free trade. Trade models, in the new 77" show that it is possible that export subsidies and tariffs may in fact favour the protecting nation.

The point that government interventions could raise national welfare by shifting oligopoly rents from foreign to domestic firms was first formalised in a model by Brander and Spencer [1983]. They said that in principle, government policies such as export subsidies can serve the same purpose as investment in excess capacity in the IO literature on entry deterrence.

While one strand of trade theorists have held that protection increases domestic market power, there has been a second proposition that protection, by initially generating monopoly rents, generates excessive entry and thus leads to inefficiently small scale production [see Dixit & Norman 19803. However, an increase in competition through entry may leave firms unable to charge a markup on marginal cost sufficient to cover average cost. The result will be exit and more market power.

The ideas of entry deterrence in the new IO are assimilated in the New IT in Dixit & Kyle [19853. If a firm commits itself into producing, by making an irreversible investment i.e. sunk costs, it would be socially optimal to provide an export subsidy. And with this subsidy, the firm will find its entry justified. In other words, firms can make strategic moves designed to affect government decisions; if the firm moves first, the government has to provide a subsidy. Yet, if the government commits itself not to provide a subsidy, entry would be deterred. The point is that while export subsidy, given entry, increases welfare it would be optimal to deter entry.

Government policies might serve the 'strategic' purpose of altering the subsequent incentives to firms, and act as a deterrent to foreign competition. Clearly a tariff can give domestic firms a strategic advantage in the domestic market the

same way export subsidies give them an advantage in foreign markets. Krugman classifies four themes on the implications of new international trade literature on trade policy Csee Krugman 1990: chap.14]:

(a) The relation between trade policy and the market power of domestic firms,

(b) Role of price discrimination and dumping in international markets,

(c) The possibility that government action can serve a 'strategic' role in giving domestic firms an advantage in oligopolistic competition, and

(d) Whether IO theory gives new arguments in favour of protection.

It stands to reason that scale economies are likely to be most important in the manufacture of intermediate goods since the scope for product differentiation of products is very low in intermediate goods when compared to consumer goods Csee Ethier 1979, 1982b]. In such a situation, scale economies can cause a concentration of the industry in a country when such a good is non-tradable Csee Helpman & Krugman 1985]. The presence of scale economies also offers a great incentive to dump.

In the new international trade dumping xs viewed as an asymmetric modal in which a domestic monopolist confronts price-taking foreign firms; the assumption is that the domestic market is somehow closed to imports while allowing the domestic firm to export. This is the underlying condition of Grander and Spencer's model of dumping [1983]. Their results are pivotal on transport costs: if transport costs *are* high, but not high enough to prevent trade, trade based solely on dumping leads to losses. If they are low, trade is beneficial. Of course there are many other reasons for which firms dump. Ethier [1982c] points out that dumping can arise out of sluggish adjustments of the key determinants of trade.

The new international trade theory is relevant to our study on two counts: (a) it deals with economies of scale and <b) the

analysis of optimal trade policies in the face of trade liberalisation.

Traditional trade liberalisation advocates an elimination or drastic reduction of government-imposed restrictions on trade to make way for 'free' trade. But in the light of the New *IT,* governments *are* viewed as key players in international trade in their roles as formulators of strategic trade policy. The new *IT* theory thereby offers a novel perspective on trade liberalisation: strategic trade interventions can be justified on the grounds of domestic and foreign market imperfections. And to the extent trade is propelled by oligopolies and further, by the exploitation of scale economies, trade theory is inextricably intertwined with industrial organisation.

Having reviewed the literature on entry barriers and entry deterrence in the new IO and trade literature, we outline the methodology of our study in the following section.

A NOTE ON METHODOLOGY

This study is set in mainstream industrial organisation. While our notion of entry barriers is derived from the old IO, we have used the analytical tools of the new *10* to study the effectiveness of entry barriers in in deterring the entry of new firms in the Indian petrochemical industry. Both the Chicago School and the Contestable Market paradigms *are* ruled out because of their stringent conditions pertaining to entry. Their narrow definition of entry barriers do not include the factors that we consider entry deterring; they are after all the outcome of profit maximisation behaviour!

The government has liberalised the petrochemical industry in the aim of enhancing competition and obtaining efficient outcomes. The earlier regulatory regime had resulted in a highly oligopolistic industrial structure. The study commences on the premise that entry barriers do exist in high fixed-cost industries

with scale economies such as the petrochemical industry in India. The structure of the industry itself is dependent upon the nature and extent of these entry barriers - both artificial and natural.

An examination of India's liberal industrial and trade policies in the petrochemical industry indicate that they have eliminated artificial entry barriers. But natural entry barriers not only persist but are accentuated. We then proceed to analyse the implications of these natural entry barriers on the entry deterring strategies of firms in the petrochemical industry.

Bain's work [1956] and many other subsequent studies, as the review of literature illustrates, define barriers to entry as one of the determinants of structure amongst others like concentration, scale economies, high fixed costs etc. In our study, barriers to entry are not determinants of structure but each of the structural determinants of the industry have entry-deterring properties. For example, if concentration, the existence of excess capacities and vertical integration *are* determinants of industrial structure as they *are* in the Indian petrochemical industry, each one of them constitute an entry barrier.

An analysis of the petrochemical industry in India reveals that it continues to be concentrated thus forming an oligopoly. The two other factors that support the oligopolistic nature of the industry are vertical integration and excess capacities.

Concentration is measured both by four-firm concentration ratios and the Herfindahl index CD-I-index). The Herfindahl index is used as the most appropriate for our sample of firms in the petrochemical industry. The index reflects both the number of firms and their relative size. It is based on easily observable variables and is easy to calculate. The H index is calculated as follows:

$$H = \sum_i S_i^2$$

where S_i is the market share of the vth firm.

We have however used market share in terms of output and not sales. The market share based on output in fact reflects the share based on sales in an intermediate goods industry. The four firm ratios and an analysis of dominant firms are used to make up for the deficiencies of the H-Index.

Concentration ratios indicate the market power held by an interdependent group of firms. When the ratio is high, a few firms dominate the market and, with some degree of collusion, can raise prices and perform other conventional monopoly actions. Higher concentration makes effective collusion more probable. The market power that these oligopolists exert can be as great as if the firms were unified into one dominant firm. Therefore concentration is an indicator of diluted monopoly power.

The pattern of vertical integration was determined by tracing the diversification in a sample of firms in the petrochemical industry. Vertical integration takes place when a firm diversifies into neighbouring products in the production process.

Excess capacities was determined by the capacity utilisation rates of firms at present, and the *anticipated* excess capacities. Future excess capacities are estimated by comparing the capacities created by plants that are being built and estimated demand in the economy. However, petrochemical firms have to expand capacity in a discrete or lumpy manner. This gives rise to an excess of unutilised capacities in a periodic fashion: a non-strategic or *innocent* entry-barrier. It is however not possible to separate excess capacities into those that are innocent and those that *are* built to serve a strategic purpose. We can only determine whether excess capacity in a firm is entry deterring or not regardless of the firm's intention.

We then offer three models in the theoretical framework of the new *JO* to examine the entry deterring possibilities in an industry with high fixed costs (& scale economies). The three models analyse how the structural factors of excess capacity

(through scale economies), vertical integration and concentration provide opportunities for incumbent firms to deter entry. The models *are:*

Model 1: Excess Capacities , Step-wise Capacity Function and Entry Deterrence.

Model 2: Vertical Integration and Entry Deterrence

Model 3: Imperfect Competition, Prices and Tariffs

The models assume that the incumbents *are* monopolists in the first period. The assumption of monopoly is not stringent and is in fact only a simplification since firms in an oligopoly situation can collude and simulate a monopoly situation. Entry is postulated in the second period and the two firms become Cournot duopolists. We have assumed Cournot competition on the following grounds:

(a) Once large capacities have been established, firms can vary their output in infinitesimal quantities. This implies that the existence of scale economies, lumpy investments wherein once fixed costs are sunk, the firm can vary its output strategically.

(b) Prices are *are* not flexible enough to enable Bertrand competition.

The Cournot model we have followed is briefly as follows: In game theoretic terms, the Cournot model is a one-period game in which N firms (N > 2), simultaneously choose output levels of identical products. If Q is total output and P(Q) is the market inverse demand function (which is assumed to be common knowledge), sellers' payoffs are given by their profit function:

$$\Pi_i = q_i P(q_i + q_{-i}) - C_i(q_i) \qquad i = 1,2...N \qquad .1)$$

where q_i is firm i's output and $q_{-i} = Q - q_i$ is the total output of its rivals. The first order necessary conditions for each q_i to be a best response to the corresponding q_{-i} are as follows:

$$\partial\Pi_i/\partial q_i = P(Q) + q_i P'(Q) - MC \quad (q > =0 \quad i = 1,2 \ldots N \qquad \ldots(1.2)$$

where mc_i is firm i's marginal cost $< \partial C / \partial q_i$ land $P'(Q) = dP(Q)/dQ$. A Nash equilibrium in pure strategies provides a solution to (1.2) [see Schmalensee 1988:645].

Licensed capacities of petrochemical firms *are* far below efficient scales in the pre-liberalisation period. Liberalisation policies stipulated a Minimum Efficient Scale of operation, as one measure to increase competition in the industry. First-mover firms who expanded capacities (to take advantage of scale economies) could build excess capacities. Model 1 illustrates how incumbent firms build excess capacities and deter the entry of new firms and pre-empt capacity expansions of other firms thereby accentuating their market power.

Delicensing was another important component of liberalisation. Delicensing enabled firms in the petrochemical industry to vertically integrate. Model 2 shows how firm behaviour of vertical integration can preclude further entry (both in the input and product market) thereby accentuating the dominant power of the incumbent.

Our analysis of industry structure indicates that the petrochemical industry was highly concentrated in the pre-liberalisation phase. Liberalisation policies facilitated firms to hold excess capacities and integrate vertically. Therefore, the industry continues to maintain its oligopolistic character. Model 3 examines the implications of liberal trade policies for the concentrated petrochemical industry in India.

The entry deterring effects of concentration, vertical integration and excess capacities in the Indian petrochemical industry leads us to suggest different forms of government intervention.

NOTES

The terms state and government are used interchangeably.

Privatisation as used in Western economies, particularly the U.K. connotes divestiture i.e. a partial or total sale of the state owned enterprise. In the Indian context, the term privatisation has a much broader connotation.

[3] In June 1966 the rupee was devalued by 57.5"/. against the sterling. The effective devaluation was, however, estimated at 21.6% for exports and 42.3% for imports [Bhagwati & Srinivasan 1975:92]. The currency devaluation was expected to boost exports, restrict imports and channelise resources into more productive and efficiency areas. This was the first step towards rectifying the distortions that had crept into the economy through controls.

There is a consensus amongst economists that Indian industry underwent a prolonged stagnation between the mid-1960s and mid-1980s Csee Shetty [1978], Ahluwalia [1985] etc.]. However, there has been an extensive debate regarding the reasons for this stagnation between those who prescribe to supply-side and demand factors. Liberalisation policies attempt to tackle the supply-side bottlenecks in the hope that demand constraints will consequently be taken *care* of.

"Appendix A companies manufacture goods reserved for the public sector under Schedule-A to the IPR [1956] or for production in the small scale sector.

[6] See CMIE [1990] The Liberalisation Process, A19-A20 for details.

This assumption is made in Mani [1992], where entry automatically implies greater competition.

Economies of scale the unit cost of producing an output (single or composite) under a given technology (with no technical change). There are *economies of scale* in some interval of output if the average cost is decreasing there.

A related idea is that of returns to scale: here both the output and input proportions are kept fixed, and one compares the amount of (the simple or composite) output f(x) produced by a given input vector x with the amount produced by vector λx, for $\lambda > 1$. *Increasing returns to scale* are said to prevail if $f(\lambda x)$ is greater than $Xf(x)$. Under some conditions increasing returns to scale are equivalent to economies of scale. [The New Palgrave: A Dictionary of Economics, Vol.2.)

[9] There are two ways in which *MES* is calculated:

(a) Engineering estimates obtained by analysing technical data.

(b) By examining the distribution of plant sizes:
- The survivor-technique attempts to identify the size class of a plant which is seen to be expanding relative to others over a period of time and argues that the lower bound (or average size) of this class represents *MES*.
- By observing plant sizes where firms operate more than one plant, on the premise that the plant must have reached output rates of at least *MES* Csee Davies *et al* 1988:53-4].

[10] The Herfindahl index in this case is simply ES/Xc.

Total Cost in such an industry is:

$$TC = MC + F$$

$$AC = \frac{MC + F}{Q}$$

which is a rectangular hyperbola.

[12] Davies [1988: 933 says that this third argument is particularly difficult to develop formally without some specified model of incumbent behaviour. Any analysis has to take recourse to modeling the oligopoly game and this is what we have done in Chapter 4.

In our study the terms industrial and market structure *are* used synonymously as is the practice in Industrial Organisation literature and also in our study.

Despite differentiation, low scales and low concentration mean that there is little price discipline as there *are* few barriers to entry and new entry tends to eliminate abnormal profits.

[15] Shepherd defines entry as follows:"Entry is a process separate from entry barriers, and it is also complex. It has at least three elements: size, speed and probability of occurrence... Only when all three elements *are* substantial is entry significant." [Shepherd 1984:5813

[6] See J.B. Clark [1887], the Limits of Competition, Political Science Quarterly, Vol. 2, No. 1 pp45-61 cited in Hause and Du Rietz [1984]. Also see Clark [1902], the Control of Trusts cited in Gilbert [1989a].

[7] There are other ways by which entry occurs: entry by acquisition and/or mergers. In the Indian context, entry by investment is more prevalent and therefore the study defines entry in terms of investment.

What is interesting is that Franco Modigliani's paper on "New Developments on the Oligopoly Front" in the Journal *of Political Economy* [1958] focussed on entry as did A.K. Dixit's paper more than 20 years later on ""Recent Developments in Oligopoly Theory", *American Economic Review*, [1982].

The 'rival' and radical approaches in IO theory such as the Austrian and Marxian Schools have been briefly but excellently reviewed in Davies *et al* [1988].

[20]This categorisation is fallowed by Davies et al [1988] and appears to be standard and appropriate.

[21]To be sure, this presents a need to pick and choose. Roughly, if the issues *are* ones of price, output, efficient factor proportions and the like, the production function set up applies. If, however, the object is to assess the comparative efficacy of alternative economic and organisational instruments, recourse to the newer theories, which expressly engage the relevant micro-analysis is indicated.

If "the neoclassical theory of the firm treats the firm as a monad, the dyad is the basic relation on which the firm as a nexus of contracts focuses." [Williamson 19903

Adam Smith recognised the central role of entry in the theory of supply. In *An Inquiry into the Nature and Causes of the Wealth of Nations* he says "When by an increase in the effectual demand, the market price of some particular commodity happens to rise a good deal above the natural price, those who employ their stocks in supplying that market are generally careful to conceal this change. If it was commonly known, their great profit would tempt so many new rivals to employ their stocks in the same way, that, the effectual demand being fully supplied, the market price would soon be reduced to the natural price, and perhaps for some time even below it. If the market is at a great distance from the residence of those who supply it, they may sometimes be able to keep the secret for several years together, and so long enjoy their extraordinary profits without any new rivals. Secrets of this kind, however, it must be acknowledged, can seldom be long kept; and the extraordinary profit can last very little longer than they are kept." (Smith [1776] 1937 p 60) But it was Bain who formalised the role of entry in an industrial economics framework.

[4]These definitions are from Tirole [1988:3063.

Sylos postulated that entrants expect that established firms will not accommodate entry by reducing their output. Modigliani's formulation states that the limit output is the smallest pre-entry output for which entry is not profitable.

The limit pricing model has been treated extensively in the industrial organisation literature. See Tirole [1988], Jacquemin [1987] or any standard textbook.

[tf]All else being equal, the lower the limit price the flatter is the residual demand curve. Also, entry is easier if the entrant's minimum efficient scale is small and if the average cost falls quickly to its lowest level [Gilbert 1989a:482].

27

The main deficiency of Bain's analysis was that the measurement of entry barriers was necessarily subjective and vulnerable to criticism of circularity. Are barriers high in industries that have persistent profits or vice versa? And since accounting profits can differ widely from economic profits - tor example the choice of depreciation rates and the use of historical asset values - profitability itself is difficult to measure.

Comanor and Wilson's paper [1967] offers a typical example of econometric work in the pattern of Bain. They investigated regression equations of the following form:

$$r = fto + \beta_1(CON) + \beta_2(BE_1) + \ldots + \beta_{n+1}(BE_n)$$

where r = measure of profitability
ft^* = unknown coefficients
CON = seller concentration
& BE_s = variables designed to measure the structural determinants of entry barriers

The barriers to entry variables in the above example (as several other studies do in this genre) use any one or more of the four Bainian entry-barriers viz., scale economies, product differentiation, cost advantages and absolute costs of incumbent firms.

Orr's study of 71 Canadian manufacturing industries indicates that capital requirements, advertising intensity and high concentration *are* the most significant barriers to entry. He used the following model:

$$E = f_1 (\Pi_p - \Pi^* , Q)$$

Instead of using profits, Orr used E i.e. entry specified as the number of entrants per year as his dependent variable, where

Π_p = past industry profit rate

Q = past industry rate of growth of output

Π = long run profit rate predicted for the industry on the basis of the level of entry barriers where:

$\Pi^* = iz$ (X, K, A, R, r, c) and

X = market share of MS plant
K = capital requirements
A = advertising intensity
R = R & D intensity
r = risk
C = high concentration

Their analysis uses econometric tools and is based on a model of industry evolution developed by Boyan Jovanovic. They conclude that:

(a) the long-run effect of a cohort of entrants on market structure in the chemicals industry is very small;

(b) the entrants appear to fare less well in the chemical industries than in the average manufacturing industry;

(c) the relatively high growth rates of the chemical industries, do not have an appreciable effect on entry despite the common association between industry growth and entry in other studies.

Bresnahan and Reiss [1991] propose an empirical framework for measuring the effects of entry in concentrated markets. Building on models of entry in atomistically competitive markets, they show how the number of producers in an oligopolistic market varies with changes in demand and market competition. Their results suggest that competitive conduct changes quickly as the number of incumbents increase. But, they suggest that each industry has an entry threshold - i.e. a measure of the market size required to support a given number of firms. Bresnahan and Riess use econometric techniques to estimate this entry threshold. Above this entry threshold, an entrant can make a significant increase in industry competition. Below the threshold, an entrant changes it only marginally. What is novel about their approach is their attempt to draw inferences about the effects of entry without the use of the firms' prices or cost data.

Hause and du Rietz make a distinction between entry by new firms and entry through diversification and go on to consider how the rate of entry can be influenced by (a) potential entrants and (b) costs of entry. They cite minimum size of plant required for efficient entry as a significant factor in retarding entry i.e. it is a significant entry barrier.

[32] In Salop's terminology, excess capacities that deter entry but are created for non-strategic purposes are *innocent* entry-barriers.

[99] Lieberman's study of excess capacity as a barrier to entry and investment in a sample of 38 chemical product industries in the U.S. showed that incumbents rarely built excess capacities pre-emptively in order to deter entry. Using logit and log-linear models of investment behaviour, his analysis showed that entrants and incumbents exhibited similar investment behaviour, and excess capacities were not created as an entry deterrent. Lieberman's analysis indicated that excess capacities were maintained to accommodate demand variability and investment lumpiness. In fact, in only three cases were incumbents holding excess capacity for entry deterrence purposes and in all the three cases some entry did occur. The only two products in his sample of 38 where excess capacity did offer at least partial success as an entry deterrent, were characterized by slow market growth, high producer concentration and high capacity intensity.

[94] Hilke [1984] regressed entry rates on excess capacity and other variables for a 16-industry sample. The excess capacity coefficient proved negative but insignificant at standard statistical levels.

Vertical 'formation' describes vertical integration at the time the firm is created. Vertical 'expansion' describes vertical integration which occurs as a result of the internal growth of the firm creating its own new subsidiaries in the neighbouring stages. Vertical 'merger' describes vertical integration which occurs through the acquisition by one firm of an existing firm in a neighbouring stage CPerry 1989:1863.

Costs such as those required to establish the reputation of an entrant, including expenditure on technology acquisition and advertising *are* sunk costs. Once these costs are incurred they cannot be put into alternate use. Sunk costs are distinct from fixed costs in that while sunk costs are irreversible fixed costs can be retrieved.

[97] See Schmalensee [1988:663].
Economies of scale exist when the production of a single product decreases with the number of units produced; economies of scope *are* cost-saving externalities between product lines (e.g. the production of good A reduces the production cost of good B) CTirole 1988:16].

Ramsey prices maximises total surplus, subject to a break-even constraint [Brock 1983:10563.

[30] The works of these economists *are:*

Cournot,A. [1838] *Recherches sur La Theorie Mathmatique de la Richess.*

Bertrand,J. [1883] Review of Cournot's Recherches sur la Theorie Mathmatique de la Richess, *Journal des Savants,* pp 449-50.

von Stackelberg,H. [1934] *Market form und Gl eichgewicht* . Vienna, Berlin.

Schelling,T. [1960] *The Strategy of Conflict,* Harvard University Press, Cambridge Mass.

The distinction we make here is that predation deals with strategies whose rationality depends on inducing exit and preventing future entry whereas entry deterrence is concerned with the conditions that impede capital mobility.

The resulting outcomes of entry games have been classified by Fudenberg & Tirole [1984]. They provide a taxonomy of behaviour in response to entry that an incumbent may use: the 'top dog', the 'puppy-dog ploy', the 'f at cat', and the lean and hungry look'.

(a) The top dog over-invests to deter entry. This is the optimal deterrence strategy in models such as Spence [1977], and Dixit [1981]. Investment makes the incumbent tough and in response, the entrant would cower and produce less. Top dog behaviour is optimal in this case whether or not entry is actually prevented. Even if entry is allowed in the Di;:it model, the incumbent will play the top-dog role to increase its post-entry profits.

(b> The fat cat: This is an example where the incumbent's optimal price is an increasing function of investment in advertising because the advertisements lower the elasticity of demand for the product, so that more advertising makes the incumbent soft. By being soft, the fat cat encourages its rival to be less aggressive. This strategy involves over-investment (relative to the case where the strategic interactions are ignored) in order to optimally accommodate entry.

(c) The lean and hungry look: If reaction curves are upward sloping and investment makes the incumbent soft, entry prevention calls for a lean and hungry look. In the advertising example, the incumbent may under -invest (relative to no entry) in order to commit itself to aggressive pricing if entry occurs.

<d) The puppy dog ploy: The puppy dog ploy is under-investment in order to make the incumbent firm appear more friendly to a new entrant. This can be an optimal strategy if the reaction functions are upward sloping, less investment makes the incumbent soft, and the incumbent expects entry to *occur* (See Gilbert [1989:510]).

See Dixit [1982], Jacquemin [1987], for examples and extensions of the two-stage entry model.

[43]This is contrary to the contestability theorists who claim that potential competition i.e. a mere threat of entry would induce competitive forces in an industry regardless of structure.

[44]Only downward sloping reaction functions allow for entry deterrence through excess capacity hence the assumption of Cournot competition.

[45]Eaton & Lipsey [1980] dub this *type-A artificial monopoly*. They provide an alternative in *type-T natural monopoly* to be the one in which cost minimising decisions with respect to durability, replacement and maintenance of capital amply that there is no point in time at which entry is profitable, and a *type-T artificial monopoly* to be one in which *strategic decisions* with respect to capital prevent there being any point in time at which entry is profitable.

The desirability of such a strategy depends, of course, on the ease with which the fixed assets of the independent producers can be shifted to other industries. If these assets are to some extent specialised to the production of the final product in question, the monopolist can impose losses on the independents and reduce the market value of their fixed assets, though he must sacrifice some profit to do this. He must weigh this sacrifice against the expected present value of the savings it would yield in asset acquisition cost. If the squeeze strategy is not optimal, the monopolist would presumably acquire the fixed assets he needs at their current market value and then refuse to sell the intermediate good to potential competitors, or sell it only at such a high price that nobody else would find it profitable to produce the final product in question [Schmalensee 1973:448].

The historical underpinning for the case of infant industry protection is outlined in Irwin [1991].

Venables & Smith [1986] offer a cursory account of this departure in trade theory. Also see Caves [1980].

Graham's exposition led to an intense debate between him and Knight. Knight's view was that Graham's analysis of the possible losses from trade was valid if the economies of scale are external to the firms and internal to the industry but not if economies of scale are internal to the firm. See the following articles for a gist of the Knight-Graham debate on tariff protection:

Graham,F.D. [1923] Some Aspects of Protection Further Considered, *Quarterly Journal of Economics,* Vol.37, p119-227.

Graham,F.D. [1925] Some Fallacies in the Interpretation of Social Costs: A Reply, *Quarterly Journal of Economics*, Vol.39, 324-330.

Knight,F.H. [1924] Some Fallacies in the Interpretation of Social Costs, *Quarterly Journal of Economics*, Vol.38, p582-606.

Knight,F.H. [1925] On Decreasing Costs and Comparative Costs: A Rejoinder, *Quarterly Journal of Economics*, Vol.39, p331-333.

Early literature defines dumping as price discrimination between national markets. Apart from sporadic instances, dumping is thus treated either as profit maximisation by a discriminating monopolist or as an oligopolistic tactic to eliminate competition or to enforce a cartel (predatory dumping).

[51]See Shepherd [1979:188] for an exposition of different measures of concentration indices.

These demand estimates have been worked out by the Kapur Committee and the Sengupta Committees. Our study draws heavily -from these two reports in the determination of future excess capacities.

Chapter 2

THE STRUCTURE OF THE INDIAN PETROCHEMICAL INDUSTRY

The petrochemical industry is among the most important and dynamic sectors of an industrial economy. The manufacture of petrochemicals which absorbs only about 5% of the world's oil supplies is nevertheless important for two chief reasons. Firstly, because of its linkages with other industries both backward into petroleum refining (its basic input is naphtha, a by-product of petroleum refining) and more importantly, because of its forward linkages into a multitude of downstream products such as synthetic fibres, synthetic rubber, plastics, fertilisers, paints and synthetic detergents. Such an 'enveloping' industry can give an impetus to all-round industrial development.

Secondly, the petrochemical industry has gained ground as a producer of substitutes for natural products made from fast depleting resources (such as wood, metal etc.) or for products that cannot keep pace with demand (e.g. wool, cotton, silk, soap etc.). This ensures that the consumption basket can keep expanding despite the depletion of natural resources. In fact, in the West the impetus for the industry (whose origin is as recent as the 1920s) came in the 1940s from the need to provide man-made substitutes for a variety of natural goods that were in short supply during the War period. In Less Developed Countries (LDCs), the petrochemical industry has gained ground where the value added component derived from indigenous hydrocarbon sources are large, entailing in higher returns and higher domestic value added. But, in LDCs, (the reservoirs of petroleum and natural gases), the industry has had a late start.

•In India, as in most LDCs, the government has played a major role in shaping the structure of the petrochemical industry. Initially, the sector was totally protected from foreign competition: and domestic firms were heavily regulated. Based on the rationale of infant industry protection, the government shielded the nascent domestic industry from import competition.

with protection policies such as high tariff rates, quota restrictions apart from an outright ban on the import of certain products.

In the domestic petrochemical industry, the government owned a considerable share through public sector investment, and regulated private companies. The public sector had a monopoly in the manufacture of feedstocks and dominated the production of intermediate petrochemicals. Private companies were predominant in downstream petrochemicals. Regulation consisted of the licensing of (a) the entry of new firms and (b) the capacity expansion of incumbent firms. Licensing was restricted by domestic demand and involved the parceling of the domestic market among firms. The result was a highly concentrated, and oligopolistic industrial structure. With liberalisation, the government has sought to increase competition in the industry. The impact of these policies can be examined through an analysis of the industry's structure.

The structure of an industry is determined by the configuration of firms in that industry and their individual or collective market power. According to traditional industrial organisation taxonomy, the petrochemical industry is an 'homogeneous oligopoly'.[2] Homogeneous because product differentiation is insignificant in the petrochemical industry - being a producer of intermediate, non-branded, homogeneous inputs into other industries. An oligopoly because increasing returns to scale and consequently high scales of operation and high costs of investments results in concentration which is a competition limiting factor.

A priori, scale economies and consequently increasing returns to scale *are* associated with large plant sizes. Therefore, entry to the industry involves high investment costs - a Bainian entry barrier. Since few firms have the wherewithal to enter, the outcome is high concentration. Incumbent firms grow by (a) expanding capacity of the same product or (b) by vertical integration. Both these strategies *are* entry deterring factors

for new firms. Concentration, excess capacities and vertical integration are entry barriers which increases the oligopolistic interdependency of firms and reduces the likelihood of intra-industry competition.

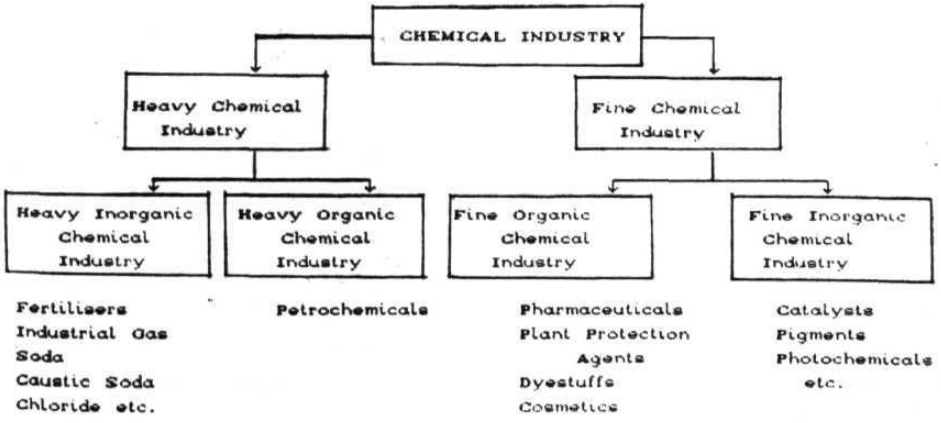
This chapter will trace the growth and development of the petrochemical industry in India before outlining the industry's structure. A brief technical backdrop precedes the analysis, to enable a better understanding of the petrochemical industry.

TECHNICAL BACKGROUND

Petrochemicals are those chemicals which *are* derived from petroleum or natural gas. Although some of these chemicals were earlier derived from coal, our study confines itself to the technical aspects of the manufacture of petrochemicals derived from petroleum. Figure 2.1 illustrates the place of petrochemicals in the larger universe of the chemical industry.

Figure 2.1

Structure of the Chemical Industry



Source:UNIDO/IS/572, p6.

Crude oil or crude petroleum, often called rock oils, predominantly contain hydrocarbons which have to undergo a re-fining process in the first stage of manufacturing. The products produced through the refinery process are normally divided into three broad categories viz., <i) light distillates such as motor oil and petrol, (ii) middle distillates such as diesel and kerosene and (iii) heavy ends such as bitumen, furnace oil and lubricants. The basic raw material for the petrochemical industry called feedstocks *are* of hydrocarbon origin. They are:

(i) Liquid products from petroleum refineries like naphtha, kerosene and cracked Liquid Petroleum Gas (LPG); and

(ii) Products from natural gas fractionisation i.e. C_2, C_3, C_4 fractions and natural gasolene condensates.

The natural gas fractions are:

C - for fertilisers

C_2/C - for petrochemicals

C_3/C_4 for domestic LPG

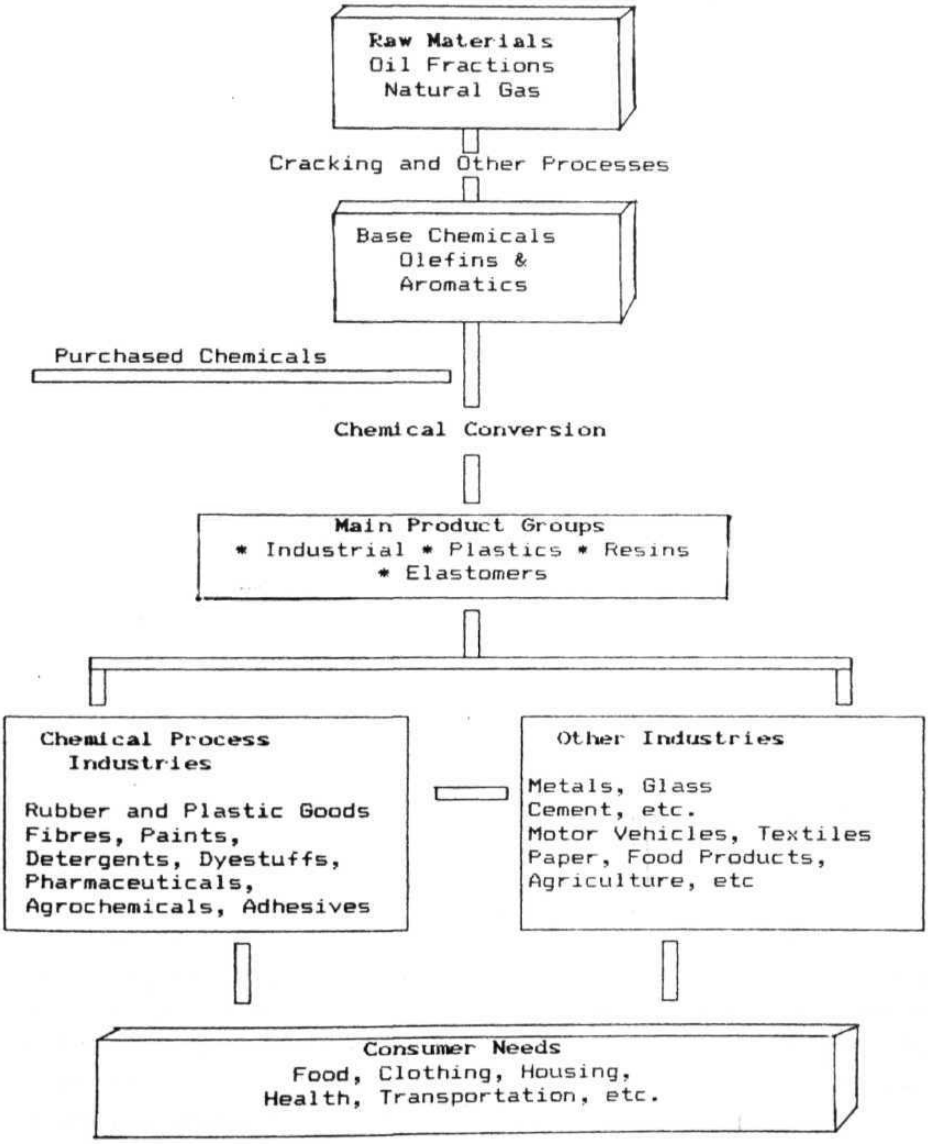
NGL - petrochemicals

(C_2/C fractions for petrochemicals form about 10% of the **total** natural gas).

There *are* three main stages in the chain between raw materials and consumer goods in the petrochemical industry. The first stage involves the manufacture of base chemicals from feedstocks usually on a very large scale. In the second stage, these base petrochemicals *are* converted into a range of intermediate chemicals which *are* inputs into a range of downstream industries. The third stage involves the manufacture of petrochemical end-products which *are* inputs for a variety of end-use manufacturing. The petrochemical industry therefore includes all the three stages i.e. the manufacture of base chemicals, its conversion into main product groups and then to petrochemical end products. Figure 2.2 illustrates this technical process in the petrochemical industry.

Figure 2.2

Production Process in the Petrochemical Industry



Source : Report of the Committee for Perspective Planning of the Petrochemical Industry 1986-2000: Chairman: D.V. Kapur, Department of Chemicals and Petrochemicals, Ministry of Industry, GOI.

Petrochemical units *are* usually elaborate and operate continuously with catalytic promotion and *are* highly automated. Consequently, they require a large scale of operation to secure an economic advantage. Therefore, by their very nature, petrochemical units are very much subject to the consideration of *minimum economic size.* In fact, the question of plant sizes assumes economic significance in any operation where the capital cost of the plant represents a substantial factor in the cost of the finished product. So far as the plant can be operated at its maximum capacity, it is clear that there is an economic incentive to design it on the largest possible scale. In practical terms, there are certain economic limits to the scale of manufacturing operations. One is the mechanical aspects of engineering: beyond certain sizes, some items of equipment are unlikely to be available (and duplication of single items destroys the whole basis of obtaining a benefit from scale). On the other hand, although there *are* engineering limits to scales of operation, plants must also establish a minimum size that can be economically viable.

The most important raw material for producing petrochemicals is naphtha, a by-product of petroleum refining. An alternative is LPG. The two basic processes receiving the feedstocks and manufacturing the primary products *are* the steam cracker[9] for olefin production and the catalytic reforming for aromatics production. The olefin group includes ethylene, propylene and butadiene. The aromatics group consists of benzene, toluene and xylenes.

The liquid fractions *are* reprocessed in the refinery. The yield is in the form of aromatics and green oil which is the ideal feedstock for carbon black manufacturing. From the naphtha fraction the catalytic reformer produces a blending component for the petrol pool. Thus there *are* two main primary product groups - olefins and aromatics.

Steam crackers, for the manufacture of olefins, mostly use naphtha (more than 65%), ethane and LPG (25%) and gas oil (<10%).

Naphtha is "cracked" into base chemicals or petrochemical building blocks. The product mixture from the steam cracker yields ethylene as the main product in the separation process. The ethylene block (which includes ethylene dichloride (ED), ethylene glycol (EG), ethyl benzene, ethylene oxide (EO)) constitute the major intermediate building block in the petrochemical production chain. The other primary products *are* propylene, butylene and butadiene. Propylene and butadiene are by-products of cracker plants and their production depends upon the feedstock. The naphtha cracker produces more propylene and butadiene when compared to gas crackers. Accordingly, to meet the demand of propylene and butadiene from cracker plants, a suitable combination of naphtha crackers and gas crackers *are* necessary unless an alternate route for producing propylene (PP)and butadiene (BTD) namely propane dehydrogenation is feasible."*

/When intermediate petrochemicals *are* converted to either consumer goods or part of raw materials by the addition of different auxiliary materials and a series of chemical conversions they are called downstream products. These downstream products may be broadly classified into two sub-groups - fibres and polymers. These *are* used for the manufacture of various consumer goods and end-use products in a range of industries.

Synthetic fibres include Polyester Filament Yarn (PFY), Polyester Staple Fibre (PSF), Nylon Fibre and Acrylic fibre. The intermediates for synthetic fibre include Di-methyltetraphathalate (DMT), Purified Terephthalic Acid (PTA), Caprolactum (CPL) and Paraxylene (PRX). The polymer group includes elastomers and plastics. The elastomers *are* Styrene Butadiene Rubber (SBR), Butadiene Rubber (BR) and other synthetic rubbers such as Poly Butadiene Rubber (PBR), used for the manufacture of tyres, and rubber material for household, agricultural and industrial applications. Plastics include both thermoplastics and thermosets. The major thermoplastics *are* Low Density Polyethylene <LDPE), Poly Vinyl Chloride (PVC), High Density Polyethylene (HDPE), Polypropylene (PPL), Polystyrene (PS) and ABS Resins. The thermosets, i.e plastic raw materials are PF, UF, MF and CA

Moulding Powders. These plastics have a range of applications in engineering, transportation, communication and agricultural use apart from special uses in space research and electronics. Other petrochemical intermediates both of aromatic and olefin origin are used in the manufacture of synthetic detergents, various industrial solvents and chemicals." The extensive use? of petrochemicals is illustrated in the following table:

Table 2.1
Sectorwise Consumption of Petrochemicals ('000mt)

	80-81	-82	-83	-84	-85	-86	-87	-88	-89	89-90	g (%
Housing & Construction	35	34	36	43	54	60	66	74	84	92	10.15
Agriculture	70	70	83	96	113	133	134	150	156	188	10.38
Transport	57	51	68	75	81	89	90	97	106	119	13.32
Textiles	83	112	157	158	166	204	245	261	321	336	15.01
Industrial Applications	79	80	92	105	118	138	148	165	178	212	10.38
Health Care	6	7	8	9	10	10	12	14	17	20	12.80
Packaging & Household	102	104	120	130	144	157	151	180	202	227	8.33
TOTAL	432	458	564	616	686	791	846	944	1064	1194	10.70

Source: Expert's Group on Petrochemicals [1993].
g:— compound growth rate.

The above table shows that the petrochemical industry is an important supplier of intermediate inputs into a whole range of industries and there has been an increase in its use.

GROWTH AND DEVELOPMENT OF THE INDIAN PETROCHEMICAL INDUSTRY

Though the manufacture of polystyrene commenced in 1957, it was not until the late 1960s that the petrochemical industry made headway in India. Union Carbide (India) Ltd. (UCIL) commissioned a small 20,000 tpa naphtha based ethylene cracker followed by a 60,000 tpa one by National Organic Chemicals Limited (NOCIL). Both UCIL and NOCIL were established by the private sector with foreign equity holding. These two firms provided the initial thrust to the industry but the industry's growth was hampered by modest plant sizes and the licensing restrictions of the regulated regime. It was not until the first world-capacity cracker

(established by the? Indian Petrochemical Company Ltd. (1PCL) at Vadodara), became operational in 1978-7? did the petrochemical industry in India take off.

The petrochemical industry is not only a very young industry in India but also per capita consumption of its products is one of the lowest in the world.[6] The late and restricted development of the Indian petrochemical industry was partly because the petroleum refining industry in India had not taken off and partly because of the tight balance of payments situation in the mid-1960s. In addition, the petrochemical industry did not call for a high priority since consumer goods derived from petrochemicals were not part of the consumption basket for the bulk of the population. And, since 25% to 40% of the variable inputs in petrochemicals are energy inputs, there were serious doubts about promoting an industry that was both capital and energy intensive in a capital and energy-scarce country like India.

The development of the petrochemical industry has been in consonance with government policy. In the initial period, the industry grew in a protected environment with output constrained by capacity licensing. In this case, investors interpreted the granting of a licence as a protection against over supply. Therefore output depended on government demand projections. Consequently the petrochemical industry became a seller's market for a variety of reasons. For example, demand could be underestimated, or there would be a lag between licences cleared and the commencement of production. In addition, the licence raj enabled established producers to lobby against the granting of licences to new entrants. The seller's market thus created a situation where there was little incentive to produce at optimal size, develop an export market or innovate since the domestic market absorbed all supply. Plants put up as recently as 1980s too were built to cater to domestic demand and they were tiny by world standards. And coupled with the small sizes, high capital & energy costs, foreign exchange shortages and high customs duty on machinery and inputs resulted in a high cost of production making Indian manufacturing incompetitive.

Petrochemical industry gathered momentum in the 1970s due to three major developments. Firstly, on the supply side, the domestic production of hydrocarbons increased substantially with the development of petroleum refineries in the country. The by-products of crude oil refining, the feedstocks for the production of petrochemicals gradually replaced chemicals produced from coal. As the country's crude oil output stepped up, the petrochemical industry was given a boost by the government in order to mop up the by-product naphtha in petroleum refining Later, with the discovery of natural gas at Bombay High and High Bassein and the construction of the Hazira-Bijapur-Jagdishpur (HBJ) pipeline gas became the alternative feedstock for the petrochemical industry. In addition, the extraction of naphtha from gas was more cost effective than naphtha from crude which was mostly imported. The government began to promote the use of gas not only for fertiliser production but also for power generation and petrochemicals. In 1985, after a clear feedstock picture had emerged from the Bombay High gas fields, a 300,000 tpa gas-based cracker at Nagothane was planned. The decision to go ahead with this complex amidst world-wide recession, was in response to growing domestic demand.

Secondly, on the demand side, the use of consumer and intermediate petrochemical products progressively gained favour on account of economic and functional efficiency. And thirdly, synthetic products increasingly became a part of the consumption basket for a large section of the population. The availability of a wide range of petrochemical products created a burgeoning market for plastics, synthetic fabrics, synthetic rubber, synthetic detergents and a host of other products;/ Tables 2.2 provide the growth rate of consumption of selected petrochemicals in the country.

Table 2.2
Growth Rates in Consumption of Selected Petrochemicals (%)

Products	1964-65 to 1969-70	1969-70 to 1974-75	1974-75 to 1979-80	1979-80 to 1984-85	1984-85 to 1990-91
Polymers: (Total)	22.8	8.7	16.3	11.7	12.9
LDPE/LLDPE	15.5	6.5	21.3	11.5	7.9
HDPE	43.7	21.5	16.5	7.5	13.4
PP	35.0	-	119.0	19.0	28.0
PVC	27.1	6.9	11.3	13.8	11.3
PS	12.8	2.0	4.4	9.6	14.7
Synthetic Rubber		1.4*	11.8	9.0	7.1
Synthetic **Fibres: (Total)**			28.2	15.0	18.0
NFY			10.8	11.0	3.3
AF			51.7	29.9	14.5
PSF			32.0	4.6	19.1
PFY*			70.1	26.4	24.0
PSF+PFY			40.1	14.2	22.1

Source: Sengupta Report [1992] & Expert's Group Report on Petrochemicals [1993].
- : Figure for the years 1965-66 to 1974-75.
: PFY is also broadbanded.

The high growth rates in the petrochemical industry have been accompanied by a structural change that has implications for the public/private mix of investments, the scale of operation and the nature of competition. The following table provides an overall view of the industry at the end of the Sixth and Seventh Plans.

Table 2.3
Indian Petrochemical Industry

	End of VI Plan	End of VII Plan
Investment (Rs mn) (in 1986 prices)	28980	80210
Public	8860 (31%)	27760 (35%)
Private	20120 (69%)	52450 (65%)
Capacity ('000mt)	1258.7	2901.9
Public	672.8 (53%)	1435.5 (49%)
Private	585.9 (47%)	1466.4 (51%)
Consumption ('000mt)	1575.5	3043.4
Feedstock	Naphtha	Naphtha/Gas,
Scale (Index ethylene) (mta)	130000	300000
Major complexes	2	3
Technology	Lag	Contemporary
End Users	Predominantly (Over 90%) in Small Scale Industries.	
Market Competition	Limited	Intensive

Source: Planning Commission cited in Doshi [1989].

All the standard indicators of growth such as investment, capacity and consumption have increased substantially in the VII Plan period. On the technology front, there was a shift in basic feedstocks from naphtha to gas based plants. This was part of a policy to use gas from the HBJ pipeline and Bombay High as well as upgrading technology. And, concomitant to technology upgradation, scales of operation has increased substantially. For example, for ethylene, plant size increased from 130,000 tpa <capacity) to 300,000 tpa.

However, what is interesting is the mix of private and public investment. The private sector presence in the petrochemical industry (in terms of capacity) was 47% in the Sixth Plan period and it increased to 51% during the Seventh Plan thus, overtaking public sector capacity. Absolute investment in the private sector is also substantially greater. In terms of total investment, the public sector constituted between 31 - 35% of the total investment in the VI and VII Plans. However, this investment is significant for two reasons: (a) the bulk of the

investment is in the IPCL which is a large integrated complex (the largest in India) and dominates the petrochemical scenario in the country and (b) the public sector has near-monopoly control over basic feedstocks. The private sector's stronghold is in downstream units.

Thus, both private and public sector ownership thrives in most phases of petrochemical manufacture. The only phase that was completely in the public sector was the manufacture of feedstocks. With the opening up of the refining sector to the private sector, this will no longer be the monopoly of the public sector. However, the public sector is the leader in the production of feedstocks and synthetic resins. In other sub-sectors such as synthetic fibres, rubbers and detergents, private sector participation is much higher than in the synthetic resins sector. As much as 70% of the aggregate production of fibres, rubbers and detergents is already in the hands of the private sector [Vergara & Babelon 1990:25].

A look at the top 10 petrochemical companies show that five are in the public sector and five in the private. IPCL is clearly the largest company. And it is also the most diversified. It manufactures a total of 18 petrochemicals while IOC and Bharat Petroleum manufacture benzene and toluene which are basic inputs. The private companies *are* more specialised, and operate in downstream industries.

Table 2.4
Top Ten Petrochemical Companies
(Ranked in Terms of Total Production)

(1990-91)

	Company		Output (mt)	Output (%)	No.of Products
1.	IPCL	(PS)	563,145	22.85	17
2.	Reliance		439,987	17.85	5
3.	NOCIL		260,470	10.75	12
4.	Cochin Refineries	(PS)	76,820	3.12	2
5.	T.N. Petrochemicals		76,204	3.09	1
6.	Bongaigon Refinery	(PS)	73,335	2.98	4
7.	Bharat Petroleum	(PS)	68,426	2.78	1
8.	IOC	(PS)	60,884	2.47	2
9.	Bombay Dyeing		60,081	2.44	1
10.	Chemplast		49,556	2.01	2
	Total for 10 Companies		1,881,089	76.33	

Source: Compiled from Company-wise Production of Petrochemicals (1983-84 to 1990-91), Monitoring and Evaluation (Petrochemicals) Section, Department of Chemicals and Petrochemicals, GOI.
Note: (PS) :- Public Sector Companies.

With burgeoning demand for petrochemical based goods, supply was also boosted with the ready availability of gas which provided an alternative to naphtha based feedstocks. In the 1970s and 1980s, it became a status symbol for local governments to establish a naphtha or gas cracker plant in their states. The state governments of Gujarat, Rajasthan, Punjab, Haryana, Madhya Pradesh and Uttar Pradesh joined the fray with West Bengal, Andhra Pradesh, Karnataka and Tamil Nadu for petrochemical projects in their states. In addition, many top industrial houses started entering the industry for the first time or decided on backward integration into the petrochemical industry. The establishment of petrochemical projects became a symbol of progress akin to the steel complexes in the early years of post-independence industrialisation. The only difference now was that the private sector was as interested in investing in petrochemicals as the public sector despite the high cost of investment and the long gestation lags. The following table indicates the spurt projected investments in the recent past.

Table 2.5
Major Petrochemical Investments Envisaged

	Name of the Project	Approx. Investment (Rs. Crs>
1.	Gandhar (IPCL)	2290
2.	Vizag <UB)	2400
3.	Auriya (GAIL)	2500
4.	NOCIL (expansion)	2000
5.	Haldia (Tata)	2600
6.	VAM Organics	1540
7.	Salimpur (J.K.)	1500
8.	Mangalore (Birla)	1540
9.	Hazira (RPL)	3000
10.	RIL (PTA)	800
11.	RPG (LINDE)	840
12.	Napco (Aromatics)	840
13.	IPCL (Engineering Plastics)	500
14.	GSFC (Caprolacturn)	400
15.	JCT (Caprolactum)	300
16.	HLL	300
17.	U.B.(Butyl Rubber)	350
18.	Finolex (PVC)	320
19.	ICI (Acrylic)	300
20.	JCT (MEG)	400
21.	Modi (Caprolactum)	450
22.	Deepak	400
23.	FACT	212
24.	Harrison	275
25.	S.N. Dyechem	275
26.	Nirma	300
	TOTAL	26632

Source: Expert's Group Report on Petrochemicals [1993].

The petrochemical industry in India is clearly a booming industry: its growth in the 1980s and early 1990s as been tremendous in terms of capacity expansions, output and consumption. The Indian petrochemical industry registered significant growth in a protected environment during a period of world-wide recession. Given the trend of the economy towards liberalisation, it becomes important to see this growth in the context of international markets.

In a comparative study of the petrochemical industry in six Asian countries including India, Vergara & Babelon [1990] pinpoint the following features of the Indian situation:

(a) Lowest per capita user,
(b) Large importer of intermediates and resins,
(c) Moderate to high growth rates,
(d) Large expansions under consideration,

<e> About to start the use of gas, and
(f> Limited feedstock availability. (Gas is not in surplus and India is expected to be a naphtha importer in the long run). CTheir sample included Korea, India, China, Thailand, Malaysia and Indonesia.]

The largest impediment to India's competitiveness say Vergara and Babelon, are supply factors that have been critically dependent on (a) feedstock availability & price, (b) scale and capital cost and (c) location in relation to market. This resulted in a high cost structure for petrochemicals.

Supply Factors

In India, the petrochemical industry started with the intention of mopping up naphtha by-products from petroleum refining. But high growth rates of consumption especially in the 1980s led to chronic shortages in building blocks and downstream products which slowed down market development. Burgeoning demand, coupled with a relatively high import resistance resulting from high protection rates and import restrictions led to a high price structure. The following table illustrates the price difference of international and domestic prices in selected petrochemicals in 1992. The difference is large despite the decrease in tariff rates in the 1993-94 budget.

Table 2.6

Tariff Protection for Some Key Petrochemicals

(1993)

Product	c.i.f. Price $/mt	Rs./mt	Domestic Price	Nominal Protection	Current Tariff Rates (%)
Fibre and Fibre Intermediates:					
DMT	530	16430	32000	1.95	70
PTA	520	16120	32500	2.02	70
PSF	1120	64720	66000	1.90	85
POY	1950	60450	75000	1.24	85
AF	1800	55800	94000	1.68	85
NFY	4500	139500	134000	0.96	85
Plastics & Raw Materials:					
LDPE	760	23560	36000	1.53	65
LLDPE	680	21080	32500	1.54	65
HOPE	540	16740	29000	1.73	65
PP	500	15500	31000	2.00	75
PVC	530	16430	24500	1.49	45
PS	620	19220	42000	2.18	55
Others:					
OX	390	12090	24500	2.03	40
Benzene	300	9300	14900	1.60	15
LAB	700	21700	34750	1.60	85
PRX	390	12090	25600	2.12	40
MEG	360	24000	11160	2.15	70
ACN	660	20460	36000	1.76	70
Caprolactum	1300	40300	61500	1.53	60

Source: Expert's Group Report on Petrochemicals [1993]
Note: Tariffs prevailing as on 1.3.1993;
US * = Rs.31/-: prices prevailing in December 1992.

Supply factors are manifested in the cost differentials of petrochemicals. These cost differentials are due to (a) conversion costs and (b) cost of inputs. Even if tariff reductions ensure that inputs *are* available at 'international' prices, conversion costs that hinge on technology and scales of operation hamper the competitiveness of Indian industry.

The cost differential due to technology hinges upon the source of feedstock i.e. crude oil or gas. OPEC induced changes in feedstock prices in the 1970s have provided a competitive edge to natural gas based plants in the US to the detriment of naphtha

based facilities in Europe. Added to this was the setting up of new gas based plants with extremely low feedstock costs in the Middle East and Canada, which sharpened world wide competition. (For example in Saudi Arabia, LPG is supplied at zero cost to petrochemical firms since the alternative is to flare the gas). This led to major production shifts wherein there was a general scramble towards the high technology downstream parts of the business. A classic example is of Japan which stopped manufacture of ethylene and shxfted to more complex downstream petrochemicals.

The other aspect of conversion costs rests on the scale of operation in firms. The plant sizes of Indian firms do not compare with foreign giants even in LDCs as the following table indicates.

Table 2.7
Global Trends in Petrochemical Plant Sizes
(Plant Sizes in '000 mta)

Product	Developed (US WE,Far East) (1)	Middle East (2)	SE Asia (3)	India (4)
Ethylene	300-700	100-700	100-300	100-300*
Polyethylene	60-300	60-400	60-150	
EO/EG	80-300	80-150	50-200	21
PP	40-300	50-200	40-140	2-90
VCM	100-500	150-300	150-200	
PVC	30-200	60-300	20-40	4-55
Styrene	80-300	100-300	60-80	
PS	10-70	20-80	10-30	16-18
DMT/PTA	30-350	60-70	20-400	3-100
Caprolactum	100-120	50	-	20-50
LAB	30-70	50	-	43-75
PSF/PFY	20-80	10	5-100	2-25
ACN	50-180	50-80	25-50	
PBR/SBR	20-40	20-40	80	6-20

Source: Col.(l) - (3): Expert's Group Report on Petrochemicals [19933.
Col.(4): Compiled from CMIE [1993] Market and Market Shares.

*: MES of 300,000 tonnes has been stipulated and two firms are planning on expanding capacity to reach this level.

Plant sizes in India are not even comparable to those in South East Asia (apart from exceptions like ethylene and PVC) and

they are far smaller than those in the Middle East and the Developed world. In an industry where scale (i.e. plant sizes) is linked to costs and therefore efficiency, small sizes hinder the competitiveness of Indian firms in international markets.

The international competitiveness of products is evaluated by examining its Domestic Resource Cost (DRC).[12] DRC estimates for petrochemical products in India by three separate studies are provided in the following table.

Table 2.8
DRC Estimates for Petrochemicals

Product	Kelkar/ BICP Study 1984-88	Sengupta Study 1991-92	Kadekodi Study 1992-93	Scale Factor ('000 tpa) Existing Domestic	Scale Factor ('000 tpa) Existing Int'l	Nominal Tariffs (%) 1993 94
LDPE	0.40 to 0.97	0.567 to 0.655	0.693 to 0.748	80	100	65
HDPE	0.37	0.482 to 0.597	1.144	80	100	65
PP	0.54 to 4.50	0.498	1.026	60	100	75
Benzene	1.71	0.421	0.654	24	100	15
PRX	6.87	0.546	1.545	49	100	40
PBR	2.7	-	-	20	25	40
SBR	2.44 to 2.94	-	-	80	100	40
PSF	1.14 to 2.41	-	-	60	60	85
NFY	2.45	-	-	25	25	85
PFY	1.32 to 1.64		-	25	25	85

Source: Kadekodi [1993], Domestic Resource Costs (DRCs) of Petrochemicals cited in Expert's 8roup on Petrochemicals [1993].

The BICP estimates *are* based on the cost-price data during 1984-88 and for the scales of operation that existed then.[13] Their study observes that while thermoplastics (except for polypropylene) were competitive, other petrochemicals such as benzene, paraxylene, synthetic rubbers and fibers were not. The low domestic value added in these products were due to high costs of domestic feedstocks and uneconomical conversion rates due to small size.

Later studies by Sengupta and Kadekodi also examined the competitiveness of the Indian petrochemical industry through DRC estimates. Sengupta's estimates suggest that India has the potential to become competitive in almost all olefins including MEG, PS & PVC except, perhaps, for ACN. And also aromatics including caprolactum, except for PTA. His study reveals that in the long run, the gas route can also become an efficient substitute for naphtha as the basic feedstock, provided gas price is linked to fuel oil and not naphtha.

Kadekodi's estimates'[5] indicate that DRCs for HDPE, PP, Paraxylene and DMT are not efficient. He attributes this inefficieny to two factors: (a) uneconomic sizes of plants and (b> dumping prices of these products.

The short-run estimates of DRC by Kadekodi and that of Sengupta for the long run suggest good investment prospects in India for almost all segments of the petrochemical sector, provided, (a) tariff structures on raw materials and capital goods are brought down except for only those products such as ACN, PTA DMT & paraxylene, <b> prospects for economies of scale are explored, (c) dumping prices are watched, (d) yas pricing is linked to fuel oil.

Demand Factors

On the demand side, petrochemcial firms *are* constrained by (a) domestic demand and <b) world market. If domestic demand does not support efficient sized firms, the companies would have to export. The constraints are that: (a) excess capacities exist in

the West, and <b) the oligopolistic nature of the world petrochemcial industry employs deterring strategies similar to those employed by incumbent Indian firms in the domestic market.

The world petrochemical industry is dominated by huge transnational companies predominantly of Western origin. The USA is the largest producer of petrochemicals followed by Japan, a distant second, and Western Europe. The major companies are: DuPont, Dow and Union Carbide in the United States; Bayer, BASF and Hoechst in West Germany; Phone-Poulenc in France; ICI in the U.K.; Sumitomo, Mitsubishi and Mitsui in Japan; DSM in the Netherlands and Ciba-Geigy in Switzerland [Gray & Walter 1991:112].

In the developing world, the major petrochemical manufacturers *are* Brazil, Mexico, Saudi Arabia and Taiwan. While oil producing countries like Saudi Arabia and Mexico produce the major building blocks such as ethylene, propylene and benzene, oil importing LDCs like Korea and Taiwan import the feedstocks and specialise in the manufacture of plastics and man-made fibres.

International trade and investment have played a major role in the petrochemical industry. Trade flows run across the entire chemical spectrum ranging from primary petrochemicals like ethylene to downstream products like PVC. Upstream manufacturing is concentrated on 'world scale' plants located in close proximity to feedstock sources. Downstream manufacturing, on thp other hand has been highly dependent on assured access to markets. Trade volume has exceeded $100 b. in recent years with heavy concentration of trade between Organisation for Economic Cooperation and Development (OECD) countries. At the same time a number of LDCs have been promoting the growth of their own petrochemicals leading to major changes in production and trade patterns [Gray & Walter 1991:112].

An important characteristic of the world petrochemical market has been the highly volatile nature of prices. These wide fluctuations are illustrated in the following table:

Table 2.9
International Spot Prices of Petrochemicals: 1986 to June 199:
(FOB US, Gulf, NWE in US *)

Product	High	Low	Normal	Deviation From		From Normal To
Ethylene	660	270	400	-32	to	+65
Propylene	1050	525	600	-12	to	+75
Butadiene	600	160	200	-20	to	+200
Benzene	750	260	390	-26	to	+115
Orthoxylene	650	250	380	-70	to	+117
Methanol	280	50	120	-58	to	+ 133
LDPE	1500	600	720	-14	to	+114
HDPE	1400	570	560	-29	to	+75
PP	1450	440	680	-37	to	+107
PVC	1300	400	540	-20	to	+160
PS	1700	600	660	-33	to	+89
Paraxylene	915	320	380	-11	to	+164
DMT	900	400	510	-12	to	+18
PTA	800	435	520	-21	to	+45
MEG	1850	275	340	-21	to	+82
ACN	1000	440	690	-20	to	+82
Caprolactum	2000	1200	1380	-27	to	+21
PSF	1850	950	1160	-10	to	+76
PFY	2300	1275	550	-29	to	+28
AF	1820	1300	1760	-19	to	+14
NFY	5250	3500	3310	-18	to	+24

Source: Expert's Group Report on Petrochemicals [1993].

Apart from demand pull factors pushing up prices, the high production costs of petrochemical manufacturing ensured that domestic prices remain high. These high production costs were a result of both high capital costs and small scale of production when compared to global trends.*[0] Table 2.10 provides the comparison of cost of production for four synthetic fibres.

Table 2.10
Comparison of Production Cost of Synthetic Fibres

(1992)

Product	India	LDCs	DCs.	Price Difference
PFY (Capacity: 20,000 tpa)				
Raw Materials	52.52	24.52	24.52	Higher by:
Manufacturing Costs	14.00	6.00	6.00	
Depreciation	16.93	10.74	9.98	91.25% - LDCs
Total Rs/Kg	99.45	52.00	50.48	97.01% - DCs
Total $/Kg	3.23	1.73	1.66	
NFY (Capacity: 12,000 tpa)				
Raw Materials	92.37	49.08	49.08	Higher by:
Manufacturing Costs	16.34	7.00	7.00	
Interest	17.96	12.67	11.88	78.927. - LDCs
Depreciation	19.00	12.67	11.88	82.917. - DCs
Total Rs/Kg	145.67	81.42	79.64	
Total $/Kg	4.66	2.71	2.66	
PSF (Capacity: 60,000 tpa)				
Raw Materials	52.52	24.52	24.52	Higher by:
Manufacturing Costs	6.50	3.50	3.50	
Interest	6.13	4.12	3.80	97.577. - LDCs
Depreciation	6.49	4.12	3.80	101.127. - DCs
Total Rs/Kg	71.64	36.26	35.62	
Total $/Kg	2.39	1.21	1.19	
ASF (Capacity: 15,000 tpa)				
Raw Materials	37.71	21.75	21.75	Higher by:
Manufacturing Costs	6.87	2.77	2.77	
Interest	9.10	6.08	5.70	72.607. - LDCs
Depreciation	9.63	6.08	5.70	76.257. - DCs
Total Rs/Kg	63.31	36.68	35.92	
Total $/Kg	2.11	1.22	1.20	

Source: Study Commissioned by DCPC in 1992 cited in Expert's Group on Petrochemicals [19933.
Note: Figures in *V. are* from RIL Data Base cited in Expert's Group on Petrochemicals [1993].
Conversion at LERMs of Rs. 30/- = US $.

Indian costs for synthetic fibres *are* greater than that of DCs and even that of other LDCs. Table 2.11 provides a more detailed cost structure of a typical secondary level chemical plant.

Table 2.11

Typical example of a Secondary Level Petrochemical Plant
(Estimates Project Cost at 1992 levels)

US $ = Rs.30/-

Particulars	Indian Cost (Rs.Lakhs) (a)	International Norms (b)
Land & Development[1]	108.82	108.82
Civil Works[2]	1341.26	1117.7
Plant & Machinery:[3]		
Imported:	2046.42	1056.68
Indigenous:	5031.00	4042.80
Technical Knowhow:[4]	1444.80	746.43
Detailed Engineering[5]	341.12	757.67
Technical Assistance	231.95	110.05
Misc. Fixed Assets	310.50	220.60
Pre-Operative Exp.	1184.55	645.24
Margin Money	479.95	228.00
Total	12520.37 (39% higher)	9016.00
Sources:		
Equity[6]	4444.0	4508.00
Debts (FC/Rs Loan)	8076.37	4508.00
TOTAL	12520.37	9016.00
Interest on term/FC[7]	1696.37	351.00
Depreciation	1190.00	603.06

Source: UB Group Data Bank cited in Expert's group on Petrochemicals [1993].

Notes: All the above figures *are* for comparative purposes only and should not be taken on their face value.
(a) is based on an actual plant in India.
(b) is based on a quotation received from the technology licences for a plant in South East Asia.

(1) Since data is site specific, for comparison purposes, the same figures have been used.

(2) Indian costs *are* about 20% higher on account of higher cost of building material.

(3) The total Indian cost of plant and machinery is around 40% higher due to 55% import duty and freight cost on imported goods.

(4) Indian costs are around 50% higher considering the 35% tax on know-how fees and the higher charges for expatriate assistance.

(5) Detail engineering costs in India *are* only around 50% of international costs.

(6) Projects in India have a higher debt/Equity ratio on account of the stipulated 20-25% promoter's contribution in project financing.

(7) Indian costs *are* much higher on account of high interest rates on term loans and working capital loans.

Economies of scale play a significant role in the economic viability and profitability of a petrochemical plant. Small-scale plants can cater to domestic demand only in highly protected markets. Tariff rates are thereby linked to the specification of minimum economic scale. However, in a liberalising economy, scale economies gain prominence because of the growing competitiveness in industry. Large scales of production become a pre-requisite both to withstand competitive imports and to enter export markets. Increasing liberalisation in Indian industry led to large expansions of capacities. The initial policy changes stipulated a minimum size that was far greater than average plant sizes so firms were encouraged to expand existing capacities to *MES*. Later, with delicensing of the industry and anticipation of enormous growth in demand (i.e. domestic demand), firms planned for large-scale capacity expansion. The following table illustrates the proposed capacity expansions in the Indian petrochemical industry.

Table 2.12
Installed Capacity of Select Petrochemicals: Existing and Proposed

Product	Installed Capacity (Existing Plants) (1)	Capacity on going Projects (2)	Additional Capacity Approved (3)	Capacity of Proposed Projects Yet to be Approved (4)	Total Capacity <5>	% rise (6)
1. Ethylene	604	346	1404	850	3204	430.46
2. Propylene	313	192	456	338	1299	315.01
3. Butadiene	67	50	129	143.4	389.4	481.19
4. LDPE/LLDPE	201.8	180	75	340	796.8	294.85
5. HDPE	55	180	80	360	675	1127.27
6. PP	121	100	225	350	796	557.85
7. PVC	192	200	150	200	742	286.46
8. Polystrene	20	40	176	0	236	1080.00
9. Styrene	37	80	262	0	379	924.32
10. SBR	80	80	67	0	227	183.75
11. PBR	20	0	0	80	100	400.00
12. LAB	163.5	40	240	0	443.5	171.25
13. Alfa Olefin	0	0	135	0	135	
14. DMT	141	40	0	0	181	28.37
15. PTA	150	50	400	0	600	300.00
16. Caprolactum	20	100	200	0	320	1500.00
17. EO	41	0	14	0	55	34.15
18. EG	100	180	215	100	595	495.00
19. ACN	24	70	0	70	164	583.33
20. Paraxylene	214	0	272	0	486	127.10
21. Orthoxylene	55	0	60	0	115	109.09
22. Benzene	308.2	0	238.42	65.5	612.12	98.61
23. Toluene	56.85	0	9.35	0	66.2	16.45

Source: Compiled from Sengupta Committee (Interim Report) [1990].

Large capacity expansions have taken place in the Indian petrochemical industry and further expansion is being proposed by many firms. While initial capacity expansions were geared to cater to domestic demand, it is possible that a problem of excess capacity would arise in a liberalised economy. It is however the excess capacities that individual firms build up that are instrumental in shaping the structure of the industry which provides the playing field for firm behaviour. And an analysis of this structure enables us to study the possible outcome of liberalising the petrochemical industry in India. The following section will therefore outline the structure of the Indian Petrochemical industry.

INDUSTRIAL STRUCTURE

Two interlinked factors have moulded the growth and development of the petrochemical industry in India. These are:

(a) The nature and form of government intervention, and

(b) The structure of the industry

Government intervention includes its regulatory role as well as its role as a producer of petrochemicals in the public sector. The structure of the industry rests largely on:

<1) Government policy,

(2) The intrinsic characteristics of the industry, and

(3) Firm strategies.

While government intervention in the restricted regime wrought several artificial entry barriers both to regulate capacity build-up and expansion in the domestic industry, and to regulate trade, especially, imports. In the liberalisation era, these artificial barriers have been brought down in two ways: (a) by domestic liberalisation policies which have delicensed industries and have facilitated the entry of new firms as well as capacity expansions of incumbent firms and subscribed minimum economic scales of operation; and (b) trade liberalisation which has meant the gradual lowering of tariff barriers. In order to examine the implications of these liberal policies on the structure of the industry, one has to take into account the intrinsic characteristics of the petrochemical industry.

The most significant characteristic of the petrochemical industry is that of increasing returns to scale. This directs that optimal firms be large which, in turn, implies high investment costs (of both entry and expansion). When optimal plant sizes *are* large (especially when compared to demand in a still restricted domestic market), there is a tendency for a build up of a concentrated market. A concentrated market can impede competition as well as entry

The onslaught of liberal industrial policy, especially delicensing and the specifications of *MES* (*MES* is large compared to the average installed capacity of domestic firms and not international plant sizes), has the following implications for

firm behaviour or strategies. Entrant firms must build large (*MES*) capacities and build integrated complexes. Incumbent firms expand to *MES* (at least) and create capacities in allied products and thereby integrate vertically. Therefore, government intervention and the removal of artificial entry barriers shape firm behaviour in a concentrated market. This includes vertical integration and capacity build-up. The following section will analyse the structural determinants of the petrochemical industry by examining concentration, and the nature of capacity expansions notably vertical integration and excess capacity build-up.

Structural Determinants

The petrochemical industry, the supplier of intermediate inputs to end-use manufacturers is a homogeneous oligopoly. The classification is determined by the significance of product differentiation, scale and concentration in an industry. In the petrochemical industry, there are no brand names and therefore, product differentiation in the conventional use of the term does not exist. That leaves scale and concentration as the most significant determinants of industrial or market structure in the petrochemical industry.

The petrochemical industry has high costs of investments and is one of increasing returns where economies of scale play a significant role. This ensures that firms *are* large and subject to demand conditions, limit the extent of competition possible in an industry. Empirical work in industrial organisation is replete with examples of collusive oligopolies where firms charge high prices and obtain excess profits.

The structure of the petrochemical industry is determined by examining the following characteristics of the industry:

(a) Concentration,
(b) Vertical integration, and
(c) Scale of operation

These factors deal with the supply aspect of the industry. Assumptions about demand underlie this way of looking at industrial structure. If domestic demand constraints *are*

significant or likely to plateau, domestic industry has two options. Firstly, the firm's ability to compete in the international market and export gains importance. In this context, the domestic industry will have to simulate an industrial structure similar to those found in other petrochemical producing countries, and find an export niche. Secondly, in an autarkic situation, demand constraints will lead to market share rivalry. In either case, changes take place in the industry's structure.

(a) Concentration

The concentration of an industry is, the extent to which a small number of firms achieve a dimension of economic power in an industry. Industry concentration is an important determinant of the nature of competition in an industry. Perfect competition is one extreme where firms are small in number in relation to the size of the total market so they cannot influence prices individually. In this case concentration is low. The other extreme is a monopoly where there is a single seller and concentration is absolute. In most industries, the situation is in between.

A bird's eye view of the configuration of firms in the petrochemical industry provides an indication of the extent of concentration. In an increasing returns industry, the optimal scale of operation restricts the number of firms in an industry. Consequently, firms sizes are large and there is a tendency for high concentration to build up. The following table illustrates the number and size distribution of firms for select petrochemical products in 1990-91.

Table 2.13
Number and Size Distribution of Firms (1991-92)

product	# of Units	Range of Installed Capacity (tpa)	Top 4 Firms	Market Share (%)
Synthetic Fibres:				
1. VFY	8	19,200 - 4,200	Century Textiles & Ind. Ltd.	24.9
			Indian rayon	22.9
			National Rayon	19.3
			Kesoram Industries	10.8
2. VSF	5	1,55,125 - 2,250	Grasim Industries	90.0
			South India Viscose	9.9
3. NFY	13	29,600 - 2,000	JCT Ltd.	16.2
			Modipon Ltd.	15.8
			Baroda rayon	12.5
			Garware Nylons	11.1
4. PFY	19	25,125 - 2,000	Reliance Ind.	27.6
			Century Enka	9.6
			DCL Polyesters	9.0
			Petrofils Co-op	7.2
5. PPFY	7	2,750 - 500	Rajasthan Petro-Synthetics	46.8
			Parasrampuria Synthetics	14.1
			Guj. Filaments	8.8
			Alembic Chem. Works	4.9
6. PSF	10	45,000 - 7,968	Reliance Ind.	40.0
			ICI India Ltd.	12.6
			IOC Ltd.	7.9
			Bongaigon Refinery & Petrochemicals Ltd.	7.5
7. PPSF	4	4,300	Alembic Chem. Works	86.0
8. ASF	7	24,000 - 12,000	J.K. Synthetics	94.0
			GTM Synthetics	3.9
			APM Industries	1.0
			Sharman Woollen Mills	0.7
9. RTY	3	7,000 - 4,900	DCM Shriram Ind.	50.3
			Century Textiles	49.7
			National Rayon	NA
10. NTY	7	14,660 - 1,700	SRF Ltd.	24.9
			J.K. Synthetics	18.3
			Century Enka	17.3
			National rayon	14.3

Polymers, Plasticisers & Elastomers:

product	# of Units	Range of Installed Capacity (tpa)	Top 4 Firms (Market Share '/.)	
1. LDPE	2	1,60,000 - 13,000	IPCl	89.5
			Bindal Agro Chem.	10.5
2. HDPE	1	50,000	Polyolefins Ind.	100.0
3. PP	2	90,000 - 2,500	IPCL	99.4
			Polyolefins Ind.	0.6
4. PVC	9	55,000 - 4,500	Chemplast	29.8
			IPCL	27.4
			DCM Shriram Con. Ltd.	22.5
			DCW Ltd.	16.2
5. PS	2	18,000 - 16,000	McDowell & Co. Ltd.	54.9
			Polychem Ltd.	45.1
6. ABS	3	14,600 - 1,686	ABS Ind. Ltd.	77.5
			Polychem Ltd.	20.7
			Guj. Binil	1.8
7. PMM	1	3,500	GSFC	100.0
8. ACN	1	25,973	IPCL	100.0
9. PM	2	500 - 330	Century Enka	100.0
			Garware Nylons	NA
10. Expanded Polystyrene	4	3,100 - 362	BASF India Ltd.	38.6
			McDowell ltd.	35.3
			Beardsell	25.8
			Camphor & Allied Products	0.2
11. Elastomers (Synthetic Rubbers)	4	20,000 - 6,250	IPCL	82.3
			APAR Ltd.	14.1
			Guj. Apar Polymers	3.4
			Synthetics & Chemicals Ltd.	NA
12. VAM	3	20,000 - 10,000	VAM Organic Ltd.	68.3
			Polychem Ltd.	31.5
			Gujchem Distilleries	Neg.

Other Inter-mediate Petrochemicals:

product	# of Units	Range of Installed Capacity (tpa)	Top 4 Firms (Market Share %)	
1. Styrene	4	17,500 - 900	McDowell & Co Ltd.	62.4
			Po lyc hem	37.6
			Herdillia Chemicals	NA
			Synthetics ft Chemicals Ltd.	NA
2. LAB	3	75,000 - 43,500	T.N. Petroproducts	45.1
			Reliance Industries	31.7
			IPCL	23.2
3. Ethylene Glycol				
	5	21,500 - 750	India Glycols Ltd.	62.9
			IPCL	25.9
			Reliance Industries	10.8
			Ganesh Benzoplast Ltd	0.5
4. Xylenes	2	49,000 - 35,000	IPCL	84.2
			Bongaigon Refinery & Petrochemicals Ltd.	15.8
5. PTA	1	1,00,000	Reliance Industries	100.0
6. DMT	4	60,000 - 3,000	Bombay Dyeing	50.5
			IPCL	27.5
			Bongaigon Refinery & Petrochemicals Ltd.	21.7
			J.K. Synthetics	NA
7. Caprolactum				
	2	50,000 - 20,000	FACT	79.3
			GSFC	20.7
8. Phthalic Anhydride				
	6	25,000 - 8,600	Asian Paints	26.9
			Mysore Petrochemicals	18.2
			Thirumalai Chem.	17.6
			Shri Ambuja Petrochem	12.8

Source: Compiled from CMIE Market and Market Shares, February 1993.

Note: The date on products i.e. output etc. in the petrochemical industry can only be indicative. The CMIE Market and Market Shares £1993: 6023 specifically states that the problem of lack of uniformity in the names and scope of products was particularly difficult in the petrochemical industry where companies club a large number of products under some broad nomenclature. This pre-empts any accurate analysis of data at the product level.

Table 2.13 indicates that the sine range of capacity installed is large for many of the petrochemical product groups. Consequently, the range of market share is also large. While this table is only suggestive of the existence of concentration, there are other methods by which concentration can be measured.

The most simple measure of concentration is the 4-firms concentration ratio. Table 2.14 illustrates the case of the petrochemical industry. The table indicates that of the 35 petrochemicals cited, the top four firms had 100% of the market share in 23 cases. And in 11 cases, the shares were greater than 50%. This indicates an extremely high degree of concentration in these petrochemical product groups. The basic drawback of this method of calculating concentration is that adequate weightage is not given to all the firms in the industry (only the top four are taken into account). Nor is adequate weightage given to the size of the firms. Concentration ratios therefore provide only a limited picture of concentration. An alternate method of measuring concentration in an industry is by using the Herfindahl index.[18] Table 2.15 displays the Herfindahl index for a range of petrochemicals for the years 1983-84 and 1990-91.

Table 2.14
Four Firm Concentration Ratios

(%)

Petrochemicals	Share of Top 4 Firms* 1987-88	1989-90	1991-92
Synthetic Fibre:			
1. Viscose Filament Yarn	76.5	76.7	78.0
2. Viscose Staple Fibre	100.0	100.0	100.0
3. Modal Staple Fibre			100.0
4. Nylon Filament Yarn	63.8	57.7	54.4
5. Polyester Filament Yarn			57.3
6. Polypropylene Filament Yarn			98.1
7. Polyester Staple Fibre	68.2	63.6	64.5
8. Polyprolylene Staple Fibres			100.0
9. Acrylic Staple Fibre			100.0
10. Rayon Tyre Yarn			100.0
11. Nylon Tyre Yarn			73.5
12. Polyester Chips			99.9
Polymers, Elastomers & Plasticisers:			
13. LDPE			100.0
14. HDPE			100.0
15. Polypropylene			100.0
16. PVC			96.5
17. Polystyrene			100.0
18. ABS			100.0
19. Polymethyl Methacrylate			100.0
20. Acrylonitrile			100.0
21. Polyamides			100.0
22. Polyurethane			100.0
23. Expanded Polystyrene			100.0
24. Synthetic Rubbers			100.0
25. VAM			100.0
Other Petrochemicals:			
26. Methanol	94.5	85.7	87.6
27. Styrene			100.0
28. LAB			100.0
29. Xylenes			100.0
30. PTA	100.0	100.0	100.0
1. DMT			100.0
2. Caprolactum	100.0	100.0	100.0
3. Phthalic Anhydride	100.0	100.0	82.4
4. Rubber Chemicals		100.0	99.9
'• Synthetic Resins			58.0

Source: Compiled from CMIE [1993] Market & Market Shares
Figures marked with (*) indicate that less than four firms exist.

Table 2.15
Concentration in the Petrochemical Industry

	Petrochemicals	No of Firms	1/n 1990-91	1/n 1983-84	A in No of Firms	HI - Index 1983-84	HI - Index 1990-91
	Synthetic Fibre						
1.	Acrylic Fibre	3	0.33	0.5	1	0.60	0.42
2.	NFY	11	0.09	0.13	3	0.13	0.09
3.	NIY/TC	7	0.14	0.2	2	0.23	0.17
4.	PFY	19	0.05	0.1	7	0.21	0.17
5.	PSF	10	0.11	0.2	5	0.24	0.17
	Synthetic Rubber						
6.	SBR	2	0.5	1.00	1	1.00	0.87
7.	PBR	1	1.00	1.00	0	1.00	1.00
	Thermoplastics						
8.	LDPE	3	0.33	0.33	0	0.53	____
9.	HDPE	1	1.00	1.00	0	1.00	1.00
10.	Polystyrene	2	0.50	0.5	0	0.5	0.53
11.	Polypropylene	1	1.00	1.00	0	1.00	1.00
12.	PVC	5	0.20	0.25	0	0.33	0.22
	Plastic Raw Materials						
13.	CA Moulding Powder	1	1.00	1.00	0	1.00	1.00
14.	UF Moulding Powder	3	0.33	0.33	3	0.36	0.45
15.	PF Moulding Powder	2	0.25	0.2	-1	0.53	0.77
16.	MF Moulding Powder	3	0.33	0.33	0	0.34	0.52
	Other Petrochemical Intermediates						
17.	Acrylonitrile	1	1.00	1.00	0	1.00	1.00
18.	Caprolactum	2	1.00	1.00	1	1.00	1.00
19.	DMT	3	0.33	0.5	1	1.00	0.37
20.	LAB	3	0.33	1.00	2	1.00	0.35
21.	Benzene	11	0.09	0.11	2	0.32	0.22
22.	Toluene	11	0.09	0.14	4	0.74	0.46
23.	ABS Resins	4	0.25	-	4	1.00[1]	0.46
24.	Butanol	4	0.25	0.33	1	0.37	0.40
25.	Butadiene	3	0.33	0.33	0	0.37	0.49
26.	Ethylene Dichloride	2	0.50	1.00	1	1.00	0.55
27.	Butyl Acetate	2	0.50	0.5	1	0.51	1.00
28.	Diacetone Alcohol	2	0.50	0.5	0	0.50	0.50
29.	Diethylene Glycol	3	0.33	1.00	2	1.00	0.58
30.	Ethylene	2	0.50	0.33	-1	0.59	0.53
31.	Ethylene Oxide	2	0.50	0.5	0	0.68	0.60
32.	MEG	3	0.33	0.5	1	0.53	0.51
33.	Isopropanol	1	1.00	1.00	0	1.00	1.00
34.	Orthoxylene	2	0.50	1.00	1	1.00	0.65
35.	Mixed Xylene	1	1.00	1.00	0	1.00	1.00
36.	Paraxylene	3	0.33	1.00	2	1.00	0.15
37.	Phthalic Anhydride	7	0.14	0.17	1	0.21	0.22
38.	Propylene	4	0.25	0.33	1	0.47	0.41
39.	Styrene	3	0.33	0.33	0	0.33	0.34
40.	VAM	2	0.50	-	2	0.50[1]	0.50[2]
41.	PTA	1	1.00		0	-	1.00

source: Compiled from Companywise Production of Petrochemicals (1983-84 to 1990-91), Monitoring and Evaluation (Petrochemicals) Sction, Department of Petrochemicals , GDI, New Delhi.
1:- Figure is for 1984-85 2 :- Figure is for 1989-90

Compare 1/n and the H-index for 1990-91 and 1983-84. The number of firms 1/n = H indicates. competitiveness, while the degree of imperfect competition rests on the extent H > 1/n. Though there have been changes in the concentration, it has been only in terms of the degree of high concentration. Table 2.15 shows that in 1990-91, out of 41 petrochemicals, 9 were manufactured by monopolies while H > 1/n in 26 products. In 1983-84, the comparable figures were 16 monopoly producers and 19 products where IH > 1/n in 40 petrochemicals. So while entry has reduced the number of petrochemical having single monopoly producers, concentration *per se* has not decreased. In fact, 35 petrochemicals have concentrated markets in both the years.

One basic drawback of the H-Index is that its usefulness is limited to the extent that the number of firms in the industry is large. In this case the size distribution is skewed and the H index measures concentration adequately. However, it becomes an inadequate measure of concentration when the number of firms is small. In this context it becomes important to examine yet another indicator of concentration.

The dominant firm approach is another method of examining the degree of economic power enjoyed by firms in an industry. This approach involves an examination of the extent to which dominant firms exist in an industry. Dominant firms are defined as those firms which have more than 50V. of the market share, in our case total output. Table? 2.16 provides the list of dominant firms in the petrochemical industry.

Table 2.16
Dominant Firms in the Petrochemical Industry (1991-92)

	Petrochemicals	# of firms	Share of largest firm (%)		Remarks
	Synthetic Fibre:				
1.	Acrylic Fibre	3	J.K. Synthetics	45.75	
2.	NFY	11	Modipon	11.84	
3.	NIY/TC	7	J.K. Synthetics	17.27	
4.	PFY	19	Reliance	36.00	
5.	PSF	10	Reliance	36.73	
	Synthetic Rubber:				
6.	SBR	2	Synthetics & Chem.	92.87	
7.	PBR	1	IPCL	100.00	
	Thermoplastics:				
8.	LDPE	3	IPCL	100.00	
9.	HDPE	1	Polyolefins Ind.	100.00	
10.	Polystyrene	2	Hind. Polymers	82.43	
11.	Polypropylene	1	IPCL	100.00	
12.	PVC	5	IPCL	30.00	
	Plastic Raw Materials:				
13.	CA Moulding Powder	1	Mysore Acetate	100.00	
14.	UF Moulding Powder	3	Nuchem Plastics	56.60	
15.	PF Moulding Powder	2	Indian Plastics	59.51	
16.	MF Moulding Powder	3	Indian Plastics	89.6:3	
	Other Petrochemical Intermediates:				
17.	Acrylonitrile	1	IPCL	100.00	Public Sector
18.	Caprolactum	2	GSFC	77.42	Public Sector
19.	DMT	3	Bombay Dyeing	47.35	
20.	LAB	3	T.N. Petroproducts	42.12	
21.	Benzene	11	BPCL	27.95	
22.	Toluene	11	IOC	39.85	
23.	ABS Resins	4	ABS Plastics	50.tt4	
24.	Butanol	4	NOCIL	52.81	
25.	Butadiene	3	IPCL	62.95	Public Sector
26.	Ethylene Dichloride	2	NOCIL	62.42	
27.	Butyl Acetate	2	Somaiya Organic	97.91	
28.	Diacetone Alcohol	2	NOCIL	51.49	
29.	Diethylene Glycol	3	Indian Glycols	43.20	
30.	Ethylene	2	IPCL	63.98	Public Sector
31.	Ethylene Oxide	2	NOCIL	67.47	
32.	MEG	3	Indian Glycols	49.65	
33.	Isopropanol	1	NOCIL	100.00	
34.	Orthoxylene	2	IPCL	77.52	Public Sector
35.	Mixed Xylene	1	IPCL	100.00	Public Sector
36.	Para>:ylene	3	Reliance	71.12	
37.	Phthalic Anhydride	7	Thirumalai Chem.	25.52	
38.	Propylene	4	IPCL	48.43	Public Sector
39.	Styrene	3	Hind. Polymers	41.66	
40.	VAM	2	Vam Organic	56.64	
41.	PTA	1	Reliance	100.00	

Source: Compiled from Company-wise Production of Petrochemicals 1983-84 to 1990-91), Monitoring and Evaluation (Petrochemicals Section), Department of Chemicals and Petrochemicals, GOI, New Delhi. * :- Figure is for 1984-85.

In the above table, dominant firms *are* in the bold type while the other figures represent the market share of the largest firms. In 1990-91, there were dominant firms in as many as 26 petrochemical products out of 41 . This, was when market, share was strictly taken as 50% in order to demarcate a dominant firm from other firms. It was predominantly the public sector that had gained dominance in as many as 11 products and had the largest market share in two other products.

This section has analysed the petrochemical industry using three indicators of concentration. What emerges clearly is that concentration and, thereby, market power of firms in individual product groups of the petrochemical industry exhibit a high degree of concentration.

Concentration examines the market power of firms in particular product groups. However, it is possible for firms, which do not exhibit dominance in any particular product groups, to be powerful through vertical integration. The following section examines vertical integration in the petrochemical industry.

(b) Vertical Integration

A firm is vertically integrated when two or more successive stages of production are organised within the same firm. A firm can integrated either backwards or forwards. Backward or 'upstream' integration occurs when the firm begins to manufacture an input into its original product. Forward or 'downstream' integration involves using the firms' output to make a more finished product than earlier. The inherent advantages of vertical integration is the elimination of contractual or market exchanges within the boundary of the firm.

The petrochemical industry consists of a series of consecutive but separate production processes - the manufacture of feedstocks at one end to the production of final petrochemical products which *are* then used for manufacturing consumption goods at the other end. A firm located at any point on this production Process may choose to integrate backwards or forwards.

A firm chooses to integrate backwards for two main reasons. First, to take advantage of greater economies of scale in upstream industries. In the petrochemical industry, economies of scale *are* highest in upstream production and become lower as firms become more specialised. And second, to have control over input supply. Forward integration takes place in order to (a) take advantage of greater value added in downstream industries, and (b) to provide a guaranteed market for the firm's inputs. In both cases, the appropriation of transaction costs offers a significant advantage to the firm that vertically integrates.

Liberalisation policies in India have created an environment in which it is possible for firms to integrate vertically. The delicensing of industries and the removal of MRTP asset limit have, together, ostensibly facilitated the entry of firm into allied production processes. The following table illustrates the nature of vertical integration of some firms in the petrochemical industry.

Table 2.17
Vertical Integration in the Petrochemical Industry

1. **Baroda** Rayon

1962	Filament Rayon Yarn
1974	Nylon Filament Yarn
1976	Polyester Filament Yarn
1978	Nylon Tyre Cord Project (work started)
1978	Polyester Chips
1979	Caprolactum
1981	Nylon Tyre Cord Project (production)
1982	MEG
1991	As a measure of backward integration, the company proposed to install a polyester polycondensation plant to meet the requirements of polyester chips with a capacity of 4 tonnes per day (tpd).

2. **Bongaigon Refinery and Petrochemicals** Ltd.

1979-80	Xylenes and DMT (Work started in 1977)
1981-82	Work on PSF project started (1979-80 - project was conceptualised.)
1985-86	DMT
1987-88	PSF

3. **Cochin Refineries**

	Naphtha canalised through the IOC
1988	Plans expansion for a Rs.80 crs aromatic plant to manufacture benzene and toluene

4. **Gujarat State Fertilisers** Co. (GSFC)

1974	Caprolactum
1983	Polymers Corporation of Gujarat was amalgamated with GSFC.
1990	Gujarat Nylons (a GSFC subsidiary) was amalgamated with GSFC.

5. **IPCL**

1973	DMT commercial production
	Mixed Xylene ""
	Orthoxylene ""
1974	Paraxylene
1975	C9 aromatics
1978	Carbon Black
	Ethylene glycol
	Polybutadiene rubber
	LDPE/ LLDPE
	Polypropylene
	Benzene extraction

	Acrylonitrile
1979	Acrylic Fibre
	Ethylene oxide
1984	PVC/VC
	Ethylene Dichloride
1986-87	Polypropylene
1989	Ethylene
	Propylene
	LDPE (HDPE underway)
1990-91	LLDPE and PP end use products

6. J.K. Synthetics

1960	Nylon plant capacity 800 kgs (the Country's first)
1964	Acrylic Staple fibre (licence received)
1971	Nylon tyre cord and synthetic fibre (trial production)
1972	Nylon Tyre Cord,
	Nylon Staple Fibre
	Polyester Staple Fibre
1973	Nylon Yarn
1978	DMT
	MEG
1979	ACF production commences
1984-85	Polyester industrial yarn
1988	Approvals sought for the following products to be manufactured at its Saleempur plant: Propylene, Aery1onitrile, Ethylene Oxide, Diethylene Glycol & Triothylene Glycol
1989	Letters of Intent for the following products: Benzene, Orthoxylene, Paraxy1ene, PTA
1990-91	An MOU was signed with the IOC for supply of naphtha for the aromatics and PTA project.

(J.K. Petrochemicals was set up to take care of the petrochemical operations of the firm.)

7. Polychem Ltd.

1957	Polystyrene
1963	Styrene Monomer
1979	ABS
1983	VAM

8. Modipon Ltd.

1973	Polyester Filament Yarn
1977	Nylon Filament Yarn
1978	Polyester Chips plant was commissioned
1981-82	Polyester POY yarn

1983-84	LI for nylon industrial tyre fabrics
1990-91	Planning backward integration into caprolactum and raw material

9. NOCIL

[Part owner of Polyolefins Industries which it set up in May 1964 in collaboration with Farbwerke Hoechst A.G. Germany to manufacture HDPE and processed polyethylene products].

1968	Ethylene
1970s	PVC 2-ethyl hexanol
1977	Gas Cracking Plant: Ethylene Propylene
1979	Dichloroethane from waste hydrochloric acid as an input into the manufacture of vinyl chloride.

Proposed manufacture of ethylene, propylene, butadiene, benzene and aromatics. The proposed downstream units are for the manufacture of LLDPE, HDPE, PS, and styrene.

Polyolefins industries Ltd. (promoted by NOCIL)

. 1964	HDPE (20,000 tpa) and Ziegler catalysts and 5,600 tonnes of processed products made out of HDPE
1968	Production of HDPE
1971	N-Butene - 1 required for the manufacturing of HDPE

10. Reliance

1980	PFY Polyester Chips
1986	PSF under broadbanding scheme
1987-88	PTA/LAB
1988	MEB HDPE PVC
1990-91	LLDPE Propylene Butadiene and other C_4s Acrylic Fibre Paraxylene
1991-92	PVC
1992-93	MEG HDPE
1993	EO EG ACN pp SBR Styrene Polystyrene } planning stages.

At present, the company has a project underway to manufacture feedstocks such as ethylene, prupylent & butadiene apart from planning expansion into petroleum refining which will enable it to manufacture naphtha.

11. Synthetics and Chemicals

1961	Synthetic rubber
1963	Styrene,
	Butadiene
	Synthetic lattices and rubbers
1977	Nitrile rubber
1984	Polystyrene
1983	Styrenated rubber for captive consumption
1989-90	Acetaldehyde

Source: Compiled from Bombay Stock Exchange Directory (various issues).

A classic example of the strategic advantages of vertical integration in the Indian petrochemical industry is the case of paraxylene manufacture. Paraxylene is the basic input for the production of PTA and DMT, which are used to make synthetic fibres. And the PTA and DMT *are* used in alternate (i.e. substitute) routes to manufacture synthetic fibres. Bombay Dyeing and Reliance are rival companies which manufacture synthetic fibres. While Reliance uses the PTA route, Bombay Dyeing uses the DMT route. Reliance, the monopoly producer of PTA, has its captive paraxylene plant. The manufacturers of DMT, apart from Bombay Dyeing, namely IPCL and Bongaigon, both have captive paraxylene plants too. Bombay Dyeing which requires paraxylene as an input has to rely on Reliance (its arch-rival) or IPCL which would off-load surplus but could not guarantee continuous supply of inputs.[22] In November 1989[23] excise on paraxylene was abolished and import duty was cut by *10%.* to 80%. In fact, the government was being pressurised to ban the import of paraxylene since total domestic capacities were greater than domestic demand. And Reliance began to supply paraxylene from what was originally meant for captive consumption, to Bombay Dyeing at a cost equivalent to the landed cost of imported paraxylene regardless of cost of Production. This is a clear example of how a firm is disadvantaged when it is not vertically integrated while its rival *firms are.*

(c) Scale of Operation

One of the components of the liberal industrial policy of the Government of India has specified the minimum economic scales for a range of petrochemical products. These figures are prescribed minimum scales. A firm is free to expand beyond this limit. This is more so when demand constraints *are* a limiting factor.

While the petrochemical industry was still licensed, the government stipulated a Minimum Economic Scale of operation to allow firms to operate at optimal scales. While an *HE'S* policy becomes redundant after delicensing, firms will still have to operate at optimal levels since efficiency in the petrochemical industry is linked to scale of operation. Most of the firms will have to expand in order to operate at optimal levels.

In a situation where economies of scale are significant, demand constraints become limiting factor for the expansion of firms. When economies of scale are high, firm sizes are large. Therefore, only a few firms (of optimal size) are adequate to service the market, when the number of firms exceeds this optimal number, capacity underutilisation results. On the other hand, if there *are* few firms, concentration is high. These firms can enhance their market power in a variety of ways that *are* typically oligopolistic. Economies of scale are thereby significantly intertwined with firm size, concentration and capacity utilisation. The following table illustrates the capacity utilisation of firms in the Indian petrochemical industry:

Table 2.18
Differences of Capacity Utilisation Between Firms (1991-92)

(+)

Product	No. of firms	Average	Highest	Lowest
Synthetic Fibres:				
1. Viscose Filament Yarn	8	89.91	138.5	53.2
2. Viscose Staple Fibre	5	88.39	92.65	66.85
3. Nylon Filament Yarn	13	43.6	157.5	3.1
4. Polyester Filament Yarn	19	150.1	244.5	35.1
5. Polypropylene Filament Yarn	7	58.8	64.4	7.6
6. Polyester Staple Fibre	10	61.9	122.5	29.2
7. Polypropylene Staple Fibre	4	19.8		
8. Acrylic Staple Fibre	7	73.5	104.5	63.3
9. Rayon Tyre Yarn	3	42.2	92.5	48.7
10. Nylon Tyre Yarn	7	119.3	133.9	86.9
Polymers, Elastomers & Plasticisers:				
11. LDPE	2	-	50.4	
12. HDPE	1	68.0	61.8	
13. Polypropylene	2	45.2	46.0	15.6
14. PVC	9	88.4	122.7	16.4
15. Polystrene	2	63.0	66.5	59.0
16. ABS	3	36.1	36.9	33.7
17. Acrylonitrile	1	86.6	86.6	
18. Expanded Polystrene	4	73.3	195.9	0.6
19. Synthetic Rubbers	4	41.2	83.2	11.2
20. VAM	3	325.1	449.1	77.1
21. Polyamides	2	37.6		
22. Polymethyl Methacrylate	1	88.9	88.9	
23. Plasticisers	10	35.4	69.9	8.2
Other Petrochemicals:				
24. Styrene	4	60.0	75.2	31.1
25. LAB	3	96.9	104.6	92.4
26. Ethylene Glycol	5	-	94.8	
27. PTA	1	162.7	162.7	
28. DMT	4	94.0	100.4	48.1
29. Caprolactum	2	66.3	100.6	52.5
30. Phthalic Anhydride	6	66.4	93.8	39.4

Source: Compiled from CMIE, Market and Market Shares, February 1993.

Note: Where there is a single producer or figures are available for one producer the capacity utilisation is placed between the highest and lowest.

From the above table, it is difficult to generalise about capacity utilisation in different product groups. What is clear is that in products which have a large number of firms manufacturing it, the range between the firms which have the highest and lowest capacity utilisation is high. This implies that although average capacity utilisation across firms is high, all firms do not use installed capacity adequately. The above table indicates capacity utilisation in one year. The following table indicates capacity utilisation of select petrochemicals from 1960-61 to 1990-91.

Table 2.19
Capacity Utilisation of Select Petrochemicals (%)

Year Product	1960-61 (1)	1970-71 (2)	1980-01 <3)	1990-91 (4)
Synthetic Fibres:				
1. VFY	88.23	100.21	107.18	89.91
2. Viscose Tyre Cord	-	91.69	84.02	
3. VSF	83.77	87.98	83.97	88.39
4. AFY	106.94	97.15	54.22	
5. NFY	-	102.88	94.13	43.6
6. Nylon Tyre Cord	-	302.5	105.35	
7. PFY	-	83.89	126.02	150.1
8. Polyester Fibre	-	106.64	83.26	
Thermoplastics:				
9. LDPE	-	122.07	70.01	
10. HDPE	-	114.93	69.81	61.8
Thermosets:				
11. PF Moulding Powder	62.51	124.85	59.06	
12. UF Moulding Powder	38.24	73.68	62.26	
13. PVC Resin	-	90.28	41.07	88.4
Other **Petrochemicals:**				
14. Benzene	73.14	48.47	71.76	
15. LAB	-	-	55.89	96.9
16. DMT	-	-	105.44	94.0
17. Caprolactum	-	-	69.73	66.3

Source: Col (1) to (3) *are* compiled from India Database.
Col (7) from CMIE Market and Market Shares [1993].
Note: Capacity Utilisation is calculated by dividing total installed capacity by total production, and converting it into a percent.

Table 2.19 indicates a high level of capacity utilisation (on the average) for select petrochemical products. However, till 1980-81, capacity installed was licensed to match demand. And the period from 1980-81 to 1990-91 has been one of tremendous growth in petrochemical consumption in India. Capacities have also expanded and may outstrip domestic demand resulting in excess capacities.

The scale of operation of most of the firms are way below the *MES* prescribed by the government and considerations of optimal resource use. The following table illustrates the scale of operation of select petrochemicals:

Table 2.20
Scale of Operation of Select Petrochemicals

1991-92)

	MES '000 tpa	No of Firms	No.of Firms > MES	Average Installed Capacity '000 tpa	Capacity Utilisation (%)	Market Share Largest Firm
Synthetic Fibres:						
1. PSF	60	10	-	23.62	61.9	40.4
2. PFY	25	19	1	12.66	150.1	27.8
3. ACF	20	7	2	-	73.5	94.0
Synthetic Rubber:						
4. SBR	100	4	-	12.36	41.2	82.5
5. PBR	50					
Thermosets:						
6. LDPE	100	2	1	80.00	-	85.5
7. HDPE	100	1	-	50.00	61.8	100.0
8. PPL	100	2	-	46.25	45.2	99.4
9. PVC	100	9	-	28.95	88.4	29.8
Other Petrochemical Intermediates:						
10. PTA	200	1	-	100.0	162.7	100.0
11. CPL	100	2	-	35.00	66.3	79.3
12. LAB	80	3	-	59.5	96.9	45.1
13. ACN	80	1	-	30.0	86.6	100.0
14. DMT	100	4	-	34.5	91.0	100.4

Source: Col (1) Doshi [19893 MES is as prescribed by the Government of India.
Col (2) - (5) CMIE , Market and Market Shares, [1993].

The above table indicates that very few firms operate at the required MES. For firms to take advantage of increasing returns to scale, they will have to expand capacities. This implies that the installed capacity for a range of petrochemicals will expand substantially in the country.

The extent to which domestic capacities will expand on the basis of approvals that have been given to investors has been estimated by the Sengupta Committee [see Table 2.53. These capacities, when matched against demand estimates for the same period show an excess. This difference has been calculated by the Sengupta Committee and is presented in the following table:

Table 2.21
Capacity Gaps

('000 mt)

Product	Excess of the total additional proposed/approved capacity over the additional required	
	1994-95	1999-00
1.LDPE/LLDPE	420	346.8
2.HDPE	405 (375)	275 (231)
3.Polypropylene	591 (568)	496 (468)
4.PVC	257 (209)	52 (-19)
5.PS	151 (142)	111 (97)
6.Styrene	278 (267)	229 (212)
7.SBR	155 (147)	112 (99)
8.PBR	55 (50)	29 (21)
9.BR	25 (22)	9 (4)
10.NR	4.3(4)	2.8(2)
11.EO(not for MEG use)	6 (23)	8 (3)
12.EG	428 (410)	335 (306)
13.Alfa-Olefin	80 (79)	15 (2)
14.ACN	61 (50)	9 (-8)
15.Paraxylene	228 (200)	96 (132)
16.0rthoxylene	9 (-3)	-36 (-53)
17.DMT	nil	nil
18.PTA	384 (360)	181 (135)
19.Benzene	158 (108)	-29 (-100)
20.Toluene	4 (-3)	-10 (-18)
21.Caprolactum	188 (173)	125 (104)
22.LAB	246 (256)	149 (117)

Source: Sengupta Committee Report [19903.
Note: Figures in brackets *are* estimates of capacity requirement at 90"/. capacity utilisation.

However, demand estimates made by the Sengupta Committee are lower than the Kapur Committee estimates. In fact, one of the main contentions of the Sengupta Report was that the Kapur Committee overestimated demand substantially giving incorrect signals for capacity planning The following table provides the demand estimates of the two committees for selected petrochemical product groups.

Table 2.22
Demand Estimates

('000 mt)

Product	Sengupta Committee		Kapur Committee		(4) - (2)
	1994-95	1999-00	1994-95	1999-00	
	(1)	(2)	(3)	(4)	(5)
1.Synthetic Rubber	159.00	255.00	156.50	212.00	-43
(a) SBR	71.60	114.80			
(b> PBR	44.50	71.40			
(c) BR	25.40	40.80	-		
2.LDPE/LLDPE	305.00	450.00	480.00	708.00	258
3.HDPE	270.00	400.00	378.00	555.00	155
4.Polypropylene	205.00	300.00	286.00	420.00	120
5.HDPE and PP	475.00	700.00	664.00	975.00	275
6.PVC	435.00	640.00	485.00	713.00	73
7.PS	85.00	125.00	82.00	120.00	-5
8.MEG	167.00	165.00	260.00	264.00	99
9.Styrene	100.75	150.26	NA		
lO.Acrylonitrile	102.60	154.40	139.60	215.40	61
11.DMT	181.00	-	-	181.00	
12.PTA	216.40	-	-	419.00	
13.Paraxylene	258.30	390.00	255.00	400.00	10
14.Orthoxylene	106.00	151.00	106.00	151.00	0
15.Caprolactum	131.80	195.20			
16.Benzene	453.70	641.40	570.00	858.00	216.6
17.Toluene	62.00	76.00	62.00	76.00	0
18.Ethylene	1028.00	1569.50	1371.00	2023.00	454
19.Propylene	493.40	719.40	600.00	884.00	164.6
20.Butadiene	95.80	153.00	102.00	140.00	-13

Source: Kapur Committee Report [1986].
Sengupta Committee Report [1992].

Table 2.22 col.5 provides the difference between Kapur and Sengupta demand estimates for 1999-2000. Even after providing for the 'exaggerated' estimates of the Kapur committee, a comparison between col.5 (Table 2.22) with the expected excess capacity in Table 2.21, shows that planned capacity is higher than expected

domestic demand. Of the 12 petrochemicals where comparative data is available, 7 products show an excess when Kapur estimates *are* taken into account. (The figure is 18 out of 22 for Sengupta's estimates).

This section has established that the petrochemical industry in India has the following characteristics:

(a) Concentration,
(b) Vertical integration, and
(c) Anticipated excess capacities and capacity underuti1isation.

In an autarkic or protected market, these characteristics provide a natural entry barrier; firms will be able to deter the entry of new firms and accentuate their market power. Alternatively, in the face of clear-cut trade liberalisation, firms will have to enter the export market and face foreign firms in the domestic market. In either case, the nature of entry barriers in the Indian petrochemical industry will determine its structure and consequently the extent of competition in the industry.

BARRIERS TO **ENTRY**

The nature of competition in an industry is dependent upon the extent and nature of entry barriers present in the industry. Table **2.23** presents the entire range of entry barriers that was present in the Indian Petrochemical industry in the pre-liberalisation period as well as the barriers that, are likely to arise after liberalisation. The barriers that are inherent to the industry are of course present in both periods.

Artificial entry barriers reigned supreme in the pre-1iberalisation phase. What did these barriers do? Firms required licences to produce and match the domestic demand estimates of the government. Since domestic demand was limited, firm sizes were small and not of optimal size. In addition, incumbent firms were not allowed to expand for fear of creating economic concentration. (The fact remains that the number of firms was small enough for concentration to exist).

Uneconomic plant sires and concentration could co-exist only in a protected market. And the infant industry argument for protection perpetuated the situation. Tariff rates were high and quota restrictions prevented the free import of feedstocks as well as downstream petrochemicals.

With liberalisation, all the domestic barriers to entry were removed and trade restrictions were slowly rationalised. In the

Table 2.23

Barriers to Entry in the Petrochemical Industry

Artificial Entry Barriers	Natural Entry Barriers
1.Licensing of : a. investment level, b. installed capacity, c. output level, d. output mix.	Barriers due to intrinsic characteristics of the industry: 1. High cost of investment a portion of which is sunk.
2. Reservation for public sector.	2. Economies of Scale.
3. Quota restrictions on imports.	3. Step-wise capacity expansion and the resulting excess capacities.
4. Tariff restrictions on imports.	barriers due to firm strategies:
5. Restrictions on foreign equity participation and the operation of foreign firms in the domestic market.	1. Concentration. 2. Vertical Integration. 3. Excess Capacities (for strategic purposes).

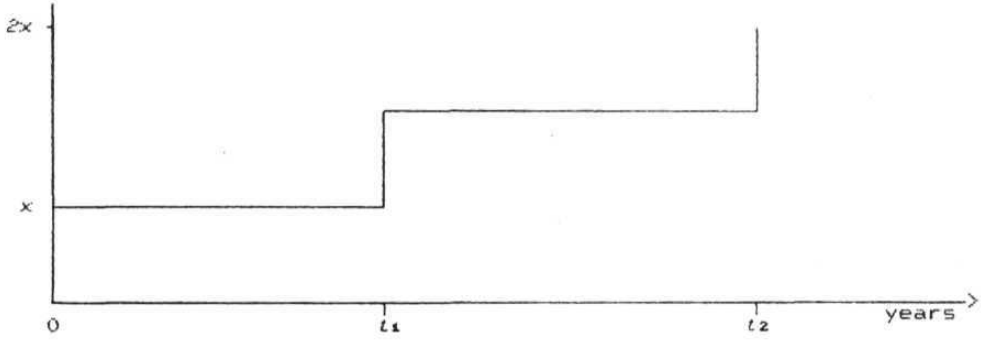
Domestic sphere, the policy framework allows new firms to enter freely and incumbent firms to expand. This gives rise to excess capacity build-up and vertical integration in a concentrated market.

Excess capacities and vertical integration did exist in the Pre-liberalisation *era* because of licensing. And this licensing was restricted by domestic demand. In the post-liberalisation

period, capacity build-up is anticipated to exceed domestic demand and result in market share rivalry. And vertical integration contributes to building up market power.

Entry barriers that arise out of what is inherent to the context of the firm the intrinsic be it the high cost of investment of firms seeking entry or those planning expansion are a result of scale economies. In addition, investments are inherently lumpy. Lumpy investments leads to a step—wise capacity expansion as the following figure indicates:

Figure 2.3
Capacity Expansions



The period 0 to ti is the gestation period i.e the number of years taken to set up the plant. The plant might be producing at less than x initially, but it has the potential of producing x with only variable costs. Therefore, any difference in production between x and the actual output is the excess capacity. The pattern is repeated for any further expansions.

To conclude, artificial entry barriers erected in the pre-1iberalisation era have been removed while trade barriers have been removed only partly. In the post-liberalisation period, natural barriers have arisen and the entry deterring actions of these barriers can have anti-competitive effects. We first examine how government intervention has built up artificial entry barriers in the regulated phase of industrial policy and how these

barriers were removed in the liberalised phase in the following chapter. The discussion will be in the context of the petrochemical industry in India.

NOTES

[1]UNIDO No. 20 IS/480, p1.

[2]See Hay and Morris [1979: 201-23.

[3]As the word itself implies, cracking involves the breaking down of large molecules into smaller ones. Originally, the heavier oil was cracked by heating under pressure. Nowadays, cracking is carried out at lower temperatures and pressures in the presence of catalysts e.g. silica and alumina [See Patel 1971 and Waddams 1980 for more details].

[4]See the Kapur Committee Report , Vol. 2, p84.

[4]See Annexure 1. This provides the end uses of major petrochemicals.

[6]For example, the average per capita consumption of plastics in India is 0.67kg compared to the world average of 13 kg [see Kapur Committee Report, 1986, Vol.1, p9.].

There was a tapering off of huge investments which were planned in the II and III Plans because of the resource crunch and the balance of payments problems.

[8]Technology Planning for Petrochemicals, [1988: 138].

The use of gas for petrochemicals has the highest value added (Rs. 13,000 per tonne of gas) compared to that of power generation (Rs. 300) and fertiliser (Rs. 2000) [Business India, March 20 April 2, 19893. However, such a comparison is not valid across such industries of diverse importance. Power is an infrastructural need, fertiliser is subsidised by the government and petrochemicals is a highly protected industry.

While the use of gas is technologically more efficient than naphtha from crude oil refining, naphtha is tradable while gas is less so. The country has limited resources of both.

Many of the major business houses like the Tatas, Birlas, Ambanis, Singhanias, Goenkas, Mallyas and Muthiah made determined +forts. to set up a cracker or aromatics plant.

[12]Domestic Resource Costs (DRCs) measure the height of protection and the costs incurred thereof. DRCs are calculated by adjusting estimates of inputs of primary factors of production (usually capital and labour) to reflect shadow prices, rather than market prices.

The DRC formula is :

$$DRC_i = \sum_j \frac{S_j V_{ji}}{IVA_i}$$

where S_j is the shadow price, or opportunity cost, of the jth domestic factor of production, V_{ij} is the amount of the jth factor used per unit of output of i and IVA_i is the international value added in the ith activity.

Kruegar, A.O. [1984] Trade Policies in Developing Countries R.W. Jones & P.B. Kenen [Ed.] *Handbook of International Economics,* Vol.1, Elsevier Science Publishing Co., North-Holland.

The BICP study calculated DRCs as the ratio of domestic value added to international value added.

Sengupta assumes a 600,000 tonne mother cracker capacity as the long run international scale and deduced the long-run marginal costs of producing major olefins and some major aromatics. He then estimated DRCs for petrochemicals based on the LRMC and *cif* prices prevailing in 1991-92.

Kadekodi examines DRCs using a cost-benefit approach in viewing investment opportunities in 1992-93.

Indian firms are finding it difficult to acquire capital for *HE'S* plants that are, in fact, modest when compared to world sizes. For example, after Mafatlal acquired Shell's 33% holding in NOCIL, its long delayed cracker expansion plan had to be recast. After the withdrawal of Shell the Rs.6,000 cr investment tab became awesome, and the project had to be split into two phases. And the naphtha cracker capacity was also lowered from the earlier 375,000 tonnes tD 300,000 tonnes [Business Today May 22-June 6, 19933.

The absence of brand names does not imply an absence of consumer loyalty *or* product differentiation through marketing efficiencies, consumer contacts etc.

Suppose there are *n* firms in an industry, and Si. 15 the market. share of firm ι. The Herfindahl Index (DH) is the sum of squares of the market shares of the firms in an industry, i.e.:

$$DH = S_1^2 + S_2^2 + S_3^2 + \ldots + S_n^2$$
$$= \Sigma S_i^2$$
$$= \frac{1 + (CV)^2}{N}$$

where CV is the coefficient of variation of firms size [see Davies *et al* 1988:823. It is therefore clear that DH = 1 in a pure monopoly and OH = 1/N in cases where all the firms in an industry have equal market shares.

[19]For e.g., if there are only 2 firms manufacturing a certain product with equal market share. The DH index is 0.5 and $1/n = 0.5$ which indicates competitive behaviour. However, studies of firm behaviour are replete with examples where only two or three firms manufacturing a product can collude and simulate monopoly behaviour.

Shepherd [1979:63] defines a dominant firm as "...by usage, one with 50% of the market or more. In actual markets, the dominant firm usually has about twice the next firm's share."

Strictly speaking, *vertical formation* describes vertical integration which occurs at the time the firm is created. *Vertical expansion* describes vertical integration which occurs as a result of the internal growth of the firm when it creates its own subsidiaries in the neighboring stages. *Vertical merger* describes vertical integration which occurs through the acquisition by one firm of an existing firm in neighbouring stages Csee Perry C1989:186].

For instance, on two occasions, IPCL failed to meet the requirements of Bombay Dyeing which had to borrow the crucial raw material from other sources on one occasion. and shut down on another.

[23]Business Standard, November 1, 1989.

Chapter 3

GOVERNMENT INTERVENTION AND ARTIFICIAL ENTRY BARRIERS

Government intervention in Indian industry through industrial and trade policies has been two-pronged: (a) as a producer in the public sector, and (b) as a regulator of firms in the private sector. The contours of industrial policy in the immediate post-independence *era* was designed to promote rapid industrialisation through an interventionist government in a largely autarkic environment. The liberalisation process which started from the early 1980s, involved a reduction of the government's role both as a producer and regulator. This shift is amply reflected in policies towards the petrochemical industry in India.

The regulation of domestic industry relied heavily on stringent licensing rules which directed where a firm was to be located as well as how much of what it could produce. These regulations can be perceived as introducing artificial entry barriers, in order to channelise investment into areas of national priority through licensing. The rationale for such licensing was that India, a developing country, could ill-afford the 'wasteful competition and non-priority investment that would result from such 'unregulated' investment. The licensing policies had two main goals:

(a) To create capacities in tune with plan targets, and
(b) To prevent concentration of economic power.

Licensing policies essentially restricted the setting up of new units as well as undertaking substantial capacity expansions in almost all sectors. And large business houses (MRTP houses) required separate permission to invest or expand, aimed at regulating the concentration of economic power. In addition, several 'core' areas were reserved for the public sector. Entry of new firms and/or expansion of existing firms was allowed only when the government foresaw a shortfall in supply. Thereby the capacity of firms was linked to domestic demand and capacity creation was strictly controlled.

On the trade front, an industrialisation strategy aimed at self-reliance resulted in high tariff rates and/or quota restrictions on imports. The infant industry argument provided much of the rationale for protecting the domestic environment to allow indigenous industry to take root. Artificial entry barriers such as tariffs, quotas and stringent FERA laws on investment limited the entry of foreign firms and goods.

After an initial phase of high growth, these controls, over time, had become inefficient and dysfunctional. The regulatory framework led to inefficient high cost industries, uneconomic scales of production and a situation in which exports could be competitive only with large subsidies. There was a growing awareness that this strategy had outlived its usefulness as a strategy for industrialisation. Economists who were critical of continuing this strategy suggested a range of market oriented solutions. Since the late mid-1970s the government began to address the problems of industrial stagnation by gradually dismantling the restrictive industrial and trade? policies.

The government has played a major role in creating and maintaining petrochemical industries in many LDCs as well as India. The government's role has traditionally been to protect the industry during its infancy (Korea, Taiwan), to control production of output (Korea, Japan, India) and to provide a stimulus for its establishment and growth (Thailand, Malaysia). As market share and competitiveness increase, the role of government has generally decreased [see Vergara & Babelon 1990:15-163.

India is now in the transitional stage between an era where industrialisation was 'planned' in a protected environment and an era of liberalisation where market forces increasingly determine the nature of industrial growth. A significant component of this transition has been the decreasing role of the government in economic activity. In the pre-liberalisation period, government intervention created artificial entry barriers in the industrial sector in order to tailor industrial growth to domestic needs in

an import-substituting economy. Later, liberalisation policies have sought to reduce these artificial barriers in order to bring about competition in a more open economy. And government policy towards the petrochemical industry reflects these changes. Liberalisation policies were initially extremely ad hoc in nature but when pieced together formed the foundation of the liberalisation process in the Indian industry. The government has not only reduced the extent of the public sector, but there has been a decline in its regulatory role. The following section will examine the changes that have taken place in the government's role both as a producer and regulator in the Indian petrochemical industry.

GOVERNMENT AS PRODUCER: THE ROLE OF THE PUBLIC SECTOR

The petrochemical industry was not considered a priority sector till the early 1970s and hence the public sector did not provide an early impetus for the industry as it had done for other core areas. Private entrepreneurs were initially not attracted to the industry due to the high cost of investment and the long gestation period. Since domestic demand was low, licensed capacity was small and production stagnated; while inefficiencies through uneconomical scales of production crept in.

It was however the policy of self-reliance that indirectly triggered the growth of the petrochemical industry in the country. The discovery of oil and the setting up of domestic oil refining units that were set up for the purpose of self-reliance in petroleum was instrumental in starting off the petrochemical industry in the country. It was then that the government entered the petrochemical industry to make use of the locally available naphtha by-product as a feedstock in the petrochemical industry. The government set up the Indian Petrochemical Corporation Ltd. (IPCL) an integrated complex to enter the industry at multiple stages, from basic feedstocks to downstream petrochemicals. In establishing the IPCL, the government performed the typical function of a public enterprise in an LDC - that of promoting

investment in a crucial sector where private industry was not forthcoming.

The government capacity as a producer is manifested not only in the IPCL but in joint ventures such as the GSFC and refineries which produce feedstocks and basic inputs viz., naphtha, benzene and toluene [see Figure 3.13.

Table 3.1
Public Sector: Basic Inputs

	Company	Product
1.	IPCL	Benzene Ethylene Glycol Ethylene Oxide
2.	Bharat Petroleum Corporation	Light Naphtha Benzene Toluene
3.	Madras Refineries	Propylene C_4 streams for Methyl Ketone and Polybutenes
4.	Fertilisers & Chemicals (Travancore) Ltd. (FACT)	Caprolactum

Source: Public Enterprise Survey, (1990-91), Department of Public Enterprises, Ministry of Industry, New Delhi.

In 1985, after a clear feedstock picture had emerged from the Bombay High fields, the government set up the Nagothane cracker complex. This made the government a near monopoly in the manufacture of feedstocks. And coupled with the fact that the IPCL was the biggest petrochemical complex in the country, the public sector dominated the industry.

The public sector and the private sector at present have about an equal presence in the petrochemical industry in India in terms of capacity.[2] Although the public sector in general and IPCL in particular continue to have a significant presence, the entry of other firms especially from the private sector has definitely eroded their market share. From Table 3.2 it as seen

that apart from a few petrochemical intermediates, there has been a perceptible decline in the market share of the public sector in synthetic fibre, elastomers and thermoplastics has decreased.

Table 3.2
Public Sector in the Petrochemical Industry

Petrochemical	"%. Share (1983-84)	"%. Share (1988-89)	%. Share (1991-92)	Dominant Public
Synthetic Fibres:				
Acrylic Fibre	72.19	56.17	50.23	IPCL
Elastomers:				
Poly Butadiene	100	100	82.5	IPCL
Thermoplastics:				
Polypropylene	100	100	99.4	IPCL
PVC	-	31.3.7	27.4	IPCL
Other Petrochemical **Intermediates:**				
Acronlonitrile	100	100	100	IPCL
Caprolactum	100	100	100	GSFC/FACT
DMT	100	50.55	49.5	IPCL/ Bongaigon
LAB	-	-	23.65	IPCL
Butadiene	48.86	63.53	NA	IPCL
Diethylene Glycol	-	69.61	NA	IPCL
Ethylene	74.4	61.59	NA	IPCL
Ethylene Oxide	19.92	27.54	NA	IPCL
MEG	61.7	57.01	NA	IPCL
Isopropanol	100	100	NA	IPCL
Orthoxylene		100	100	IPCL/ Bongaigon
Mixed Xylene	100	100		IPCL
Paraxylene	100	100	NA	IPCL/ Bongaigon

Source: Compiled from (1) Companywise Production of Petrochemicals (1983-84 to 1990-91). Monitoring and Evaluation (Petrochemicals) Section, Department of Chemicals and Petrochemicals, GOI, New Delhi.
(2) CMIE, Market and Market Shares (1993).

Although the public sector has shrunk, it continues to be significant for two reasons: (a) since the largest petrochemical company is IPCL in the public sector, and (b) it has control over basic feedstocks and manufacturing of upstream

petrochemicals. The public sector therefore has some role in the entire production process - from upstream naphtha/gas cracking to downstream industries. The picture that emerges is one of the public sector dominating the upstream industries while petrochemical units lower down the production process have a large private sector presence.

The integrated complex 1PCL in the public sector continues to dominate the petrochemical industry in India. In the late 1960s, an aromatic plant in Baroda owned and operated by 1PCL was commissioned; followed by an integrated naphtha-based olefins complex with an ethylene capacity of 130,000 tpa including a number of downstream units.

The aromatic plant of the IPCL was commissioned in 1973 and the olefin and downstream units in 197B. The plant in Baroda was set up to mop up the naphtha feedstocks from the nearby Koyali refinery. In the first phase, the aromatic units set up a capacity for 40,500 tonnes of xylene and 24,000 tonnes of DMT. In the second phase, the olefin complex, consisting of a basic naphtha cracker, set up capacity for 143,000 mt of ethylene, 80,000 mt of propylene, 22,000 mt of butadiene and 23,000 mt of benzene. These basic chemicals are used to make downstream products like LDPE, PP, PVC, SR, AF, LAB, MEG & EG. In the third phase in 1989, the IPCL obtained a letter of intent for setting up an integrated gas based petrochemical complex at Gandhar (Bharauch). A gas cracker unit was commissioned in Nagothone in July 1990. These investments have enabled the IPCL to gain enormous market power in the petrochemical industry. The following table illustrates the dominant presence of IPCL in the Indian petrochemical industry.

Table 3.3

IPCL in the Petrochemical Industry

(1991-92)

Petrochemical	Installed Capacity	% of total	Production	% of total
Synthetic Fibres				
Acrylic Fibre	24000	SO	-	-
Olefins				
LDPE	160000	21.74	80581	89.5
Polypropylene	90000	97.30	41429	99.4
Polyvinyl Chloride	55000	31.66	44199	80.4
Acrylonitrile	30000	100	25973	100
Aromatics				
LAB	43500	24.37	40906	23.65
DMT	30000	21.74	30121	23.22
Ethylene Glycol	13900	-	8953	25.9
Elastomers	20000	40.45	16635	82.5

Source: Compiled from CMIE, Market and Market Shares [1993].

The IPCL is today the largest manufacturer of petrochemicals in the country and also produces the most diverse range of products. At present, the IPCL ranks first both in terms of size and in terms of output. At 535,321 tonnes per annum, it produces 28.46X of the total output in the industry. It also manufactures the most diverse range of petrochemicals from building blocks on one end to end products on the other. However, the liberalisation process has led to the opening up of the public sector to private entrepreneurs, thus a potential threat to IPCL's dominance. On the policy front, the role of the public sector in the liberalisation era has been eroded in two ways. Firstly, private firms are now allowed to operate in the? petroleum sector. Since petrochemical feedstocks are the by-products of petroleum refining, the production of feedstocks will no longer be the monopoly of the public sector. Secondly, two public sector companies in the petrochemical industry IPCL and FACT have been among the 30 public enterprises where the government has disinvested its share to the tune of 20"/.. The entry of private shareholding is expected to induce these PEs to act competitively.

The other significant aspect of government intervention has been its role as a regulator of the private sector by means of industrial and trade policies. Liberalisation has heralded a gradual erosion of these restrictions. The subsequent section reflects the transition in the government's regulatory role in the Indian petrochemical industry.

GOVERNMENT AS REGULATOR: POLICY INTERVENTIONS

The latent demand for petrochemical inputs in various industries surfaced in the 1980s making room for fresh entry. Therefore, apart from the public sector, a large number of private firms entered the petrochemical industry and incumbent firms chalked out extensive expansion plans. Both entry and expansion was regulated by the government within the restricted policy framework that prevailed at that time. Government policy towards the petrochemical industry fell into the broad parameters of regulatory policy, during the regulatory regime as well as the liberalisation period.

From the mid-1970s, the licensing system that: governed industrial and trade decisions was gradually dismantled. These policy changes, broadly termed liberalisation, culminated in the New Industrial Licensing Policy (NILP) 1991 and the Export and Import Policy [1992-97] apart from a number of interim pronouncements.

The NILP [1991] package was designed to 'unshackle Indian industry from the myriad administrative and legal controls which have become unnecessary in the changed national and global environment'[9]. Barring 18 industries where the government would retain control, licensing restrictions were removed from the rest of the industry. This, the policy statement declared, would enable entrepreneurs to 'freely develop their industries, become more competitive nationally and internationally, more efficient and modern'.[5] The separate permission required by the MRTP houses for investment and expansion was abolished. And the list of industries reserved for the public sector was reduced from 17 to

6. In addition, private sector participation was allowed even in industries on the reserved list. The EXIM Policy [1992-97] liberalised imports by removing all goods (apart from a short negative list) from quantitative restrictions. However, tariffs continued to remain quite high and non-uniform. These far reaching changes were also applicable to the petrochemical industry.

An important input into policy-making in the petrochemical industry has been the recommendations of a number of committees set up by the government. While the committees were expected to work within the broad parameters of the policy framework prevailing at that time, the recommendations were based on the developing the industry in India. And some of the recommendations have become part of the government's policy towards the petrochemical industry. There have been five major committee reports on the petrochemical industry since 1960, and the recommendations of these committees reflect the direction of the policy change.'

The first report was submitted by the Kane Committee in 1961. The report makes tentative estimates of the prospects of growth of the petrochemical industry in the country at a time when it was in its infancy. But restrictive industrial and trade policies ensured that the growth of the industry remained low key till the mid 1970s when the public sector made an entry. The Lovraj Kumar Committee of 1978 (almost two decades later) sought to consolidate the position of the petrochemical industry in view of the petrochemical giant IPCL coming up at that time.

Soon after, the government initiated a series of policy measures to liberalise the economy. Therefore the question of efficiency gained predominance, and in the petrochemical industry, efficiency and scale of operation are linked. It is in this context that the Ganguly and Mehta Committees[0] in 1986 and 1988 respectively, sought to estimate and stipulate the *MES* of plants where licensed capacity was not dependent on domestic: demand but efficiency. Since the petrochemical industry was still being

licensed, the stipulation of *MES* would ensure that capacities increased enormously. The focus of the next report, that of the Kapur Committee submitted in 1986, was to calculate detailed demand estimates for petrochemicals till the turn of the century to facilitate planning for capacity expansion.

In 1991, liberalisation had gained momentum and the petrochemical industry was by and large delicensed. The earlier problems of estimating demand for licensing and the stipulation of MES became redundant. The Sengupta Committee set up in 1990 was initially supposed to revise the Kapur Committee estimates of demand. Due to the changing environment, the committee tackled the question of planning for the growth of the industry in a liberalising economy. The gradual reduction of trade restrictions gained importance since the policy changes attempted to force the domestic petrochemical industry to be internationally competitive. The focus of the Rakesh Mohan Committee brought out in 1993 was the recommendations of tariff reductions in a phased manner.

The following section will elaborate on the recommendations of these committees and place them in the context of evolving policies. The emphases will be on how the recommendations of a number of committees form the basis of liberalisation policies in the petrochemical industry.

Government Committee Reports;

The government's interest in promoting the petrochemical industry was evident as early as 1960 when the Ministry of Commerce and Industry set up a committee under the chairmanship of K.P. Kane to study the growth prospects of the fledgling industry in India. What actually spurred this interest was the increasing availability of petrochemical raw materials at the end of the Second Five Year Plan. A surplus of naphtha was available with the development of the petroleum refineries in the country as well as the discovery of natural gas in Assam. These new sources of raw materials called for an appraisal of the direction of development of the petrochemical industry, which was the task of

the Kane Committee. This committee was entrusted with the task of preparing the agenda for the development of the petrochemical industry for the Third and Fourth Five-Year Plans. Based on the report's demand forecasts (which envisaged a very rapid growth rate), the committee worked out production targets for a variety of petrochemical products. The committee emphasised three issues: (a) the size of plants, (b) the location of units, and (c) trade policies.

Although the committee never specified actual plant size, it was clear that minimum economic size based on domestic demand was a consideration when drawing up production targets. This was specially true of cracker sizes. The committee emphasised that "it would be more advantageous to put up a few large naphtha cracking units rather than putting up a large number of small units which would not be as economical as the larger units. In this connection, they mentioned that the MES for a cracker would be 10,000 tons/per year" [1961:71].

While there was specific emphasis on the need for Indian industry to be competitive (viz. international plant sizes and export potential), the objective of balanced regional development also held sway. The report suggested that four major crackers should be set up - North, South, East and West and all other intermediate petrochemical plants should be serviced by these crackers.

However, 1965 to 1977 was the period of industrial stagnation in India. The production and consumption of petrochemicals in India was constrained not only by domestic capacities, but also on account of import control as necessitated by the foreign exchange limitation. It was not until the mid-1970s that petrochemical products began to form a part of the consumption basket for a greater proportion of the population. The government interest in the petrochemical industry was reactivated in 1978 and the Planning Commission set up a working group on petrochemicals under the chairmanship of Lovraj Kumar to formulate the programme for the development of the petrochemical

industry for the Five year Plan [1978-83]. This was just before the largest government-owned company IPCL was to go on stream.

Lovraj Kumar Committee - 1978

The Lovraj Kumar Committee viewed the question of size as central to the task of planning for the development of the petrochemical industry. The report's recommendation on size linked *MES* firstly to technology and secondly to the degree? of protection the government could offer the industry.

The calculation of *MES* was essentially based on technological factors. However, the Lovraj Kumar Report did not. impose an additional constraint of domestic demand which was the important consideration in the Kane report. The report pointed out that the manufacture of petrochemical intermediates was highly capital intensive and there existed substantial economies of scale. Therefore it was clearly advantageous to "establish the largest possible size of plants, the limiting factor to the size being only the availability of technology and equipment" [p xv] .

The report also stipulated that, "The government should also announce the minimum sizes of new grass-roots plants below which no plants will be permitted to be erected. It would be highly desirable if the government could also announce the quantum of duty protection that is likely to be afforded" [p xx]. The committee thus recognised the sensitivity of MES to duty and protection [p55]. What comes out very clearly is that as long as protection is ensured, plants could be of optimum size. The Lovraj Kumar Report's stipulation on size in fact reflects the evolving policies directed at liberalisation in the economy. The fact that the report did not limit the extent of production (and thereby size) to domestic demand but related output to *MES* technology, implied that the efficiency criterion was gaining importance. Domestic liberalisation was supported to the extent that, while the petrochemical units were still being licensed, the licensed capacities would be optimal.

On the other hand, plants could be of optimum size only when they were not constrained by demand either domestically or globally. Since domestic demand was still picking up, the committee recommended protection to the industry in order to allow plants to be of optimal size without being competed out of the market by imports. That is, plant sizes could be optimal as long as protection was ensured. Thus trade? liberalisation was kept in abeyance.

The significance of size (and thereby efficiency) was again apparent when the government commissioned two studies by the Ganguly and Mehta Committees in quick succession to explore the question of minimum economic size. These reports were not a comprehensive study of the petrochemical industry to make recommendations in the direction the industry should grow but were specifically on the stipulation of *MES* as part of the early liberalisation initiatives.

The Ganguly Committee investigated and arrived at the appropriate *MES* of a variety of petrochemicals based on international prices of petroleum and input date of the domestic industry.

The input data comprised: (a) investment and capacity, (b) operating cost and (c) prices of inputs and products. Some aspects of technology were incorporated by taking into account conversion costs. The *MES* was based on the estimated price of output when compared to the ratio of product to raw material. For petrochemicals where such details were- not available, such as elastomers, polystyrene and acrylic fibre, *MES* was based on global plant sizes. The government announced the *MES* of 22 petrochemicals in 1986 based on the recommendation of the Ganguly Committee.

However, *MES* is liable to change when the variables on which it is based (i.e. input and product prices) are volatile? apart from changing technology. The government felt that it was necessary to review the Ganguly estimates of *MFS* (apart from adding some more products to the list) in view of the changes in

the world market of petrochemical products since the earlier report was prepared. In 1988 the Mehta Committee was therefore constituted to review the earlier MES and extend the coverage to other lines of manufacture in the petrochemical industry.

The Mehta Report stated that the *MES* calculated earlier were underestimated since they were based on higher international prices prevailing then. It was therefore not sufficient to rely on an economic analysis based on international price and domestic cost data but also to examine sizes of plants 'that have come up and *are* under consideration the world over in the recent past.' The Mehta Committee examined global trends in plant sizes especially in the U.S. and Asian countries such as Korea to arrive at their estimates of *MES.* These estimates substantially pushed up the earlier figures. Table 3.4 provides the Mehta recommendations for MES, as against those that existed earlier.

Note the enormous upgradation for naphtha/gas cracker plants. For instance, the IPCL plant at Vadodara, the largest plant in India, was only of 1.3 lakh tpa capacity. The capacity of the plant would have to be more than doubled to attain *MES* of production.

Table 3.4
Mehta Committee Recommendations for MES

(tpa)

Product	Present	Proposed
Synthetic Fibre:		
1. Polyester Staple Fibre	30	60
2. Polyester Filament Yarn	15	25
3. Nylon Filament/Industrial Yarn	12	15
4. Acrylic Fibre	12	20
Thermoplastics:		
5. LDPE	90	100
6. LLDPE	60	80
7. HDPE (slurry process)	50	100
8. HDPE (swing Process)	-	160
9. Polypropylene	50	100
10. PVC & VCM	100	100
11. Polystyrene	30	40
Synthetic Rubber:		
12. SBR	80	100
13. PBR	50	50
14. Butyl Rubber	-	25
Feedstocks:		
15. Naptha/Gas Cracker	-	300
Other Petrochemicals:		
16. ABS	5	20
17. DMT	100	100
18. PTA	100	200
19. Caprolactum	100	100
20. LAB	60	80
21. Acrylonitrile	70	70
22. Styrene	80	80
23. MEG	60	100
24. Pthalic Anhydride	15	20
25. Oxo-Alcohal	30	30
26. Propylene Oxide/Polyols	12	25
27. EPDM	-	10
28. Alpha Olefin	-	100
29. Polybutene	-	5
30. VAM	-	10
31. BOPP Film	-	5
32. Polyester Film	-	5

Source: Economic Times, 11-4-1989.

By the mid-1980s, it **was** clear that the nascent petrochemical **industry offered** tremendous potential **for growth. It was one of the fastest growing industries.** It was not only supplementing **natural materials** like cotton, wood and wool but had

rapidly forged linkages with other industries. The government therefore constituted the third major committee under the chairmanship of D.V. Kapur to formulate a perspective plan for the petrochemical industry till the turn of the century.[12]

Kapur Committee - 1986

The Kapur Committee's Report (submitted in 1986) was an in-depth study of the end products of petrochemicals to arrive at a perspective planning for the industry till the turn of the century. The committee assumed various scenarios of growth of the economy and industrial output in particular to estimate demand for a variety of petrochemicals. It recommended capacity and investment requirements upto 2000 AD keeping in view the size of the home market. Amongst the recommendations which would have an impact on the structure of the industry were its suggestions regarding plant sizes and import policy. The report endorsed shifting the priority towards petrochemicals as necessary and therefore called for:

(a) Substantial increase in production capacities,
(b) Raising the level of MES of production,
(c) Reduction of tariff rates, and
(d) Increased use of natural gas as a preferred feedstocks for the industry.

Regarding size, the committee suggested that, "...in the long term interest of the petrochemical industry, it was better to exercise the option of investing in economic size domestic capacities". And, "...these capacities should not be looked upon side red as limiting and licensing of larger capacity plants if required, to obtain maximum advantage of economy of scale should not be discouraged. Further, the recommendations tor minimum economic capacities should be periodically reviewed in the context of changes in technology and other developments which would affect the economics of production. And, if the existing sub-optimal plants want to reach the minimum economic size in phases by demonstrating that in this process they would be able to reduce the cost of production then we should encourage them to do so."

Regarding import policy the report urged that, "...the duty of components may be withdrawn or should as a matter of principle be much lower than that applicable for complete equipment", to provide necessary impetus for progressive indigenisation. The committee recommended a dynamic import policy which would require regular monitoring of international price and production trends. This was in view of the wide fluctuations in the international market which makes it difficult to maintain stable tariffs and the expectations that production of new cost-effective plants in Saudi Arabia and Korea would create a glut in the market.

The Kapur Committee Report was critical of the heavy and multi-scale levies on the petrochemical products which had been instrumental in stifling demand. Considering the fact that petrochemical products *are* essential and not luxury items, and form part of the basic needs of the people, the committee made several recommendations to ensure that petrochemical products were available at a reasonable price to the consumer. They were:

(a) The price of feedstocks, namely, naphtha/gas may be fixed at the same level as that fixed for fertilisers. The administered price of naphtha may alternatively be fixed on the import parity price of naphtha corresponding to the international crude oil price which is likely to stabilise in the long term;

(b) Since our energy cost was also high, besides allowing any conservation steps to be adopted, it is recommended that the fuel oil/LSHS price be brought at par with that charged for fertiliser production;

(c) The excise duty on polymers which vary from 30 to 407. may be brought down to the minimum level of 15% of the basic value. Similarly the duties on synthetic fibres may be gradually reduced to bring it to the level of 50% of the basic value; and

(d) While continuing with policy of OGL, the import duties may be so rationalised as to bring the landed cost of various products closer to the indigenous prices reached after rationalising excise duties.

The focus of the Kapur Committee Report was to estimate demand till the turn of the century and thus facilitate capacity Planning for a range of petrochemical products. But given the capital and energy-intensive nature of the industry, and the fact that many firms were expanding, these capacity expansions would

lead to a glut in the market. Since the competitivoness of the industry was in doubt, and coupled with the large irreversible capital investment, this expansion would then lead to a waste of resources. The *cracker* plants were initially set up to mop up surplus naphtha from refineries. However, *pe*trochemical consumption in India being supply-driven, there was a spurt in the use of naphtha for this growing industry. But the use of naphtha for power generation held greater priority and the left-over naphtha was estimated to be adequate only for the existing units. And a deficit was forecasted for the Eighth Plan.[14]

'Sengrupta Study - 1992

The fourth study of the petrochemical industry was by R.P. Sengupta and commenced in 1990 when the V.P. Singh Government commissioned a review of the large capital-intensive petrochemical projects considered by the previous government. During the course of the Seventh Five Year Plan quite a number of projects were approved, and substantial additional capacities were licensed in the public and the private sectors. Given the trend of actual consumption of the products during the late 1980s it appeared that the Kapur Committee had been over-optimistic regarding the growth of the domestic demand and, consequently, overestimated the capacity requirements of a number of petrochemicals based on aromatics. In addition, many states vied with one another for a petrochemical *cracker* and this meant that apart from overlicensing capacity in the private sector, there were many projects which had come for approval in the public sector. Sengupta was requested to review the demand projections made by the Kapur Committee and thereby judge whether capacity planning had been over-optimistic.

The Sengupta Committee Report provides estimates of long-run demand of petrochemical products in India and derives the implication for supply in terms of capacity planning. Its report discusses the demand-supply balance and choice *of* feedstock for different petrochemical products - feedstocks and intermediates in order to economise on costs. The report covered three broad areas of petrochemicals:

(a) Polymers and elastomers among the olefins,
(b) Synthetic fibres based on aromatics, and
(c) Synthetic detergent based on both olefins and aromatics i.e. Alfa Olefins and Linear Alkyl Benzene (LAB).

The Sengupta Report was the first post-liberalisation' report on the petrochemical industry. Sengupta questions the validity of development-planning especially for industries, in a liberalising economy. However, liberalisation in India has not been so much the abandoning of governmental interventions as much as rationalising the choice pf instruments and developing new institutional arrangements for plan implementation. Therefore, "such rationalisation seems to aim at the maximisation of reliance on market constraints which *are* imperative on grounds of important social considerations and various externalities."

The Sengupta Report examined the Kapur Report and questioned whether, given the actual consumption of petrochemicals in the late 1980s, the Kapur Committee had been too optimistic regarding the growth of the domestic market and consequently capacity requirements.

> "It is thus absolutely clear that if all proposals and approved projects for capacities of ethylene, propylene and butadiene *are* implemented, there will be serious underutilisation of capacity in the industry unless India can enter the export market of petrochemical in a significant way. It is apprehended that the conversion of all approved/proposed capacities into actual installed ones would lead to serious problem of capital productivity in this highly capital intensive sector. Since capital is *a* scarce resource of the country, immediate steps, therefore, need to be taken by the government to phase out the implementation of petrochemical projects which are already approved/considered over a longer planning horizon in order to avoid wasteful use of capital."

Obviously if capacities *are* likely to be in excess of the required additional capacity to meet the home market, the industry would have to be export oriented. In fact in a market economy it is inevitable that there would be some wastage of capital and capacities in the process of adjustment of demand and supply forces. This would be particularly acute if the market was confined to the domestic one. In addition, the industry would in act, face the serious risk of recession if it relied only on the

domestic market and did not reorient itself towards export with immediate effect [pl4].

The crux of the Sengupta Report's conclusions *are* that in view of the nature of the petrochemical industry, it should De-al lowed to operate in a market environment. "In view of the nature and priority of end-use of petrochemicals it is quite clear that this industry does not define any of the commanding heights of the economy nor any sector of high socio-economic priority. *The industry can be relatively left to market forces for its future development " [*p 111 *Italics mine],*

Sengupta therefore recommended that the industry should be subjected to the 'compulsions of orienting itself at least partially towards export not only for self-financing, but also to ensure that it suffers less on account of any short-run on medium-run inadequacy of demand in the domestic market. This is particularly important in view of our observations regarding the rationale of capacity licensing in a developing, capital *scarce* economy' [plll].

In the context of liberalisation, it was necessary to have economically viable complexes which could produce petrochemicals at internationally competitive prices. And it was therefore necessary to take a fresh policy initiative if the Indian industry was to become a significant player in the world market. Therefore, the task of the next committee, the Rakesh Mohan Committee was to identify policy measures which would help the industry acquire a globally competitive edge.

Rakesh Mohan Committee - 1993

The Rakesh Mohan Report firmly takes the petrochemical industry out of the limitation of domestic demand and situates it in a liberalising economy. Therefore the thrust of the report is on trade - the ability of the domestic industry to face imports of foreign competitors and their ability to export. Therefore the estimation of duties and tariff rates a*re* the core of the Rakesh Mohan recommendations.

What the Rakesh Mohan Report omits entirely is the question of size or scale of operation which was one *of* the most important considerations for the earlier committees. This was not surprising since liberalisation measures had completely removed the licensing of petrochemical industries (apart from a few hazardous and environmentally sensitive chemicals) and firms were free to operate at any scale. However, it had become imperative to structure tariffs in such a fashion as to force domestic firms to operate at competitive or optimal sizes keeping in view the global scales of operation. If tariff rates were to be progressively reduced, i.e. if protection was reduced , then firms would have to operate at global scales in order to be competitive. The Rakesh Mohan Committee offered the following time-frame in which to reduce tariffs.

Table 3.5
Recommended Phasing for Tariff Reduction

Product	Tariff Level (%)					
	1992-93	93-94	94-95	95-96	96-97	97-98
FEEDSTOCKS:						
Naphtha/LPG/ Kerosene/NGL Propane	0	0	0	0	0	0
BUILDING BLOCKS:						
Ethylene	25	15	25	20	15	10
Propylene	80	15	25	20	15	10
Butadiene	40	15	25	20	15	10
Benzene	25	15	25	20	15	10
M-Xylene	110	40	25	20	15	10
Toluene	110	40	25	20	15	10
INTERMEDIATES:						
Ethyl Benzene	40	15	25	30	20	15
Styrene	40	15	30	25	20	15
EDC	40	15	30	25	20	15
VCM	10	10	30	25	20	15
Paraxylene	85	40	70	55	40	25
Orthoxylene	110	40	70	55	40	25
N-Paraffins	50	50	70	55	40	25
DMT/PTA	110	70	70	55	40	25
MEG	110	70	70	55	40	25
ACN	65	40	70	55	40	25
Caprolactum	50	60	70	55	40	25
END-PRODUCTS:						
Polymers:						
LDPE/LLDPE	65	65	50	40	35	25
HDPE	65	65	50	40	35	25
PP	72	75	50	40	35	25
PVC	35	45	50	40	35	25
PS	55	55	50	40	35	25
Synthetic Fibres:						
PSF	110	85	65	50	40	30
PFY	110	85	65	50	40	30
ASF	110	85	65	50	40	30
NFY	110	85	65	50	40	30
Others:						
LAB	110	85	65	50	40	30
Alpha Olefins	110	85	65	50	40	30

Source: Experts' Group Report on Petrochemicals [1993].

Note: Tariffs for the years 1992/93 & 1993/94 are as per budget proposals.
Tariffs for the years 1994/95 to 1997/98 are the Group's recommendations.

The tariff reductions in Table 3.5 have been calculated keeping in view, a) structure of tariffs in comparable countries in Asia, and b) the duty increases along the chain of products according to increases in value addition. Since the maximum tariff level does not exceed 20-30% in most Asian countries, the Rakesh Mohan recommendations scaled down Indian tariff levels to a maximum of 30% over a period of five years. In addition, import duties levied were based at the stage of value addition i.e. increasing duties along the value chain with the highest duties on finished products. The following table illustrates the proposed duty structure.

Table 3.6
Proposed Customs Duty Structure

A. Basic Feedstocks: *Graduated Tariff Protection of 0 - 10%*		
Naphtha	Benzene	C4s
Ethylene	Toluene	
Propylene	Xylene	
Butadiene	Isobutylene	
B. **Intermediates:** *Graduated Tariff Protection 15 - 25%*		
Ethylene Oxide	Propylene Glycol	Acrylonitrile
Ethylene Dichloride	Phenol	DMT
Ethyl Benzene	Styrene	Ethylene Glycol
Vinyl Chloride	Caprolactum	LAB
Propylene Oxide	PTA	MTBE
C. Finished Products: *30 - 40%*		
LDPE/LLDPE	SBR	Polyols
HDPE	PBR	Isocyanates &
PVC	IIR	other derivatives
PP	EPDM	
PS	PSF	
ABS	PFY	
PET	Nylons	

Source: Expert's Group Report on Petrochemicals [1993].

The report also stressed on the need to shift from quantitative controls to tariffs and then rationalise tariffs. But given the volatile nature of the prices of petroleum and its Products and excess capacities that exist, two problems arise: (a) the ability of domestic firms to react quickly to these price

changes and compete with foreign firms, and (b) to be cautious about dumping. The report points out that countries that want to dump their products target exports to those countries which are in the process of liberalising their imports through a lowering of tariff and non-tariff barriers, and India could be one such target. To counter problems of dumping, the report made a strong case for the imposition of counterveiling duties on a case-by-case basis.

The government committees that we have discussed in this section were set up to advise on the development of the petrochemical industry within the broad parameters of the government's policy framework. Further, the recommendations of the some of the committees such as those of Ganguly, Mehta and Rakesh Mohan form the specificities of the government's liberalisation policy in the petrochemical industry. These policy changes *are* part of the overall government policy changes veering towards liberalisation in industry and trade. The nature of these changes in the petrochemical industry will be examined in the following section.

Changes in Policy Interventions: The Liberalisation Process

Liberalisation in Indian industry is a result of a gradual process of dismantling domestic industrial policies and the reduction of trade barriers by the government. While both domestic and trade liberalisation has to be in tandem to be effective, there is often a lag between the two in order to minimise the disturbances arising out of such adjustments. In the Indian petrochemical industry, while domestic liberalisation began early and was clear cut, trade liberalisation has had a very hesitant beginning and continues to be ad hoc. This pattern is in consonance with the general framework of liberalisation in India. We now outline the two strands of liberalisation in the Indian petrochemical industry.

Domestic Liberalisation

Industrial policy changes in the liberalisation era have seen a gradual relaxation of controls on industry. This implies a relaxation of rules that governed entry and scale of operation in a firm, i.e. entry of new firms and expansion and diversification of incumbent firms in the petrochemical industry. The following are the industrial policy changes that have removed or reduced barriers on the entry of firms to the industry:

Licensing: All but eighteen industries were exempt from licensing requirements under the NILP (1991). These 18 industries were further reduced to 15 in an amendment to the NILP (1991) in April 1993. Therefore industrial licensing has been abolished for all products except for a short- list of industries related to security and strategic reasons. Naphtha and gas crackers are hazardous and thereby require compulsory licensing. Amongst the downstream units which require licensing *are:* EO/EG, LDPE (Sp.gr (0.94), polycarbonates and PMMA. The major downstream units that no longer require licensing a*re:* LDPE, HDPE , PP, PS, ABS, fibe intermediates and synthetic rubbers, detergent intermediates and some polymer intermediates.

Automatic clearance is being given for the import of capital goods being serviced by foreign exchange purchased from the market. Even the import of second-hand goods are presently being allowed in some sectors without the use of licensing procedures.

Removal of MRTP Limits: Expansion of capacity by large business houses which were earlier restricted by MRTP limits were totally removed. Petrochemical units which were earlier restrained by MRTP limits would be free to expand and diversify. This eliminates the requirement of prior approval of the government for the establishment of new undertakings, mergers, amalgamation and takeovers.

Opening up the Public Sector: The private sector was allowed investment in as many as 10 areas so far reserved for the public sector. Though the private sector continues to have a strong presence in the petrochemical industry, the feedstocks being used by this industry were so far under the direct control of the public sector. Now by opening up refineries to private sector participation, the private sector can also produce feedstocks.

' The specification for MES was part of government policy and has been periodically reviewed based on the recommendations of the Ganguly, Mehta and Kapur committees. Select industries were

Table 3.7

Prescribed Minimum Economic Scale of Operation

Petrochemical	As Recommended By			
	Ganguly Committee (1)	PP Committee (2)	Mehta Committee (3)	GOI Policy (4)
Synthetic Fibres				
1. PSF	30		60	60
2. PFY	15		25	25
3. AF	12		20	20
4. NFY	12		15	
Synthetic Rubber:				
5. SBR	80	80	100	100
6. PBR	50	50	50	50
7. BR	30	-	25	25
Thermoplastics:				
8. LDPE	90	100	100	100
9. LLDPE	60	80	80	100
10. LLDPE & HDPE	-	80		
11. HDPE	50	60	100/80	100
12. PP	50	60	100	100
13. PVC	100	100	100	100
14. PS	30	-	40	40
Other Petrochemicals:				
15. PTA	100	100	200	200
16. Caprolactum	100	-	100	100
17. LAB	60	50	80	80
18. ACN	70	70	70	80
19. Styrene	80	-	80	
20. EO/EG	60	60	100	
21. Paraxylene	-	100		
22. Orthoxylene	-	100		
23. Benzene	-	100		
24. Alfa Olefin	-	100	100	
25. DMT				100
26. MEG				100
27. Petroleum Resin				15
28. Propylene Oxide				12
29. Methanol				100
30. Plasticizer Alcohol				40
31. Formaldehyde				00
32. Phthalic Anhydride	15			
33. ABS	5			

Source: Columns (1) Mehta Report [1988] Annexure 1.
(3) Economic Times 11-4-1989.
<2> & (4) Doshi [1989].

Note 1 :- DMT/PTA

prescribed MES of operation in order to exploit scale economies and to make Indian industry cost effective. In cases where the industry was delicensed, MES would only indicate a recommended minimum size. However for industries that required licensing, MES is a significant indicator of operational size and size of entry. Table 3.7 provides the government policy regarding MES.

Two policies that were important in the initial years of liberalisation dealt with the decrease of restrictions on the expansion and diversification of firms. These were:

Re-endorsement of capacity: Licensed capacity in select industries was increased by an additional 25% over and above the highest production level achieved during the past five years. And automatic growth was allowed in some industries.

Broadbanding: All existing and new industrial units will be provided with a broadbanding facility to enable them to produce any article so long as no additional investment in plant and machinery is involved. Further, exemption from licensing substantial expansion of existing petrochemical units.

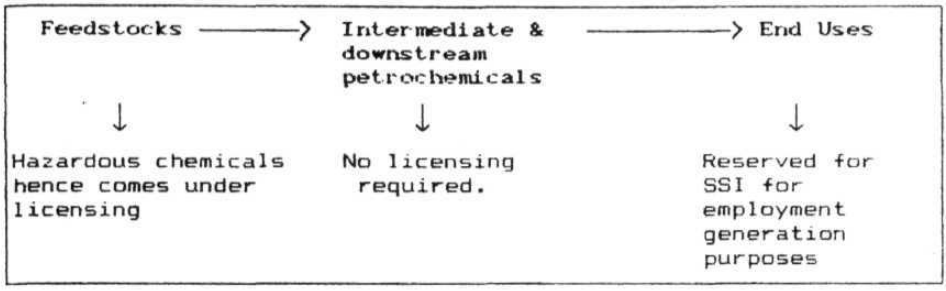
In view of a complete relaxation of licensing in all but 18 industries under the NILP (1991), the above policies became redundant. However, some petrochemicals especially the basic inputs require licensing because of their hazardous nature. They *are* ethylene, propylene, butadiene, benzene, toluene, o-xylene, m-xylene, p-xylene, ethylene glycol, ethylene oxide and polyethylene having a specific gravity of less than 0.94 [see Jain 1991:11].

Many of the end-products which have petrochemical inputs come under schedule III of the NILP (1991) which is the list of items reserved for exclusive manufacture in the small-scale sector. The main items are:

a. Art silk/man-made fibre hosiery (11 items),
b. Rubber products,
c. Plastic products,
d. Injection moulding thermo plastic products,
e. Selected chemicals and chemical products mainly for laboratory use,
f. Artificial dyes and colours,

g. Domestic PVC pipes,
h. Sports goods, and
i. Bicycle, tricycle and perambulators. [Jain 1991: 72]

Therefore the following pattern in policy-making can be discerned:



From the above diagram, it is clear that the licensing policy pertaining to the petrochemical industry is guided by multiple objectives. Firstly, by continuing the licensing of -feedstocks where the public sector dominates, the government ostensibly exercises control over safety and environmental procedures. Secondly, by restricting the manufacture of many of the end uses in small-scale units, the objective of employment generation is kept in view. And thirdly, the whole range of intermediate petrochemical products that may, potentially benefit from economies of scale and competition, have been delicensed.

The NILP (1991) relaxed rules pertaining to foreign investment and foreign technology agreements which included automatic approval of foreign technology agreements and for 51% foreign equity approvals. The list included:

<a) Heavy organic chemicals including petrochemicals,
<b> Chemicals other than fertilisers,
(c) Synthetic resins,
(d) Plastics,
(e) Man-made fibres,
(f) Synthetic rubber,
(g) Synthetic detergent,
(h) Miscellaneous chemicals for industrial use only ,
<i) Rubber chemicals, and
(j) Polyols. [See Jain 1991: 67].

These liberalised industrial policies had a significant impact on the conditions of entry in the intermediate and

end-product range of petrochemical manufacturing. Even the manufacture of feedstocks was no longer the sole purview of the public sector and was opened up to the private sector too.

The initial liberalisation policies were focused on *MES* and broadbanding. Entry had to be on a large scale (to be commensurate with *MES) and incumbent firms had to expand capacity at least to MES.* With broadbanding, firms were allowed to choose the product mix of output within a stipulated range of products *without* increasing overall capacity. Firms were therefore free to enter allied areas of manufacturing, i.e. integrate vertically. The removal of MRTP asset limits provided an environment whereby well-established firms which could muster the high investment **costs** could enter the industry.

The most far-reaching of the liberal industrial policies was the delicensing of intermediate and end-product range of petrochemical in the **New** Licensing and Industrial Policy [NILP] statement of 1991. It removed all artificial, i.e. government-erected, obstacles to the entry of new firms and the expansion of incumbent firms. While domestic liberalisation policies were systematic in bringing down artificial barriers, trade policy in the same period not only lagged behind but was not as systematic.

Trade Liberalisation

While changes in industrial policy have been across the board, changes in trade policy have been ad hoc and not as clear cut. Indian industry has been protected for so long that its ability to **face** foreign competition was severely impaired. This results in **a** variety of lobbying tactics on the part of industrialists to retain a protected market.

In addition, Indian firms find themselves unable to react quickly and **adapt** to changes in trade policy. A classic example is the case **when the** import duty on caprolactum was cut from 80% o 50%. as part of **the** liberalisation policy. With the tariff cut,

imports became Rs.78,000 per tonne as against Rs. 83,000 per tonne charged by FACT. FACT soon accumulated stocks of 300 tonnes valued at Rs. 25 crs which it had to sell at a rebate and incur losses. The only other company producing caprolactum - GSFC did not have problems since its products were inputs for its subsidiaries and the cost difference was absorbed in the transaction.

The Indian import policy has been a combination of tariffs, quotas and outright bans on specified products and product groups. Very often, the import of certain goods is tied up with an export obligation. For example, in 1989 the government had released import licences for NFY manufacturers to meet 25% of the caprolactum requirement - caprolactum is a basic input for NFY manufacturing. An additional 25% was licensed against a further export obligation.

Trade liberalisation involves any shift from a more restricted policy to a less restrictive one. And the effects of trade liberalisation are initially and specifically on the relaxation of controls on imports. Imports have been classified in the following manner:

Banned List: Exports and imports of items on the banned list are totally prohibited.

Restricted List: Items on the restricted list are not permitted to be imported except against a licence or in accordanre with a public notice issued on this behalf.

Canalisation: Exports and imports of these items can be only through the agencies designated by the Central Government.

Open General Licence (OGL): Items on the OGL List may be freely imported subject to the payment cf specified customs duties.

Trade is liberalised whenever there is a shift from a restricted regime to a less restricted regime. That is, a shift from the Banned List to a Restricted List, or from a Restricted List to OGL constituted liberalisation because of the relative-ease trade especially imports. Similarly, trade liberalisation occurs when a previously canalised item is de-canalised. All these

examples constitute shifts in quantitative restrictions and can be examined by analysing shi-fts in quotas in the EXIM policy reports. **Trade** liberalisation also occurs when tariff rates *are* reduced for the import of items on the OGL. We now list out the specific liberalisation policies pertaining to the petrochemical industry. **The** following table provides the changes in tariff structures for **select** petrochemicals over the past ten years.

Table 3.8
Tariff Structure of Petrochemicals

Product	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92
SYNTHETIC FIBRES											
PSF											
Total Duty	165X	170%	* 170% + 9000	175% + 9000	175% + 9000	185X + 9000	190% + 9000	180% + 9000	180% + 7000	1 BOX + 7000	
Rs./mt.											
PFY											
Total Duty	205% •	205% +	225% +	225% •	225% +	225% +	205% +	205% +	180% •		
	78750	93750	105000	105000	98750	83750	56120	58920	66000		
Rs./mt.						145683	129974	107261	116447	127956	
if											
Total Duty	125% +	125% +	135% +	140% f	140% +	150% t	155% +	145% +	145%+	150% +	
	12500	17500	30000	30000	30000	22500	22500	18350	21270	9000	
Rs./mt.			50250	56876.50	60551.50	50107	56333	56427	57439	47723	
•FT											
Total Dutr	125% +	130% +	135% +	140% +	140% +	140% +	140% +	130% +	130% +	100% +	
	64750	64750	72250	76250	70000	70000	7000	41760	43830	60000	
Rs./mt.						141804	139208	105598	130796	135724	
THERMOPLASTICS											
LDPE/LLDPE											
Total Dutr					219.5%	186%	179.5%	88.5% + 2600	88.5% + 2600	90.70% + 3945	97.25% 3945
Rs./mt.					16165	13332	16456	19069	17060	16536	20058
Polypropylene											
Total Duty					125.7%	160%	127.5% + 3250	95%	95%	90.7% + 6575	97.5% + 6575
Rs./mt.					13464	14230	18786	16191	19224	18357	22075
HOPE											
Total Duty					155.6%	160%	160%	160%	140.5%	140.5%	88.5% f 8320
Rs./mt.					12738	11829	15355	29642	61658	22053	24234
P?C											
Total Duty					241.9%	40% f 14700	40% + 10570	40% + 5600	40% + 5600	42% + 9940	89.8% + 2920
Rs./mt.					17245	17510	13979	11592	11125	14460	13952
Polystyrene											
Total Duty					155.6%	248%	188% + 6000	128%	92%	74% + 2100	97.25% 1315
Rs. /mt.		745	665		1120	1624	1445	1300			1200

OTHER PETROCHEMICALS

LAB Total Duty Rs./mt.						95*	95%	95*	95%	100%	110%
Alpha Olefins Total Duty Rs./mt.						150*	150*	150*	150*	110*	110%
Benzene Total Duty Rs./mt.						40%	40%	40%	25*	40*	40%
Orthoxylene Total Duty Rs./mt.						80* + 833 3302	120* + 1499 6952	125* + 1667 7546	125% + 2680 12135	125* + 2115 9575	110* + 2472 10319
Paraxylene Total Duty Rs./mt.	Rs.550	Rs.550	Rs.550	fis.550	fis.550	80% + 15% 5909	85* + 15* 6370	120* + 15.75% 13097	90* + 15.75* 14639	80* 5852	
DMT Total Duty Rs./mt.	125*	130%	135*	140%	HO* 10125	190% + 300 16405	190* 13173	195* 17154	195% 19761	150% + 3780 18753	
PTA total Duty Rs. /mt.		10491		11348	20354	140%	140*	190 + 15% 3000 18438	190* • 15* 22147	195* 26297	195* 150* + 15.75* 21999
MEG fotal Dutr Rs./mt.	80% + 8%	85* + 8*	105* + 10*	110* + 10* 7352	110* + 10* 6831	110* + 10% 7865	150* + 10% 21269	155* • 15.75* 16266	90* • 15.75* 13037	150* + 15.75	
Caprolactum total Duty Is./it.	25* • 29.925*	25* + 29.925*	85% f 15.75*	90% f 15.75*	90* f 15*	90* + 15*	90* + 15* 23812	75* + 15.75* 24577	75% + 15.75* 29420	75* + 15.75* 29125	

Source: **Compiled from Expert's** Group Report on **Petrochemicals** [1993].

We see from Table 3.8 that tariffs continue to be high for all categories of petrochemicals thus continuing protection to the industry. Tariff reductions in the industry have been *ad hoc* and not systematic. Trade liberalisation has therefore not yet begun in the Indian Petrochemical industry. In Table 3.9 we examine the tariff changes for some petrochemicals in a chronological order.

Table 3.9
Trade Liberalisation: Changes in Tariffs (1983-1993)

Year	Product	Policy Changes
Synthetic Fibres & Intermediates:		
1992 (1-3-1992)	Ethyl Benzene, Styrene butene-1 & pure Octanes	A basic customs duty of 40% has been prescribed on these products.
1989 (30-10-1989)	Paraxylene	Basic Customs duty has been reduced from 45% to 35% ad. valorem.
1988 (1-3-1988)	Viscose Staple Fibre & tow	Basic duty increased from 50% to 60%.
1987 (1-3-1987)	Synthetic & Woollen Rags	Basic duty increased from 20% to 30%..
1986 (16-4-1986)	DMT	Basic duty increased from 150% to 150% plus Rs. 3 per kg
1986 (16-4-1986)	PTA	Basic duty hiked -from 150% to 150% plus Rs.3 per kg. Auxillary duty remains at 40%.
1986 (1-3-1986)	PTA	Basic duty reduced from 150% plus Rs. 10 per kg to 150%..
1986 (1-3-1986)	DMT	Basic (standard) duty decreased from 150% plus Rs.10 per kg to 150%.. The basic (preferential) duty decreased from 140% plus Rs.10 per kg to 140%. Counter-veiling duty remains at 40%,. Duty is only 140% if imported from Mauritius, Seychelles or Tongo.
1986 (17-2-1986)	PTA	Basic duty hiked from 150% to 150% plus Rs.10 per kg.
1985 (4-10-1985)	VSF	On improved varieties of like HWM, polynasic etc., basic duty hiked from 40% to 55%..
1985 (30-9-1985)	DMT	Basic (standard) rate of duty hiked from 100% to 150% & counterveiling duty reduced from 20% to 12%.. The basic (preferential) rate of duty hiked from 90% to 140%..

Cont..d

Year	Product	Policy Changes
1985 (30-9-1985)	PTA	Basic duty hiked form 100% to 150"/.. Auxiliary duty remains at 40%.
1985 (18-9-1985)	Viscose Staple Fibre	Basic duty hiked from 35% to 557..
1985 (17-6-1985)	Nylon & Polyester Filament Yarn	A conditional removal of basic duty of 1007. & auxillary duty of 257. completely.
1985 (23-5-1985)	Nylon Tyre Yarn	Basic duty of 1007. plus Rs.11 per kg reduced to 757..
1985 (17-2-1985)	DMT	Basic (standard) duty increased from 1507. to 1507. plus Rs. 10 per kg. The basic (preferential) duty increased from 1407. to 1407. plus Rs. 10 per kg.
1985 (11-1-1985)	Viscose Staple	VSF other than high density & high weight, basic duty reduced from 257. to 357., auxiliary duty reduced from 10% to 57. & counterveiling duty of Rs. 4 per kg plus 107. scrapped.
1983-84	Acrylic Fibre	Reduction of duty which is at present 1007. (basic), 407. (auxillary) and Rs. 11.25 per kg (counterveiling).
Plastics and Intermediates:		
1990 (16-5-1990)	Polyethylene & co-polymer of ethylene	Polyethylene & co-polymers of ethylene (other than polyethlene-based sheathing compound and insulations compound) having a specific gravity of less than 0.95 have been exempted from customs duty in excess of 107. ad valorem and whole of additional duty levied under Customs Tariff Act (CTA) 1975.
1990	Plastic Products	The 157. cut, which was imposed on imports of raw materials, components, and after sales service spares by actual users engaged in the manufacture of plastic products by use of

Cont..d

Year	Product	Policy Changes
		Restoration of 15'/. cut on import of raw materials, components and spares by actual users.
1990 (16-5-1990)	Polyethylene & Co-polymers of ethylene	Polyethylene and co-polymers of ethylene (other than polyethylene based sheathing compound and insulation compound) having a specific gravity of less than 0.94, have been exempted from customs duty in excess of 10% ad valorem and whole of additional duty levied under CTA (1975).
1989 (18-9-1989)	Polypropylene	Concentrated dispersion of colouring matter in polypropylene (polypropylene master batch) for the manufacture in polypropylene multi-filament yarn has been exempted from the basic customs duty in excess of 70% ad valorem, subject to certain conditions.
1989 (1-9-1989)	LDPE	LDPE-based sheathing compound or insulation compound has been levied with 50% basic customs duty,
198. (9-7-1987)	Styrene Monomer	Auxiliary duty of 25'/. plus Rs. 1,700 per tonne has been decreased to 20'/. plus Rs.1,700 per tonne. An additional auxiliary duty of 457. has been imposed.
1987 (8-7-1987)	Styrene Monomer	Auxiliary duty of 45'/. has been scrapped. Instead a basic duty of 25% plus Rs. 1,700 per tonne has been imposed.
1986 (31-12-1986>	Propylene co-polymers	Basic duty reduced from 200'/. to 60%. Valid till 28-2-1987.
1986 (1-3-1986)	LDPE moulding powder & granules	Basic duty hiked from 60'/. to 80% (for HDPE, basic custom duty is 607.. Auxillary duty hiked from 357. to 407.).

Cont..d

Year	Product	Policy Changes.
1986 (1-3-1986)	Polypropylene	Basic duty of 60"/. and auxiliary duty of 40% imposed.
1985 (29-7-1985)	LDPE moulding powder & granules	Basic duty reduced from 1007. to 60% & auxiliary duty reduced from 40"/. to 35%.
1985 (17-3-1985)	Plastics	Counterveiling duty of 12% imposed on certain varieties of plastics while basic and auxillary duty remain unchanged at 100"/. & 40"/. respectively.
Synthetic Rubbers:		
1988 (26-5-1988)	Nylon Tyres	Ribbed lug & semi-lug varieties of nylon tyres exempted from basic customs duty in excess of 60%.
1986 (17-2-1986)	Synthetic Raw Rubber	Basic duty reduced from 100"/. to 60%.
Others:		
1989 (3-7-1989)	Ethylene	Ethylene? has been exempted from basic customs duty an excess of 207. & whole of additional (counterveiling) duty but levied with 57. auxillary duty.
1989 (30-6-1989)	Butadiene	Butadiene, when imported for the manufacture of synthetic rubber has been exempted from basic customs duty in excess of 407. and whole of additional duty but levied with 57. auxillary duty.
1988 (1-6-1988)	Ethylene Dichloride	Basic duty on ethylene dichloride for the manufacture of polyvinyl chloride resin has been reduced from 25% to 157. and auxillary duty has been totally exempted.
1984 (29-10-1984)	Butadiene	Basic duty reduced from 707. to 357., auxillary duty reduced from 407. to 307. and counterveiling duty of 127. scrapped.

Cont..d

Year	Product	Policy Changes
1984 (29-9-1984)	Vinyl Chloride Monomer	Basic duty of 10X imposed on VCM for the manufacture of PVC resins.
1984 (20-9-1984)	Ethylene Dichloride	Ethylene dichloride for the manufacture of PVC resins, basic duty reduced from 10'/. to 20"/., auxillary duty of 40'/. & counterveiling duty of 12% scrapped.
1983-84	Vinyl Pyridine	Reduction of duty from 105% ad valorem to 65% ad valorem.

Source: Report on Currency & Finance, Reserve Bank of India, Vol. I - Economic Review (various issues).

The above table covers tariff revisions that were declared in the liberalisation period. However, there does not appear to be any clear cut 'liberalisation', i.e. a systematic reduction in tariffs and a decline in the extent of protection given to the domestic industry. The other category of trade liberalisation is the removal of quota restrictions, which in the Indian context means a shift to OGL.

Table 3.10
Trade Liberalisation: Changes in Quotas
(1983-93)

Year	Product	Policy Changes
Fibre & **Intermediates:**		
1989	Paraxylene	Import of paraxylene will be made available only by IPCL under OGL on the basis of foreign exchange released by the government in its favour.
1987	Man-made Fibre	Man-made fibres, tow yarns ft synthetic rags can be imported by Actual Users but shall be required to register their import contracts with the Textile Commissioner.

Cont..d

Year	Product	Policy Changes
1984	Man-made fibres etc.	Man made fibre, tow, yarn, raw wool/etc., subject to import contracts registered with the Textile Commissioner in advance.
1983	Viscose Filament Yarn	VFY (-first quality) below 600 deniers was included in the OGL list of imports.
1983	Viscose Filament Yarn	VFY below 600 deniers, other than first quality, would be canalised through public sector agencies.
1983	Acetate Filament Yarn	AFY other than first quality was canalised through STC for imports.
1983	Acetate Filament Yarn	Cupramanium filament yarn and AFY (first quality) was allowed for import by Actual Users and others under OGL for stock and sale.
Synthetic Rubber:		
1986	Synthetic. Rubber	Synthetic Rubber, except for butyl rubber, silicon rubber, neoprene/chloroprene/hypalon/ viton, bromobutyl/chlorobutyl, PTFE and EPDM was added to the list of Limited Permissible items, after being removed from the OGL List.
Others:		
1991 (13-2-1991)	Petrochemicals	Thirty-five items which included ethylene and butene-diol were snifted to OGL from the Limited Permissible List. The duty remains the same as before. Among items that were listed in the import policy for the first time was Vinyl Chloride Monomer.

Cont..d

Year	Product	Policy Changes
1989	Chemicals & Allied	New input-output norms indicating the quantum of import allowed with duty exemption for specified export products in various categories of exports like engineering, chemical & allied products, textiles and food have been announced.
1988	Chemicals & Allied Products	New input-output norms fixed for some varieties of raw materials that can be imported against specified export products.
1987	Acrylonitrile	Included in the list of Limited Permissible items of raw materials.
1986	ABS Resins	ABS resins/granules/moulding powder (all grades) were included in the list of restricted items.
1984	Polystyrene	Polystyrene resin/ granules/ moulding powder and sheet glass were removed from the list of Limited Permissible items. Polystyrene resin/ granules/ moulding powder was transferred to the list of Automatic Permissible Items to be imported as a chemical & allied item.
1984	Polystyrene	Polystyrene resin/ granules/ moulding powder were included in the list of Automatic Permissible Items of imports which *are* not allowed to Export Houses against additional licences.

Source: Report on Currency & Finance, Reserve Bank of India, Vol.1- (various Issues).

The above tables *are* not exhaustive and only pertain to the 1980s but they clearly show the *ad hoc* nature of the policy Prescriptions. A cursory reading of the tables that pertain

predominantly to imports clearly indicates that trade liberalisation has not been as clear-cut as domestic liberalisation. In most liberalisation programmes, domestic liberalisation precedes trade liberalisation, and this has been the case in the liberalisation of the petrochemical industry in India. And, trade liberalisation is a politically sensitive issue and is more difficult to implement than domestic liberalisation.

Attempts to streamline trade liberalisation policies start only in the 1990s. The recommendations of the Chelliah Committee on Tax Reforms called for a graduated dut/ structure with higher duties on value added products. The Chelliah recommendations in the petrochemical industry are in line with the Rakesh Mohan Committee recommendations for the rationalisation of import. (These recommendations have yet to be implemented.)

The EXIM policy 1992-97 has a fundamentally new feature in tune with liberalisation. It claims to "substantially eliminate licensing, quantitative restrictions and other regulatory and discretionary controls". The policy statement provides a Negative list of Imports and Exports on grounds of Public Policy . The import of some goods is not banned outright, but is placed under restrictions like licensing, registration, ceiling limits etc. The policy also makes it clear that the import of consumer goods and durables will continue to be under restraint because of economic reasons and on 'grounds of safety, security, environment, employment and the like'. The negative list in the EXIM policy 1992-97 include the following items which *are* relevant to the petrochemical industry:

Figure 3.11

Negative List of Imports

Items	Restrictions
1. Man-made and Blended Fabrics	Not permitted to be imported except against a licence *or* in accordance with a public issued in this behalf.
2. Polyester Staple Fibre and tow.	Permitted to be imported only against a licence or in accordance with a public notice.
3. Naphtha	Canalised through IOC Ltd.

Source: Export and Import Policy [1992-97].

The role of the government in the liberalisation era in the petrochemical industry has focussed on delicensing and the dismantling of trade barriers in the industry. These changes point towards the increasing role of market forces in the production and exchange (i.e. trade) of petrochemical products.

In a liberalising environment firms had to gear themselves to coping with quick changes that arise when market forces dominate economic decisions. A major problem was pricing of products. In the regulated regime, the government set up cost plus prices of many feedstocks. Apart from having administered prices for feedstocks particularly naphtha (and oil & gas from which naphtha is derived), the government referred other petrochemical problems to the BICP. In the liberalised period, the ceiling regulations on prices were gradually reduced. At present, all prices including that of naphtha are determined by market forces.

After liberalisation was initialised several sorts of mismatching arose in the industry, especially since the domestic industry was liberalised and firms were not competitive in the international market. There was severe lobbying to persuade the government not to licence (for products that were still licensed since they were hazardous) capacities greater than domestic demand. The lack of domestic demand led to two kinds of problems:

(1) Firms will have to export, and if they are not competitive, exports *are* subsidised by the government. For e.g., in the case of LAB, a shortage turned into a glut when both Reliance and T.N. Petroproducts began production. The manufacturers were forced to export with the aid of huge subsidies from the government.

(2) Firms will lobby to keep out further competition using government support. In the case of VAM manufacture, both VAM Organic Chemicals and Polychem opposed the proposal of South India Viscose to set up a VAM project. Their argument was that their joint capacity was 55,000 tpa as against a projected demand of 44,000 tpa by the end of the century and therefore. there was no justification to allow fresh capacity. (When firms cannot use government policy to deter entry of new firms in the liberalised *era,* the possibilities of other strategies being used become greater.)

This mismatching would have to be adjusted in a market framework and are outside the purview of government control. The unifying features of the changes in government policy pertaining to industrial and trade policy was its intention of reducing entry barriers in industry in the hope of creating a competitive industrial structure. In the next section we examine the inter-connections between liberalisation policies, industrial structure and entry barriers in the petrochemical industry.

GOVERNMENT INTERVENTION, ENTRY BARRIERS AND INDUSTRIAL STRUCTURE

Government intervention in the controlled and regulated phase of the India's industrialisation process was wrought through myriad policies pertaining to domestic industry and trade. These policies created an environment where domestic industry was supply-driven and protected and essentially cushioned by a variety of artificial entry barriers.

Industrial policy focussed on licensing and the active participation of the public sector in manufacturing goods in the core sectors. Licensing essentially prevented the entry of new firms into an industry where the capacity of existing firms could cater to domestic demand. Licensing also precluded the expansion of existing firms unless demand estimates showed growth.

Industrial policy thereby parceled out the existing market amongst a few firms and barred the entry of new firms, and thereby competition. Such a policy in the petrochemical industry resulted in small plant sizes without taking into considerations scale economies, and thereby, efficiency. And since there were few firms surrounded by high artificial barriers to entry, the industry was highly concentrated and oligopolistic.

The cordoning off of certain areas to the monopoly of the public sector also precluded the entry of private firms. Private sector participation was banned in petroleum refining thereby ensuring a public sector monopoly on the production of feedstocks to the petrochemical industry. The integrated public sector complex IPCL catered to many intermediate petrochemicals to the entire domestic market. Fresh capacities could not be licensed unless domestic demand was greater than the existing capacities. The public sector acquired a monopoly and thus prevented the entry of private firms.

On the trade front, high tariff and non-tariff barriers stemmed the inflow of imports and foreign capital. As long as adequate domestic capacity existed, prohibitive tariffs would preclude the entry of foreign goods. Government policy thus sought to erect a variety of artificial barriers to entry in order to match supply to domestic demand. Scarce capital was directed into areas of national priority without considerations of cost or efficiency.

The government evolved a series of liberalisation policies to induce competition in domestic industry. These policies have eliminated or reduced artificially created barriers that (a) limited the entry of new firms into an industry; (b) regulated the expansion of incumbent firms; and (c) barred imports. The following table summarises the implications of liberalisation policies for entry:

Table 3.12
Liberalisation Policies - Implications -for Entry

Liberalisation Policies	Implications for Entry
1. Delicensing	a. Expansion of capacity by incumbents. b. Facilitation of Entry by new firms
2. Minimum Economic Scale	a. Expansion of capacity by incumbents if installed capacity is below MES b. Facilitates large-scale entry by new firms
3. Removal of MRTP Ceiling	a. Facilitation of expansion by incumbent firms b. Facilitation of large-scale entry by new firms
4. Broadbanding	a. Diversification b. Freedom of output mix c- No capacity expansion but rearrangement within capacity limit
5. Allowing entry by private firms hitherto the purview of the public sector	a. Facilitates entry of new private sector firms
6. Shift from quota to tariffs **i.e. Shift** to OGL	a. Facilitation of Imports but the volume of imports would depend on tariff levels
7. Reduction of tariffs rates	a. Facilitation of imports but volume of imports would depend on tariff levels

In the petrochemical industry, the policy of delicensing enabled the entry of new firms and facilitated the expansion of capacity by incumbents in intermediate and downstream processes. (Only a limited number of chemicals deemed hazardous would continue to be licensed).

The prescription of *MES* and the policy of broadbanding were part of the early liberalisation policy packages, but became redundant after the NILP [1991] removed licensing for a variety of petrochemicals. *MES* coaxed firms to expand to efficient scales

and facilitated large scale entry by new firms. The stipulation of MES became increasingly insignificant with delicensing and the downgrading of trade barriers. If firms have to compete, they would have to take advantage of scale economies and operate at an efficient size without being directed to do so.

The policy of broadbanding gave the manufacturer the freedom of output mix. While the firm was not allowed to expand capacity, it could re-arrange its product range over a 'band' of allied products.

The removal of MRTP ceilings facilitated the entry of large business houses that were previously prevented by MRTP regulations. These were firms that would have the capability of large-scale investment that the petrochemical industry required.

Areas that were reserved for the public sector were thrown open to the private sector. Private sector firms could enter petroleum refining thereby breaking the public sector monopoly on petrochemical feedstock production. Since licensing was by and large removed on other petrochemical products, private firms could manufacture chemicals on which the public sector had a monopoly.

On the trade front, liberalisation policies reduced barriers to entry by decreasing tariff rates and removing tariff barriers. There was a shift to OGL for many items and from 1993 there is a systematic attempt to reduce tariff barriers.

Liberalisation has therefore meant the systematic removal of artificial barriers to entry in the domestic industry and a reduction on trade barriers. While liberalisation has been ostensibly encouraging entry, this entry has been in terms of capacity expansions and diversification of firms into allied product lines, i.e. vertical integration. And these factors *are* well known natural entry barriers.

There exist two types of natural entry barriers in the Petrochemical industry. Barriers that *are* intrinsic to the industry are that of high cost arising out of scale economies, and

are present both in the pre and post-liberalisation period. Firm strategies of capacity expansion (where excess capacities are built up) and vertical integration that have been facilitated by liberalisation policies *ar&* the second type of natural barriers. And the repercussions of these strategies on industrial structure *are* interesting.

The petrochemical industry has exhibited a high level of concentration from 1983-84 to 1990-91. Liberalisation policies ostensibly facilitates firms to hold excess capacities and integrate vertically. And if these strategies enable incumbent firms to prevent entry, the anti-competitive effects of these policies become apparent. In other words, entry-deterring behaviour of firms in an industry that is already concentrated can accentuate oligopoly power. It is in this context that we analyse the entry-deterring properties of excess capacity and vertical integration in the following chapter. And in order to investigate the implications of trade liberalisation in an industry characterised by scale economies, we develop a model to compare the welfare implications of free trade in such an industry.

NOTES

There has been extensive debate on strategies of industrialisation in India. One of the earliest critiques was by Bhagwati and Desai [1970], and has discussed at length the demerits of the regulatory control system and the restricted foreign trade regime. Also see Bhagwati [1987], Bhagwati & Srinivasan [1976], Ahluwalia [1985], and Wolf [1982].

While the private sector held 51% of total capacity, the public sector constituted 49% at the end of the VII Plan. See Doshi, L.N. [1989], Table 2.

[9]Although the NILP (1991) is a continuation of the policy of liberalisation that has been going on since the mid- 1970s, the compulsions and the magnitude of the changes proposed makes this policy statement more important than any since 1956.

Liberalisation reforms pertaining to industrial policies fall into three categories:

1) Measures to facilitate capacity creation,
2) Measures to facilitate output expansion, and
3) Measures to remove procedural impediments.

This became 15 subsequently.

These 18 industries were further reduced to 15 in an amendment to the NLIP (1991) in April 1993.

The Mehta and Ganguly Reports were limited in their scope, i.e. to that of estimating MES. Neither of these reports have been published.

[7]The terms of reference of the Kane Committee were:

(a) An assessment of the types and quantities of materials whose production may have to be organised in petrochemical industries;
(b) To evolve a suitable pattern for development in India in the context of the integrated pattern of production of petrochemicals in advanced countries;
(c) To assess the extent to which the aromatic as well as aliphtic raw materials may have to be produced as petrochemicals during the period 1961 to 1971; and
(d) To recommend the pattern of development of petrochemical industries in the country [Kane Report 1961:23.

This period is generally corroborated in many studies. See Shetty [1978], Ahluwalia [1985] etc.

The following were the terms of reference of the Lovraj Kumar Committee:

(a) To review estimates of domestic demand, capacity and production in 1977-78 and 1978-79 in relation to what was anticipated in the Fifth Plan, determine the reasons for major deviations and suggest remedial measures.

(b> To determine the likely level of demand for major petrochemical products in 1982-83, 1983-84 and 1987-88 taking into account the projections in the Draft Plan (1978-83), the economics of substitution of traditional scarce materials by petrochemicals, and the optimal utilisation of manufacturing capacity of major petrochemicals units that had been created already.

(c) To study what measures should be taken to increase the consumption of certain petrochemicals (such as thermosetting resins) where domestic manufacturing capacity is under utilised, provided this increased use is established as cost effective in relation to alternative materials.

<d) To recommend the most desirable manner in which the manufacturing capacity for major petrochemicals should be increased (after examining the merits of import and domestic manufacture) including the time-phasing of investment recommended (fixed and working capital as also the likely maintenance expenditure indicating also the rupee and foreign exchange expenditure) and output expected and the most cost effective locations taking into account such factcrs as the possible regional disposition of likely demand, the possibility of capturing export markets, the economies of expanding existing plants (including their rationalisation and modernisation) and the characteristics of raw materials available in the country on an assured long-term basis.

(e) To estimate the likely level of domestic produc Lion from the manufacturing schemes recommended and the consequent level of imports and exports of major petrochemicals.

(f) To estimate the investment required.

<g) To estimate the quantum of skilled man power.

(h) To indicate broadly the respective roles of the public and private sectors (including levels of likely investment) in achieving the desired expansion in the petrochemical industry as also major aspects of a policy that will enable timely fulfillment of the recommendations made including facilities and technical services that should be provided to enable finally saleable petrochemical products to reach acceptable specifications.

(i) To review the existing situation in R & D and make recommendations thereof.

(j) To suggest improvements in the planning, implementation and monitoring systems ....

[Report of the Reconstituted Group on Petrochemicals [1978] (Chairman: Lovraj Kumar), GOI].

[10]The Ganguly Report [1986] and Mehta Report [1988] remian unpublished and were policy inputs into the stipulation of MES that was part of the earlier liberalisation package.

[11]This is borne out in Kelkar & Kumar [1990].

[12] The Kapur Committee estimated the demand for 21 intermediate petrochemicals using econometric models, trend analysis, production-derived demand, consumption-based forecast and replacement forecasts. Bases on industrial deficits and MES of plants, the number of units required to satisfy demand was identified for 13 out of 21 products.

See 'Perspective Planning of Petrochemical Industry: Executive Summary of D.V. Kapur Committee - Summary and Recommendations, *Urja*, January 1987/59.

According to the Kapur Report "... indigenous naphtha will be in short supply. The situation can be partly checked if the naphtha earmarked for power plants can be replaced by providing gas, as and when fields are discovered" [Volume 3, p 83.

[15] See Sengupta Committee Report, p 42.

In conversations with various committee members, it was revealed that during the course of their investigations, it was the industrialists themselves who were not in favour of MES. The stipulated MES (which were still modest when compared to world sizes) were large compared with their ability to garner the capital to invest.

'The following 18 industries continue to require licensing under NILP [1991]:
(1) Coal; (2) Alcohol; (3) Petroleum; (4) Sugar; (5) Cigarettes; (6) Motor car; (7) Hazardous chemicals & drugs; (9) Assets; (10) Paper and newsprint; (11) White goods; (12) Entertainment electronics; (13) Animal fats; (15) Tanned or dressed fur skins; (16) Electronic aerospace; (17) Defense equipment; and (18) Industrial explosives. (Source: Jain [1991]).

However these units would henceforth require only a memorandum of information to be filed with the SIA and not be subjected to MES classification.

Some of these definitions are from the Export and Import Policy, 1 April 1992 - 31 March 1997, Ministry of Commerce, GOI.

[20] Economic Times, 5 August, 1993.

[21] Export and Import Policy, 1 April 1992 -31 March 1997, Ministry of Commerce, GOI.

[22] Our study assumes that output competition rather than price competition underlie firm strategies of expansion and diversification. This assumption enables us to build entry deterrence models using Cournot competition.

[23] See Business India, March 20-April 2, 1989.

[24] See Business Standard, November 27, 1989.

Chapter 4

NATURAL ENTRY BARRIERS AND INDUSTRIAL STRUCTURE

The liberalisation of industrial and trade policies was initialised in India in order to increase competition in the domestic industry and obtain efficient outcomes. In the previous chapter, we examined how liberalisation policies can be perceived as having removed or reduced artificial entry barriers in the Indian petrochemical industry. Liberalised industrial policies reduced legal restrictions on the entry of new firms and the expansion and diversification of incumbent firms. The underlying assumption of liberalisation policies was that the absence of entry barriers would create a competitive industrial structure in the petrochemical industry. What was not taken into account was the presence of natural entry barriers.

There are two types of natural entry barriers in the Indian petrochemical industry: (a) those that *are* intrinsic to the industry and (b) those that arise out of firm strategies. In the petrochemical industry, characterised by high fixed costs and scale economies, natural entry barriers gain predominance as the main deterrents to the building up of competitive industrial structures. The existence of these barriers result in limiting the extent of competition in an industry, and thereby creating an oligopolistic structure and dominant market power for the incumbents.

An intrinsic entry barrier in the petrochemical industry is the high fixed costs of investment. Investment is invariably lumpy and high due to scale economies and other technological factors. Since scales of operations *are* large, much of the initial cost in plant and machinery is not only huge, but a substantial portion of it is sunk. That is, if the firm decides to leave the industry, it cannot easily transfer its investment (in assets) to an alternative use. The lump/ nature of the investment compounds the problem, even of incumbent firms. If incumbents want to expand beyond existing capacities, they will

have to invest in large expansions disproportionate to the desired increase in output.

If the minimum economic scale (*MES*) is sufficiently large relative to the market, it poses an additional dimension to the entry game. Entrants will not come in unless they believe that they can make a profit after entry, which may not be the case even if existing firms are earning a profit. In the case of a large *MES,* a new firm will have to open an efficient sized plant substantially increasing industry capacity. The post-entry price would then be lower than the pre-entry price, and thereby entry can become non-viable. A firm that enters a market with less than *MES* will have a higher unit cost than the incumbents and will leave itself vulnerable to strategic behaviour. When *MES* is large and plants of less than *MES are* very inefficient, incumbent firms will be able to exercise their market power without inducing entry.

The second type of natural entry barriers *are* those that arise out of firm behaviour. Liberalised industrial policy has by and large, removed artificial barriers to entry. Our analysis of the structure of the petrochemical industry threw up two interesting features about how firms invest in the petrochemical industry as a result of liberalisation policies. The first was capacity expansion of incumbent firms. This gives rise to excess capacities or the potential for excess capacity creation given that firms will have to expand at least to *MES* in order to survive in a liberalised economy. Secondly, many firms have integrated vertically Csee Table 2.173.

The expansion of capacities coupled with vertical integration by incumbent firms can be potentially entry deterring and, thereby, accentuate their market power. The strategic behaviour of creating excess capacities and vertically integrating is somewhat aided by the intrinsic barriers in the petrochemical industry of high fixed costs and scale economies. High fixed costs of investment (when a portion of it is sunk), and the lumpy nature of capacity expansion give rise to sunk' excess

capacities. This signals the desire of the incumbent to defend dominant market power.

The technology of the petrochemical industry favours vertical integration at least from the production of feedstocks to downstream petrochemicals.[1] When the incumbent is vertically integrated, it serves to increase the entrant's cost - the entrant will have to compete by entering as a vertically integrated complex which requires substantial investments. And because such entry is risky (with the added problems of *MES* at each stage), the cost of capital will be higher for an entrant than an incumbent thus placing entrants at a cost disadvantage when compared to operating firms.

Liberal trade policies reduce artificial barriers to trade through a reduction in tariffs and the removal of quantitative restrictions. However, as the literature in the New International Trade has shown, freer trade need not lead to competitive outcomes when the industry (both domestic and global) is characterised by scale economies Dr increasing returns to scale. The case for optimal trade policy thus becomes greater in the Indian petrochemical industry.

This chapter presents three model-: to examine natural barriers in the petrochemical industry. Two models will analyse the entry deterring potential of firms that expand capacities and vertically integrate. The third model will examine the impact of trade liberalisation on an imperfectly competitive industry. All the three models *are* set in the theoretical framework of the New Industrial Organisation with the added dimension of trade in the third model. The models assume the following four conditions:

(a) Firms *are* Cournot competitors,
(b) Firms face symmetrical demand conditions,
(c) Firms have identical cost functions,
(d) Fixed costs are large of which a significant portion is sunk.

Cournot competition is assumed primarily because once large capacities (due to lumpy investments and scale economies) have been established, firms can vary their output in infinitesimal

quantities. Therefore, firms can vary output strategically and thereby compete in a Cournot fashion. Price competition is not directly observable and is sufficiently examined even in a Cournot framework.[3] Although most petrochemical -firms *are* multi-product firms, the assumption of single product firms in the models is necessary for simplification.

The models in fact assume that the incumbent is a monopolist. This assumption of monopoly is not stringent and is only a simplification since firms in an oligopoly can collude and simulate a monopoly situation. The incumbent is also the first mover. All the models are two-period models. The models first set out the initial conditions under which the monopolist operates in the first period. The potential entrant enters in the second period and the incumbent and entrant operate as Cournot duopolists. The model then investigates the conditions tinder which the entrant can be deterred in the two periods and compares the two situations to make conjectures about the entry deterring possibilities of the firm's strategies.

Model 1 examines the entry deterring conduct of firms through the presence of excess

Model 2 examines the entry deterrent. strategies of firms through vertical integration.

Model 3 analyses the welfare implications of free trade (ft thereby entry of foreign firms) in a highly concentrated domestic industry by comparing the conditions under autarky, free trade and the imposition of tariffs.

These models ignore all lags thus reducing the dynamic aspects to the barest minimum. Either entry does not occur at all in which case the established firm continues in a stationary state or else it occurs at once, and the post-entry equilibrium is established at once, so that the resulting duopoly continues in its stationary state. This simplification has been allowed for in many studies Csee Dixit 1979 & 1980, Spence 1977 etc.:.

(1) EXCESS CAPACITIES, STEP-WISE CAPACITY FUNCTION AND ENTRY DETERRENCE

One of the outcomes of liberalised industrial policy has been the large-scale capacity expansions of incumbent firms. And one of the reasons for these expansions is the emphasis on efficiency in a liberalised economy that is linked to MES in the petrochemical industry. Since the installed capacity of firms are far below the *MES,** Firms will have to expand at least to *MES* to survive in a liberalised economy. The following table illustrates the lumpy nature of capacity expansions of some firms in the Indian petrochemical industry.

Table 4.1
Capacity Expansions of Petrochemical Firms

1.	**Baroda** Rayon	
	1975	Licensed Capacity Expansions - Nylon yarn from 1800 to 2100 tpa
	1977	Nylon Yarn from 1740 to 2436 tpa Polyester Yarn from 360 to 576 tpa
	1979	Nylon tyre yarn from 1000 to 1700 tpa
	1982	Nylon tyre cord fabrics from 1700 - 3400 tpa
	1982	PFY -From 276 tpa to 1777 tpa NFY from 2436 tpa to 3500 tpa
	1983	PFY from 1777 tpa to 3500 tpa
	1985	Caprolactum doubled capacity
	1989	PFY 1777 to 10,000 tpa under the broadbanding scheme (BS/Aug 21 - Sept 3/1989/p65) NFY 2436 to 5000 tpa NTC 4000 to 6000 tpa PFY 1777 to 10777 tpa (BS/Oct 2-15/1989/146)
2.	DCW	
	1990	Expansion of PVC from 25,000 to 50,000 tpa (FE/Feb 8/1990)
3.	GSFC	
	1986	Caprolactum from 30,000 to 100,000 tpa following MES.
4.	IPCL	
	1982-83	DMT from 24,000 tpa to 30,000 tpa
	1988	Orthoxylene from 21,000 tpa to 45,400 tpa Paraxylene from 17,000 tpa to 48,600 tpa

5- J.K. Synthetics

1982	NIY/TC to 5000 pta ACF from 10000 to 12000 pta
1983	NFY (LOI) to 6000 pta
1984-85	Nylon Tyre Cord by 2000 tpa Polyester Industrial Yarn by 6000 tpa NFY from 6000 tpa to 15000 tpa PSF from 12000 tpa to 30,000 tpa
1989-90	Nylon Tyre Yarn from 1700 tpa to 10200 tpa PSF from 12000 tpa to 30000 tpa PFY to 11,730 tpa PTA capacity increased to 20,000 pta

5. NOCIL

1977	PVC from 20,000 tpa to 50,000 tpa 2-ethyl hexanol from 10,000 tpa to 30,000 tpa
1988-89	Ethylene from 150,000 tpa to 300,000 tpa

6. Reliance

1988	MEG from 60,000 tpa to 100,000 tpa HDPE from 50,000 tpa to 100,000 tpa LAB to 100,000 tpa under re-endorsement of capacity
1989-90	LAB to 80,000 tpa under MES.
1990-91	HDPE from 100,000 tpa to 160,000 tpa PTA from 100,000 tpa to 200,000 tpa under MES
1991-92	Ethylene from 320,000 tpa to 400,000 tpa under MES

7. Synthetics and Chemicals

1984	SBR from 24,000 tpa to 80,000 tpa
1991	Styrenated phenol from 400 tpa to 1,200 tpa

Source: Compiled from BSE Directory (various issues) and Economic Newspapers.
ET:- Economic Times
FE:- Financial Express
BS:- Business Standard

With the stipulation of MES, the likelihood of incumbent firms expanding and building up excess capacities becomes very high. CSee Table 4.2]

Table 4.2
Minimum Economic Scales and Demand

	MES '000 tpa (1)	Demand Estimates K (2)	Demand Estimates S (3)	No of Firms (4)	No.of Firms > MES (5)	(1)÷ (2) (6)
Synthetic Fibres:						
1. PSF	60	280	288	11	-	4.67 (4.8)
2. PFY	25	350	352	22	1	14 (14.8)
3. ACF	20	148	138	8	2	7.4 (6.9)
Synthetic Rubber:						
4. SBR	100	212	255	6	—	1.4 (1.7)
5. PBR	50					
Thermosets:						
6. LDPE	100	708	450	2	1	7.08 (4.5)
7. HDPE	100	555	400	3	-	5.55 (4)
8. PPL	100	420	300	2	-	4.20 (3)
9. PVC	100	713	640	7	-	7.13 (6.4)
10. PS	40	125	120	2	-	3.13 (3)
Other Petrochemical Intermediates:						
11. PTA	200	419		1	-	2.01
12. CPL	100			2		
13. LAB	80			5		
14. ACN	80	215	154	1	-	2.69 (1.93)
15. DMT	100	181		4	-	(1.81)

Source: Col (1) Doshi [1989]. MES is as prescribed by the Government of India.
Col (2) Kapur Committee [1986], Estimates for 1990-00.
Col (3) Sengupta [1992], Estimates tor 1990-00.
Col (4) & <5> CMIE, Market and Market Shares, [1993].

While most firms operate at below *MES,* the domestic market is not large enough to sustain all the firms (in the industry and those that have planned entry) once they begin to operate at efficient scales. Col.6 in Table 4.2 indicates the number of firms the market for a particular product can sustain in a closed economy given *MES as spec i f i ed* fcy *the government* (world scales *are* much larger). Incumbent firms that expand first, not only benefit from the first-mover advantage, but also create excess capacity which can deter future entry. Moreover, as the cost penalty for operating at a sub-optimal scale is substantial,

the smaller firms will be forced to exit. For example, take the case of PFY as illustrated in Table 4.2. There are now 22 producers of the product of which only one producer is operating at MES. The market can sustain only 14 efficient sized firms, thus making the other eight firms potentially redundant. Those firms that are quick to expand will have a first mover advantage?. If the cost of operating at sub-optimal scales is high, the other firms will be forced to exit.

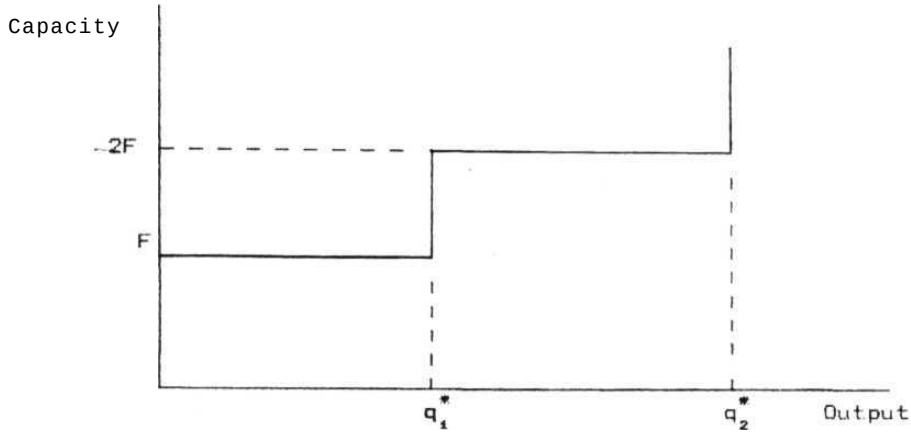
Excess capacity can be either innocent or strategic entry barriers (to use Salop's [1979] terminology]. The nature of investment in the petrochemical industry being inherently lumpy, the excess capacities that arise out of these expansions while maximising profits, become innocent entry barriers. Or, excess capacities can be held for strategic purposes, i.e. deliberately, in order to deter entry and exercise dominant market power. In practice however, it is difficult to differentiate between innocent and strategic excess capacities. What becomes important is the consequence of such excess capacities: are they entry deterring and thereby accentuate the incumbent's market power? The following model examines the entry deterring nature of excess capacities in the petrochemical industry.

A portion of the fixed cost (denoted by F in our models) is sunk, and this in fact makes the entry game inherently asymmetrical. The incumbent is the first mover who hat already sunk his cost in advance i.e. in the first stage, so that in the second-stage equilibrium, it will have a current cost advantage over the entrant. The entrant in fact has to incur the full cost of producing any desired output level. The second-period cost asymmetry ensures the incumbent a larger share of the post-entry market, which may be sufficient to deter entry.

The Model

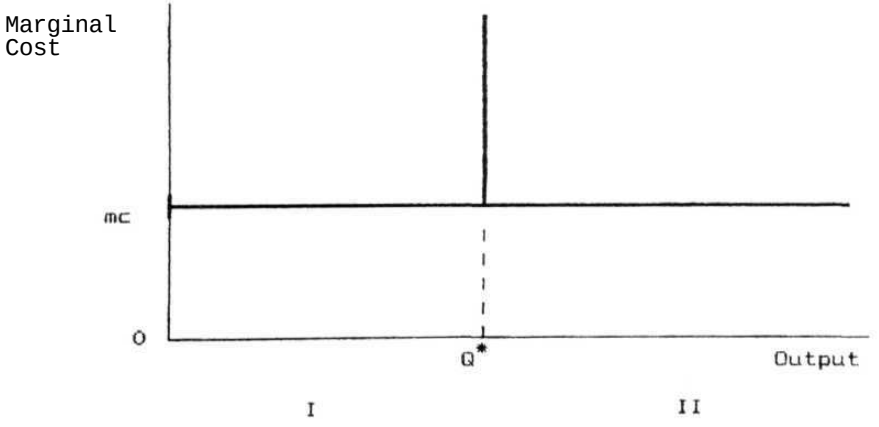
The petrochemical industry has high fixed costs and a step-wise capacity function. Fig. 4.1 illustrates the discrete capacity expansions of a typical firm in the petrochemical industry.

Figure 4.1
Step-Wise Capacity Function



In Fig. 4.1, a fixed cost F (of which a portion is sunk) has to be incurred by which a firm can produce q_1 at full capacity by incurring variable costs. But, to expand beyond q_1, the manufacturer has to incur an additional fixed cost F by which he can expand to q2. This step-wise capacity, or discrete capacity function gives rise to the following inverted 'T'shaped marginal cost curve.

Figure 4.2
Inverted 'T' Marginal Cost curve



q is defined as the maximum output that can bo produced with fixed cost F. An additional fixed cost F has to be incurred to produce even one unit of extra output.[5] In marginal cost terms, (See Fig. 4.23, *mc* is assumed constant till q where capacity installed by the first F is exhausted. After the additional fixed cost is incurred, marginal cost is again constant. Therefore, marginal cost is:

$$mc = C \text{ for } q < q^* \text{ and } q > q^*$$
$$= C + F \text{ for } q = q^*$$

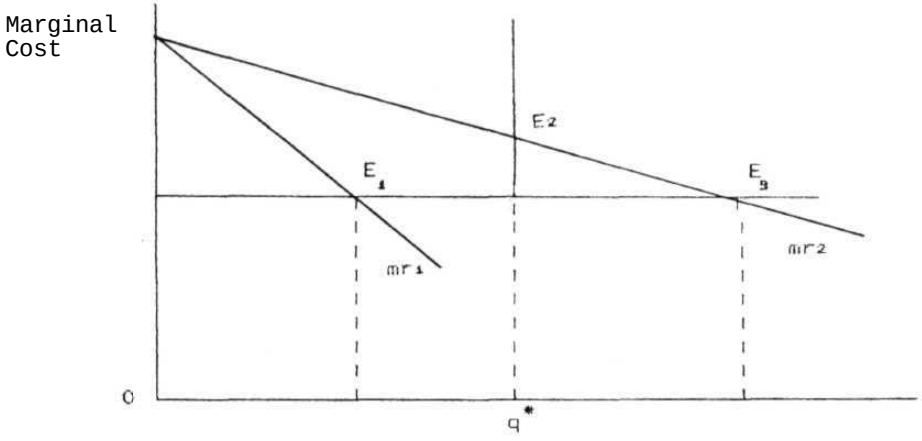
Bunk costs, by definition, *are* committed before the production period commences. If they were expended as a flow simultaneously with production they would not be sunk. Therefore the assumption of an inverted 'T' marginal cost curve appears quite plausible.

Our model consists of an entry game between a Cournot monopoly incumbent and an entrant. (The incumbent is assumed to be a monopolist to simplify the model. The results ought not to differ should the incumbents be a close oligopoly.)

Specification of Q (Benchmark capacity)

We now outline the specification of a benchmark capacity and set out the rules of incumbent behaviour. The incumbent is assumed to be a monopolist. Given the inverted *T mc* curve, Fig 4.3 represents two possibilities of incumbent behaviour.

Figure 4.3
Equilibrium Positions



If the monopolist has marginal revenue MR_1 which cuts the marginal cost curve on the first segment, he behaves like an ordinary monopolist and produces on the demand line corresponding to E_1. However, if marginal revenue is MR_2, he has the option of producing at E2 or E3.[7] At E2, he will produce at full capacity but will not incur additional fixed cost to produce beyond q for which he will have to incur an additional fixed cost F.

A linear demand function of the following form is assumed:

$$p = A - Bq$$

Marginal cost is:

$$mc = C \text{ for } q < q^*$$

$$mc = C + F \text{ for } q = q$$

$$\& \quad mc = C \text{ for } q > q$$

where C is a constant.

The Cournot profit (Π_i) of the monopolist incumbent at E_3 is:

$$\Pi_i = \frac{(A - C)^2}{4B} \qquad \ldots (4.1)$$

The incumbent's profit is as in (4.1) at $q = q^*$ since fixed cost F is incurred till $q = q^*$ and an additional F at $q = q^*$. The comparison of pro-fits between E2 and E9 becomes meaningful only when $\Pi_i > 0$ at E9. If $\Pi_i < 0$, then the incumbent will not bother to expand beyond q^*.

At E1, let the demand function be:

$$p_i = A - Bq .$$

$$\therefore \Pi_i^* = (A - Bq^* - C)\, q^* - F \qquad ...(4.2)$$

where Π_i is the profit of the incumbent before he expands.

We now try to find out for what values of q , is $\Pi > \Pi_i$ or when E1 is preferred to E9, i.e. the benchmark capacity (0.) on which rests the incumbent's decision whether to expand or not. The values of q such that $\Pi > \Pi_i$, is calculated as follows:

$$\text{If } n^* > \Pi_i \text{ then } 0 > \Pi_i^* > \Pi_i \qquad ... \ (4.4)$$

From (4.1) and (4.2) :

$$\Pi_i^* - (A - Bq^* - C)\, q^* - F = \frac{(A - C)^2}{4B} - 2F$$

$$\therefore \ 0 > Bq^{*2} - Aq^* + Cq^* + \frac{(A - C)^2}{4B} - F$$

$$\therefore \ Bq^{*2} - Aq^* + Cq^* + \frac{(A - C)^2}{4B} - F < 0$$

q is exogenously determined and is dependent on F and the corresponding capacity. The benchmark capacity Q is defined such that:

(a) If $q = Q$, the monopolist is indifferent between producing at E2 and E9.

(b) If $q < Q$, he would prefer Π_i to Π_i i.e. he would not prefer to expand beyond fixed cost F i.e. capacity corresponding to F.

The benchmark capacity is then defined as that value of q such that $\Pi_i = \Pi_i$. Q is calculated by solving the following quadratic:

Let $\phi = \Pi_i - \Pi_i^*$, then

$$= Bq_i^{*2} - (A + C)q^* + \frac{(A - C)^2}{4B} - F < 0$$

Solving the above quadratic:

$$\frac{(A - C) \pm \sqrt{(A-C) - 4\ B\ (A - C)^2 - F}}{2B} < 0$$

$$\frac{(A - C) \pm \sqrt{4BF}}{2B} < 0$$

The two roots are:

$$\therefore \hat{Q}_L = \frac{(A - C) + \sqrt{4BF}}{2B} < 0 \quad \&$$

$$\& \ \hat{Q}_S = \frac{(A - C) - \sqrt{4BF}}{2B} < 0 \quad \&$$

$\frac{(A - C)^2}{4B} - F$ is the positive intercept on the y - axis.

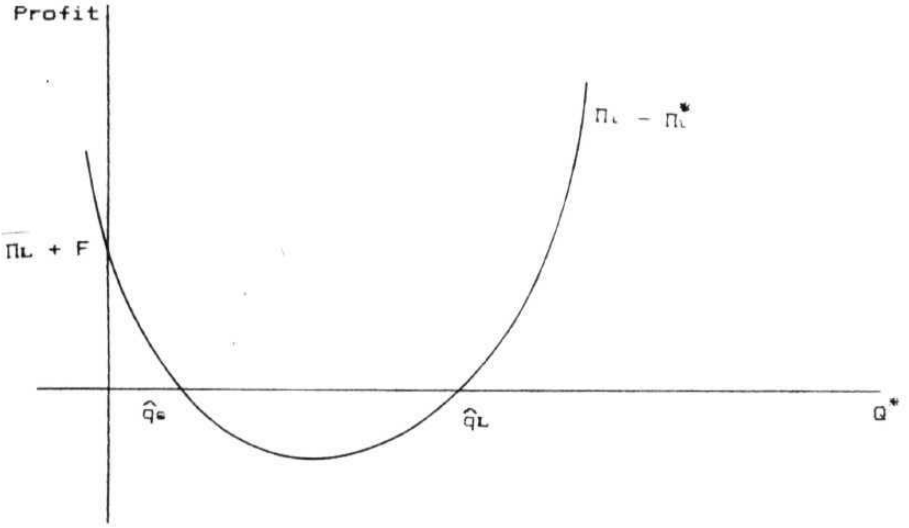
Since $\Pi_i = \frac{(A - C)^2}{4B}$

$\Pi_i + F = \frac{(A - C)^2}{4B}$ is the intercept on the y-axis.[8]

The following figure represents $\Omega = \Pi_i - \Pi_i^*$:

Figure 4.4

$\Pi - \Pi^*$



From the above figure it is clear that for

$0 < q^* < \hat{q}_S$	$\Pi_L < \Pi_L^*$
$\hat{q}_S < q^* < \hat{q}_L$	$\Pi_L > \Pi_L^*$
$\hat{q}_L < q^* < \hat{q}_S$	$\Pi_L < \Pi_L^*$

A potential entrant is now introduced into the model and the conditions under which entry can take place are specified. In a Cournot duopoly, where the entrant faces symmetrical demand conditions and identical cost functions similar to that of the incumbent, duopoly profits

$\Pi_d = \frac{(A - C)^2}{9B}$ and quantity produced is $q_d = \frac{(A - C)}{3B}$

If fixed cost $F < \frac{(A - C)^2}{9B}$, i.e. if fixed costs are lower than duopoly profits, the entrant will enter. The quantity

produced by the entrant may be lesser or greater than the quantity produced by the hypothetical duopolists in the market i.e.

$$q^* < \frac{(A-C)}{3B} \quad \text{or} \quad q^* > \frac{(A-C)}{3B}$$

In the first section we shall consider the case when $q^* < \frac{(A-C)}{3B}$ i.e. the duopoly quantity.

(I) When $q^* > \frac{(A-C)}{3B}$: The incumbent does not have an incentive to expand and the entrant enters with fixed cost F and the incumbent and entrant play a duopoly game.

The duopoly profits are:

$$\Pi d = \frac{(A - C)^2}{9B} - F$$

If $\Pi d > 0$ then $\frac{(A-C)^2}{9B} > F$, the entrant has an incentive to enter and both firms will operate. In this case the incumbent cannot deter entry rationally. However, if $\Pi d < 0$, $\frac{(A-C)^2}{9B} < F$, entry will not occur as the incumbent will try to deter entry because his profits are affected.

If $F < \frac{(A-C)^2}{9B}$, the entrant has an incentive to enter. The incumbent may decide to expand. Therefore:

$$\Pi i > 0$$

$$\Rightarrow \Pi i = \frac{(A-C)^2}{4B} - 2F > 0$$

$$\therefore = \frac{(A-C)^2}{4B} > 2F$$

$$\therefore \frac{(A-C)^2}{8B} > F$$

When $\frac{(A-C)}{8B} > F$, the incumbent considers expansion in order to deter entry.

We can now conclude that if:

$\frac{(A-C)^2}{9B} < F < \frac{(A-C)^2}{8B}$, the entrant will stay out of the market. or his entry is deterred.

a) If $F < \frac{(A-C)^2}{9B}$: Duopoly profits are greater than zero and the entrant has the incentive to enter.

b) If $\frac{(A-C)^2}{8B} > F$: Entrant does not enter but the incumbent considers expansion.

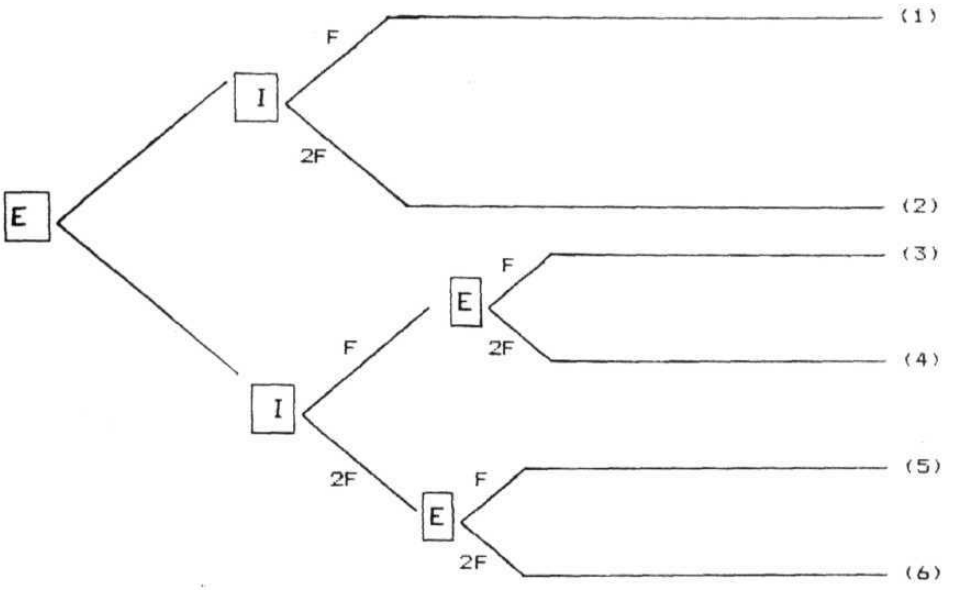
c) If $\frac{(A-C)^2}{8B} < F$: The monopolist produces on the vertical segment of the MC curve. He does not expand, but produces at full capacity.

Notice that the incumbent and the entrant behaviour hinges on F (fixed cost) which is high, implying that the cost of entering the industry is high. For example, the fixed cost of investment for an entrant in the Indian petrochemical industry is as high as Rs.2500 crs for Auriya (GAIL) [see Table 2.2]. The cost of expansion is also high - the NOCIL expansion outlay is Rs.2000 crs. The cost of entering into a single product production is as high as Rs.800 crs. (RIL for PTA production). The cost on plant and machinery alone for a typical petrochemical plant is more than SOX of the outlay Csee table 2.11].

The Entry Game

We now consider the case where the duopoly profits are at $q < \frac{(A-C)}{3B}$. The entry game between the incumbent and the entrant is explored, and the entire set of conditions under which entry can be deterred are set out. In this case the entrant enters, and both the duopolists have an option of expanding. To facilitate analysis of the entry deterring strategies in this circumstance, we construct the following tree diagram:

Figure 4.5
Tree Diagram of the Entry Game



E : Entrant
I : Incumbent

F : fixed cost F (no expansion)
2F : fixed cost 2f (expansion)

The above tree diagram represents an extensive form game **and all the** above **four strategies** *are* sub-game perfect **equilibrium. Every node** is **a** decision making node, the decision **being made either by the entrant (E) or the incumbent (I). The end nodes are payoffs. The payoffs** of the incumbent and entrant, **corresponding to the end nodes in the** tree diagram are as follows:

1) There is no entry and incumbent does not expand:

$$\Pi_i\ (F,O) = (A - Bq^* - C)\ q^* - F$$
$$\Pi_e\ (O) = (O)$$

2) There is no entry and incumbent expands:

$$\Pi_i\ (2F,O) = \frac{(A-C)}{4B} - 2F$$
$$\Pi_e\ (O) = O$$

3) Entrant enters with capacity F and incumbent does not expand:

$$\Pi_i\ (F,F) = (A - 2Bq^* - C)\ q^* - F$$

$$\Pi_e\ (F,F) = (A - 2Bq^* - C)\ q^* - F$$

4) Entrant enters with capacity 2F and incumbent does not expand:

$$\Pi_i\ (F,2F) = \frac{(A - Bq^* - C)\ q^*}{2} - F$$

$$\Pi_e\ (F,2F) = \frac{(A - Bq^* - C)^2 q^*}{4B} - 2F$$

5) Entrant enters with F and incumbent expands:

$$\Pi_i\ (2F,F) = \frac{(A - Bq^* - C)^2}{2} - 2F$$

$$\Pi_e\ (2F,F) = \frac{(A - Bq^* - C)^2 q^*}{4B} - F$$

6) Entrant enters with 2F and incumbent expands:

$$\Pi_i\ (2F,2F) = \frac{(A-C)^2}{9B} - 2F$$

$$\Pi_e\ (2F,2F) = \frac{(A-C)^2}{9B} - 2F$$

After having noted down all the six possibilities, our interest is in determining when entry can be deterred. Looking at it from the incumbent's point of vxew, we have four entry deterring strategies:

1) F if F & F if 2F, i.e. the incumbent will continue to operate at initial capacity F regardless of whether the? entrant wants to enter at F or 2F (expanded capacity):
entry can be deterred if

1a. $\Pi_i\ (F, F) \geq \Pi_i\ (2F, F)$ & $\Pi_e\ (F, F) \leq 0$

1b. $\Pi_i\ (F,2F) > \Pi_i\ (2F, 2F)$ & $\Pi_e\ (F, 2F) \leq 0$

i.e. the incumbent's profit at initial capacity is greater than that after expansion and entrant profits *are* less than zero after entry (at F or 2F).

2> 2F if F & 2F if 2F, i.e. the incumbent expands of whether the entrant plans entry at F or 2F:
entry can be deterred if

2a. Π_i (2F, F) > Π_i (F, F) & Π_e (2F, F> < 0

2b. Π_i (2F,2F) > Π_i (F, 2F) & n* (2F, 2F) < 0

i.e. the incumbent's profit after expansion is greater than before expansion and entrant does not make profits on entry at all.

3) F if F & 2F if 2F, i.e. the incumbent matches the entrant's proposed capacity at F or 2F:
entry can be deterred if

3a. Π_i (F, F) > *Tli* (2F, F) & Π_e <F, F) < *0*

3b. Π_i (2F,2F) > Π_i (F, 2F> & Π_e (2F, 2F> < 0

i.e. the incumbent's profit before expansion is greater than that after expansion, and entry at F is unprofitable, *or* the incumbent's profit after expansion is greater than his profits before expansion, and entry at 2F is unprofitable.

4) 2F if F and F if 2F, i.e. the incumbent expands if the entrant enters at F and does not expand if entry is at 2F:
entry can be deterred if

4a. *Tli* (2F, F) > Π_i (F, F) & Π_e <2F, F> < 0

4b. Π_i (F,2F) > Π_i (2F, 2F> & n. (F, 2F) < 0

i.e. the incumbent's profit after expansion is greater than before expansion and entry at F is unprofitable *or* the incumbent's profit prior to expansion is greater than after expansion and entry at 2F is unprofitable.

Conclusion

The above model has established a number of strategies by which an incumbent firms can deter entry by holding excess capacities. Model 1 represents an industry where scale economies are significant and investments are lumpy thus simulating the conditions of the Indian petrochemical industry. The presence of scale economies and the lumpy nature of investment automatically create excess capacities - these capacities *are* 'innocently' created but *are,* nonetheless, entry deterring. The incumbent also

has an option of deliberately creating excess capacities to deter entry. The market power of incumbent firms is thereby accentuated and limits the extent of competition in the industry.

The incumbent firm has three main advantages: (a) a first-mover advantage of early entry, (b) he has sunk a proportion of his cost and thus increases his stake in retaining dominant market power and (c> the lumpy nature of the investment where he builds excess capacity that are innocent entry barriers. Any policy to build a competitive industrial structure in the Indian petrochemical industry would have to nullify or reduce the incumbent's advantage without jeopardising efficiency.

One of the policy options is to grant subsidies to the entrant to offset sunk costs and make entry profitable. The government can thereby create a contestable market. However, there are two basic problems. First, subsidies create distortions in the economy and will not result in an efficient outcome at the macro level. Secondly, subsidies can encourage the entry of inefficient sized firms. An alternative would be to offer a subsidy to entrants equivalent to sunk costs to entrant in the upstream petrochemical products (where sunk costs *are* larger) and restrict this segment to the public sector, Firms producing downstream petrochemicals (where sunk costs *are* lower) can be allowed to compete.

A second policy option is to frame a pricing policy to change demand conditions so that incumbent firms do not have an incentive to expand. in Fig.4.3, a pricing policy that will ensure that the marginal revenue curve cuts the marginal cost curve in the first segment, ensures that the incumbent does not have an incentive to expand. However, the difficultites of calculating externally enforced or 'administrative' prices for a number of petrochemicals are not only numerous but may not reflect the changing conditions of the market and thereby creates distortions in supply and demand conditions.

A third policy option would be to restrict the capacity expansion of incumbent firms beyond *MES*. In the above model, we

have observed that any expansion beyond benchmark capacity Q_0 (equivalent to MES) can be entry deterring. By not allowing incumbents to expand beyond Q_0, entry can be encouraged and thus, firms can be forced to share the market. This policy option is akin to licensing where licensed capacity itself is over MES, thus defeating the purpose of domestic liberalisation. The products where MES is large, and a single firm can cater to the market, the problem of domination still has to be checked.

However, forcing firms to share the market does not preclude vertical integration. By restricting capacity expansions to encourage entry, the entrant could well be a producer in the petrochemical industry seeking integration, either backwards in the input market or forwards into the product market. The next model will illustrate how vertical integration can be entry deterring. In fact, the threat of entry by a new firm can hasten the process of vertical integration.

(2) VERTICAL INTEGRATION AND ENTRY DETERRENCE

Liberalised industrial policies have encouraged the expansion and diversification of incumbent firms. As a result, many firms have integrated vertically in the Indian petrochemical industry. Firms have integrated backwards to take advantage of greater scale economies at a previous stage in the production process apart from building an assured source of inputs. Firms integrate forwards to produce products with greater value added apart from ensuring a market for their output. The strategy of the firm to integrate vertically gives rise to two kinds of entry barriers. One is that of high cost of entry i.e. an entrant would also require to be vertically integrated to be able to compete thus adding to the its investment costs. Secondly, entry into any one product is effectively precluded because of the transaction economies the incumbent enjoys as a result of integration.

Liberalisation policies in India have enabled firms to vertically integrate by removing barriers to expansion by incumbent firms. Firms have integrated both forward into the manufacture of downstream petrochemicals and backward into the manufacture of feedstocks. Both these forms of vertical integration have been examined in Chapter 2. But to illustrate, the classic example of vertical integration in the petrochemical industry has been the case of Reliance. The company commenced with the manufacture of synthetic and blended fabrics and synthetic fibres in the early 1980s. In the late 1980s, the company began the manufacture of PTA, the basic input into the manufacture of synthetic fibre as well as an in-house paraxylene plant, a raw material for producing PTA. In the 1990s, the company has started a refinery, and thereby manufacturing the feedstocks for its petrochemical units. The following model will examine the entry-deterring properties of vertical integration .

The Model

this model examines entry deterring strategies of incumbent firms when vertical integration takes place. There are two

markets, the product market and an input market. Firm 1 (F_1) is a monopolist in the product market and Firm 2 (F_2) is a monopolist in the input market. Both the monopolists *are* Cournot competitors. The model assumes backward integration, though the result can be extended to forward integration.

We first establish the initial conditions i.e. the profits of the firms Fi and F2 in their respective markets before vertical integration takes place. F_1 is a monopolist in the product market q and F2 is a monopolist in the input market q_v.

Initial Conditions:

Let p and q be the price and quantity of a product.

Let p_v and q_v be the price and input quantity of the input.

Fixed proportions are assumed i.e. a fixed proportion of q_v is necessary to produce a unit of q. Therefore total cost (TO:

$$TC(q) = f_q + p_v q \quad \ldots \quad (4.3)$$

where fq is the fixed cost in the production of q.

The demand function for q is assumed linear and is:

$$p = A - Bq \quad \ldots (4.4)$$

Correspondingly, the demand function for q_v is:

$$pw = K - L q_v$$

which includes the demand from q too.

The total cost of manufacturing qw is :

$$TC(qw) = fw + Cqw \quad \bullet\bullet\bullet \quad (4.5)$$

where fw is the fixed cost incurred in the manufacture of qw.

The profit function of F_1 is:

$$\Pi(q) = (A - Bq) - fq - P_v q \text{ [from (4.3) \& (4.4)]} \ldots (4.6)$$

In order to maximise F_1's profits, the first order condition of (4.6) must be *zero.* Therefore,

$$\frac{\partial \Pi(Q)}{\partial Q} = 0$$

$$\frac{\partial \Pi(Q)}{\partial Q} = A - 2BQ - Qv = 0 \qquad \ldots (4.7)$$

From (4.6) & (4.7) :

$$q = \frac{A - pv}{2B} \quad \& \quad p = \frac{A + pv}{2}$$

$$\& \quad \Pi(q) = \frac{(A - pv)^2}{4B} - fq$$

Similarly, the profit function of Fz in the input market is:

$$\Pi(qv) = (K - Lqv)\, qv - fv - Cqv \qquad \ldots (4.8)$$

Maximising Fz's profits by equating the first order condition of (4.8) to *zero:*

$$\frac{\partial \Pi(qv)}{\partial qv} = 0$$

$$\therefore \quad \frac{\partial \Pi(qv)}{\partial qv} = K - 2Lqv - C = 0$$

$$\therefore \quad qw = \frac{K - C}{2L}$$

$$pv = \frac{K + C}{2} \qquad \ldots (4.9)$$

$$\& \quad \Pi(qv) = \frac{(K - C)^2}{4L} - fv$$

Vertical integration now takes plac. . F1, the monopolist in the product market begins to manufacture his own input qv, i.e. F1 integrates backwards. This implies that the demand function pv - K - Lqw will change since the demand for the input qw in the input market suffers a negative shock. Because of our assumption of **fixed proportions, we assume that the input qw was being bought as much as q by F1. Therefore:**

$$q = \frac{A - Pv}{2B} = \tilde{qv} \qquad \ldots (4.10)$$

q is the amount of qw demanded by the integrated firm F1 for the manufacture of product q.

Writing (4.10) as an inverse demand function, i.e. in terms of pw:

$$p_v = A - 2Bq_v$$

From (4.5), the total inputs being produced is :

$$q_v = \frac{K - p_v}{L} \qquad \ldots (4.11)$$

The direct demand in (4.11) includes the input manufactured by the vertically integrated firm Ft which is qv and F2 which is q_v.

qv the input (q_v) manufactured by the non-integrated firm F2 is:

$$\bar{q}_v = \tilde{q}_v - q_v$$

$$= \left\{ \frac{A - p_v}{2B} \right\} - \left\{ \frac{K - p_v}{L} \right\} \ldots \text{ from (4.10) \& (4.11)}$$

$$= \frac{2B\,(K - p_v) - L\,(A - p_v)}{2BL}$$

$$\therefore \quad p_v = \frac{2BK - LA}{2B - L} - \frac{2BL}{2B - L}\,\bar{q}_v$$

The above equation is re-written in the following simplified form:

$$\bar{p}_v = V - U\bar{q}_v$$

$$\text{where } V = \frac{2BK - LA}{2B - L} \quad \& \quad U = \frac{2BL}{2B - L}$$

and pv becomes p_v to correspond with qw.

The demand function (4.8) is being faced by both F_1 and F2 in the integrated market, i.e. the integrated firm as well as the unintegrated firm.

Let qv be the amount of qw sold by the integrated firm F_1.
Let qw be the amount of qw sold by the unintegrated firm F2.

It is assumed that the integrated firm not only manufactures its own needs but also supplies inputs to other firms.

Therefore the profits by a firm in the input market is:

$$\Pi(q_v) = V - U\,(q_v^1 + q_v^2)q_v^1 - f_v - Cq_v^1$$

$$q_v^1 = q_v^2 = \frac{V - C}{2U}$$

$$\bar{p}_v = \frac{V + 2C}{3}$$

$$\Pi(q_v^1) = \Pi(q_v^2) = \frac{(V - C)^2}{9U} - f_v$$

where $\Pi(q_v^1)$ are the profits of Ft, the integrated firm in the input market &

$\Pi(q_v^2)$ **are** the **profits of** F_2, the unintegrated firm in the input market.

CNote that F_1, the integrated firm makes profits both in the **product** market and the input market.]

The total profits of the integrated firm F_1 are:

$$\Pi(F_1) = n<q) + \Pi(q_v^1)^p$$

Entry in **the Product Market**

A potential entrant (E) is now introduced into the product **market. We** now compare two situations:

a) Entry conditions before Ft has integrated &

b) Entry conditions after F_1 has integrated into the input market.

(a) The entrant E enters the product **market** q. The change in **the** demand function in the product market q **is:**

$$p = A - B\ (q_E + q_I) \qquad \ldots\ (4.12)$$

where qc is the quantity of q produced by the entrant E &

q_I is the quantity of q produced by the incumbent Ft

Assuming symmetrical demand functions, and identical cost functions, where pv is the price of the input q_v, the costs of E & Ft **are:**

$C_E = fq + p_v q_E$ for the entrant

& $C_I = fq + pw\ q_I$ for the incumbent F_1.

Maximising profits and under conditions of Cournot competition:

$$q_E = q_I = \frac{A - p_v}{3B} \qquad \ldots\ (4.13)$$

$$p = \frac{A + 2p_v}{3}$$

$$\& \quad \Pi(q_E) = \Pi(q_I) = \frac{(A - p_v)^2}{9B} - f_q \qquad \ldots (4.14)$$

After entry, the entrant and the incumbent form a duopoly and serve the product market equally as seen in (4.13) and (4.14).

From (4.8) we know that if $\Pi(q_E) > 0$, the entrant will enter. In fact, if $\Pi(q_E) = \Pi(q_I) > 0$ the incumbent would allow for entry since duopoly profits *are* greater than zero. $\Pi(q_E) = \Pi(q_I) < 0$, provides a rationale for the incumbent to deter entry.

If $n(q_c) = \Pi(q_I) > 0$

then $\frac{(A - p_v)^2}{9B} - f_q > 0$

or $\frac{(A-p_v)^2}{9B} > f_q$

The total quantity of output (q) produced in the product market is:

$$q_E + q_I = 2\left[\frac{A - p_v}{3B}\right]$$

This change in q will consequently cause a shift in q_v (the input market) where the new q_v (q_v), under the assumption of fixed proportion is:

$$\Delta q_v = \text{Combined duopoly output} - \text{monopoly output}$$

$$= q_v^* - q_v$$

$$= 2\left[\frac{A - p_v}{3B}\right] - \left[\frac{A - p_v}{3B}\right]$$

$$= \frac{A - p_v}{6B}$$

A q_v is the additional qw that is required for the manufacture of q, after an increase in q beinq bought upon by entry.

$$\hat{q}_v = q_v + \Delta q_v$$

where q_v is the total input required in the input market after entry in the product market.

$$\hat{q}_v = q_v + \Delta q_v$$

From (4.9) and (4.13):

$$\hat{q}_v = \frac{K - p_v}{L} + \frac{A - p_v}{6B}$$

$$\therefore p_v = \frac{6BK + LA}{6BL} - \frac{6BL}{6B + L}\hat{q}_v$$

We re-write the above equation as :

$$\hat{p}_v = V_1 - U_1\hat{q}_v \qquad \ldots (4.15)$$

where $V_1 = \frac{6BK + LA}{6BL}$

& $U_1 = \frac{6BL}{6B + L}$

& p_v is $\hat{p}_v$ to correspond with $\hat{q}_v$.

F2 (the producer of inputs) is still a monopolist. in the input market since entry has occured only in the product market, and before vertical integration takes place. F_1 faces demand as in (4.15). Therefore his profits are:

$$\Pi(q_v) = (V_1 - U_1 \hat{q}_v)\, \hat{q}_v - f_v - C\hat{q}_v$$

Maximising his profits w.r.t. q_v and equating it to zero :

$$\hat{q}_v = \frac{V_1 - C}{2U_1}$$

$$\hat{p}_v = \frac{V_1 + C}{2}$$

$$\Pi(q_v) = \frac{(V_1 - C)^2}{4U_1} - f_v$$

(b): The entrant enters the product market after vertical integration takes place.

The profit's of the incumbent in the product market arp:

$$\Pi(q_I) = A - B(q_I + q_E)\, q_I - f_q - Cq_I \qquad \ldots (4.16)$$

The profits of the entrant are:

$$\Pi(q_E) = A - B(q_I + q_E)\, q_E - f_q - Cq_E \qquad \ldots (4.17)$$

The difference in the cost function between (4.16) and (4.17) arises because the entrant in the product market cannot buy his inputs at marginal cost, he has to buy it at the market price pv. The integrated firm F_I gains by using his own inputs priced at marginal cost.

Intuitively it is clear that entry can be deterred if:

$$\Pi(q_I) \geq f_q > \Pi(q_E)$$

To maximise the profits of the incumbent and entrant, the first order derivatives of (4.16) and (4.17) are equated to *zero:*

$$\frac{\partial \Pi(q_I)}{\partial q_I} = A - 2Bq_I - Bq_E - C = 0 \qquad \ldots (4.18)$$

$$\frac{\partial \Pi(q_I)}{\partial \Pi_E} = A - 2Bq_E - Bq_I - pv = 0 \qquad \ldots (4.19)$$

From (4.19):

$$q_E = \frac{A - Bq_I - pv}{2B}$$

Substituting the above value for q_E in (4.18):

$$q_I = \frac{A + pv - 2C}{3B} \qquad \ldots (4.20)$$

$$\& \quad q_E = \frac{A + C - 2pv}{3B} \qquad \ldots (4.21)$$

q_I and q_E are the output of the incumbent F_I and entrant E in the product market. This results in corresponding changes in the input market.

Previously, $p_v = K - Lq_w$ included the quantity of the input demanded by the incumbent F_1. Now, the change in the demand for q_v is the result of two factors:

<a) Ft has vertically integrated into the input market and thereby not only produces its own input but. also enough to sell in the input market &

(b) Entry has occured in the product market resulting in a demand for input by the entrant from the input market.

The new quantity qw, q_v is:

$$\dot{q}_v = q_v - \Delta q_v$$

$$\Delta q_v = \left(\frac{A - p_v}{2B} \right) - \left(\frac{A + C - 2p_v}{3B} \right)$$

$$= \frac{A + p_v - 2C}{6B}$$

By substituting the value of Δq_v in $q_v = q_v - Aqw$

$$\dot{q}_v = \left(\frac{K - p_v}{L} \right) - \left(\frac{A + p_v - 2C}{6B} \right)$$

From the above equation we get:

$$p_v = \frac{6BK - LA}{6B - L} - \frac{6BL}{6B - L} \dot{q}_v$$

We re-write the above as:

$$\dot{p}_v = V_2 - U_2 \dot{q}_v \qquad \ldots (4.22)$$

where $V_2 = \frac{6BK - LA}{6B - L}$

& $U_2 = \frac{6BL}{6B - L}$

and pw is p_v to correspond with q_v

Equation (4.22) is the changed demand function in the input market after the entrant has entered the product market where F_1,

has integrated into the input market. The demand function in the product market is:

$$p = A - B(q_I + q_E)$$

$$= A - B\left[\frac{A + p_v - 2C}{3B} + \frac{A + C - 2p_v}{3B}\right] \quad [\text{from (4.20) \& (4.21)}]$$

$$= \frac{A + p_v + C}{3}$$

The price pv is infact p_v since it is the price after integration and entry. The above equation can therefore be written as:

$$p = \frac{A + \dot{p}_v + C}{3}$$

$$\therefore \Pi(q_I) = (p - C)\, q_I - f_q$$

$$= \left[\frac{A + \dot{p}_v + C}{3} - C\right]\left[\frac{A + \dot{p}_v - 2C}{3B}\right] - f_q$$

$$= \frac{(A + \dot{p}_v - 2C)^2}{9B} - f_q$$

Similarly, profits for the entrant in the product market are:

$$\Pi(q_E) = \frac{(A + C - 2\dot{p}_v)^2}{9B} - f_q$$

Entry can be deterred if and only if

$\Pi(q_I) > 0$ and $\Pi(q_E) \leq 0$

If $\Pi(q_I) \geq 0$ then $\dfrac{(A + C - 2C)^2}{9B} > f_q$

If $\Pi(q_E) \leq 0$ then $\dfrac{(A + C - 2\dot{p}_v)^2}{9B} < f_q$

We know that $p_v > C$, therefore looking at the numerators in the expressions for $\Pi(q_I)$ & $\Pi(q_E)$ we can conclude that $\Pi(q_I) > \Pi(q_E)$.

If $\Pi(q_I) > \Pi(q_E)$ then

$$\frac{(A + C - 2\dot{p}_v)^2}{9B} - f_q > \frac{(A + C - 2\dot{p}_v)^2}{9B} - f_q$$

We can therefore conclude that before integration entry cannot be deterred rationally and the incumbent and the entrant can play a duopoly game. However, after vertical integration takes place, entry can be deterred since $\Pi(q_I) > \Pi(q_E)$ and Net $\Pi(q_E) < 0$.

Entry in the Input Market

We now look at the other alternative of entry in the input market. We have a situation where there are two firms: Fi the integrated firm and F2 the original incumbent in the input market.

The market demand function is:

$$\dot{p}_v = V_2 - U_2 \dot{q}_v$$

where $\dot{q}_v = \dot{q}_v^1 + \dot{q}_v^2$

where $\dot{q}_v^1$ = quantity of input produced by the integrated firm F_1
& $\dot{q}_v^2$ = quantity of input produced by F_2 (the integrated firm.

Examining the profits of the two firms:

$$\Pi(\dot{q}_v^1) = [V_2 - U_2(\dot{q}_v^1 + \dot{q}_v^2)]\, \dot{q}_v^1 - f_q - C\, \dot{q}_v^1 \quad \ldots (4.23)$$

$$\Pi(\dot{q}_v^2) = [V_2 - U_2(\dot{q}_v^1 + \dot{q}_v^2)]\, \dot{q}_v^2 - f_q - C\, \dot{q}_v^2 \quad \ldots (4.24)$$

Maximising (4.23) and (4.24) w.r.t. $\dot{q}_v^1$ & $\dot{q}_v^2$ respectively and equating the first order conditions to zero:

$$\dot{q}_v^1 = \dot{q}_v^2 = \frac{V_2 - C}{3U_2}$$

$$\dot{p}_v = \frac{V_2 + 2C}{3U_2}$$

$$\Pi(\dot{q}_v^1) = \Pi(\dot{q}_v^2) = \frac{V_2 - C}{3U_2} - f_y$$

Therefore the total profits of the integrated firm F_1 are:

$$\Pi(F_1) = \Pi(\dot{q}) + \Pi(\dot{q}_v^1)$$

A potential entrant E is now introduced into the input market after vertical integration has occurred. We now compare two situations:

(a) entry conditions before F_1 integrates &
(b) entry conditions after F_1 integrates.

(a) Before integration, the demand and cost functions in the input market are:

$$p_v = K - L\, q_v$$

$$\& \; C = f_v + C\, q_v$$

After the entrant enters, F2 (the incumbent) and the entrant play a duopoly game- The profit function of the incumbent (F_2) in the input market 15 as follows:

$$\Pi(q_v^2) = [K - L\,(q_v^2 + q_v^E)]\, q_v^2 - f_v - Cq_v^2 \qquad \ldots (4.25)$$

The profit of the entrant in the input market will be as follows:

$$\Pi(q_E) = [K - L\,(q_v^2 + q_v^E)]\, q_v^E - f_v - Cq_v^E \qquad \ldots (4.26)$$

Maximising (4.25) and (4.26) w.r.t. q_v^2 & q_v^E respectively, and equating the first order conditions to zero:

$$\Pi(q_v^2) = \Pi(q_v^E) = \frac{(K - C)^2}{9L} - f_v$$

The entrant will enter if $\Pi(q_v^E) > 0$. Since $\Pi(q_v^2)$ is also positive when $\Pi(q_v^E)$ is positive, the incumbent does not have an incentive to deter entry.

(b): Entry now occurs in the input market after F_1 has integrated. The input market is now being served by three firms:

(1) the entrant with quantity q_v^E

(2) the incumbent (F_2) with quantity q_v^2 and

(3) the vertically integrated firm F_1 with quantity q_v^1.

The demand function is now

$$\hat{p}_v = V - U(\hat{q}_v^E + \hat{q}_v^1 + q_v^2)$$

The corresponding quantities are:

$$q_v^E = q_v^1 = q_v^2 = \frac{V - C}{4U}$$

The price in the input market is:

$$p_v = \frac{V + 3C}{4}$$

and the profits are :

$$\Pi(\hat{q}_v^E) = \Pi(\hat{q}_v^1) = \Pi(q_v^2) = \frac{(V - C)^2}{16U} - f_v$$

If $f_v > \frac{(V - C)^2}{16U}$, the entrant does not enter and the case lapses into a duopoly with firms F_1 and F_2 in the market where

$$\Pi(q_v^1) = \Pi(q_v^2) = \frac{(V - C)^2}{9U} - f_v$$

Entry can be deterred as long as

$$\frac{(V - C)^2}{16U} < f_v < \frac{(V - C)^2}{9U}$$

i.e. as long the three-firm profit is less then fixed cost and less than the duopoly profits. When there is only one firm, an entrant can enter and play a duopoly game with the incumbent. The firm that integrates vertically creates a duopoly in the input market thereby precluding entry.

When one firm integrates, entry can be deterred as long as

$$\frac{(V - C)^2}{16U} < fv < \frac{(V - C)^2}{9U}$$

In fact we can quite confidently establish the following inequality:

$$\frac{(V - C)^2}{16U} < \frac{(V - C)^2}{9U} < \frac{(K - C)^2}{9L}$$

where $\frac{(V - C)^2}{16U}$ are profits of the firms in the input market after integration and entry occurs, i.e. when three firms share the market.

$\frac{(V - C)^2}{9U}$ are profits of the firms in the input market after integration and entry is deterred.

$\frac{(K - C)^2}{9L}$ are the profits of the firms in the input market when there is no integration and the entrant enters.

It is clear $\frac{(K - C)^2}{9L} > fv.$ and that $\frac{(K - C)^2}{9L} > \frac{(V - C)^2}{9U}$

i.e. when firms are not integrated, entry cannot be rationally deterred. However, the firm can integrate in order to preclude entry by creating a duopoly in the input (or integrated) market, which cannot sustain an additional firm.

Conclusion

The above model illustrated how entry can be deterred in both the product and input market through vertical integration. When firms are not integrated, entry cannot be rationally deterred if the market can sustain a duopoly. However, the firm can integrate, create a duopoly in the input market (or integrated market) and thus preclude entry.

The integrated firm has an additional advantage when *MES* is large (relative to the market). The incumbent automatically raises the cost of entry by vertical integration. If entry has to be effective, the entrant will have to compete with the incumbent as an integrated firm, which raises the cost of entry. And if the incumbent is already operating at *MES*, the residual demand may be insufficient for efficient entry. Vertically integrated firms can, thus, not only deter vertically integrated entry but also entry into each product market. The integrated incumbent firm thereby reinforces his market power and accentuates the oligopolistic structure of the industry.

The incumbent obviously takes advantage of transaction costs by integrating. A firm's strategic behaviour of vertical integration cannot be easily prevented since he is already assured of profits in hie original market. Excess capacities in a neighbouring product does not deter him, since he is seeking an assured market for his product (by forward integration) or an assured source of input (by backward integration). He thereby has a dual advantage: (a) he prices the captive component of his inputs at less than market price and (b) he creates further excess capacities in the integrated market which serves to keep out fresh entry.

Policy options available to reduce the advantages of an integrated firm are limited. The MRTP Act could be activated in cases where the integrated firm prices its products in order to under cut competition. Such practices are, however, extremely difficult to prove. Alternatively, the public sector could dominate the upstream petrochemical product markets, and private firms could be prevented from full vertical integration. In such a case an inefficient public sector could jeopardise the efficiency of the entire industry. Trade policy could be framed in a manner that could discipline domestic firms that enjoy the patronage of the government.

Models (1) and (2) have examined the entry deterring strategies that firms employ when domestic liberalisation takes

place. Policy options to dampen the efficacies of these strategies have pointed to the importance of trade. Firstly as a **means** of extending the market and increasing demand. And secondly, the framing of tariff structures which ran discipline the domestic producers who are supported by the government either through subsidies or as a monopoly public sector. Our next model examines trade liberalisation in an industry characterised by imperfect competition.

(3) IMPERFECT COMPETITION, PRICES AND TARIFFS

Liberalised trade policies reduce tariff levels and remove other quantitative restrictions in order to eliminate artificial barriers to trade and increase competition. But what are the repercussions of trade liberalisation when the industry exhibits increasing returns to scale and is concentrated, as in the case of the petrochemical industry in India?

Models 1 and 2 have illustrated how domestic liberalisation enables incumbents to deter entry and perpetuate their dominant market power. As shown in Chapter 2, the industry in India continues to exhibit high concentration from the early 1980s to 1991-92. And firm strategies of holding excess capacities and vertical integration will deter entry and suppress competition in the industry. Model 3 will examine the consequences cf trade liberalisation in an imperfectly competitive industry.

As we have observed in Chapter 3, trade liberalisation in the Indian petrochemical industry has not been as systematic as domestic liberalisation. The Expert Group on Petrochemicals which has suggested a framework by which trade liberalisation could be systematised was submitted in 1993. These recommendations are /et to be implemented. This model, therefore, offers a scenario of the consequences of trade liberalisation in the Indian Petrochemical industry.

The Model

The effect of trade liberalisation of an imperfectly competitive industry is examined in the this model. Imperfect competition is represented by the high level of concentration in the industry due to scale economies. The number of firms in equilibrium is limited by scale economies which are a source of concentration. The initial conditions are set in a situation where there is no trade (i.e. autarky prevails) and the domestic industry is concentrated. We then compare two situations:

(a) when free trade is allowed &
(b)) when trade is allowed with the imposition of tariffs.

We assume that there is no trade and the domestic market is concentrated. The linear demand function facing the domestic firm is defined as follows:

$$p_i = A - Bq_i - d \sum_{Q_{-i}} q_i \qquad \ldots (4.27)$$

where p_i = price of the i^{th} firm

q_i = quantity of the i^{th} firm &

Q_{-i} = industry output less the quantity of the i^{th} firm q_i.

Demand conditions are assumed symmetric, cost functions are assumed identical and mc (marginal cost) is assumed constant at C. The profit of the i^{th} firm is therefore:

$$\Pi_i = (A - Bq_i - d \sum_{Q_{-i}} q_i)q_i - Cq_i \qquad \ldots (4.28)$$

To maximise the profit of the i^{th} firm, the first order conditions of (4.28) w.r.t. q_i must be zero. Therefore,

$$\frac{\partial \Pi_i}{\partial q_i} = A - 2B q_i - d \sum_{Q_{-i}} q_i - C = 0 \qquad \ldots (4.29)$$

n equations for n firms can be derived like the one in (4.29) firms. However, since demand functions are assumed symmetric and cost functions are identical :

$$Q_{-i} = (n-1)\, q_i$$

Therefore, (4.29) is re-written as follows:

$$\frac{\partial \Pi_i}{\partial q_i} = A - 2Bq_i - d\,(n-1)q_i - C = 0$$

$$\therefore \quad q_i = \frac{A - C}{2B + (n-1)d} \qquad \ldots (4.30)$$

Substituting the above value of q_i in (4.27):

$$p_i = A - Bq_i - d\,(n-1)q_i$$

$$= A - B\left[\frac{A - C}{2B + (n-1)d}\right] - d\,(n-1)\left[\frac{A - C}{2B + (n-1)d}\right]$$

$$\therefore p_i = \frac{AB + C\,[B + (n-1)d]}{2B + (n-1)d} \qquad \ldots(4.31)$$

From equation (4.29) it is obvious that A > C. (If A was less than C there would be no production). The denominator of (4.31) therefore has to be positive.

$$\therefore \frac{\partial p_i}{\partial n} = \frac{\partial (cnd)}{\partial n} = bd\,(c-A)$$

Since A > C, the above expression is negative.

$$\therefore \frac{\partial p_i}{\partial n} > 0 \qquad \ldots(4.32)$$

This implies that the number of firms in the market and prices are inversely related, i.e. as n decreases, p increases.

From (4.28) we derive the relationship between profits and the number of firms in the market:

$$\Pi_i^n = (A - Bq_i - d\sum_{q_{-i}} q_i)q_i - Cq_i$$

$$=(A - Bq_i - (n-1)d\,q_i - C)q_i$$

When n firms are competing, we can assume that price will be equal to marginal cost. Substituting p_i from (4.31):

$$\Pi_i^n = \left(\frac{AB + C\,[B + (n-1)d]}{2B + (n-1)d} - C\right) q_i$$

$$= \left(\frac{AB - CB}{B + (n-1)d}\right) q_i$$

Substituting from (4.30) for q_i:

$$\Pi_i^n = \left(\frac{AB - CB}{B + (n-1)d}\right)\left(\frac{A - C}{B + (n-1)d}\right)$$

$$= B\left(\frac{A - C}{B + (n-1)d}\right)^2$$

Since A > C, it is clear that

$$\frac{\partial \Pi_i}{\partial n} < 0 \qquad \text{for } i = 1,2,\ldots,n \qquad \ldots (4.33)$$

The above inequality indicates an inverse relation between the profits of individual firms and the number of firms in an industry. Because fixed costs, F are high in the petrochemical industry, we can infer from (4.33) that if there are too many firms, they may not be able to recover their fixed cost. We can therefore deduce that:

$\Pi_i^{(n-1)} > F > \Pi_i^n$.

Correspondingly,

$p_i^{(n-1)} > p_i^n$.

Free Trade and Trade with Tariffs

One foreign firm is introduced in the previous model with the existing n domestic firms. The foreign firm offers its product at price p_f and quantity q_f. For the sake of simplicity, it is assumed that q_f is a constant as under quotas when the entire quota is used up.

The demand function of the i^{th} firm in the domestic market is:

$$p_i = A - B q_i - d Q_{-i} - d Q_f \quad \ldots (4.34)$$

Since Q_f is a constant, the intercept of (4.34) is:

$$K = A - d Q_f$$

Therefore (4.34) is re-written as :

$$p_i = K - B q_i - d Q_{-i}$$

Since there are n firms in the domestic market $Q_{-i} = (n-1)q_i$:

$$p_i = \frac{KB + C\,[B + (n-1)d]}{2B + (n-1)d} \quad \text{[From (4.31)]} \quad \ldots (4.35)$$

& $$q_i = \frac{KB - C}{2B + (n-1)d} \quad \text{[From (4.32)]} \quad \ldots (4.36)$$

We now assume that a tariff t is imposed on imports such that costs

$$C = c + t\,q_f$$

Therefore the profit function of the foreign firm is:

$$\Pi_f = [\,A - Bq_f - dQ - c - t\,]\,q_f$$

To maximise the profits of the foreign firm, we equate the first order conditions of (4.35) to zero.

$$\therefore \frac{\partial \Pi_f}{\partial q_f} = A - 2Bq_f - dQ - c - t = 0$$

Substituting for Q [from (4.38)] in the above equation:

$$\frac{\partial \Pi_f}{\partial q_f} = A - 2Bq_f - d\left(\frac{K - c}{2B + (n-1)d}\right) - c - t = 0 \quad \ldots (4.37)$$

$$\therefore Q_f = q_f = \frac{(A - C)(2B - d) - t\,(2B + (n-1)d]}{2B + 2B(n-1)d - nd^2} \quad \ldots (4.38)$$

The above equation can be re-written as:

$$Q_f = 1 - mt \text{ where } \quad 1 = \frac{(A - C)(2B - d)}{2B + 2B(n-1)d - nd^2} \;\&$$

$$\& \; m = \frac{2B + (n-1)d}{2B + 2B(n-1)d - nd^2}$$

We assume that B > d since for the foreign firm, its own price elasticity (B) will be greater than the cross price elasticity (d). So the denominator in the expression (4.37) is positive. Therefore:

$$\frac{\partial Q_f}{\partial t} < 0 \quad \ldots (4.39)$$

The inequality in (4.39) implies that by imposing a tariff on the foreign firm, the quantity imported into the domestic market decreases.

Substituting $K = A - d\,Q_f$ in our q_i equation in (4.36):

$$q_i = \frac{K - C}{2B + (n-1)d} = \frac{A - dQ_f - c}{2B + (n-1)d} \quad \ldots (4.40)$$

Substituting for Q_f [from 4.38] in (4.39):

$$q_i = \frac{A - d(1 - mt) - c}{2B + (n-1)d} \qquad \ldots (4.41)$$

From (4.41) it is clear that:

$$\frac{\partial q_i}{\partial t} > 0$$

The above inequality implies that by imposing a tax on the foreign firm, the quantity supplied by domestic firms will increase.

The Effect of Tariffs on Domestic Prices:

Substituting for K in (4.35):

$$p_i = \frac{KB + C[2B + (n-1)d]}{2B + (n-1)d} \qquad \text{since } K = A - dQ_f$$

$$\therefore \quad p_i = \frac{B[A - dQ_f] + C[2B + (n-1)d]}{2B + (n-1)d}$$

Substituting for $Q_f = 1 - mt$ in the above equation:

$$p_i = \frac{B[A - d(1 - mt) + c[B + (n-1)d]}{2B + (n-1)d} \qquad \ldots (4.42)$$

From (4.42) it is clear that:

$$\frac{\partial p_i}{\partial t} > 0$$

The Effect of Tariffs on Domestic Profits:

$$\Pi_i = \frac{B(K - c)^2}{2B + (n-1)d}$$

Substituting for $K = A - dQ_f$ in the above equation:

$$\Pi_i = \frac{B(A - dQ_f - c)^2}{2B + (n-1)d}$$

Further, substituting for $Q_f = 1 - mt$ in the above equation:

$$\Pi_i = \frac{B[A - d(1 - mt)Q_f - c]^2}{2B + (n-1)d}$$

$$\therefore \frac{\partial \Pi_i}{\partial t} = 2B\,(A - d1 + dmt - c)\,dm > 0$$

$$\Rightarrow \frac{\partial \Pi_i}{\partial t} > 0$$

The above inequality shows that the profits of the domestic firms increase as tariffs increase.

From the model that we have developed so far, we have the following results:

$\frac{\partial pi}{\partial n} < 0$ i.e. the price of a good 'i' and the number of firms producing 'i' are inversely proportional.

$\frac{\partial \Pi_i}{\partial n} < 0$ i.e. the profits of firms producing 'i' is inversely related to the number of firms producing 'i'.

$\frac{\partial Qf}{\partial t} > 0$ i.e. the quantity of imports Qf is inversely related to the tariff rate 't'.

$\frac{\partial qi}{\partial t} > 0$ i.e. the quantity produced by q_i is positively related to the tariff rate 't'.

$\frac{\partial pi}{\partial t} > 0$ i.e. the price of good 'i' is positively related to the tariff rate 't'.

$\frac{\partial \Pi i}{\partial t} > 0$ i.e. the profits of firms producing 'i' is positively related to the tariff rate 't'.

We first postulate a scenario where there is free trade and foreign firms do not have tariff restrictions to domestic markets.

We then have n domestic firms and 1 foreign firm. Examining profits it is clear that:

$\Pi_i^{n+1,o} < 0$ since $\frac{\partial \Pi i}{\partial n} > 0$ & $\frac{\partial \Pi i}{\partial t} > 0$

where $\Pi_i^{n+1,0}$ are the profits of one foreign firm and n domestic firms when there are no tariffs and

$\Pi_i^{n+1,t}$ are the profits of n domestic firms when there are tariffs.

Since $\Pi_i^{n+1,0} < F$ where the market cannot sustain (n + 1) firms, some firms are forced to exit. If we denote x as the number of firms which exit:

$$\Pi_i^{(n+1)-x,0} > \Pi_i^{n+1,t} > \Pi_i^{n+1,0}$$

We can then construct the following inequality:

$$\Pi_i^{(n+1)-x,0} > \Pi_i^{n+1,t} > F > \Pi_i^{n+1,0}$$

Examining corresponding prices:

$$p_i^{(n+1)-x,0} > p_i^{n+1,0} \quad \text{since } \frac{\partial p_i}{\partial n} < 0$$

$$\& > \Pi_i^{n+1,t} \quad \& \quad \frac{\partial p_i}{\partial t} < 0$$

Therefore:

$$p_i^{(n+1)-x,0} > p_i^{n+1,t} > p_i^{n+1,0}$$

$\left[p_i^{n+1,t}\right.$ is impossible because it soon lapses to $\left.p_i^{(n+1)-x,0}\right]$

Conclusion

This model has compared profits and prices of firms when there is free trade and trade with tariffs. The expected outcome of free trade is increase in competition. However, because the domestic industry is highly concentrated and economies of scale limit the number of firms a market can sustain, a complete removal of trade barriers does not result in competition.

In our model, profits in a free trade scenario is π_i^{n+1}, where the market cannot sustain (n + 1) firms. The entry of foreign firms (or goods) forces the exit of x firms and increases the concentration in the domestic industry. Profits soar to π_i , and prices are the highest at p_i' . The higher price results in a welfare loss for consumers on account of *iree* trade in an imperfect market.

With the imposition of tariffs, profits are lower at π_i^{n+1}, and so *are* prices at p_i ' . Therefore in imperfect markets, tariffs *are* beneficial from the consumer's point of view since it depresses the consequences of concentration. However, if tariffs *are* prohibitive, an autarky situation prevails. The situation will be similar to the cutthroat competition that arises as a consequences of free trade, but the competition will be among domestic firms. Scale economies determine the number of firms a market can sustain. If the number of firms is greater than the optimal number, the 'extra' firms will be forced to exit, thus increasing concentration. The incumbent firms will take advantage of domestic liberalisation to deter further entry. These entry deterring strategies could be that of holding excess capacities and/or vertical integration as shown in Models (1) & (2). In this situation, there *are* two policy options available to the government:

(a) to formulate a pricing policy to curb monopoly or oligopoly pricing in the industry, or
<b) to formulate a tariff policy that will form the basis of strategic trade management.

From Model 3, we know that the number of firms (n) in the market and prices *are* inversely related, i.e. as n decreases, p increases. If n is larger than what scale economies permit [see Table 4.2 for examples in the Indian petrochemical industry] cutthroat competition depresses prices so weaker or peripheral firms will be forced to exit, leaving the market more concentrated. The government can fix a price P_i (based on long-run marginal cost such that:

$p_i^{(n-1)} > p_i^* > P_i^n$ where

$p_i^{(n-1)}$: price when some firms have exited.

p_i^* : an exogenously fixed price (by the government)

P_i^n: price when n is greater than scale economies permits.

$p_i^* > P_i^n$ to ensure that firms recover fixed costs. The corresponding profit inequality is:

$\Pi_i^{(n-1)} > \Pi_i^* \geq F > \Pi_i^n$.

When tariffs *are* prohibitive and competitive imports are non-existent, there is a net welfare gain for the consumer when the government regulates prices. Prices *are* lowest when n firms compete. But because of scale economies and high fixed costs, the market cannot sustain n firms. Without government regulation of prices, the consumer pays p_i' which is greater than the administered price p_i. And, producers profits are lower at Π_i (since $\Pi_i > \Pi_i$) but high enough to cover fixed casts. However, price regulation creates distortions. An alternative option would be to use tariffs to discipline domestic firms.

Trade liberalisation in the Indian petrochemical industry involves a reduction in tariff levels. Model 3 shows that tariff rates should be linked to the extent of scale economies in an industry. The larger the scale economies for a product, the higher should be the tariff. In the petrochemical industry, scale economies *are* greatest for feedstocks and gradually decrease for downstream petrochemicals. Higher tariffs must therefore be imposed on feedstocks, and gradually lower tariffs for downstream petrochemicals. Tariffs should offer enough protection to allow domestic units to operate at *MES* (at least) but should not be prohibitive. (As seen earlier, prohibitive tariffs would necessitate price regulation in the domestic industry.) Firms in downstream petrochemicals will not only have to be competitive (since tariff rates *are* lower), but can import upstream

petrochemicals if the domestic industry cannot take advantage of both scale economies and tariff protection.

The Rakesh Mohan recommendations for tariff reductions offer a graduated framework as illustrated in the following table.

Table 4.3
Proposed Tariff Structure

A. Basic Feedstocks: *Graduated Tariff Protection of 0 - 10%*

Naphtha	Benzene	C4s
Ethylene	Toluene	
Propylene	Xylene	
Butadiene	Isobutylene	

B. **Intermediates:** *Graduated Tariff Protection 15 - 25%*

Ethylene Oxide	Propylene? Glycol	Acrylonitrile
Ethylene Dichloride	Phenol	DMT
Ethyl Benzene	Styrene	Ethylene Glycol
Vinyl Chloride	Caprolactum	LAB
Propylene Oxide	PTA	MTBE

C. **Finished** Products: *30 - 40%*

LDPE/LLDPE	SBR	Polyols
HDPE	PBR	Isocyanates &
PVC	IIR	other derivatxves
PP	EPDM	
PS	PSF	
ABS	PFY	
PET	Nylons	

Source: Expert's Group Report on Petrochemicals [1993].

As shown in Table 4.3, the Rakesh Mohan recommendations prescribe a complete removal of tariffs for feedstocks, and progressively increase tariffs for downstream petrochemicals. In the light of the results of Model 3, the tariff rates for feedstocks should be at an optimal level (to enable domestic firms to operate at *MES*) and should be progressively decreased for downstream industries.

FIRM STRATEGIES AND ALTERNATIVE FORMS OF GOVERNMENT INTERVENTION

The first two models in the above section illustrate firm behaviour as an outcome of domestic liberalisation in the Indian petrochemical industry. We have assumed that the firms operate in a closed economy where there is no trade. In Model 1, the incumbent firm builds excess capacity and thereby deters entry. In Model 2, the incumbent firm integrates vertically and deters entry. The industrial structure remains oligopolistic and incumbent firms retain their dominance in the market. This situation is summed up in Model 3. When there is no trade or tariffs *are* prohibitive, prices are the highest. Cut-throat competition will force some domestic firms to exit (if the number of firms in the market *are* greater than what scale economies permit) and concentration increases. On the other hand, free trade will lead to international cutthroat competition where firms which will be forced to exit may be domestic (Indian) firms and prices are determined by global oligopolies. The complete removal of trade barriers under trade liberalisation thereby has an adverse impact on consumer welfare. In such a situation, the government can use tariff policies to ensure optimal outcomes.

The basic shortcomings of the models are the assumptions of linear demand, identical cost functions and single product firms. These assumptions *are* made to simplify the models - substantial differences in results are not expected under alternate assumptions. The Kapur and Sengupta Reports have utilised both linear and log-linear models to estimate demand for petrochemicals. Our assumption of a linear demand function rests on **these** reports.

Identical cost functions for the entrant and incumbent are based on the reasoning that the differences in technology between producers are not significant enough in the Indian petrochemical industry to warrant the use of different cost functions. This is **partly** because the petrochemical industry in the country is relatively recent and the difference in the technology used by the

incumbent and entrant *are* assumed to be similar enough to warrant the use of identical cost functions.

The assumption of single product firms was necessary for simplifying the models. Most petrochemical firms are necessarily multi-product because a number of by-products are produced in the complex chemical process flows in the industry. In Model 1, we have assumed that the incumbent produces a single main product, the capacity of which he expands. In Model 2, the firm integrating vertically is assumed to be a single product firm until it integrates into a neighbouring product. A multi-product firm would have integrated into an additional neighbouring product likewise.

In Models 1 and 2, incumbent firms enjoy first-mover advantages - whether of expanding and building excess capacities or integrating vertically - enabling them to deter entry and protect their dominant power. In Model 1, the lumpy nature of investment in the petrochemical industry favours first-movers. The fact that expansion (by incurring sunk costs) enables them to build excess capacities signals the incumbent's desire to defend its power.

In Model 2, the technology in the petrochemical industry -favours vertical integration from the production of feedstocks to downstream petrochemicals. As Model 2 illustrates, an incumbent can deter entry into a particular market by integrating vertically into that market. The entrant has an option of fully integrated entry but is again at a disadvantage. Fully integrated entry, providing demand conditions permit, requires substantial investment, a portion of which is sunk. Because such entry is risky, the cost of financial capital is higher for the entrant than the incumbent thus placing the entrant at a cost disadvantage compared to operating firms.

Any government endeavour to increase competition in the Indian petrochemical industry would have to ensure that the advantages incumbents enjoy *are* offset by government support to entrants. Since scale economies are highest for upstream

petrochemicals, the government could restrict its support to entrants in these markets. Such support could take the form of subsidies equivalent of sunk costs. The government car. thereby 'create' a contestable market. And these entrants can be public: sector companies. By restricting upstream petrochemicals to the public sector, and allowing private firms in downstream petrochemical markets, the incumbency advantage of vertical integration is also reduced. The basic drawback of Subsidies is: (a) it creates distortions in the economy (the very distortions that liberalisation attempts to remove) and (b) resource? constraints hamper such support. An alternative would be the formulation of a pricing policy which covers long turn marginal costs and dissuades oligopolistic pricing. Regulating prices, however, may be feasible for select petrochemicals but difficult for all petrochemicals.

Alternatively, as Model 3 indicates, tariff policies could be designed in a fashion to discipline domestic firms and ensure competitive outcomes. Tariff rates should be linked to scale economies for a particular product. The higher the scale economies, the higher the tariff rate. This enables domestic firms to produce at efficient scales. Tariffs, however, should not be prohibitive. Downstream firms then have an option of importing their inputs if upstream units *are* not efficient despite tariffs that allow them to operate at economic scales.

The tariff policy should also cope with the problem of dumping. In a situation of global over-capacity exports are a means of survival and this is the situation in many petrochemical producing countries. Firms in these countries target their exports (and dump) to countries which are in the process of liberalising imports. Anti-dumping measures will have to be strengthened— an institution would have to be set up to deal with complaints concerning injury from 'import surges' and offer relief in a way that does not lead to interminable or discriminatory protection.[10]

In this section we have attempted to examine alternate forms of government intervention that will be necessary in the Indian petrochemical industry in the post liberalisation period. Firm strategies that *are* an outcome of domestic liberalisation result in incumbent firms reinforcing their dominant market power. Despite policies that were designed to increase competition, the industry continues to be oligopolistic – the petrochemical industry can in fact be termed a 'natural' oligopoly. In such a situation, an optimal trade policy would have to be designed to discipline the domestic market and ensure welfare-improving outcomes.

NOTES

Credit may be more forthcoming to incumbents who want to integrate vertically than to entrants who want to set up integrated complexes.

Most studies assume Cournot behaviour because of the robustness of the results and this assumption is compatible with the conditions in the petrochemical industry.

Firms have to operate at a certain minimum economic scale for efficiency even though the stipulation of MES is no longer part of government policy.

We assume that q can be produced with capacity F and at q, the marginal cost, mc = C + F i.e. the firm expands. In the subsequent analysis it becomes clear that we have considered and ε in the neighbourhood of q , such that for $\varepsilon < q$, full capacity is reached.

The above definition of marginal cost is in contrast to Dixit's model [1979] where

mc = C for q < q

= v + s for q > q giving rise to a Z' shaped marginal cost curve.

Ware [1984] argues that when the instrument of strategic committment takes the form of sunk costs, which both the incumbent and the entrant have to bear, as in Dixit's paper, a three-stage model rather than the two-stage model is required. Rather than to extend the entry game to three periods, perhaps the inverted 'T' marginal cost curve represents sunk costs adequately. Given the essentially asymmetric nature of the entry game where the incumbent has the first mover advantage, he incurs only variable costs in the second period.

[6] This shift from MR_1 to MR_2 can be on account of any positive shock that affect demand conditions. In the petrochemical industry, it could be due to increased demand in downstream industries which tends to substitute synthetic petrochemical based products for natural products that either in short supply *or* qualitatively inferior.

[7] From the quadratic, we have:

$$\phi = Bq_i^{*2} - (A - C)\, q^* + \frac{(A - C)^2}{4B} - F$$

$$\frac{\partial \phi}{\partial q^*} = 2Bq^* - (A - C)$$

We have two values of q^* such that:

$$q^* = \hat{q} = \pm \frac{\sqrt{(A - C)} \pm \sqrt{BF}}{2B}$$

where $q^* > 0$ i.e. both roots are positive

Substituting $q^* = \hat{q}$ in (1) we get

$$\frac{\partial \phi}{\partial q^*} = 2B \left[\frac{(A - C) + 2\sqrt{BF}}{2B} - (A - C) \right]$$

$$\& \quad \frac{\partial \phi}{\partial q^*} = 2B \left[\frac{(A - C) - 2\sqrt{BF}}{2B} - (A - C) \right]$$

Therefore,

$$\frac{\partial \phi}{\partial q^*} = 2\sqrt{BF} > 0 \qquad \& \qquad \frac{\partial \phi}{\partial q^*} = -2\sqrt{BF} < 0$$

where $\hat{q}_S < \hat{q}_L$.

[8] The entry of F_1 into the input market is possible even if excess capacities exist in the input market since F_1 makes profits in both the input and product markets.

[9] See Finger [1992] for a comprehensive study of issues on the dumping literature.

CONCLUSIONS

This study has been an attempt to examine the policy implications of liberalisation in the Indian petrochemical industry. While liberalisation policies have eroded or reduced artificial entry barriers, the accentuation of natural entry barriers perpetuates an oligopolistic industrial structure. Therefore the benefits of competition that ought to be forthcoming through liberalisation policies do not materialise. The following are some of the important observations that the study brings out.

Liberalisation policies were initiated to increase competition in Indian industry. They essentially remove what we have termed artificial entry barriers in order to encourage entry and thereby increase competition. There is a clear demarcation between domestic liberalisation and trade liberalisation in the Indian petrochemical industry. Domestic liberalisation policies were initiated in the early 1980s and has been systematic in bringing down restrictions and controls on the entry of new firms and the expansion of incumbent firms. Domestic liberalisation commenced with the policies of broadbanding, reendorsement of capacity, prescribing a minimum efficient scale of operation and opening up the public sector; and culminated in the N1LP [1991] where all petrochemicals (apart from those that were deemed hazardous) were delicensed. On the other hand, trade liberalisation has been ad *hoc* and hesitant. It was only in 1993 that the Rakesh Mohan Committee sought to systematise trade liberalisation and drew up a graduated framework for tariff reduction. These recommendations *are* yet to be implemented.

Domestic liberalisation policies have ostensibly brought down artificial entry barriers in the petrochemical industry. But the existence of natural barriers has been detrimental to the building up of competitive structures in the industry. Characteristics intrinsic to the nature of the petrochemical industry such as scale economies, high fixed casts (a portion of

which is sunk) and the lumpy nature of investment have enabled incumbent firms to take advantage of domestic liberalisation and perpetuate their dominant power. The entry deterring nature of firm behaviour in the post liberalisation phase was illustrated with the help of models set within the framework of the new industrial organisation.

The models are two-period models that assume Cournot competition between firms. In the first period the incumbent firm is assumed to be a monopolist and is a first-mover. The potential entrant enters in the second period and the two firms operate as duopolists. These models enabled us to investigate the conditions under which the entrant could be deterred and make conjectures about the entry deterring possibilities of the firm's strategies. The strategies of holding excess capacities (as evidenced by the conditions set out in Model 1) and vertical integration (in Model 2) were possible due to domestic liberalisation policies.

In the pre-liberalisation period, the licensed capacities of petrochemical firms were far below efficient scales. Early liberalisation policies stipulated a minimum efficient scale of operation to enable firms to take advantage of scale economies and be efficient. Later with delicensing, although a MES was not stipulated, firms would have to operate at scales that would be efficient. First mover firms who expanded capacities (to take advantage of scale economies) would build excess capacities which would deter the entry of new firms. The fact that the incumbent had incurred sunk costs to create excess capacities showed a will to defend dominant market power.

Model 1 established a number of strategies by which an incumbent firm could deter entry by holding excess capacities. While the intrinsic characteristics of scale economies and the lumpy nature of the investment automatically create excess capacities that are 'innocent' entry barriers, the incumbent can also deliberately expand (and hold excess capacities) in order to deter entry.

Deliceusing also enabled incumbent firms to vertically integrate. The act of vertical integration nr,t only enabled the integrating firms to take advantage of transaction costs, assure a market for his products (or inputs) but also precluded entry (both in the input as well as product market). The incumbent firm could thereby accentuate his dominant market power.

Model 2 illustrated how entry can be deterred in both the product and input market through vertical integration. An incumbent's entry into a neighbouring product i.e. vertical integration cannot be prevented because he is already assured of profits in his original market. Nor can excess capacity prevent vertical integration since the firm is seeking an assured market for his product (by forward integration) or an assured source of inputs (by backward integration). Vertical integration can however prevent fresh entry. In addition, the vertically integrated firm automatically raises the cost of entry — if entry has to be effective, the entrant will have to compete with the incumbent as an integrated firm thus raising the cost of entry.

Models 1 and 2 illustrated how firm strategies. of holding excess capacities and vertical integration could deter entry and accentuate the dominant market power of incumbents. Although domestic liberalisation policies eroded artificial entry barriers, it was clear that these policies enabled firms to erect natural entry barriers and act in a manner that would deter fresh entry. Firm strategies nf expansion (and thus creating excess capacities) and vertical integration were facilitated by domestic liberalisation policies. Such behaviour did not lead to a competitive industrial structure (which was the aim of liberalisation). On the other hand, the industry continued *in* exhibit high levels of concentration.

Any policy intervention to build a competitive industrial structure in the Indian petrochemical industry would have to nullify or reduce the advantages of incumbency without jeopardising efficiency. One policy option would be to grant subsidies to the entrant to offset sunk costs and make entry

profitable. In effect, the government attempts to create a contestable market. However, such subsidies not only create distortions in the economy, hut also encourages the entry of inefficient sizes firms. Moreover, resource constraints would hamper such a policy.

The second policy option would be to frame a pricing policy that influences demand patterns such that incumbents do not have an incentive to expand and deter entry. However, there are too many difficulties in calculating administrative prices for a large number of petrochemicals; and such prices rio not reflect the the changing conditions of the market.

A third alternative would he to restrict the capacity expansion of firms beyond *MES* - in effect forcing the entry of new firms and market sharing. However, in cases where *MES* is large and a single firm can cater tn the entire market, the problem of domination still has to be checked. And, restricting capacities implies a reversal of liberalisation policy akin to licensing. However, such a policy does not curb the vertical integration of incumbent firms which has been shown to be entry deterring.

"The technology in the petrochemical industry supports vertical integration from the manufacture nf feedstocks to downstream petrochemicals. Policy options available to restrict the advantages that an integrated firm enjoys are limited. The MRTP Act could he activated to investigate rases where vertically integrated firms price their products in nrder tn deter entry and thereby limit competition. Such practices are, however, extremely difficult to prove.

The dominance of incumbent firms could to an extent, be controlled by restricting the upstream petrochemicals to the public sector. In this case, public sector enterprises do not have an incentive to expand in order to deter entry. Private firms producing downstream petrochemicals integrate backwards beyond a point and the incumbency advantages of vertical

integration *ar&* thereby reduced.integration is reduced. However, an inefficient public sector can jeopardise the entire petrochemical industry. In this situation, trade policy gains significance as a means of ensuring competitive structures. The implications of trade liberalisation is outlined in Model 3 which is set in the new *IO* but with the added dimension of trade.

Model 3 illustrated how free trade would lead to increased concentration: when the number of firms in the industry is greater than what scale economies permit, some firms would have t.n exit. Domestic firms would therefore need a tariff to enable them t. operate at efficient scales. However if tariffs were prohibitively high, trade would have no role to play and domestic firms would be concentrated and oligopolistic on account of domestic liberalisation. It therefore becomes important to draw up an optimal tariff policy where tariffs would be linked to scale economies fur the manufacture of the product - tariffs should he higher for products with high scale economies such as feedstocks and progressively lower for downstream petrochemicals. The recommendation that stems from Model 3 *art?* in fact contrary to what the Rakesh Mohan Committee has recommended. The tariff structure they recommend stipulates that upstream petrochemicals should have nil or low tariffs and that tariffs should te higher for downstream petrochemicals. Our results show that as economies of scale are higher in upstream petrochemicals, tariffs should be correspondingly higher than for downstream petrochemicals where scale economies *are:* lower.

Out study has examined the consequences of liberalisation in the petrochemical industry in India. While liberalisation policies were designed in order to increase the level of competition in an industry, the outcomes are linked to industrial structure, and firm behaviour. The causal links between liberalisation policies and competition are therefore not simple. Our case study of the petrochemical industry in India illustrated how domestic liberalisation policies in fact accentuate the market power of incumbent firms and perpetu. te an oligopolistic industrial structure. And given the structure of the

petrochemical industry there is no simple link between the decrease in tariffs (i.e. trade liberalisation) and competition either. Tariffs are necessary and should be designed in a manner to curb the advantages incumbent firms enjoy in an oligopolistic situation.

BIBLIOGRAPHY

Reports and Documents

Annual Report 1992-93, Department of Chemicals and Petrochemicals, Ministry of Chemicals and Fertilisers, GOI.

Bombay Stock Exchange Directory, (various issues).

Centre for Monitoring the Indian Economy, [1986] The Liberalisation Process.

Centre for Monitoring the Indian Economy, [1990] The Liberalisation Process.

Centre for Monitoring the Indian Economy, [1992] Trends in Industrial Production: 1981 - 1991.

Centre for Monitoring Indian Economy, [1992] Key Financial Data on Large Business Houses.

Centre for Monitoring the Indian Economy, [1992] Market and Market Shares.

Centre for Monitoring the Indian Economy, [1993] A Review of the Central Budget: 1993-94.

Centre for Monitoring Indian Economy, [1993] Key Financial Data on Large Business Houses.

Centre for Monitoring the Indian Economy, [1993] Market and Market Shares.

Centre for Monitoring the Indian Economy, [1994] Market and Market Shares.

Companywise Production of Petrochemicals (1983-84 to 1990-91), Monitoring and Evaluation (Petrochemicals) Section, Department of Chemicals and Petrochemicals, GOI, New Delhi.

Economic Reforms: Two Years After and the Task Ahead, Discussion Paper, Department of Economic Affairs, Ministry of Finance, GOI, New Delhi.

Experts' Group Report on Petrochemicals, [1993] Chairman: Rakesh Mohan, GOI, (Unpublished).

India: An Industrialising Economy in *Transition*, [1988] A World Bank Country Study.

India Database (1990), H.L.Chandok and the Policy Group.

Indian Petroleum and Petrochemical Statistics, Department of Petrochemical Statistics, Department of Petroleum, GOI (various issues).

Minimum Economic Sizes of Petrochemical Plant s, [1986] Chairman: S. Ganguly, (Unpublished).

Minimum Economic Sizes of Petrochemical Plants, [1988] Background Note for the Committee Meeting: Chairman: J. J. Mehta (Unpublished).

Perspective Plan for Petrochemicals: Proceedings of the Seminar Organised by the Indian Chemicals Manufacturer's Association, New Delhi, May 3, 1978.

Perspective Planning of the Petrochemical Industry of India: (Interim Report), [1990], (R. Sengupta: Honorary Consultant), Planning Commission, New Delhi, GDI.

Perspective Planning of the Petrochemical Industry of India, C19923, (R. Sengupta: Honorary Consultant), Planning Commission, New Delhi, GOI.

Report of the Committee on Trade Policies, [1984] Chairman: Abid Hussain, Ministry of Commerce, GOI.

Report of the Petrochemical Commi t tee, [1961] Chairman: G.F. Kane, Ministry of Commerce and Industry, New Delhi, GOI.

Report of the Reconstituted Group on Petrochemicals, [1978] Chairman: Lovraj Kumar, GOI.

Report on Aromatics, [1988] Bureau of Industrial Costs and Prices, Ministry of Industry, GOI.

Report of the Committee for Perspective Planning of Petrochemical Industry, (1986-2000 A.D.), (Chairman: D.V. Kapur) [19863 Department of Chemicals & Petrochemicals, Ministry of Industry, GOI.

Reserve Bank of India, Report on Currency and Finance, (various issues).

Studies on the Structure of the Industrial Economy: Strategies for Cost Reduction: Some Lessons from BICP Studies: [1988], Bureau for Industrial Costs and Prices, New Delhi, GOI.

Technology Planning for Petrochemicals, [1988] Indian Institute of Management, Ahmedabad & Indian Petrochemical Corporation Ltd., Baroda.

United Nations Industrial Development Organisation, [1984] World Demand for Petrochemical Products and the Arab Petrochemical Industry, Sectoral Working Paper Series, No.20, IS/480.

United Nations Industrial Development Organisation, [1985] The Petrochemical Industry: The Sector in Figures, Sectoral Studies Series, No.20, Volume II, IS/572.

United Nations Industrial Development Organisation, Industry and Development, Global Report 1988/89.

Abiru,M. [1988] Vertical Integration, Variable Proportions and Successive Oligopolies, *The Journal of Industrial Economics*, Vol.36, No.3, pp.315-25.

Agarwal,R.N. [1991] Market Structure and Profitability Relationships in a Regulated Industry, *The Indian Economic Journal.* Vol.39, No. 2, pp.120-35.

Ahluwalia, I .J. [1985] *Industrial Growth in India,* Oxford University Press, New Delhi.

Akram-Lodhi,A.H. [1990] The Political Economy of Trade Liberalisation in India, *Journal of Contemporary Asia,* Vol.20, No.2, pp.359-70.

Alagh,Y.K. [1987] Policy, Growth and Structural Change in Indian Industry,' *Economic and Political Weekly*, Vol.22, No.19-21, pp.57-60.

Alagh,Y.K. [1991] *Indian Development, Planning and Policy,* Vikas, New Delhi.

Acquier,A. & Caves,R. [19793 Monopolistic E;:port Industries, Trade Taxes and Optimal Competition Policy, *The Economic Journal* . Vol.28, No.355.

Bailey,E.E. [Ed.] [1987] *Public Regulation:* tem *Persepct.ives in Institutions and Policies,* MIT Press, Cambridge.

Bain,J. [19543 Economies of Scale, Concentration and the Conditions of Entry in Twenty Manufacturing Industries, *The American Economic Review*, Vol.44, No.1, pp. 15-39.

Bain, J. [1956] *Barriers to New Competition: Their Charac ter and Consequences in Manufacturing Industries*, Harvard University Press, Cambridge.

Baumol,W. & Willig,R. C19813 Fixed Cost, Sunk Cost, Entry Barriers and Sustainability of Monopoly, *The Quarterly Journal of Economics,* Vol.95, pp.405-31.

Baumol,W. [1982] Contestable Markets : An Uprising in the Theory of Industry Structure, *The American Economic Review*, Vol.72, No.l, pp.1-15.

Baumol,W., Panzar,J. & Willig,R. [1986] On the Theory of Perfectly Contestable Markets, xn J. Stiglitz & F. Mathewson, CEd.3 *New Developments in the Analys is nf Market Struc ture,* MIT Press, Cambridge, Mass.

Bhagawan, M.R. C19883 India's Industrial and Technological Policies into the Late 1980s, *Journal of Contemporary Asia,* Vol.18, No.2, pp.220-23.

Bhagwati,J. & Desai,P. [1970] *India: Planning for Industrialisation and Trade Policies Since 1951*, Oxford University Press, London.

Bhagwati,J. & Srinivasan, T. N. [1976] *Foreign Trade Regimes and Economic Development - India*, Macmillan, New Delhi.

Bhagwati,J. [1987] *Indian Economic Performance and Policy Design*, Sir Purushottam Das Thakurdas Memorial Lecture deliverer) in Bombay.

Bhagwati,J. C19893 Is Free Trade Passé After All? *Weltwirtschaftliches Archiv*, Vol.25, pp.17-44.

Bhagwati J. & Srinivasan, T.N. [1993] *India's Economic Reforms*, Ministry of Finance, GOI, New Delhi.

Bhattacharya,C.D. C19903 Economic Liberalisation with Import Substitution, in A. Guha, CEd.3 *Economic Liberalisation, Industry Structure and Growth in India*, Oxford University Press, New Delhi.

Blair,R.D. & Keserman,D.L. C19833 *Law and Economics of Vertical Integration and Control*, Academic Press, New York.

Bokil,S.V. C19903 A Study of the Liberalisation in the Southern Cone Countries of Latin America: Lessons for India, in A. Guha, CEd.3 *Economic Liberalisation, Industry Structure and Growth in India*, Oxford University Press, New Delhi.

Bonano,G. & Brandolini,D. CEd.3 [1990] *Industrial Structure in the New Industrial Economics*, Clarendon Press, Oxford.

Bork,R. [1969] Vertical Integration and Competitive Processes, in J.F. Weston, & S. Peltzman CEd.3 *Public Policy Toward Mergers*, Goodyear Publishing Company, California.

Brander,J.A. & Krugman,P.R. [1983] A Reciprocal Dumping Model of International Trade, *Journal of International Economics*, Vol.15, Nos.3/4, pp.313-21.

Brander,J.A. & Spencer,B.J. C19833 International R ft D Rivalry and Industrial Strategy, *The Review of Economic Studies*, Vol.50, pp.707-722.

Brander,J.A. & Spencer,B.J. C19843 Tariff Protection and Imperfect Competition, in H. Kierzkowski CEd.3 *Monopolistic Competition and International Trade*, Oxford University Press, Oxford.

Brander,J.A. [1986] Rationale for Strategic Trade and Industrial Policy in P.R. Krugman CEd.3 *Strategic Trade Policy and the New International Economics*, MIT Press, Cambridge.

Bresnahar.,T. & Schmalensee,R. CEd.3 [1987] *An Empirical. Renaissance in Industrial Economics: An Overview*, Basil Blackwell, Oxford.

Bresnahan,T. [1989] Empirical Studies of Industries with Market Power, in R. Schmalensee & R.D. Willig [Ed.] *Handbook of Industrial Organisation, Vol II,* Elsevier Science Publishers B.V., Netherlands.

Bresnahan,T.F. & Reiss,P.C. [1991] Entry and Competition in Concentrated Markets, *Journal of Political Economy,* Vol.99, No.5, pp.977-1009.

Brock,W.A. [1983] Contestable Markets and the Theory of Industry Structure : A Review Article, *Journal of Political Economy,* Vol.91, No.6, pp.1055-66.

Bulow,J., Geanakoplos,J. & Klemperer,P. [1985] Holding Excess Capacity to Deter Entry, *The Economic Journal,* Vol.95, No.377, pp.178-82.

Butterfield,D.W., Kubursi,A.A. & Welland,J.D. [1984] A Model of the Petrochemical Industry, *The Journal of Energy and Development* , Vol.9, No.2, pp.299-335.

Button,K. & Swann,D. [1989] *The Age of Regulatory Reform,* Clarendon, Oxford.

Carter,J.R. [1978] Collusion, Efficiency and Antitrust, *The Journal of Law and Economics,* Vol.21, No. 2, pp. 435-44.

Caves,R.E., Khalizadeh-Shirazi,J. & Porter,M.E. [1975] Scale Economies in Statistical Analysis of Market Power, *The Review of Economics and Statistics,* Vol.48, No.2, pp.296-307.

Caves,R.E. & Porter,M.E. [1977] From Entry Barriers to Mobility Barriers: Conjectural Deterrence to New Competition, *Quarterly Journal of Economics,* Vol.91, No.2 ,pp.241-61.

Caves,R.E. [1980] International Trade and Industrial Organisation, *The Journal of Industrial Economics,* Vol.29, No.2, pp.113-117.

Chandrashekar,C.P. [1987] Investment Behaviour, Economies of Scale and Efficiency in an Import Substitution Regime: A Study of Two Industries, *Economic and Political Weekly,* Vol.22, No.19-21, pp.61-72.

Chandrashekar,C.P. [1988] Aspects of Growth and Structural Change in Indian Industry, *Economic & Political Weekly,* Vol.23, Nos.45-47, pp.2357-70.

Choksei,A.M. & ' Papageorgieu,De M., CEd.3 [1986] *Economic Liberalisation in Developing Countries,* Basil Blackwell, Southampton.

Clark,J.B. [1940] Toward a Concept of Workable Competition, *The American Economic Review,* Vol.30, No.2, pp.241-56.

Clark,K., Davies,S. & Waterson,M. C1984] The Profitability Concentration Relation: Market Power *or* Efficiency, *The Journal of Industrial Economics,* Vol.32, No.4, pp.435-50.

Cremier,M., Marchand,M. & Thisse,J-F. [19893 The Public Firm as an Instrument for Regulating an Oligopolistic Market, *Oxford Economic Papers,* Vol.41, No.2, pp.283-301.

Corden,W.M. [19903 Strategic Trade Policy: How New? How Sensible?, *World Bank Working Paper* , No. 396.

Comanor,W. & Wilson,T.A. [19673 Advertising, Market Structure and Performance, *The Review of Economic Statistics,* Vol.47, pp.423-40.

Datta-Chaudhuri,M. [1990] Market Failure and Government Failure, *The Journal of Economic Perspectives,* Vol.4, No.3, pp.25-39.

Dasgupta,P. & Stiglitz,J.E. [1988] Potential Competition, Actual Competition and Economic Welfare, *European Economic Review,* Vol. , pp.569-77.

Davidson,C. & Deneckere,R. [19863 Long-Run Competition in Capacity, Short-Run Competition in Price, and the Cournot Model, *The Rand Journal of Economics,* Vol.17, No.3, pp.404-15.

Davies,S., Lyons,B. with Dixon,H. & Geroski,P. [1988] *Surveys in Economics: Economics of Industrial Organisation,* Longman, New York.

Demsetz,H. [1982] Barriers to Entry, *The American Economic Review,* Vol.42, No.1, pp.47-57.

Demsetz,H. [1983] The Structure of Ownership and the Theory of the Firm, *The Journal of Law and Economics,* Vol.26, pp.375-93.

Dertouzos,M.L., Lester,R.K. & Solow, R.M. [1989] *Made in America: Regaining the Productive Edge,* (The MIT Commission on Industrial Productivity), MIT Press, Cambridge.

Dixit,A.K. [1979] A Model of Duopoly Suggesting a Theory of Entry-Barriers, *The Bell Journal of Economics,* Vol.10, pp.20-32.

Dixit,A.K. [1980] The Role of Investment in Entry Deterrence, *The Economic Journal,* Vol.91, pp.95-106.

Dixit,A.K. [1982] Recent Developments in Oligopoly Theory, *The American Economic Review (P&P),* Vol.72, No.2, pp.12-17.

Dixit,A.K. & Stern,N. [1982] Oligopoly and Welfare: A Unified Presentation with Applications to Trade and Development, *European Economic Review,* Vol.19, No.1, pp.123-43.

Dixit,A.K. [1983] International Trade Policy for Oligopolistic Industries, *The Economic Journal* , Vol.94, pp.1-16.

Dixit,A.K. and Kyle,A.S. [1985] The Use of Protection and Subsidies for Entry Promotion and Deterrence, *The American Economic Review*, Vol.75, No.1, pp.139-52.

Dixit,A.K. [1987] Strategic Aspects of Trade Policy, in T.F. Bowley [Ed.] *Advances in Economic Theory*, Fifth World Congress, Cambridge University Press, Cambridge.

Dornbusch,R. [1992] The Case for Trade Liberalisation in Developing Countries, *The Journal of Economic Perspectives*, Vol.16, No.l, pp.69-85.

Doshi,L.N. [1989] *Development in India's Petrochemical Sector*, Paper presented at the Conference on Asia-Pacific Petrochemical Refinery Integration (CAPRI), Houston, Nov. 5-7, 1989.

Dunne,T., Roberts,M.J. & Samuelson,L. [1989] Firm Entry and Post Entry Performance in the U.S. Chemical Industries, *The Journal oj Law and. Economics*, Vol.32, No.2(2), pp.S233-71.

Dutta,D.K. [19923 Planning and the Regulatory Role of the Indian State, *Journal of Contemporary Asia,* Vol.22, No.l, pp.82-93.

Eaton,B.C. & Lipsey,R.G. [19803 Exit Barriers are Entry Barriers: The Durability of Capital as a Barrier to Entry, *The Bell Journal of Economics*, Vol.11, No.?, pp.721-29.

Eaton,B.C. & Lipsey,R.G. [19813 Capital Commitments and Entry Deterrence, *The Bell Journal of Economics*, Vol .12, pp.593-604.

Eaton,J. & Grossman,G.M. [19863 Optimal Trade and Industrial Policy under Oligopoly, *The Quarterly Journal of Economics*, Vol.2, pp.383-406.

Encaoua,D., Geroski,P. & Jacquemin,A. [1986] Strategic Competition and the Persistence of Dominant Firms: A Survey, in J.E. Stiglitz & G.F. Mathewson [Ed.] *New Developments in the Analysis of Market Structure*, Cambridge, Mass, MIT Press.

Ethier,W.J. [1979] Internationally Decreasing Costs and World Trade, *Journal of International Economics,* Vol.9, pp.1-24.

Ethier,W.J. [1982a] Decreasing Costs in International Trade and Frank Graham's Argument for Protection, *Econometrica*, Vol.50, No.5, pp.1243-68

Ethier,W.J. [1982b] National and International Returns to Scale in the Modern Theory of International Trade, *The American Economic Review,* Vol.72, No.3, pp.389-405.

Ethier,W.J. [1982c] Dumping, *Journal of Political Economy,* Vol.90, pp.487-506.

Evans,D.S. [1987] The Relationship between Firm Growth, Size and Age: Estimates for 100 Manufacturing Industries, *The Journal of Industrial Economics*, Vol.35, No.4, pp.567-81.

Flam,H. & Helpman,E. [1987] Industrial Policy under Monopolistic Competition, *Journal of International Economics*, Vol.22, No.1/2, pp.79-102.

Finger, J.M. [1992] Dumping and Anti-dumping: The Rhetoric and the Reality of Protection in Industrial Countries, *The World Bank. Research Observer,* Vol.7, No . 2 , pp. 121-43.

de Fraja,G. & Delbono,F. [19893 Alternative Strategies of a Public Enterprise in Oligopoly, *Oxford Economic* Papers, Vol.41, No.2, pp.302-11.

de Fraja,G. [19913 Efficiency and Privatisation in Imperfectly Competitive Industries, *The Journal of Industrial Economics*, Vol.34, No.3, pp.311-322.

Fudenberg,D. & Tirole,J. [19833 Capital as a Commitment: Strategic Investment to Deter Mobility, *Journal of Economic Theory,* Vol.31, No.1, pp.227-50.

Fudenberg,D. & Tirole,J. [19843 The Fat-Cat Effect, the Puppy-Dog Ploy and the Lean and Hungry Look, *The American Economic Review (P&P)*, Vol.74, pp.361-66.

Fudenberg,D. & Tirole,J. C19893 Noncooperative Game Theory for Industrial Organisation: An Introduction and Overview, in R. Schmalensee & R.D. Willig [Ed.] *Handbook of Industrial Organisation*, Vol.1, Elsevier Science Publishers B.V., Netherlands.

Geroski,R. & Jacquemin,A. [1985] Industrial Change, Barriers to Mobility and European Industrial Policy, Oxford Review of *Economic Policy,* Vol.1,pp170-280.

Gilbert,R.J. & Newberry,D. [1982] Pre-emptive Patenting and the Persistance of Monopoly, *The American Economic Review*, Vol.72, pp.514-526.

Gilbert,R.J. & Harris,R.G. [1984] Competition wxth Lumpy Investment, *The Rand Journal of Economics*, Vol.15, No.2, pp.197-212.

Gilbert,R.J. [1989a] Mobility Barriers and the Value of Incumbency, in R. Schmalensee & R.D. Willig [Ed.] *Handbook of Industrial Organisation*, Vol.1, Elsevier Science Publishers B.V., Netherlands.

Gilbert,R.J. [1989b] The Role of Potential Competition in Industrial Organisation, *The Journal of Economic Perspectives*, Vol.3, No.3, pp.107-127.

Gold,B. [19813 Changing Perspectives on Sire, Scale and Returns: An Interpretative Survey, *The Journal of Economic*

Literature, Vol.19, No.1, pp.5-33.

Goldar,B. [1990] Import Liberalisation and Industrial Efficiency, in A. Guha [Ed.] *Economic Liberalisation, Industry Structure and Growth in India,* Oxford University Press, New Delhi.

Goldar,B. & Runganathan,V.S. [1991] Capacity Utilisation in Indian Industries, *The Indian Economic Journal,* Vol.39, No.2, pp.82-92.

Graham,F. [1923] Some Aspects of Trade Further Considered, *The Quarterly Journal of Economics*, Vol.37, pp. 199-227.

Gray,P.H & Walter,I. [1991] Investment-related Trade Distortion: The Case of Petrochemicals, in H.Singer, A.Hatti & R.Tandon, [Ed.] *Foreign Direct Investments*, New World Order Series, Vol.11, Indus Publishing, New Delhi.

Greenhut,M.L. & Ohta,H. C19793 Vertical Integration and Successive Monopolists, *The American Economic Review*, Vol.69, No.l, pp.137-141.

Grether,D.M. & Plott,C.R. [1984] The Effects of Market Practices in Oligopolistic Markets: An Experimental Examination of the Ethyl Case, *Economic Enquiry*, Vol.22, pp.479-507.

Grether,E.T. [1970] Industrial Organisation: Past History and Future Problems, *The American Economic Review,* Vol.50, No.2, pp.83-89.

Grossman,G.M. [1986] Strategic Export Promotion: A Critique, in Krugman,P.R. [Ed.] *Strategic Trade Policy and the New International Economics*, MIT Press: Cambridge.

Guha,A. C19903 The Political Economy of Liberalisation in India, in A. Guha [Ed.] *Economic Liberalisation,Industry Structure and Growth in India*, Oxford University Press, New Delhi.

Hamilton,C. C19893 The Irrelevance of Economic Liberalisation in the Third World, *World Development*, Vol.17, No.10, pp.1523-30.

Hammond,P.J. C19903 Theoretical Progress in Public Economics, *Oxford Economic Papers*, Vol.42, pp.6-33.

Hause,J.C. & du Rietz,G. [1984] Entry, Industry Growth and the Microdynamics of Industry Supply, *Journal of Political Economy,* Vol. 92, No. 4, pp.733-57.

Hay,D.A. & Morris,D.J. C19793 *Industrial Economics and Organisation: Theory and Evidence,* Oxford University Press, New York.

Hazari,R.K. [1986] Essays *in Industrial Policy*. Concept, New Delhi.

Helpman,E. [1984] Increasing Returns, Imperfect Markets and Trade Theory, in R.W. Jones & P.B. Kenen [Ed.] *Handbook of*

International Economics, Vol.1, Elsievier Science Publishers B.V., Netherlands.

Helpman.E. & Krugman,P.R. [1985] *Market. Structure and Foreign Trade: Increasing Returns, Imperfect Competition and the International* Economy, MIT. Press, Cambridge.

Helpman,E. & Krugman,P.R. [1989] *Trade Policy and Market Structure*, MIT Press, Cambridge.

Helpman,E. [1990] The Noncompetitive Theory of International Trade and Trade Policy, *Proceedings of the World Bank Annual Conference on Development Economics 1989*, pp. 193-216.

Hilke,J.C. [1984] Excess Capacity and Entry: Some Empirical Evidence, *The Journal of Industrial Economics*, Vol.33, pp.25-44.

Irwin,D.A. [1991] Retrospectives: Challenges to Free Trade, *The Journal of Economic Perspectives*, Vol.5, No.2, pp.201-8.

Jacquemin.A. [1987] *The New Industrial Organisation: Market Forces and Strategic Behaviour*, (Translated by Fatemah Mehta) Clarendon Press, Oxford.

Jain,R. [1991] *Guide to New Industrial Policy 1991*, Investment Publications, New Delhi.

Kahn,A.E. [1988] *The Economics of Regulation: Principles and Institutions*, MIT Press, New York.

Kelkar,L.V. & Kumar,R. [1990] Industrial Growth in the Eighties:: Emerging Policy Issues, *Economic & Political Weekly*, Vol.25, No.4, pp.209-22.

Kochanék,S. [1986] Regulation and Liberalisation: Theology in India, *Asian Survey,* Vol.26, No.12, pp.1284-1308.

Kohli,A. [1989] Politics of Economic Liberalisation in India, *World Development*, Vol.17, No.3, pp.305-28.

Kreps,D.M. [1990] *Gains Theory and Economic Modelling*, Clarendon Press, Oxford.

Kreps,D.M. & Scheinkman,J. [1983] Quantity Precommitment and Bertrand Competition Yields Cournot Outcomes, *The Bell Journal of Economics,* Vol.14, pp.326-337.

Kreps,D.M. & Wilson,R. [1982] Reputation and Imperfect Information, *The Journal of Economic Theory*, Vol.27, pp.253-79.

Krishna Rao,P.V. & Sastry,K.P. [1989] Restrictive Trade Practices Policy in India, *The Journal of Industrial Economics*, Vol.37, No.4, pp.427-35.

Kruegar,A.O. [1978] *Liberalisation Attempts and Consequences,* Ballinger for NBER: Cambridge, MA.

Kruegar,A.O. [19863 Problems of Liberalisation, in A.C. Harberger [Ed.] *World Economic Growth,* Institute for Contemporary Studies, San Francisco.

Kruegar,A.O. [19903 Government Failures in Development, *The Journal of Economic Perspectives*, Vol.4, No.3, pp.9-23.

Krugman,P.R. [19793 Increasing Returns, Monopolistic Competition and International Trade, *Journal of International Economics*, Vol.9, pp.469-79.

Krugman,P.R. [19843 Import Competition as Export Promotion: International Competition in the Presence of Oligopoly and Economies of Scale, in H.Kierzowski, [Ed.] *Monopolistic Competition and International Trade*, Clarendon Press, Oxford.

Krugman,P.R. [1987] Is Free Trade Passé? *Economic Perspectives*, Vol.1, No.2, pp.131-44.

Krugman,P.R. [1989] Industrial Organisation and International Trade, in R. Schmalensee & R.D. Willig [Ed.] *Handbook of Industrial Organisation*, Vol.11, Elsievier Science Publishers B.V., Netherlands.

Krugman,P.R. [19903 *Rethinking International Trade*, The MIT Press, Cambridge.

Lal,D. [19873 The Political Economy of Economic Liberalisation, *The World Bank* Economic *Review*, Vol.1, No.2, pp.273-99.

Lieberman,M.B. [19843 The Learning Curve and Pricing in the Chemical Processing Industries, *The Rand Journal of Economics,* Vol.15, No.2.

Lieberman,M.B. [1987a] Excess Capacity as a Barrier to Entry: An Empirical Appraisal, *The Journal of Industrial Economics*, Vol.35, No.4, pp.607-27.

Lieberman,M.B. [198763 Market Growth, Economies of Scale and Plant Size in the Chemical Processing Industries, *The Journal of Industrial Economics*, Vol.36, No.2, pp.175-91.

Lieberman,M.B. [19913 Determinants of Vertical Integration: An Empirical Test, *The Journal of Industrial Economics*, Vol.34, No.5, pp.451-66.

Lin,Y.J. [19883 Oligopoly and Vertical Integration: Note, *The American Economic Review*, Vol.78, pp.251-54.

Lossius,T. [19773 A Case Study of International Efficiency Comparisons: ICI's Synthetic Fibre's Business, in C. Bowe [Ed.] *Industrial Efficiency and the Role of the Government*, HMSO, London.

Malueg,D.A. & Schwartz,M. [19913 Preemptive Investment, Toehold Entry and the Mimicking Principle, *The Rand Journal of Economics*, Vol.22, No.1, pp.1-13.

Mani,S. [1992] New Industrial Policy: Barriers to Entry, Foreign Investment and Privatisation, *Economic and Political Weekly,* Vol.27, No.35, pp.M86-94.

Marathe,S.S. [1986] *Regulation and Development: India's Policy Experience of Controls Over Industry,* Sage, New Delhi.

Martin, S. [1988] *Industrial Economics: Economic Analysis and Public* Policy, Macmillan, New York.

Mason,R. & Shaanan,J. £19823 Stochastic Dynamic Limit Pricing: An Empirical Test, *The Review of Economics and Statistics,* Vol.64, pp.413-23.

Mason,R. & Shaanan,J. [1986] Excess Capacity and Limit. Pricing: An Empirical Test, *Economica,* Vol.53, pp.365-78.

Mehta,R. & Gupta,N.C. C19903 Determinants of Investment with Incomplete Panel Data, *The Indian Economic Journal,* Vol.38, No.2, pp.33-47.

Milgrom,P.& Roberts,J. C19823 Predation, Reputation and Entry Deterrence, *Journal of Economic Theory,* Vol.27, pp.280-312.

Murray,T. [1985] *International trade in the Petrochemical Sector: Implications for Developing Countries,* New York, United Nations.

Orr,D. [1974 3 An Index of Entry Barriers and its Applications to the Market-Structure-Performance Relationship, *The Journal of Industrial Economics,* Vol.23, No.1, pp.39-50.

Panchmukhi, V. [1979] *Trade Policies of India: A Quantitative Analysis,* Concept, New Delhi.

Patel,R.D. [1971] *Petroleum & Petrochemicals,* Thomson Press, New Delhi.

Patel,I.J. C19863 *On Taking India into the Twenty First Century (New Economic Policy in India),* Kinsley Martin Memorial Lecture delivered at Cambridge.

Patibandla,M. [1992] Industrial Decontrol and Competition Policy: A Few Conceptual Issues, *Economic and Political Weekly,* Vol.27, No.8, pp.M137-40.

Perry,M.K. [1989] Vertical Integration: Determinants and Effects, in R. Schmalensee & R.D. Willig CEd.3 *Handbook of Industrial Organisation,* Vol.1, Elsievier Science Publishers B.V., Netherlands.

Perspective Planning of Petrochemical Industry: Executive Summary of D.V. Kapur Committee - Summary and Recommendations, [1987] *Urja,* Vol.59.

Quirmbach,H.C. [1986] Vertical Integration: Scale Distortions, Partial Integration and the Direction of Price Change,

Quarterly Journal of Economics, Vol.101, pp.131-47.

Rakesh Mohan, [1992] Industrial Policy and Controls, in B. Jalan [Ed.] *The Indian Economy: Problems and Prospects*, Viking (India), New Delhi

Rodrik,D. [1992] The Limits of Trade Policy Reforms in Developing Countries, *The Journal of Economic Perspectives*, Vol.6, No.1, pp.87-105.

Rubin,B.R. [1985] Economic Liberalisation and the Indian State, *Third World Quarterly*, Vol.7, No. 4, pp. 942-57.

Salop,S. [1979] New Directions in Industrial Organisation: Strategic Entry Deterrence, *The American Economic Review (P&P)*, Vol.69, pp.335-38.

Scherer,F.M. [19803 *Industrial Market Structure and Economic Performance,* (2nd Ed.), Houghton Mifflin, Boston.

Schmalensee,R. [19733 A Note on the Theory of Vertical Integration, *Journal of Political Economy,* Vol.81, pp.442-9.

Schmalensee,R. [1981] Economies of Scale and Barriers to Entry, *Journal of Political Economy,* Vol.89, No.6, pp.1228-38.

Schmalensee,R. [1988] Industrial Economics: An Overview, *The Economic Journal,* Vol.98, pp.643-81.

Schmalensee,R. [1989] Inter-Industry Studies of Structure and Performance, in R. Schmalensee & R.D. Willig [Ed.] *Handbook of Industrial Organisation*, Vol.II, Elsievier Science Publishers B.V., Netherlands.

Schwartzman,D. [1973] Competition and Efficiency: Comment, *Journal of Political Economy,* Vol.81, No.3, pp.756-77.

Self-sufficiency at What Cost? [1990] *Financial Express*, February 19,20 & 21.

Sen,A. [1990] Trade Restrictions and Growth Constraints, in A. Guha [Ed.] *Economic Liberalisation, Industry Structure and Growth in India,* Oxford University Press, New Delhi.

Shapiro,C. [19893 Theories of Oligopoly Behaviour, in R. Schmalensee & R.D. Willig [Ed.] *Handbook of Industrial Organisation,* Vol.1, Elsievier Science Publishers B.V., Netherlands.

Shapiro,H. & Taylor,L. [19903 The State and Industrial Strategy, *World Development*, Vol.18, No.6, pp.861-78.

Shaw,R.W. & **Shaw,S.A.** [19833 Excess Capacity and Rationalisation in the West European Synthetic Fibres Industry, *The Journal of Industrial Economics,* Vol.32, No.2, pp.149-66.

Shepherd,W.G. [19723 The Elements of Market Structure, *The* tonsil *of Economics and Sta t ist ics*, Vol.54, pp. 25-37.

Shepherd,W.G. [19733 Entry as a Substitute for Regulation, *The American Economic Review (P&P)*, Vol.63, No.2, pp.98-105.

Shepherd,W.G. [1979] *The Economics of Industrial Organisation*, Prentice Hall, New Jersey.

Shepherd,W.G. [1984] "Contestabi1ity" vs Competition, *The American Economic Review*, Vol.74, No.4, pp.572-87.

Shetty, [1978] Structural Retrogression in the Indian Economy Since the Mid-Sixties, *Economic and Poli tical Weekly*, Vol.13, No.6 & 7.

Siddhartan,N.S. & Dasgupta,A.K. C19833 Entry Barriers, Exports and Inter-Industry Differences ir; Profitability, fcutJopt^ *Economies*, Vol.19, No.1, pp.14-23.

Silberston,Z.A. [19723 Economics of Scale in Theory and Practice, *The Economic Journal,* Vol.82, pp.369-9.

Sosnick,S.H. [1958] A Criticism of the Concepts of Workable Competition, *The Quarterly Journal of Economics*, Vol.71', pp.380-423.

Spence,A.M. [1977] Entry, Capacity Investment and Oligopolistic Pricing, *The Bell Journal of Economics,* Vol.9, pp.532 44.

Spence,A.M. [1983] Contestable Markets and the Theory of Industry Structure: A Review Article, *The Journal of Economic Li terature*, Vol.21, No.3, pp.981-90.

Spence,A.M. [1984] Industrial Organisation and Competitive Advantage in Multinational Industries, *The American Economic Review,* Vol.74, No.2, pp.356-60.

Srinivasan,T.N. [1985/86] Neoclassical Political Economy, the State and Economic Development, *Asian Development Review,* Vol.3/4, Nos.1/2, pp.38-58.

Stigler,G.J. [1968] *The Organisation of Industry*, R.D. Irwin Homewood, Illinois.

Stigler,G.J. [1982] The Economists and the Problem of Monopoly, *Th*? American Economic Review (P&P)*, (The Richard T. Ely Lecture), Vol.72, No.2, pp.1 11.

Tirole,J. [19883 *The Theory of Industrial Organsat ion*, Ml) Press, Cambridge.

Venables,A.J. [1985] Trade and Trade Policy with Imperfect Competition: A Case of Identical Products and Tret Entry, *Journal of Internat tonal Economics,* Vol.19, Nos.1/2, pp.1-19.

Venables,A. & Smith,A. [1986] Trade and Industrial Policy under Imperfect Competition, *Economic Policy,* Vol.1, pp.622-72.

Vergara,M & Brown,D. [1988] *The New Face of the World Petrochemical Sector: Implications for Developing Countries,* World Bank Technical Paper No.84, Industry and Energy Series.

Vergara,W. & Babelon,D. [1990] *The Petrochemical Industry in Developing Asia: A Review of the Current Situation and Prospects for Development in the 1990s,* World Bank Technical Paper No.113, Industry and Energy Series.

Vernon,J.M. & Graham,D.A. [1971] Profitability of Monopolisation by Vertical Integration, Journal. *of Political Economy,* Vol.79, No.4, pp.924-5.

Vickers,J. & Waterson,M. [1991] Vertical Relationships: An Introduction, *The Journal of Industrial Economics* , Vol.34, No.5, pp.445-50.

Vickers,J. [1991] Government Regulatory Policy, *Oxford Review of Economic Policy,* Vol.7, No.3, pp.13-30.

Waddams,A.L. [1978] Chemicals *from Petroleum: An Introductory Survey,* Butler & Tannes, London (4thEd).

Ware,R. [1984] Sunk Costs and Strategic Commitment: A Proposed Three Stage Equilibrium, *The Economic Journal,* Vol.94, pp.370-8.

Waterson,M. [1982] Vertical Integration, Variable Proportions and Oligopoly, *The Economic Journal,* Vol.92, No.365, pp.129-44.

Waterson,M. [1984] *Economic Theory of the Industry,* Cambridge University Press, Cambridge.

von **Weizäcker,C.C.** [1980] A Welfare Analysis of Barriers to Entry, *The Bell Journal of Economics,* Vol.11, No.2, pp.399-420.

Westfield,F.M. [1981] Vertical Integration: Does Product Price Rise or Fall?, *The American Economic* fctvisw, Vol.71, No.3, pp.334-46.

Williamson,O.E. [1971] The Vertical Integration of Production: Market Failure Considerations, *The American Economic Review, (P&P)* Vol.61, pp.112-123.

Williamson,O.E. [1990] The Firm as a Nexus of Treaties: An Introduction in M. Aoki, B. Gustasson & O.E. Williamson [Ed.] *The Firm as a Nexus of Treaties,* Sage, London.

Wolf,M. [1982] *India's Exports,* OUP, New Delhi.

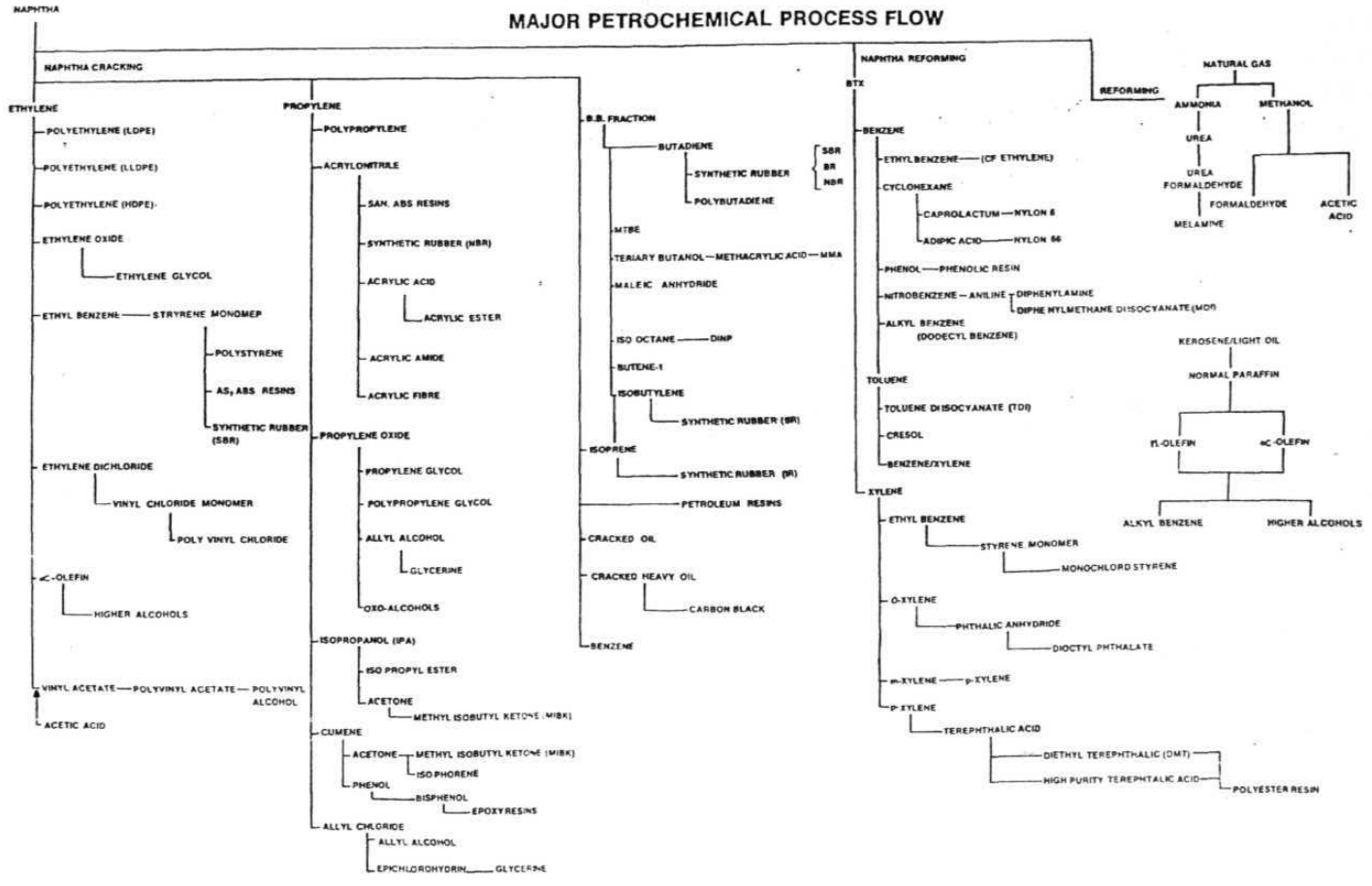
Annexure 1

End Uses of Major Petrochemicals

Petrochemicals	Major End Uses
1. LAB	Synthetic Detergents
2. MEG	Polyester Fibre Explosives
3. Ethylene Oxide	Non ionic Surfactants Ethanolamines
4. Paraxylene	PTA { Synthetic Fibres
5. Orthoxylene	Phthalic Anhydride Other non PAN uses
6. Benzene	Caprolactum Styrene Phenol LAB Nitro Benzene
7. Tuolene	Nitro Tuolene Solvent Thinners
8. Phenol	PF Resins Pharmaceuticals
9. Acetone	Pharmaceuticals Cellulose Acetate Organic Acetylene Methyl Isobutyl Ketone
10. Butanol	Paint/ Resins
11. Methanol	Formaldehyde DMT
12. Formaldehyde	Laminates Resins Moulding Powder
13. Phthalic Anhydride	Paints Dyes and Pigments
14. Petroleum Resins	Paints, Rubber

Petrochemicals	Major End Uses
15. Propylene Glycol	Pharmaceuticals Food Flavour/Perfume/ Cosmetics Polyester Resins
16. Phthalates	P.V. Leather Cloth Cables
17. Plasticiser Alcohal	PrimaryPlasticiser
18. LDPE/LLDPE	Film for Packaging Film far Canal/Reservoir Lining, Cap Covers, Nursery Bags etc. Wires & Cable Mouldings
19. HDPE/PP	Woven Sacks Films of Specific Grades Monofilaments & Ropes Pipes & Sheets Extrusions Mouldings
20. PVC	Fittings Pipes & Conduits Wires & Cables Footwear
21. Polystyrene	Refrigerators Air Conditioners Radios, TVs & Tape Recorders Cassettes Stationery, Novelties, etc.

Source: Report of the Committee for Perspective Planning of Petrochemical Industry : 1986-2000, Chairman: D.V. Kapur, Department of Chemicals and Petrochemicals, Ministry of Industry, GOI, Vol.2, p 33-34.



Source: Report of the Committee for Perspective Planning of the Petrochemical Industry: 1986 - 2000, Chairman: D.V. Kapur, Department of Chemicals and Petrochemicals, Ministry of Industry, GOI, Vol.2, p170.