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 (see 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 or increasing returns to scale. The case for optimal trade policy thus becomes greater in the Indian petrochemical industry.

This chapter presents three models 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. 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 under 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 (and 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.
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>
<thead>
<tr>
<th>Year</th>
<th>Firm</th>
<th>Capacity Expansions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975</td>
<td>Baroda Rayon</td>
<td>Nylon yarn from 1800 to 2100 tpa</td>
</tr>
<tr>
<td>1977</td>
<td>Baroda Rayon</td>
<td>Nylon yarn from 1740 to 2436 tpa, Polyester yarn from 360 to 576 tpa</td>
</tr>
<tr>
<td>1979</td>
<td>Baroda Rayon</td>
<td>Nylon tyre yarn from 1000 to 1700 tpa</td>
</tr>
<tr>
<td>1982</td>
<td>Baroda Rayon</td>
<td>Nylon tyre cord fabrics from 1700 to 3400 tpa, PFY from 276 tpa to 1777 tpa</td>
</tr>
<tr>
<td>1983</td>
<td>Baroda Rayon</td>
<td>NFY from 2436 tpa to 3500 tpa, PFY from 1777 tpa to 3500 tpa</td>
</tr>
<tr>
<td>1985</td>
<td>Baroda Rayon</td>
<td>Caprolactum doubled capacity</td>
</tr>
<tr>
<td>1989</td>
<td>Baroda Rayon</td>
<td>PFY 1777 to 10,000 tpa under the broadbanding scheme (BS/Aug 21 - Sept 3/1989/p65)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NFY 2436 to 5000 tpa</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NTC 4000 to 6000 tpa</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PFY 1777 to 10777 tpa (BS/Oct 2-15/1989/146)</td>
</tr>
<tr>
<td>1990</td>
<td>DCW</td>
<td>Expansion of PVC from 25,000 to 50,000 tpa (FE/Feb 8/1990)</td>
</tr>
<tr>
<td>1986</td>
<td>GSFC</td>
<td>Caprolactum from 30,000 to 100,000 tpa following MES</td>
</tr>
<tr>
<td>1982-83</td>
<td>IPCL</td>
<td>DMT from 24,000 tpa to 30,000 tpa</td>
</tr>
<tr>
<td>1988</td>
<td>IPCL</td>
<td>Orthoxylene from 21,000 tpa to 45,400 tpa, Paraxylene from 17,000 tpa to 48,600 tpa</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>MES '000 tpa</th>
<th>Demand Estimates K</th>
<th>Demand Estimates S</th>
<th>No of Firms</th>
<th>No of Firms &gt; MES</th>
<th>(1) + (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Synthetic Fibres:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. PSF</td>
<td>60</td>
<td>280</td>
<td>288</td>
<td>11</td>
<td>4.67 (4.8)</td>
</tr>
<tr>
<td>2. PYY</td>
<td>25</td>
<td>350</td>
<td>352</td>
<td>22</td>
<td>14 (14.8)</td>
</tr>
<tr>
<td>3. ACF</td>
<td>20</td>
<td>148</td>
<td>138</td>
<td>8</td>
<td>7.4 (6.9)</td>
</tr>
</tbody>
</table>

Synthetic Rubber:

4. SBR 100 212 255 6 1.4 (1.7)
5. PBR 50 J

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) 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 specified by 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 has 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.
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 $q_2$. This step-wise capacity, or discrete capacity function gives rise to the following inverted 'T'shaped marginal cost curve.
q is defined as the maximum output that can be produced with fixed cost F. An additional fixed cost F has to be incurred to produce even one unit of extra output. In marginal cost terms, \( m_c \) 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:

\[
m_c = \begin{cases} 
-C & \text{for } q < q^* \text{ and } q > q \\
-C + F & \text{for } q = q^*
\end{cases}
\]

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 \( m_c \) curve, Fig 4.3 represents two possibilities of incumbent behaviour.
If the monopolist has marginal revenue $MR_1$ which cuts the marginal cost curve on the \textit{first} segment, he behaves like an ordinary monopolist and produces on the demand line corresponding to $E_1$. However, \textbf{if} marginal revenue is $MR_2$, he has the option of producing at $E_2$ or $E_3$.\textsuperscript{7} At $E_2$, he will produce at \textbf{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:

$$mc = C \text{ for } q < q^*$$
$$mc = C + F \text{ for } q = q$$
$$mc = C \text{ for } q > q$$

where $C$ is a constant.

The Cournot profit ($\Pi_i$) of the monopolist incumbent at $E_3$ is:

$$\Pi_i = \frac{(A - C)^2}{4B} \quad \ldots (4.1)$$
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-fit between \( E_2 \) and \( E_9 \) becomes meaningful only when \( \Pi_i > 0 \) at \( E_9 \). If \( \Pi_i < 0 \), then the incumbent will not bother to expand beyond \( q \).

At \( E_i \), let the demand function be:

\[ p_i = A - Bq^* \]

\[ \therefore \Pi_i = (A - Bq^* - C)q^* - F \]  \( \ldots \) (4.2)

where \( \Pi_i \) 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 \( E_i \) is preferred to \( E_9 \), 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:

If \( n^* > \Pi_i \) then \( 0 > \Pi_i > \Pi_i \) \( \ldots \) (4.4)

From (4.1) and (4.2):

\[ \Pi_i^* - (A - Bq^* - C)q^* - F = \frac{(A - C)^2}{4B} - 2F \]

\[ \therefore \quad 0 > Bq^{*2} - Aq^* + Cq^* + \frac{(A - C)^2}{4B} - F \]

\[ \therefore \quad Bq^{*2} - Aq^* + Cq^* + \frac{(A - C)^2}{4B} - F < 0 \]

\( q \) 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 \( E_2 \) and \( E_9 \).

(b) If \( q < Q \), he would prefer \( \Pi_i \) to \( \Pi_i \) 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 \( \phi = \Pi - \Pi^* \), then
\[
\phi = Bq^* - (A + C)q^* + \frac{(A - C)^2}{4B} - F < 0
\]

Solving the above quadratic:

\[
\frac{(A - C) \pm \sqrt{(A-C) - 4B(A-C)^2 - F}}{2B} < 0
\]

\[
\frac{(A - C) \pm \sqrt{4BF}}{2B} < 0
\]

The two roots are:

\[
\hat{Q}_L = \frac{(A - C) + \sqrt{4BF}}{2B} < 0 \quad \&
\]

\[
\hat{Q}_S = \frac{(A - C) - \sqrt{4BF}}{2B} < 0 \quad \&
\]

\[
\frac{(A - C)^2}{4B} - F \text{ is the positive intercept on the } y - \text{axis.}
\]

Since \( \Pi = \frac{(A - C)^2}{4B} \)

\[
\Pi + F = \frac{(A - C)^2}{4B} \text{ is the intercept on the } y - \text{axis.}^8
\]

The following figure represents \( Q = \Pi - \Pi^* \):
From the above figure it is clear that for

\[ 0 < q^* < \hat{q}_L \quad \implies \quad \Pi_1 < \Pi^* \]
\[ \hat{q}_L < q^* < \hat{q}_S \quad \implies \quad \Pi_1 < \Pi^* \]
\[ \hat{q}_S < q^* < \hat{q}_L \quad \implies \quad \Pi_1 > \Pi^* \]

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.

\[ q^* < \frac{(A-C)}{3B} \] or \[ q^* > \frac{(A-C)}{3B} \]

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 \( (A-C) > F \), the incumbent considers expansion in order to deter entry.
We can now conclude that if:

\[ \frac{(A-C)^2}{9B} \leq F < \frac{(A-C)^2}{BB} \]

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 \( \frac{(A-C)^2}{BB} > F \): Entrant does not enter but the incumbent considers expansion.

c) If \( \frac{(A-C)^2}{BB} < F \): 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 50% of the outlay (See table 2.1).

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:
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:

\[
\Pi_i (F,0) = (A - Bq^* - C) q^* - F \\
\Pi_e (0) = 0
\]

2) There is no entry and incumbent expands:

\[
\Pi_i (2F,0) = \frac{(A-C)}{4B} - 2F \\
\Pi_e (0) = 0
\]
3) Entrant enters with capacity $F$ and incumbent does not expand:

$$
\Pi_i (F, F) = (A - 2Bq^* - C) q^* - F
$$

$$
\Pi_o (F, F) = (A - 2Bq^* - C) q^* - F
$$

4) Entrant enters with capacity $2F$ and incumbent does not expand:

$$
\Pi_i (F, 2F) = \frac{(A - Bq^* - C)}{2} q^* - F
$$

$$
\Pi_o (F, 2F) = \frac{(A - Bq^* - C)^2}{4B} q^* - 2F
$$

5) Entrant enters with $F$ and incumbent expands:

$$
\Pi_i (2F, F) = \frac{(A - Bq^* - C)^2}{2} - 2F
$$

$$
\Pi_o (2F, F) = \frac{(A - Bq^* - C)^2}{4B} q^* - F
$$

6) Entrant enters with $2F$ and incumbent expands:

$$
\Pi_i (2F, 2F) = \frac{(A-C)^2}{9B} - 2F
$$

$$
\Pi_o (2F, 2F) = \frac{(A-C)^2}{9B} - 2F
$$

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 view, 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. $\Pi_i (F, F) \geq \Pi_i (2F, F)$ & $\Pi_o (F, F) \leq 0$

1b. $\Pi_i (F, 2F) > \Pi_i (2F, 2F)$ & $\Pi_o (F, 2F) \leq 0$

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. \( \Pi_i (2F, F) > \Pi_i (F, F) \) & \( \Pi_e (2F, F) < 0 \)
2b. \( \Pi_i (2F, 2F) > \Pi_i (F, 2F) \) & \( \Pi_e (2F, 2F) < 0 \)

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. \( \Pi_i (F, F) > Tli (2F, F) \) & \( \Pi_e <F, F) < 0 \)
3b. \( \Pi_i (2F, 2F) > \Pi_i (F, 2F) \) & \( \Pi_e (2F, 2F) < 0 \)

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. \( Tli (2F, F) > \Pi_i (F, F) \) & \( \Pi_e <2F, F) < 0 \)
4b. \( \Pi_i (F,2F) > \Pi_i (2F, 2F) \) & \( \Pi_e (F, 2F) < 0 \)

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 difficulties 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 \( Q \) (equivalent to \( MES \)) can be entry deterring. By not allowing incumbents to expand beyond \( Q \), 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.
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 (F1) is a monopolist in the product market and Firm 2 (F2) 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 F1 and F2 in their respective markets before vertical integration takes place. F1 is a monopolist in the product market q and F2 is a monopolist in the input market qw.

**Initial Conditions:**

Let p and q be the price and quantity of a product.
Let pw and qw be the price and input quantity of the input.

Fixed proportions are assumed i.e. a fixed proportion of qw is necessary to produce a unit of q. Therefore total cost (T):

\[ TC(q) = f_q + pw \cdot q \]  

... (4.3)

where \( f_q \) is the fixed cost in the production of q.

The demand function for q is assumed linear and is:

\[ p = A - Bq \]  

...(4.4)

Correspondingly, the demand function for qw is:

\[ pw = K - L \cdot qw \]

which includes the demand from q too.

The total cost of manufacturing qw is:

\[ TC(qw) = f_w + Cqw \]  

... (4.5)

where \( f_w \) is the fixed cost incurred in the manufacture of qw.

The profit function of F1 is:

\[ \Pi(q) = (A - Bq) - f_q - pw \cdot q \] [from (4.3) & (4.4)] ... (4.6)

In order to maximise F1's profits, the first order condition of (4.6) must be zero. Therefore,

\[ \frac{\partial \Pi(q)}{\partial q} = 0 \]
\[
\frac{\partial \Pi(q)}{\partial q} = A - 2Bq - qv = 0 \quad \cdots (4.7)
\]

From (4.6) & (4.7):
\[
q = \frac{A - pv}{2B} \quad \text{and} \quad p = \frac{A + pv}{2}
\]

& \quad \Pi(q) = \frac{(A - pv)^2}{4B} - f_q

Similarly, the profit function of \( F_2 \) in the input market is:
\[
\Pi(qv) = (K - Lqv)qv - f_v - Cqv \quad \cdots (4.8)
\]

Maximising \( F_2 \)'s profits by equating the first order condition of (4.8) to zero:
\[
\frac{\partial \Pi(qv)}{\partial qv} = 0
\]
\[
\therefore \frac{\partial \Pi(qv)}{\partial qv} = K - 2Lqv - C = 0
\]
\[
\therefore qv = \frac{K - C}{2L}
\]
\[
pv = \frac{K + C}{2}
\]

& \quad \Pi(qv) = \frac{(K - C)^2}{4L} - f_v \quad \cdots (4.9)

Vertical integration now takes place. \( F_1 \), the monopolist in the product market begins to manufacture his own input \( qv \), i.e. \( F_1 \) integrates backwards. This implies that the demand function \( pv - K - Lqv \) 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 \( F_1 \). Therefore:
\[
q = \frac{A - pv}{2B} = qv \quad \cdots (4.10)
\]

\( q \) is the amount of \( qw \) demanded by the integrated firm \( F_1 \) 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:
\[ q_v = \frac{K - p_v}{L} \] ... (4.11)

The direct demand in (4.11) includes the input manufactured by the vertically integrated firm F\textsubscript{1} which is \( q_v \) and F\textsubscript{2} which is \( q_w \). \( q_v \) the input \((q_v)\) manufactured by the non-integrated firm F\textsubscript{2} is:
\[
\bar{q}_v = \tilde{q}_v - q_v \\
= \left( \frac{A - p_v}{2B} \right) - \left( \frac{K - p_v}{L} \right) \ldots \text{from (4.10) & (4.11)} \\
= \frac{2B}{2BL} \left( K - p_v \right) - \frac{L}{2B - L} \left( A - p_v \right)
\]
\[ p_v = \frac{2BK - LA}{2B - L} - \frac{2BL}{2B - L} q_v \]

The above equation is re-written in the following simplified form:
\[ p_v = V - Uq_v \]

where \( V = \frac{2BK - LA}{2B - L} \) and \( U = \frac{2BL}{2B - L} \)

and \( p_v \) becomes \( p_v \) to correspond with \( q_w \).

The demand function (4.8) is being faced by both F\textsubscript{1} and F\textsubscript{2} in the integrated market, i.e. the integrated firm as well as the unintegrated firm.

Let \( q_v \) be the amount of \( q_w \) sold by the integrated firm F\textsubscript{1}.
Let \( q_w \) be the amount of \( q_w \) sold by the unintegrated firm F\textsubscript{2}.

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:
\[ \Pi(q_v) = V - U(q_v + q_w)q_v - f_v - Cq_v \]

201
\[ q^1 = q^2 = \frac{V - C}{2U} \]
\[ p = \frac{V + 2C}{3} \]
\[ \Pi(q^1) = \Pi(q^2) = (\frac{V - C}{2U}) - f_w \]

where \( \Pi(q^1) \) are the profits of \( F_1 \), the integrated firm in the input market &

\( \Pi(q^2) \) are the profits of \( F_2 \), the unintegrated firm in the input market.

CNote that \( F_4 \), the integrated firm makes profits both in the product market and the input market.

The total profits of the integrated firm \( F_1 \) are:
\[ \Pi(F_1) = \Pi(q^1) + \Pi(q^1)^D \]

**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 \( F_t \) has integrated &
b) Entry conditions after \( F_4 \) 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:
\[ p = A - B (q_E + q_i) \]
... (4.12)
where \( q_c \) is the quantity of \( q \) produced by the entrant \( E \) &

\( q_i \) is the quantity of \( q \) produced by the incumbent \( F_t \).

Assuming symmetrical demand functions, and identical cost functions, where \( p_v \) is the price of the input \( q_v \), the costs of \( E \) & \( F_t \) are:
\[ C_E = f_q + p_v q_E \]
& \[ C_i = f_q + p_w q_i \]

Maximising profits and under conditions of Cournot competition:
\[ q_E = q_i = \frac{A - p_v}{3B} \]
... (4.13)
\[ p = \frac{A + 2p_v}{3} \]
& \Pi(q_e) = \Pi(q_1) = \frac{(A - p_w)^2}{9B} - f_q \tag{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 \( \Pi(q_e) = \Pi(q_1) > 0 \) the incumbent would allow for entry since duopoly profits are greater than zero. \( \Pi(q_e) = \Pi(q_1) < 0 \), provides a rationale for the incumbent to deter entry.

If \( n(q_c) = \Pi(q_1) > 0 \)

\[
\frac{(A - p_w)^2}{9B} - f_q > 0
\]

or \( \frac{(A - p_w)^2}{9B} > f_q \)

The total quantity of output \( (q) \) produced in the product market is:

\[
q_e + q_1 = 2 \left( \frac{A - p_w}{3B} \right)
\]

This change in \( q \) will consequently cause a shift in \( q_w \) (the input market) where the new \( q_w \) (\( q_w^* \)), under the assumption of fixed proportion is:

\[
\Delta q_w = \text{Combined duopoly output} - \text{monopoly output}
\]

\[
= q_* - q_w
\]

\[
= 2 \left( \frac{A - p_w}{3B} \right) - \left( \frac{A - p_w}{3B} \right)
\]

\[
= \frac{A - p_w}{3B}
\]

\( q_w^* \) is the additional \( q_w \) that is required for the manufacture of \( q \) after an increase in \( q \) being bought upon by entry.

\[
\hat{q}_w = q_w + \Delta q_w
\]
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:

\[
\hat{p}_v = V_1 - U_1 \hat{q}_v \quad \text{... (4.15)}
\]

where

\[
V_1 = \frac{6BK + LA}{6BL}
\]

&

\[
U_1 = \frac{6BL}{6B + L}
\]

\( \hat{p}_v \) 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 occurred 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 profits of the incumbent in the product market are:

$$\Pi(q_i) = A - B (q_i + q_E) q_i - f_q - C q_i$$ \hspace{1cm} \ldots (4.16)$$

The profits of the entrant are:

$$\Pi(q_E) = A - B (q_i + q_E) q_E - f_q - C q_E$$ \hspace{1cm} \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 $p_v$. 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:

$$\Pi(q_i) > f_q > \Pi(q_E)$$

To maximise the profits of the incumbent and entrant, the first order derivatives of (4.16) and (4.17) are equated to zero:

$$\frac{\partial \Pi(q_i)}{\partial q_i} = A - 2Bq_i - B q_E - C = 0$$ \hspace{1cm} \ldots (4.18) \hspace{1cm}$$

$$\frac{\partial \Pi(q_i)}{\partial q_E} = A - 2Bq_E - B q_i - p_v = 0$$ \hspace{1cm} \ldots (4.19)$$

From (4.19):

$$q_E = \frac{A - B q_i - p_v}{2B}$$

Substituting the above value for $q_E$ in (4.18):

$$q_i = \frac{A + p_v - 2C}{3B}$$ \hspace{1cm} \ldots (4.20)$$

$$q_i \text{ and } q_E \text{ are the output of the incumbent } F_i \text{ and entrant } E \text{ in the product market. This results in corresponding changes in the input market.}$$

205
Previously, \( p_w = K - Lq_w \) included the quantity of the input demanded by the incumbent \( F_i \). Now, the change in the demand for \( q_w \) is the result of two factors:

(a) \( F_t \) 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 occurred in the product market resulting in a demand for input by the entrant from the input market.

The new quantity \( q_w, q_v \) is:

\[
\dot{q}_w = q_w - \Delta q_w
\]

\[
\Delta q_w = \left( \frac{A - p_v}{2B} \right) - \left( \frac{A + C - 2p_v}{3B} \right)
= \frac{A + p_v - 2C}{6B}
\]

By substituting the value of \( \Delta q_w \) in \( q_v = q_w - Aq_w \)

\[
\dot{q}_v = \left( \frac{K - p_v}{L} \right) - \left( \frac{A + p_v - 2C}{6B} \right)
\]

From the above equation we get:

\[
p_v = \frac{6BK - LA}{6B - L} - \frac{6BL}{6B - L} \dot{q}_w
\]

We re-write the above as:

\[
\dot{p}_v = V_2 - U_2 \dot{q}_w \tag{4.22}
\]

where \( V_2 = \frac{6BK - LA}{6B - L} \)

\& \( U_2 = \frac{6BL}{6B - L} \)

and \( p_w \) is \( p_v \) to correspond with \( q_w \)

Equation (4.22) is the changed demand function in the input market after the entrant has entered the product market where \( F_i \),
has integrated into the input market. The demand function in the product market is:

\[
p = A - B (q_I + q_K)
\]

\[
= A - B \left( \frac{A + p_B - 2C}{3B} + \frac{A + C - 2p_B}{3B} \right) \quad \text{[from (4.20) & (4.21)]}
\]

\[
= \frac{A + p_B + C}{3}
\]

The price \( p_B \) is in fact \( p_B \) since it is the price after integration and entry. The above equation can therefore be written as:

\[
p = A + p_B + C
\]

\[
.: \Pi(q_I) = (p - C) q_I - f_q
\]

\[
= \left( \frac{A + p_B + C}{3} - C \right) \left( \frac{A + p_B - 2C}{3B} \right) - f_q
\]

\[
= \frac{(A + p_B - 2C)^2}{9B} - f_q
\]

Similarly, profits for the entrant in the product market are:

\[
\Pi(q_K) = \frac{(A + C - 2p_B)^2}{9B} - f_q
\]

Entry can be deterred if and only if 
\( \Pi(q_I) > 0 \) and \( \Pi(q_K) < 0 \)

\[
\text{If } \Pi(q_I) \geq 0 \text{ then } \frac{(A + C - 2p_B)^2}{9B} \geq f_q
\]

\[
\text{If } \Pi(q_K) \leq 0 \text{ then } \frac{(A + C - 2p_B)^2}{9B} \leq f_q
\]

We know that \( p_B > C \), therefore looking at the numerators in the expressions for \( \Pi(q_I) \) & \( \Pi(q_K) \) we can conclude that \( \Pi(q_I) > \Pi(q_K) \).
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 $\text{Net} \Pi(q_e) < 0$.

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: $F_1$ the integrated firm and $F_2$ the original incumbent in the input market.

The market demand function is:

$$p_v = V_2 - U_z q_v$$

where

$$q_v = q_i^v + q_i^2$$

where $q_i^v$ = quantity of input produced by the integrated firm $F_1$ & $q_i^2$ = quantity of input produced by $F_2$ (the integrated firm).

Examining the profits of the two firms:

$$\Pi(q_i^v) = [V_2 - U_z(q_i^v + q_i^2)] q_i^v - f_q - C q_i^v$$

$$\Pi(q_i^2) = [V_2 - U_z(q_i^v + q_i^2)] q_i^2 - f_q - C q_i^2$$

Maximising (4.23) and (4.24) w.r.t. $q_i^v$ & $q_i^2$ respectively and equating the first order conditions to zero:

$$q_i^v = q_i^2 = \frac{V_2 - C}{3U_z}$$

$$p_v = \frac{V_2 + 2C}{3U_z}$$
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.

\[ \Pi(F_1) = \Pi(q) + \Pi(q^1) \]

\[ \Pi(F_2) = K - L q_v \]

\[ \Pi(C) = f_v + C q_v \]

After the entrant enters, \( F_2 \) (the incumbent) and the entrant play a duopoly game. The profit function of the incumbent \( (F_2) \) in the input market is as follows:

\[ \Pi(q^2) = \left[ K - L (q^2 + q^E) \right] q^2 - f_v - C q^2 \]

\[ \Pi(q^E) = \left[ K - L (q^2 + q^E) \right] q^E - f_v - C q^E \]

Maximising (4.25) and (4.26) w.r.t. \( q^2 \) & \( q^E \) respectively, and equating the first order conditions to zero:

\[ \Pi(q^2) = \Pi(q^E) = \frac{(K - C)^2}{9L} - f_v \]

The entrant will enter if \( \Pi(q^E) > 0 \). Since \( \Pi(q^2) \) is also positive when \( \Pi(q^E) \) is positive, the incumbent does not have an incentive to deter entry.
(b): Entry now occurs in the input market after Fi has integrated. The input market is now being served by three firms:

(1) the entrant with quantity \( q^E \)

(2) the incumbent (F2) with quantity \( q^2 \) and

(3) the vertically integrated firm F1 with quantity \( q^1 \).

The demand function is now

\[
\hat{p} = V - U (\hat{q}^E + \hat{q}^1 + \hat{q}^2)
\]

The corresponding quantities are:

\[
q^E = q^1 = q^2 = \frac{V - C}{4U}
\]

The price in the input market is:

\[
p = \frac{V + 3C}{4}
\]

and the profits are:

\[
\Pi(q^E) = \Pi(q^1) = \Pi(q^2) = \frac{(V - C)^2}{16U} - f\nu
\]

If \( f\nu > \frac{(V - C)^2}{16U} \), the entrant does not enter and the case lapses into a duopoly with firms F1 and F2 in the market where

\[
\Pi(q^1) = \Pi(q^2) = \frac{(V - C)^2}{9U} - f\nu
\]

Entry can be deterred as long as

\[
\frac{(V - C)^2}{16U} < f\nu < \frac{(V - C)^2}{9U}
\]

i.e. as long the three-firm profit is less than 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
$\frac{(V - C)^2}{16U} < f < \frac{(V - C)^2}{9U}$

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 $\frac{(K - C)^2}{9L} > f$ 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 $ME_S$ 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 $ME_S$, 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 his 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 undercut 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 of 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 yet 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.

214
Initial Conditions

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:

\[ p_i = A - Bq_i - d \sum_{q_{-i}} q_i \]  \hspace{1cm} \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:

\[ \Pi_i = (A - Bq_i - d \sum_{q_{-i}} q_i)q_i - Cq_i \]  \hspace{1cm} \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,

\[ \frac{\partial \Pi_i}{\partial q_i} = A - 2Bq_i - d \sum_{q_{-i}} q_i - C = 0 \]  \hspace{1cm} \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:

\[ \frac{\partial \Pi_i}{\partial q_i} = A - 2Bq_i - d (n-1)q_i - C = 0 \]

\[ \therefore q_i = \frac{A - C}{2B + (n-1)d} \] \hspace{1cm} \ldots (4.30)

Substituting the above value of \( q_i \) in (4.27):

\[ p_i = A - Bq_i - d (n-1)q_i \]

\[ = A - B\left( \frac{A - C}{2B + (n-1)d} \right) - d (n-1) \left( \frac{A - C}{2B + (n-1)d} \right) \]
\[ p_i = \frac{AB + C \left[ B + (n-1)d \right]}{2B + (n-1)d} \quad \ldots (4.31) \]

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.

\[ \therefore \frac{\partial p_i}{\partial n} = \frac{\partial}{\partial n} \left( \text{cnd} \right) = bd (c-A) \]

Since \( A > C \), the above expression is negative.

\[ \therefore \frac{\partial p_i}{\partial n} > 0 \quad \ldots (4.32) \]

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:

\[ \Pi^n = (A - Bq_i - d \sum q_i)q_i - Cq_i \]

\[ = (A - Bq_i - (n-1)d q_i - C)q_i \]

When \( n \) firms are competing, we can assume that price will be equal to marginal cost. Substituting \( p_i \) from (4.31):

\[ \Pi^n = \left( \frac{AB + C \left[ B + (n-1)d \right]}{2B + (n-1)d} - C \right) q_i \]

\[ = \left( \frac{AB - CB}{B + (n-1)d} \right) q_i \]

Substituting from (4.30) for \( q_i \):

\[ \Pi^n = \left( \frac{AB - CB}{B + (n-1)d} \right) \left( \frac{A - C}{B + (n-1)d} \right) \]

\[ = B \left( \frac{A - C}{B + (n-1)d} \right)^2 \]

Since \( A > C \), it is clear that

\[ \frac{\partial \Pi^n}{\partial n} < 0 \quad \text{for} \quad i = 1, 2, \ldots, n \quad \ldots (4.33) \]

216
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:

$$n^{(n-1)} > F > n^n.$$ 

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:

$$p_i = A - B q_i - d Q_{-i} - d Q_f$$

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 $Q_{-i} = (n-1)q_i$,

$$p_i = \frac{KB + C [B + (n-1)d]}{2B + (n-1)d} \quad \text{[From (4.31)]} \quad \ldots (4.35)$$

and

$$q_i = \frac{KB - C}{2B + (n-1)d} \quad \text{[From (4.32)]} \quad \ldots (4.36)$$

We now assume that a tariff $t$ is imposed on imports such that costs
\[ C = c + t qf \]

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 \( q_f \) equation in (4.36):

\[ q_f = \frac{K - C}{2B + (n-1)d} = \frac{A - dQ_f - c}{2B + (n-1)d} \quad \ldots (4.40) \]
Substituting for $Q_f$ [from 4.38] in (4.39):

$$q_i = \frac{A - d(1 - mt) - c}{2B + (n-1)d} \quad \ldots (4.41)$$

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):

$$p_i = \frac{KB + C [2B + (n-1)d]}{2B + (n-1)d} \quad \text{since } K = A - dQ_f$$

$$\therefore p_i = \frac{B [A - dQ_f] + C [2B + (n-1)d]}{2B + (n-1)d}$$

Substituting for $Q_f = 1 - mt$ in the above equation:

$$p_i = \frac{B [A - d(1 - mt) + c[B + (n-1)d]}{2B + (n-1)d} \quad \ldots (4.42)$$

From (4.42) it is clear that:

$$\frac{\partial p_i}{\partial t} > 0$$

**The Effect of Tariffs on Domestic Profits:**

$$\Pi_a = \frac{B(K - c)^2}{2B + (n-1)d}$$

Substituting for $K = A - dQ_f$ in the above equation:

$$\Pi_a = \frac{B(A - dQ_f - c)^2}{2B + (n-1)d}$$

Further, substituting for $Q_f = 1 - mt$ in the above equation:

$$\Pi_a = \frac{B[A - d(1 - mt)Q_f - c]^2}{2B + (n-1)d}$$

219
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:

\[ \frac{\partial \Pi_n}{\partial n} < 0 \quad \text{i.e. the price of a good 'i' and the number of firms producing 'i' are inversely proportional.} \]

\[ \frac{\partial \Pi_n}{\partial t} < 0 \quad \text{i.e. the profits of firms producing 'i' is inversely related to the number of firms producing 'i'.} \]

\[ \frac{\partial Q_t}{\partial t} > 0 \quad \text{i.e. the quantity of imports Q_t is inversely related to the tariff rate 't'.} \]

\[ \frac{\partial q_i}{\partial t} > 0 \quad \text{i.e. the quantity produced by q_i is positively related to the tariff rate 't'.} \]

\[ \frac{\partial p_i}{\partial t} > 0 \quad \text{i.e. the price of good 'i' is positively related to the tariff rate 't'.} \]

\[ \frac{\partial \Pi_i}{\partial t} > 0 \quad \text{i.e. the profits of firms producing 'i' is positively related to the tariff rate 't'.} \]

We first postulate a scenario where there is free trade and foreign firms do not have tariff restrictions to domestic markets.

We then have 1 domestic firms and 1 foreign firm. Examining profits it is clear that:

\[ \Pi_n^{n+1} < 0 \text{ since } \frac{\partial \Pi_n}{\partial n} > 0 \text{ and } \frac{\partial \Pi_i}{\partial t} > 0 \]
where $\Pi_{n+1,0}$ are the profits of one foreign firm and $n$ domestic firms when there are no tariffs and $\Pi_{n+1,t}$ are the profits of $n$ domestic firms when there are tariffs.

Since $\Pi_{n+1,0} < F$ 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:

$$\Pi_{(n+1)-x,0} > \Pi_{n+1,t} > \Pi_{n+1,0}$$

We can then construct the following inequality:

$$\Pi_{(n+1)-x,0} > \Pi_{n+1,t} > F > \Pi_{n+1,0}$$

Examining corresponding prices:

$$p_{(n+1)-x,0} > p_{n+1,0} \quad \text{since} \quad \frac{\partial p}{\partial n} < 0$$

$$& > p_{n+1,t} \quad & \frac{\partial p}{\partial t} < 0$$

Therefore:

$$p_{(n+1)-x,0} > p_{n+1,t} > p_{n+1,0}$$

$[p_{n+1,0}$ is impossible because it soon lapses to $p_{(n+1)-x,0}]$

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 \( \Pi_n \), 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 equal to \( \Pi_n \), and prices are the highest at \( p_n \). The higher price results in a welfare loss for consumers on account of free trade in an imperfect market.

With the imposition of tariffs, profits are lower at \( \Pi_{n-1} \), and so are prices at \( p_{n-1} \). 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 consequence 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 \(P_v\) (based on long-run marginal cost such that:

222
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 \( p^* \) which is greater than the administered price \( p_a \). And, producers profits are lower at \( \Pi_a \) (since \( \Pi_a > \Pi^* \)) but high enough to cover fixed costs. 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%

<table>
<thead>
<tr>
<th>Feedstock</th>
<th>Tariff Protection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Naphtha</td>
<td>Benzene</td>
</tr>
<tr>
<td>Ethylene</td>
<td>Toluene</td>
</tr>
<tr>
<td>Propylene</td>
<td>Xylene</td>
</tr>
<tr>
<td>Butadiene</td>
<td>Isobutylene</td>
</tr>
</tbody>
</table>

B. Intermediates:  Graduated Tariff Protection 15 - 25%

<table>
<thead>
<tr>
<th>Intermediates</th>
<th>Tariff Protection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethylene Oxide</td>
<td>Propylene Glycol</td>
</tr>
<tr>
<td>Ethylene Dichloride</td>
<td>Phenol</td>
</tr>
<tr>
<td>Ethyl Benzene</td>
<td>Styrene</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>Caprolactum</td>
</tr>
<tr>
<td>Propylene Oxide</td>
<td>PTA</td>
</tr>
</tbody>
</table>

C. Finished Products:  30 - 40%

<table>
<thead>
<tr>
<th>Products</th>
<th>Tariff Protection</th>
</tr>
</thead>
<tbody>
<tr>
<td>LDPE/LLDPE</td>
<td>SBR</td>
</tr>
<tr>
<td>HDPE</td>
<td>PBR</td>
</tr>
<tr>
<td>PVC</td>
<td>IIR</td>
</tr>
<tr>
<td>PP</td>
<td>EPDM</td>
</tr>
<tr>
<td>PS</td>
<td>PSF</td>
</tr>
<tr>
<td>ABS</td>
<td>PFY</td>
</tr>
<tr>
<td>PET</td>
<td>Nylons</td>
</tr>
</tbody>
</table>


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 can 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.
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.