CHAPTER  I

ISSUES IN TECHNOLOGY TRANSFER AND PETROCHEMICAL INDUSTRY
The issues in technology transfer debate have undergone a qualitative change over the years. The traditional belief that an economy could overcome its underdevelopment and accelerate the growth process with the acquisition of technology has yet to be realized. Both the disillusioning practical experiences of most of the developing countries and new analyses of the factors underlying the phenomenon of technological development in recent years, have cast some doubt on this belief. Among the issues of special concern have been the inhibition of indigenous technological development in technology recipient countries and consequent continuation of their dependence on external sources of technology, appropriateness of transfer of technology to the resource endowments, needs and policy objectives of the developing countries and high costs of technology transfer emanating from imperfect market of technology.

Technology is generally termed as 'a productive asset with a commercial value'. Technologies are combined, embodied or related to a variety of other items. Most of the goods, services and technologies themselves are produced with

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these suitable combinations. Technological capacities and technological transactions involve stocks and flows which include intangible assets such as design and engineering plans, project blueprints, models, systems analyses, feasibility reports, product or process patents etc.; tangible assets such as capital goods, machinery, equipment, pilot plants etc. and human assets such as skills and knowhow at all levels of a technical managerial or organizational nature.2

A specific feature of technology is that it is constantly created, assimilated, applied, utilized, adapted, diffused, exchanged, purchased, sold and further developed by a number of means and entities. The second half of twentieth century witnessed rapid changes in the technological field. In less than forty years, this period has given rise to more inventions, innovations, adaptations and technological changes than the whole previous history of mankind.3 Most of these developments are concentrated in the industrially advanced countries.4 The developing countries need to harness this technological revolution as an instrument of growth and socio-economic development.

2. Ibid.
3. Ibid.
4. For details see Chapter - IV, pp.190-92
Technological flows can take various forms and this has given rise to its several classifications. One classification of international technology flows is based upon the possible carriers which ensure the diffusion process. Amongst these, three carriers are most prevalent. These include capital embodied technology, human embodied technology and disseminated technology. While exports of equipment, tooling and intermediate goods facilitate the transfer of capital embodied technology; education and training programs, personal contacts, professional mobility, technical assistance and international co-operation etc. ensure the transmission of human embodied technology. Patent literature, feasibility or project studies, blueprints, operating instructions etc. help in the dissemination of disembodied technology.

Another kind of classification takes into consideration the extent to which the technology has been appropriated. A clear-cut distinction has been made between 'socialized' and 'alienated' technology. 'Socialized' technology is free and its transfer may not imply a specific transaction. However,


6. Ibid.
it may involve the acquirer in buying the information medium, e.g. purchase of capital good where technology is embodied. 'Alienated' technology includes information which is not free. Hence it is acquired in a market by making payments. 7

Eckhard Siggel differentiates between product technology and process technology. He states that the former consists of the specifications and characteristics of the product and the latter includes all the knowhow necessary to produce a product. 8 Mariluz Cortes and Peter Bocock maintain a distinction between 'core technology' and 'peripheral technology'. According to them the technical expertise required to realize a hypothetical project from its conception to the point at which it is ready to start operation includes the ability to undertake the following:

a. Preinvestment, feasibility, and marketing studies;

b. Detailed preproject studies of alternative technologies which might be used in the project;

c. Basic engineering - the embodiment of central process chosen for the project into project - specific flow-sheets, layouts and designs;

7. Ibid.

d. Detailed engineering - architectural and construction plans for the plant, precise specifications of equipment and materials, installation plans, and so on;

e. Procurement and construction;

f. Training of Project staff;

g. Start-up and initial troubleshooting services

These items refer to the elements of technical knowledge. Here only items c, f and g represent the core technology that the supplier must provide. The other components are examples of peripheral technology which is not specific to a particular project or process, but is necessary for the realization of any manufacturing project.

In addition to the items listed above, the recipient needs various kinds of expertise to run the project after start up. They include management, marketing, maintenance and quality control services.

Regarding the transfer of technology R. Natarajan and Pita O. Agbese differentiate between vertical and horizontal


10. Ibid.
transfer of technology. In vertical transfer, a smooth transfer of technology takes place from idea stage through laboratory bench scale work, to pilot plant projects then to utilization of the technology developed. In case of horizontal transfer, technology is proved, developed and utilized in one industry, area or country and adapted, modified, translated and transplanted in another area or country.

Zbigniew Madej points out that vertical transfer prevails in most developed countries and science oriented societies. Biggest companies are usually better equipped to provide for vertical transfer. Since they concentrate in one enterprise research laboratories, experimental plant, marketing research units and the large capital resources required to accelerate the dissemination of an innovation. In the less developed countries and less developed industries the horizontal transfer of technology dominates.


12. Ibid.

Technology transfers between different countries are made in a number of ways. Each element of technical knowledge may be transferred in a variety of ways and even the transfer of one element may involve a number of mechanisms. However, a broad distinction can be made between 'direct' and 'indirect' transfer. In case of direct transfer the transfers may be made through direct relationships between the technology acquirer and a number of technology suppliers. On the other hand, a single technology supplier may take overall responsibility for the whole transfer and sub-contract other technology suppliers. The outright purchase of technology elements from different sources, i.e., suppliers of machinery, equipment, spare parts, technical assistance, foreign engineers and technicians, is called direct transfer of technology. It also includes training nationals for specific production projects and technical information activities. The acquisition of technology by means of direct foreign


15. Ibid.

investment, licensing, 'turnkey' arrangements form the indirect transfer of technology". 17

Though direct purchase of plant and equipment from machinery suppliers plays an important role in the direct transfer of technology, it is not the principal form of importing technology in developing countries. Firstly, direct transactions of this kind are possible only in case there are no restrictions on the availability of process technologies because of patents or proprietorship. For instance, the patented machinery will be freely available in capital goods markets, if the patents are held by the machine producer. However, if they are held by some manufacturing company which uses the machine, their availability will be limited. It makes it inevitable for a developing country to resort to some indirect contractual mechanism. Secondly, the process technology embodied in machinery makes it imperative for a developing country to obtain technical knowledge to operate such plants and makes an indirect contractual transfer inevitable. 18 For example, while the plant and equipment needed for petrochemical production may be purchased directly, the technical knowledge needed to

18. Ibid.
operate such plants may only be available from chemical companies in advanced countries. Hence, even the availability of the machinery makes an indirect contractual transfer unavoidable.\textsuperscript{19}

Indirect mechanisms play a very important role in some sectors especially where the technology is highly sophisticated and changes rapidly. The suppliers of technologies (especially MNCs) have an obvious preference for indirect mechanism, because it provides scope for monopolistic practices and also for controlling the industrial structure of the host country.\textsuperscript{20} The buyers of technology accept these mechanisms for their own reasons. These include the deficiency of technical knowledge and the inability to use it commercially in enterprises in developing countries. Several non-technological factors, e.g., expectation of high profits from foreign patents, brand names, trade marks etc. and availability of tied foreign credit are other reasons for importing technology in packaged form.\textsuperscript{21}

There are a number of contractual arrangements used in indirect transfer of technology. It often takes place by

\textsuperscript{19} Ibid.


\textsuperscript{21} For details see UNCTAD, n.14, pp.25-33.
setting up a wholly-owned subsidiary in a developing country. A wholly-owned subsidiary may be regarded as a recipient which is completely controlled by the supplying company.\textsuperscript{22} Only substantial negotiation takes place between the parent company and the government of the developing country. It is a useful mechanism for supplying technology to those countries, where the production base and technical capabilities are non-existent or so rudimentary that domestic enterprises cannot act as a 'receiving station' for technology.\textsuperscript{23}

A firm possessing a particular technology can exploit it by selling or renting it by itself without the paraphernalia of direct investment. It can license rather than export or set up subsidiaries. Licensing contains the basic element of granting a right. Export and import licenses, for instance, permit businessmen to take goods officially in and out of a country. In case of license agreement, knowhow may be obtained representing outright purchase and not implying continuity in the supply of information. It may also be purchased together with the provision for the continuing supply of data on future...

\textsuperscript{22} Ibid., p.34.
\textsuperscript{23} Ibid.
innovations or improvements. In the first case the lump sum is paid, generally based on installed capacity rather than on output. It does not prevent the licensor from granting similar rights to another enterprise. In case the licensee firm wants to expand its capacity, it will have to make additional payments.

Second type of agreement presupposes that the relationship between the licensor and licensee will be prolonged for a long time through the automatic supply of reports and data on new technological improvements, introduced by the licensor enterprise. The agreement often includes the right to use brand names or trade marks and provides for a great deal of assistance in marketing as a means of safeguarding the international reputation of the licensor's trade names or processes.

The sale of turnkey plant provides another method of technology transfer. In this case the manufacturing plant is sold as a package to the technology recipient country. The contractor is generally assigned to take sole and complete

24. Ibid., p.6.
25. Ibid.
26. Ibid.
27. Sakti Mukherjee and Irani Mukherjee, *International Transfer of Technology* (New Delhi, 1989), p.3.
responsibility in project implementation from project planning until start-up. The recipient will be provided with a plant which is ready for operation. Turnkey arrangements can be carried out by either an engineering consulting firm or an industrial enterprise possessing the desired technology.28

Among the factors that influence the choice of Multinational Corporations (MNCs) between direct investment and licensing are the size of the market, the riskiness of investment, secrecy and novelty of technology, the threat to other markets from licensing, the policy of the host government, the management and strategy of the firm, the industrial market structure and the range of technologies and products involved. In general, the more attractive and politically stable the market, the newer and more tightly controlled the technology involved, the larger and more internationally involved the firm in question, the more broadly based its sources of market power and lower the 'absorptive' capacity of the potential licensee for the assets to be transferred, the more will direct investment be

preferred over licensing. However, many intermediate positions are possible between investment in wholly owned subsidiaries and licensing to unrelated firm, but the factors just mentioned cover the most significant determinants of this sort of choice.

Another channel for technology transfer is joint venture. It is important to make a distinction between two types of joint ventures: the equity joint venture, where assets, right and liabilities are shared through joint ownership of an incorporated enterprise; and the non-equity joint venture in which co-operation between partners is established on a contractual basis. The share of equity in the hands of local partners and its legal effects on the decision making mechanism have an important incidence on the technology transfer process. The following elements of transfer of technology through equity joint ventures should be considered; capitalization of technology, royalty fees and organizational arrangements including management.

30. Ibid.
32. Ibid.
Foreign partners often manage to capitalize their technological contribution as their equity share in the joint venture. This practice has often been observed in cases where the local partner is a public entity. Secondly, in case of royalty fees, payments are made to the foreign partner for certain technological contribution in addition to the profits deriving from the share of the equity. Here some countries have adopted specific criteria for the payment of royalties by joint ventures, for example, a royalty fee in proportion to the share of the foreign licensor in the joint venture.33

Non-equity joint ventures are a form of contractual cooperation between partners. Non-equity joint ventures or contractual joint ventures include all types of collaboration contracts and production sharing arrangements. It is common in many types of joint ventures to have cooperation between two or more natural or legal persons in which partners participate in the profits and losses of undertakings. There is contractual cooperation over a long period of time with a complete de-linking of resource transfer and the equity ownership of the foreign supplier of technology. In these types of undertaking, transfer of technology could be the essential objective often combining a wide variety of

33. Ibid.
arrangements concerning finance, marketing, management, etc.  

Contrary to the common belief, a joint venture is useful to the foreign investor too. Firstly, a multinational may exercise control over the company through majority participation in financial management. Secondly, it can earn profits in a protected market and lastly, this arrangement helps the foreign investor in dealing with local management problems more successfully than in the case of a subsidiary because the local partner can be used as an intermediary.

Technical assistance agreements is another channel for the transfer of technology from developed to developing countries. Here the acquirer is usually seeking not just 'technology', i.e. a license to use a particular process, but also a specific kind of technical assistance for the setting up and operation of a productive activity. The services provided under this agreement include maintenance and repair of machinery, advice on process knowhow and quality control. Under the terms of the technical assistance services, consultancy services (feasibility and market studies, definition of products, selection of location, procurement of

34. Ibid.

goods and services, etc.) and engineering services (the design, construction, starting up and operation of new and expanded plants and facilities)\(^{36}\) are also included.

Under the 'management arrangements' the operational control of an enterprise is vested by contract in a foreign entity to perform all necessary managerial functions: production management (technical and engineering aspects), personnel management, procurement of goods and services, marketing and financial management. This type of arrangement is widely used in industrial undertakings, transportation, the tourism industry etc. However, it is often a part of other arrangements such as joint ventures, turnkey projects, technical assistance, etc. The technology transfer factor consists of the transfer of organizational capacity to the acquirer or its personnel either through specific training programmes or simply by working together with the supplier. Management arrangements also provide possibilities for the acquirer to have access to technology sources.\(^{37}\)

However, the costs and benefits of alternative arrangements for transfer of technology do not depend

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37. Omer, n.31, p.35.
entirely on the selected channel as such but are affected by many other variables such as the size of the project, the sector of the economy, the bargaining power, the availability of financial resources and the policy framework of the acquiring party's country. In addition, the terms and conditions within each channel are, in general, more important than the channel itself. Indeed the potential acquirer of technology should be well aware of alternative mechanisms and maximize social benefits accordingly.

It is well known that the industrialisation process has been carried on with the help of foreign technology in under-developed countries. It was essentially because the technology is available and it saves the time and energy and offers a short-cut for growth to these countries. Therefore, technological change is an 'exogenous factor' in these economies. This also has an in built bias to remain exogenous to the system because the economic structure in these countries have been underdeveloped in generating skills required to originate, introduce or operate new technologies. In contrast, industrialisation in developed countries has resulted from an 'endogenous process' of technological advance.  

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38. UNCTAD, n.14, p.4.
Developing countries are well aware of the relevance of technology for their development, however, they are not able to exercise real choice in designing effective strategies for their technological transferation. The growth of international economic system has resulted in a profusion of institutions and mechanisms that lead to ever-widening disparities between the rich and the poor countries. Efforts have been going on for the transfer of technology from developed to developing countries with a view to bridge the technological gap between the two. But technological gap continues to exist.

ISSUES IN NORTH-SOUTH TECHNOLOGY TRANSFER: A SURVEY OF LITERATURE

The most important reason for concern in the present system for transfer of technology is that the transactions take place under imperfect market.\(^3^9\) The developing country as a buyer is a weak partner. Knowledge of the type of technology and its price is most important element in the purchase of technology. Very often the developing country does not possess this required knowledge. Hence, at the

\(^{3^9}\) UNCTAD, Guidelines for the Study of Transfer of Technology to Developing Countries, TD/B/AC.11/9 (New York, 1972), p.7.
initial stage itself, the developing country starts with a great disadvantage of not having the power of bargaining.\textsuperscript{40}

To further elaborate this, H.W. Singer states,

The country importing the technology often does not have sufficient knowledge of alternative technologies available or alternative sources of the same technology, nor has it the national capacity for debating technological matters on equal terms with experienced and shrewd representatives of Multinational Corporations, machinery and equipment salesmen, etc.\textsuperscript{41}

When the technology is first developed, its market is monopolistic. On the basis of technology borrowed from the original developer, gradually the monopolistic form of market changes to oligopolistic form with the entry of more firms in the same production lines. These market forms are maintained through institutional constraints such as right to patent which put a restriction on the free flow of information about technology and thus make it less competitive.\textsuperscript{42}

\begin{itemize}
\item \textsuperscript{40} Sumitra Chishti, "International Transfer of Technology: Myths and Facts", Productivity (New Delhi), July-September 1975, p.665.
\item \textsuperscript{42} Kewal Ram, n.35, pp.M-75 to M-76.
\end{itemize}
An UNCTAD document maintains that in an imperfect market, the technical information may be most closely guarded aspect of modern production, because emulation by others may cut out markets. The firm will part with its technological information only when price will be relatively high.  

Quoting Vaitos, Kewal Ram outlines the certain properties of the technology market which distinguish it from the commodity market. Firstly, the demand for technology is different from the demand for a commodity. If the technology becomes known to buyers somehow or the other, its demand becomes zero. Secondly, technology is purchased along with machinery and equipment as it is embodied in it. This is not true of a commodity market. Thirdly, imperfections pertaining to information flow are much more in technology market than in a commodity market. Lastly, the price of technology is determined by crude bargaining power between the licensor and the licensee. It depends upon the price quoted by the licensor and the ability of the licensee to bargain.

Carrying further this line of argument, Rhys Jenkins believes that the peculiar nature of technology as a

43. UNCTAD, Transfer of Technology, TD/106, 10 November 1971, p.3.
44. Kewal Ram, n.35, p.M-76.
commodity and the specific institutional features of international technology markets mean that the price of technology cannot be determined in the conventional way through the intersection of supply and demand curves. The final price must fall within a range determined by the minimum price which the supplier is prepared to accept and the maximum price which the buyer is prepared to pay. In this way the supplying enterprise, due to its superior bargaining power, is able to control production from the transferred technology and get high rates of return in comparison to the costs which it incurs in making the technology available.46

Different studies of the costs of technology usually distinguish between direct costs and indirect costs of technology transfer. The first refers to the payments made for technology, i.e., right to use patents, licences, knowhow and trademarks and charges for technical information and knowhow required. Indirect costs refer to certain


47. UNCTAD, n.1, p.13.
restrictions which are imposed on the buyer. 48

It is essential to mention that there are a number of problems in identifying the direct cost of technology to Third World countries with explicit technology related payments. Firstly, where technology transactions are between a MNC and a subsidiary, the division between dividends on the one hand and technology payments on the other may be determined by considerations such as tax rates or foreign exchange regulations rather than reflecting returns on different kinds of assets. Secondly, imported machinery may include an element corresponding to a change for technology. If this represented only ten per cent of the value of machinery imports to developing countries the cost of technology would be doubled. Thirdly, transfer pricing of imported parts may be used to repatriate and hence hide part of the cost of technology. 49

Thus the overt payments for technology identified may be only the tip of the iceberg so far as the direct cost of technology transfer is concerned. It may also overstate the true cost of technology transfer because dividends are often disguised as royalties. 50 Therefore, the costs of technology

48. Ibid.
49. Jenkins, n. 45, p. 79.
50. Ibid.
transfer are not only high because they are determined by negotiation with a supplier who is in a quasi-monopolistic position, but also because of various practices followed here.

In addition to the direct costs of technology transfer, certain indirect costs have been found to exist which limit the benefits to the recipient of the technology. Constantine Vaitsos has analysed some of the ways in which technology suppliers ensure these advantages. Firstly, the supplier of technology may control the production by restricting its markets. For example, a licensor may be obliged to sell all its output to a sales company which is wholly owned by the supplying company. Secondly, restriction may be imposed on the export market. Moreover, it can be exercised directly, partly through ownership and partly by insisting on having its own technical personnel in key positions in the recipient enterprise. 51

The requirement that the technology importer should obtain its inputs and its machinery from the technology supplier or a firm named by it is very common. Such a condition is commonly found in the majority of the contracts

signed by Latin American countries. Elsewhere it exists less frequently. Nevertheless, it is not always necessary to include such a clause because there is a technological tie-in for many products which makes it inevitable for the recipient to import the inputs from the technology supplier. 52

These practices tend to constrain the growth potential of the recipient. The tying of inputs secures a captive market for the technology supplier enabling him to overprice the imported parts and machinery. Restrictions on exports enable the technology supplier to segment international markets and maintain their own direct sales by excluding the buyers from this market. This also allows the suppliers to license technology to another local producer. 53 Consequently, these practices result in a loss of government revenues in developing countries. 54

It is often asserted that the technology transferred to developing countries is inappropriate to their conditions. This inappropriateness is differently perceived. The first view is based on conventional economic concept. Since developing countries are labour-rich and capital poor, they

52. Jenkins, n.45, p.80.
53. Ibid.
54. UNCTAD, n.14, p.56.
require labour-intensive technologies for the full utilization of their resources. The technologies transferred by multinational corporations are capital intensive and best suited to labour-poor and capital rich developed countries.\textsuperscript{55} It leads to several other problems. In Charles Cooper's opinion, the transfer of the wrong kind of (capital intensive) technology is the proximate cause of unemployment and maldistribution of income in underdeveloped countries.\textsuperscript{56}

The second view, advocated by Frances Stewart, is that the transfer of technology from developed to developing countries results in the manufacture of inappropriate products in these countries.\textsuperscript{57} He maintains that the characteristics of technology are largely determined by the nature of the economies for which they are designed. Most significant determinants are the income levels, resource availability and costs in the society in and for which the technology is designed, the system of organization of


production and the nature of technology in use in that society. In each of these respects, societies of advanced countries differ from those of poor countries. Hence, technology designed to suit advanced countries tends to be ill adapted or "inappropriate" to the conditions prevalent in poor countries. As a result of it the transfer of such technology to poor societies tends, to cause various distortions and inefficiencies.

The 'characteristics' of technology include various features which determine its resource use, productivity and impact on production and consumption patterns. These features refer to the nature and design of the product, the scale and organizational systems for which the technology is designed, its resource use including capital and labour intensity, materials and fuel skill requirements, and the infrastructural and complementary inputs required. Hence, the traditional characterization of techniques according to their capital or labor intensity forms only one aspect of the total characterization.

Technology designed for industrial countries produces standardized, packaged, advertised and high income products.


59. Ibid.
These are well suited to the growing elites in developing countries, having similar income levels to those, for whom the technology was initially designed. In addition to this, these techniques require high level of investible resources per employee, high levels of education and skills, sophisticated management techniques; and are associated with high levels of labour productivity and linked with the rest of the advanced technology system through inputs and outputs. If these techniques are transferred unmodified to developing countries, the result will be a concentration of resources, savings and expenditure on human resources and infrastructure on a small part of the economy. Hence, the limited resources available in the low income country tend to be underutilized. Christian N. Madu, therefore, writes, 

Technology, which is structurally dependent has to be designed to suit the needs of the receiving countries. Thus, at the design stage, the joint participation of local and MNC experts is needed to arrive at an appropriate technology.

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61. Stewart, n.58, p.346.

Hence Madu recommends the joint participation of local and MNC experts to arrive at an appropriate technology. Regarding the source of appropriate technology, H.W. Singer believes that much of the technology that would be particularly suitable and useful to developing countries may be the technology owned and controlled by smaller firms in developing countries. However these smaller firms completely lack international communication links with other developing countries. Therefore, he suggests that the smaller firms should be supported by their own governments and they should set up cooperative institutions in order to involve themselves more actively in international technology transfer.

The Multinational Corporations can also develop cheap products for poor countries. But simple technology tends to increase the chance of easy imitations. Moreover, they can easily charge higher bargaining price in case of sophisticated product. Therefore, the technologies supplied by the Multinational Corporations are oversophisticated in relation to the needs and demands of developing society.

63. Singer, n.41, p.8.
64. Ibid.
In 1980s, there have been some studies dealing with the cultural effects of technology transfer by Multinational Corporations in less developed countries. These studies lay emphasis on the negative effects of technology transfer which include the utilization of highly capital intensive technology (which does not create employment), excessive demand-creation efforts, wasteful advertising of competitive brands and workers' alienation. Thus the inappropriateness of technology transferred has been reinforced by these studies.

It is essential to mention about the classification of appropriate technology given by Stewart. First is the appropriate technology for the "modern" sector, which consists of the adaptation of modern sector advanced country technologies in more labour intensive directions. Second is the appropriate technology for the traditional sector which upgrades and improves traditional technologies.

Raphael Kaplinsky gave a different approach to the issue of appropriate technology. He propounded that increasing inequalities in the global economic performance in


67. Stewart, n.58, p.271.
the post-1970 era raised doubts about the kind of technology being transferred to the developing countries. Despite higher growth rates in these countries between 1960 and 1980, these countries witnessed lower per capita incomes, lower availabilities of medical personnel and low calorie consumption. Moreover, one third of the population of most of these countries is primarily agriculture oriented and live in rural areas. In the decade of 1980s too, these countries experienced a significant fall in per capita income and unequal distribution of income. 68

Kaplinsky has identified three aspects of appropriate technology viz., social/political, consumerist/environmental and economic/developmental. 69 The socio-political dimension had its origin in Europe. It questioned whether the advanced technology encourage the production of socially useful goods e.g. medical instruments and transport goods. It also accepted the idea that such a change on the part of industrialists is not possible without political will.

The consumerist environmental approach has been most evident in the US economy. It points out that the high

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technology has several adverse consequences for consumers. Some of them are "poverty in the midst of plenty, degradation of the environment, loss of faith in institutions, uncontrolled urban spread; insecurity in employment, alienation of youth, rejection of traditional values and inflation and other monetary disruptions". 70

The third dimension concerned with economic development originated in the Third World. This is similar to the Stewart's view discussed earlier. Large scale production technologies were inappropriate in the developing countries because they are capital and energy-intensive and these countries lack in capital as well as energy. 71

The third issue which gained prominence in the context of North-South technology transfer is that of technological dependence. The enterprise in developing countries seek transfers of most of the elements of technology and thereby make little use of local technology and skills. At the same time, they make less efforts to build up their own research and development capabilities. Furthermore, since the foreign companies offer tried and tested innovations, local design engineers are considered less efficient and knowledgeable. 72

70. Ibid.
71. Ibid.
72. UNCTAD, n.39, p.7.
Hence, the supporters of the view argue that given the oligopolistic nature of the market for technology and control exercised by the transnational corporations together with the lack of autonomous technological capabilities in the Third World, there are serious limitations to the transformations of these societies. 73

However, there has occurred a fundamental shift in the focus of the debate over the issue of 'technological dependence'. Until the late 1970s, the focus has been largely on the imbalance in the 'technological capacities of the developed and developing countries'. 74 The statistical figures of science and technology indicators of the United Nations and other organizations dramatically reflected this weakness and highlighted the profound disparities between rich and poor countries in terms of research and development expenditure, science and technological institutional infrastructure and manpower and trade in technology goods and services etc. Different indicators of imbalance in the


74. Stewart, n. 57, p. 119.
Table 1.1: Technological Capacity: Selected Indicators
(Average expressed as medians for 1970 or latest year available)

<table>
<thead>
<tr>
<th>Developed market economy</th>
<th>Developing Countries and territories</th>
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<td>Africa^a</td>
<td>Asia^c</td>
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I. SCIENCE AND TECHNOLOGY

i. Ratio of total stock of scientists and engineers per 10,000 pop. 112 5.8 22.0 69

ii. Ratio of technicians per 10,000 pop. 142.3 8.3 23.4 72.2

iii. Scientists and engineers engaged in R&D per 10,000 pop. 10.4 0.35 1.6 1.15

iv. Technicians engaged in R&D per 10,000 pop. 8.2 0.4 0.6 1.4

v. Expenditure on R&D as percentage of GNP 1.2 0.6 0.3 0.2

II. HIGH LEVEL MANPOWER

vi. Professionals and technicians as percentage of economically active population 11.1 — 2.7 5.7

vii. Percentage of the economically active population employed in manufacturing sector 25.4 3.5 10.5 14.1

viii. Literacy rates (per cent) 96^e High Low 32 77

ix. Ratio of primary and secondary enrolment to school age population 92^f 32 56 78
a. The size of the sample in this column varies by indicator, ranging from four countries in line (ii) to 25 countries in line (ix).

b. The size of the sample in this column varies by indicator, ranging from eight countries in lines (i) and (ii) to 46 countries in lines (viii) and (ix).

c. Excludes China. The size of sample in this column varies by indicator ranging from seven countries in line (vi) to 36 countries in lines (viii) and (ix).

d. Size of the sample in this column varies by indicator ranging from 7 countries in lines (i) and (ii) to 43 countries in line (viii).

e. Includes Greece and Turkey.

f. Taking upper limit of estimates where no precise figures were given, e.g. for 10-15 per cent, 15 per cent would be used for high estimate, 10 per cent for low estimate.

technological capacities of different countries are given in the Table 1.1.\textsuperscript{75}

The scholars had different opinions regarding the indicators of 'technological dependence'. Some consider the underdevelopment of the capital goods sector to be the \textit{prima facie} manifestation of technological dependence.\textsuperscript{76} They believe that the underdeveloped countries have to import capital goods for their development. This has several consequences. It forces them to export primary goods to generate necessary foreign exchange for payment. Secondly, they can not make capital saving innovations because they merely import capital goods. In this manner, they are left behind in the development process which involves the technological base of skills, knowledge facilities and organization upon which further technical progress depends so largely.\textsuperscript{77}

R.M. Bell felt that the issue of 'technological dependence' was an inherent part of the total structure

\textsuperscript{75} The data shown in the table is two decades old, yet the technological imbalance is quite obvious from it and the situation has not improved much since then.


\textsuperscript{77} Ibid., pp.146-7.
existing during the 1970s. During that period, the Third World countries were linked to the industrialized countries in political, economic and cultural aspects and were influenced by them. The notion of 'technological dependence' was derived from these wide perspectives and came to have a significant influence on thinking about science and technology policy.\textsuperscript{78}

Over the years, greater attention is being paid to examination of the processes involved in the absorption and assimilation of technology. It has been realized that transfer of technology to developing countries should be supported by an appropriate technological infrastructure in order to avoid a state of 'technological dependence' on advanced countries. The new approach believes as Mohammed B.E. Fayer puts it that the transfer of technology "... must be conceived as an instrument of change".\textsuperscript{79}

In this context, the role of learning by doing and unpackaging the technology becomes very important. The latter is a direct fruit of successful learning and a


\textsuperscript{79} Ibid., p.2.
significant instrumentality of arduous learning at the same time. Unless the Third World enterprises are in a position to unpack the technology, the process of selection, diffusion, adaptation and absorption is not facilitated. The degree of unpackaging also determines the linkages that are established with the domestic industrial structures--engineering consultancy firms, machinery manufacturers and producers of intermediates--to generate independent technological capabilities. This process is resisted by the multinational corporations because it threatens their control over technology and may bring into the market firms who may threaten their position.80

Technological dependence has important implications. Stewart divides them into four categories.81 Firstly, it raises the cost of the technology flow by reducing the bargaining power of those purchasing the technology; secondly, it is associated with loss of local control over decisions related to the technology; thirdly, technological dependence tends to marginalise local science and technology efforts and fourthly, it means that the characteristics of

80. Khanna, n.73, p.1319.

81. Frances Stewart, "Technology: Major Issues for Policy in the 1980s", in H.W. Singer and others, n.43, p.34.
the technology are often inappropriate as they are designed by different conditions.

The several issues in North-South technology transfer are interrelated and cyclical in nature. The transfer of inappropriate technology is not only a consequence of technological dependence but also reinforces the same in developing countries. Similarly, it weakens the bargaining power of these developing countries which further results in technological dependence. Thus, a vicious circle is formed wherein one problem leads to another. The present study is an attempt to analyse the various issues in capital and technology intensive petrochemical industry in the Gulf Cooperation Council (GCC) Countries. Before going into the details of the problems encountered in technology acquisition, adaptation and assimilation in GCC petrochemical projects, it is essential to discuss the characteristics of petrochemical industry and technology as well as the process of global restructuring in the petrochemical industry.

PETROCHEMICALS AND PETROCHEMICAL TECHNOLOGY

The petrochemical industry embraces numerous activities with highly complex interrelationships. In their broadest definition, petrochemicals are those chemicals that are manufactured from feedstocks obtained from oil or natural
gas. They account for the bulk of organic chemicals as the role of other organic raw materials such as coal, synthetic fuel or biomass is nowadays extremely limited. The complexity of the petrochemical industry is illustrated by the fact that it covers products as varied as primary products like intermediates manufactured by combining primary products and/or by making these react with other chemical compounds e.g. ethylene dichloride and finished products, such as some fertilizers, plastics, man made fibres, pharmaceuticals, detergents and so on. ⁸²

Primary petrochemicals, obtained directly from feedstocks, have few direct end-uses for they are chiefly converted into intermediates and/or finished products. ⁸³ The most important of these are olefins like ethylene, propylene, butadiene and aromatics like benzene, toluene and xylene. ⁸⁴ The intermediate petro-chemicals, obtained from primary products too have few direct end uses. They are mostly used for producing petrochemical products and manufacturing many other materials. The petrochemical products are used by various end-use sectors without any further chemical

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⁸³. Ibid.

processing. They may be further divided into three broad groups-- plastics (PVC, polyethylene, polypropylene etc.), synthetic fibres (nylon, polyesters, polyacrylates etc.), elastomers (butyl rubber, styrenebutadiene and polybutadiene rubbers). 85 The table 1.2 shows different petrochemical feedstocks, products and end-uses (Table 1.2).

Several characteristics of the petrochemical industry make it peculiar. Firstly, the industry is highly capital intensive. The industry enjoys one of the highest capital/labour ratios in the world. Investment per new job created is estimated at $20,000 to $100,000. 86 In addition, basic products and intermediates need higher level of investments as they advance from transformation stage to the finished products and to consumer goods. Investments required for the transformation of finished products in consumer or industrial goods (third manufacturing phase) is nearly three and five times higher than required for the production of intermediate and basic products respectively (second and first manufacturing phase). 87

85. Ibid.
### Table 1:2 Petrochemical Feedstocks, Products and End Uses

<table>
<thead>
<tr>
<th>Primary Petrochemicals</th>
<th>Petrochemical Intermediates</th>
<th>Petrochemical Products</th>
<th>Which Supply These Industries</th>
<th>To Make These End Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural gas</td>
<td>Unsaturation</td>
<td>Ethylene oxide</td>
<td>Coatings</td>
<td>Containers</td>
</tr>
<tr>
<td>Methane</td>
<td>Ethylene</td>
<td>Ethylene glycol</td>
<td>Construction</td>
<td>Plywood</td>
</tr>
<tr>
<td>Natural gas liquids</td>
<td>Propylene</td>
<td>Ethylene dichloride</td>
<td>Electrical</td>
<td>Paints</td>
</tr>
<tr>
<td>Ethane</td>
<td>Butylene</td>
<td>Vinyl chloride</td>
<td>Housewares</td>
<td>Seat covers</td>
</tr>
<tr>
<td>Propane</td>
<td>Butadiene</td>
<td>Acrylonitrile</td>
<td>Packaging</td>
<td>Wire coating</td>
</tr>
<tr>
<td>Butanes</td>
<td>Acetylene</td>
<td>Cycohexane</td>
<td>Transportation</td>
<td>Engineering material</td>
</tr>
<tr>
<td>LPG</td>
<td>Ar. Matics</td>
<td>Ethylbenzene</td>
<td>Apparel</td>
<td>Clothing</td>
</tr>
<tr>
<td>Pentanes</td>
<td>Benzene</td>
<td>Styrene monomer</td>
<td>Carpets</td>
<td>Rugs</td>
</tr>
<tr>
<td>Natural gasoline</td>
<td>Toluene</td>
<td>Phenol</td>
<td>Home furnishings</td>
<td>Upholstery fabrics</td>
</tr>
<tr>
<td>Petroleum liquids</td>
<td>Xylenes (mixed)</td>
<td>Synthetic fibres</td>
<td>Tyres</td>
<td>Tyre cord</td>
</tr>
<tr>
<td>1,3,5</td>
<td>o-Xylene</td>
<td>(e.g. nylon)</td>
<td></td>
<td>Cleaning fluids</td>
</tr>
<tr>
<td>Naphtha</td>
<td>m-Xylene</td>
<td>Solvents</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reformate</td>
<td>p-Xylene</td>
<td>(e.g. acetone)</td>
<td></td>
<td>Personal care items</td>
</tr>
<tr>
<td>Refineries</td>
<td>Toluene</td>
<td></td>
<td></td>
<td>Inks</td>
</tr>
<tr>
<td>Gas oil</td>
<td>Mittanol</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon black oil</td>
<td>Anilines</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crude oil</td>
<td>Carbon black</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: OECD, n.l., p.17.
Another feature of the petrochemical industry is the application of different assemblages of technologies for chemical processing, giving rise to many technical alternatives in the sphere of products, processes and raw materials. For instance, several basic petrochemicals can be used to produce the intermediates, styrene and DMT, whereas one intermediate can be used to produce several end-products as styrene for SBR and PS plastics. The same intermediate can be made from different basic products, such as caprolactam produced either from TPA or DMT and ethylene oxide. However, all large volume petrochemicals are synthesized from only eight basic petrochemical building blocks, namely ethylene, propylene, butylene, benzene, toluene, xylenes, ammonia and methanol. These can be produced from different feedstocks such as naphtha, LPG, ethane and natural gas or coal and shale oil. But each process, except those using ethane and natural gas, gives rise to a number of co-products. They have to be upgraded to chemical value in order to make them competitive for processing. This leads to the integrated development of petrochemical complexes and the adoption of maximum scale-up.

of plant size to reduce unit investment and production cost. 89

The petrochemical industry is research intensive with a high rate of technological dispersion. From being essentially coal-based in the 1940s, the industry has shifted almost completely to petroleum. In fact, the technology has been the key factor responsible for the petrochemical industry's remarkable resilience and adaptability to changed circumstances. 90 Moreover, the large scale plants for the production of basic petrochemicals are capital intensive requiring a continuous high utilization rate and effective maintenance. In turn, it necessitates highly qualified manpower continuously improved by special training schemes. 91

Petrochemicals are among the most energy intensive products and the energy products required by the petrochemical industry are in the form of gas and oil. Two third of the gas and oil produced, is used as feedstock for synthesising various compounds and the remainder as a source of energy required for various processes usually as heat, steam or electricity for motive power or for electrolysis

89. Ibid.

90. UNIDO, Research and Development in the Petrochemical Industry in Developing Countries, ID/WG. 448/1, 18 September 1983, p.5.

91. Al Wattari, n.88, p.35.
purposes. The industry itself produces most of the required electricity.\textsuperscript{92}

The demand for petrochemical products is price elastic. For example, natural rubber has recently gained competitiveness with synthetic rubber (the peak penetration was reached in 1973). Price elasticities operate even between petrochemical products allowing for instance, HDPE, ABS and PS, PVC to gain over LDPE film markets, LDPE and ABS respectively. Currently, the petrochemical industry is concentrated in a few large end product volume groups whose wide ranging applications and technological nature are enabling a large number of producers to produce them in various regions of the world. The intermediate and basic petrochemicals are technically integrated downstream into the production of chemical end-products and do not have markets of their own.\textsuperscript{93}

\textbf{Historical Review}

In 1985, the petrochemical industry reached a production level of half a billion US $. This industry was practically non-existent fifty years ago.\textsuperscript{94} However, few

\textsuperscript{92} OECD, n.82, p.23.

\textsuperscript{93} Ibid., pp.33-34.

industries have developed so rapidly and produced so many varied products as the petrochemical industry since the Second World War. Two main reasons for this are: a) petrochemistry makes possible efficient use of otherwise unused by-products of oil and gas refining; b) petrochemicals can generally be obtained in greater quantity and better quality than chemicals from sources such as coal, coal tar and agricultural feedstocks. 95

It was between the two World Wars that most of the major plastic materials were discovered or developed in the R & D laboratories of the largest chemical producers which were involved in the production of synthetic dyestuffs and explosives. The German Company IG Farben was responsible for most of the innovations and developments of synthetic materials (PVC, Polyethylene, acrylics, nylon-6, PVCA, polystyrene, urea etc.), followed by ICI (PVC, polyethylene, polyester) and Du Pont (PVC, polyester, nylon) - (66). 96 IG Farben's leading position can be attributed to its strong R & D base and subsequent concerted efforts prior to and during the Second World War period to attain German self-sufficiency in the production of synthetic rubber and other materials.


These materials found ready and limited applications during the war. 97

In the post-war period, with the development of polymer science and the surge in R & D activities (mainly in the US, UK and Germany), new products were discovered and the technical processes of production improved. Extensive research carried out by the leading chemical firms was responsible for most of the innovation during this period. Some of the important discoveries were made by independent researchers at universities, such as Ziegler (Germany, 1950) and Natta (Italy, 1955) who discovered that catalysts for the production of HDPE and polypropylene respectively. However, the development of products from bench scale substances to pilot plant testing, followed by large scale commercial production requires enormous research and development expenditure, industrial and technical know-how and large number of qualified personnel. These could be afforded only by the large chemical firms. 98

The era of man made materials began when suitable processes were developed during the 1940s and 1950s, some of the first commercial markets being gramophone records, car interior fittings (instead of wood), upholstery (in place of

97. Ibid.

98. Ibid.
cloth or leather). The new development first took off in the United States in the 1950s followed by Europe and Japan a few years later, where it was seen as one of the first achievement of industrial reconstruction.99

As new applications of these products were found, they started penetrating the rapidly expanding markets. Hence, the synthetic materials steadily encroached the market share held by natural materials throughout a period beginning from 1950. The following table lists (table -1.3) the consumption (million tonnes) of man-made and natural fibres from 1951 to 1984.

Table 1.3 : World Consumption of Man-Made and Natural Fibres (1951-84)

(in million tonnes a year)

<table>
<thead>
<tr>
<th>Year</th>
<th>All Fibres</th>
<th>Cotton</th>
<th>Wool</th>
<th>Rayon</th>
<th>Synthetic Fibres</th>
<th>Share of Synthetics (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1951</td>
<td>10.5</td>
<td>7.5</td>
<td>1.1</td>
<td>1.8</td>
<td>0.1</td>
<td>1</td>
</tr>
<tr>
<td>1960</td>
<td>12.6</td>
<td>8.8</td>
<td>1.2</td>
<td>2.3</td>
<td>0.3</td>
<td>2</td>
</tr>
<tr>
<td>1965</td>
<td>18.2</td>
<td>11.3</td>
<td>1.5</td>
<td>3.3</td>
<td>2.1</td>
<td>11</td>
</tr>
<tr>
<td>1970</td>
<td>21.8</td>
<td>12.1</td>
<td>1.6</td>
<td>3.4</td>
<td>4.7</td>
<td>22</td>
</tr>
<tr>
<td>1975</td>
<td>24.8</td>
<td>13.0</td>
<td>1.4</td>
<td>3.0</td>
<td>7.4</td>
<td>30</td>
</tr>
<tr>
<td>1980</td>
<td>30.4</td>
<td>14.1</td>
<td>2.0</td>
<td>3.6</td>
<td>12.7</td>
<td>35</td>
</tr>
<tr>
<td>1984</td>
<td>32.1</td>
<td>14.8</td>
<td>2.0</td>
<td>3.3</td>
<td>12.0</td>
<td>37</td>
</tr>
</tbody>
</table>


99. OECD, n.82, p.72.
The table shows a sharp rise in the consumption of synthetic fibres. The percentage of synthetics to total fibre sales rose from 1 per cent in 1951 to 37 per cent in 1984. The growth in the use of plastics cannot be shown so clearly because their markets and products are much more varied. Here it is sufficient to say that in the United States, consumption of plastics rose from about 2.5 million tonnes in 1960 to over 13 million by 1973.\footnote{100}

**Development in the 1950s, 1960s and Early 1970s**

The period prior to 1973 may be described as the golden era of the petrochemical industry. This period was marked by rapid growth of markets, technological innovations, emergence of giant plants and a rush of new entrants into the industry. In addition to this, an ample availability of feedstocks provided an exceptionally fertile situation for process development in the 1950s and 1960s.\footnote{101} In the OECD area, the petrochemical production showed a rate of growth varying between 10 per cent and 17 per cent per annum (ethylene 17 per cent, propylene 16.5 per cent, benzene 13 per cent and butadiene 10 per cent), while total industrial production

\footnote{100. Ibid.}

\footnote{101. UNIDO, Study on Trends in Technological Development in the Petrochemical Industry, (by Mohammed H. Al-Shukri), ID/WG.522/1 (Spec.), 28 October 1991, p.10.}
rose during this period by only 5.6 per cent and chemical production by 9 per cent per year. In terms of volume, the production went up for ethylene from about 3 million to 24 million tonnes, for propylene from 1.6 to 12.4 million tonnes, for benzene from 2 to 11 million tonnes, and for butadiene from 1.1 to 3.7 million tonnes.\textsuperscript{102} Many factors account for the remarkable vigour of the petrochemical industry.

The extremely favourable overall economic growth contributed to the rapid development of the petrochemical industry. Indeed, the growth was relatively stronger in those sectors that offered major potential markets for synthetic products.\textsuperscript{103} Secondly, the technical and economic sectors whereby the petrochemical sector featured prominently, contributed to the growth of the chemical industry. The chemists and chemical engineers were able to design products with new properties, various attractive applications and economically sound production processes. Moreover, the availability of low cost feedstocks coupled with steadily improving production efficiency and big economies of scale made the petrochemicals highly competitive.


\textsuperscript{103} Ibid.
in price. For instance, ethylene prices in Europe decreased by roughly half between 1955 to 1965, though later they remained more or less stable up to 1972.104

In general, ethylene production showed the largest growth in the developed countries as a whole with an annual rate of 17 per cent (35.5 per cent in Japan, 22.5 per cent in Western Europe and 11.5 per cent in the United States). Growth of propylene production was almost of the same order while overall growth of benzene production was slightly lower. Demand for butadiene rose less rapidly than for the other three products at an annual rate of 10 per cent. The lowest rate of growth in butadiene in United States was 5.2 per cent compared with the rate of growth in Japan 23.4 per cent and in Western Europe 17.7 per cent.105

In general, the growth of the industry was very high in Europe, United States and Japan compared to the general rate of economic growth due to the replacement of traditional material, as indicated in the table below:

104. DECD, n.82, pp.72-73.
105. OECD, n.102, p.8.
Table 1.4: GROWTH RATES 1965-73

<table>
<thead>
<tr>
<th>Economy</th>
<th>Total Energy</th>
<th>Oil Products</th>
<th>Unit Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ethylene</td>
<td>Plastics</td>
<td>Ethylene 1960-75</td>
</tr>
<tr>
<td>Europe</td>
<td>4.4</td>
<td>5.3</td>
<td>7.1</td>
</tr>
<tr>
<td>Japan</td>
<td>10.1</td>
<td>10.5</td>
<td>14.3</td>
</tr>
<tr>
<td>USA</td>
<td>3.7</td>
<td>4.6</td>
<td>5.7</td>
</tr>
</tbody>
</table>

Source: UNIDO, n.101, p.11.

This period (1960-1973) also witnessed breakthrough in technology in case of almost every petrochemical product and creation of a global petrochemical industry. "These years were the most fertile for technological innovations in the industry..." notes a UNIDO document.\(^{106}\) New technologies were developed in case of processes for the production of the first generation products, ethylene, propylene and aromatics, chemical intermediates such as ethylene oxide, acrylonitrile, acetaldehyde, the fibre intermediates, and most important the polymer materials e.g. high density polyethylene, propylene, suspension PVC and the elastomers etc. providing the market with highly attractive substitutes on a

\(^{106}\) UNIDO, n.101, p.11.
cost/performance basis for traditional materials and products.\textsuperscript{107}

Commercialization of progressively more efficient processes in larger and larger plants resulted into economies of large scale. In addition, the increasing number of participants in each segment of the industry created a highly competitive atmosphere which did not exist before the war. Therefore, plastics and synthetic fibre prices declined over the entire period while the prices of almost all other goods were steadily rising. As a result the profitability of manufacturing bulk chemicals and commodity plastics suffered.\textsuperscript{108}

The most significant breakthrough in technology is the achievement of Union Carbide in the development of linear low density polyethylene (LLDPE) as an extension of its UNIPOL process in 1968 producing high density polyethylene. Commercial production of LLDPE by the gas phase, fluidized bed process was started in the mid 1970s. This was the real turning point in the evolution of polyethylene technology.\textsuperscript{109}

\textsuperscript{107} Ibid., p.12.
\textsuperscript{108} Ibid.
\textsuperscript{109} Ibid.
However, new patterns were set in the dissemination of petrochemical technology in the second phase of their development (mid 1950s-1970). It was because some firms decided to license their processes to others including their competitors in order to put higher returns on their research investment. They could combine manufacturing profits and licensing fees (royalties) for this purpose. Moreover, good technology was also available from engineering firms. Therefore, manufacturing technology could be obtained from either operating companies and from research and engineering firms. Consequently, new technology was broadly licensed. Hence, the industry was globally extended in spite of the fact that the increasing competitive environment brought a very low profit margin. 110

Another aspect of the industries' globalization as a post-1970 phenomenon is the investment in foreign countries. The total foreign investment of the United States chemical industry was increasing during the seventies from US $ 2.9 billion in 1973 to about US $ 7.1 billion in 1979. The largest share comes from European companies (71 to 74 per cent). In a recently published estimate almost half of the people employed in the US chemical industry are working for

foreign owned concerns. US companies are also making investments in other countries as well as undertaking joint ventures with non-US partners. Japanese chemical firms have also taken steps to establish themselves overseas in joint venture processes with Saudi Arabian, Iranian, South Korean, Alaskan and Singaporian petrochemical establishments. 111


The petrochemical industry which had long been one of the leading sectors in industrial development entered a new but less favourable phase of its development in 1970s. This process had started before the "oil crisis" broke out at the end of 1973. Firstly, the markets using raw materials produced by the basic organic chemical sector were getting gradually saturated. During this period owing to a halt in the decline in relative prices, the substitution of synthetic products for other materials e.g. paper, timber, steel etc. was slowing down. 112 The trends in the relative prices of various materials show that it was highly favourable to petrochemicals. The price edge on competing materials continuously strengthened during the 1950s and 60s. The following table clearly explains this.

111. Ibid., p.16.
112. DECD, n.102, p.10.
Table 1.5: Trends in Relative Prices of Various Materials in United Kingdom

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Plastics</td>
<td>100</td>
<td>75</td>
<td>171</td>
<td>268</td>
<td>9.5</td>
<td>8.6</td>
<td>11.9</td>
<td></td>
</tr>
<tr>
<td>Copper</td>
<td>100</td>
<td>224</td>
<td>421</td>
<td>480</td>
<td>5.6</td>
<td>6.5</td>
<td>3.3</td>
<td></td>
</tr>
<tr>
<td>Paper</td>
<td>100</td>
<td>120</td>
<td>377</td>
<td>558</td>
<td>11.6</td>
<td>12.1</td>
<td>10.3</td>
<td></td>
</tr>
<tr>
<td>Steel</td>
<td>100</td>
<td>137</td>
<td>362</td>
<td>647</td>
<td>11.7</td>
<td>10.2</td>
<td>15.6</td>
<td></td>
</tr>
<tr>
<td>Wood</td>
<td>100</td>
<td>125</td>
<td>355</td>
<td>692</td>
<td>13.0</td>
<td>11.0</td>
<td>18.2</td>
<td></td>
</tr>
<tr>
<td>Aluminium</td>
<td>100</td>
<td>104</td>
<td>263</td>
<td>428</td>
<td>10.6</td>
<td>9.7</td>
<td>13.0</td>
<td></td>
</tr>
</tbody>
</table>

Source: OECD, n.82, p.75.

Since 1973, petrochemicals and especially plastics seem to have ceased widening their competitive price advantage over their rivals and in fact, the 1973 oil crisis caused an extremely abrupt reversal of the price trend. The crisis resulted in an increase in the price of oil which is the raw material and source of energy for petrochemicals. On an average, 1974 product prices showed an increase of 200-350 per cent over the previous years.

The 1973 oil crisis also promoted changes of attitude in users or consumers of materials. Some of these changes have been to the detriment of growth in the demand for

113. OECD, n.82, p.73.
114. Fayad and Motamen, n.96, p.41.
synthetic products. First, the fear of a chronic oil shortage, even though recently it has considerably receded, inhibited potential users of the most highly oil dependent materials to some extent. Secondly, the increasing concern for environmental protection and waste preservation through increased recycling and longer product life has encouraged users to re-evaluate some of the qualitative aspects of the competitiveness of the various materials. This has been the disadvantage of the synthetic products. Most of them including plastics are difficult to recycle (the recycling rate for plastics in Europe is only 5 per cent whereas that for aluminium is 33 per cent).\textsuperscript{115}

However, the effect of the change in energy situation on demand for petrochemicals has not been totally negative. It has also stimulated some components of demand by emphasizing one feature specific to synthetic products that is their lightness. In particular, it has made plastics more attractive to transport equipment manufacturers. But the quantities of petrochemicals used in transport sector's share is too small in relation to total output.\textsuperscript{116}

On the supply side, many petrochemical technologies had

\textsuperscript{115} Ibid., p.77.
\textsuperscript{116} Ibid.
matured in the very early 1970s. In particular, the benefits to be gained by increasing plant size and energy saving procedures reached a plateau. Moreover, the lack of expanding markets meant less opportunity to use new technology and the erratic nature of the markets meant higher risk in the development of new technology.¹¹⁷

The changes in oil price in 1973 led to the oil companies' invasion of the primary petrochemical and main thermoplastic market in Europe. These oil companies, taking advantage of their control over feedstocks, energy supply and the surplus cash flow situation, intensified their activities in the downstream production of petrochemicals.¹¹⁸

The table below (Table no. 1.6) illustrates the downstream integration of West European major oil companies into petrochemicals production.

<table>
<thead>
<tr>
<th>Year</th>
<th>Ethylene</th>
<th>Ethylene Oxide</th>
<th>Styrene</th>
<th>VCM</th>
<th>PVC</th>
<th>Polypropylene</th>
<th>LDPE</th>
<th>HDPE</th>
<th>Poly-styrene</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>50</td>
<td>23</td>
<td>24</td>
<td>9</td>
<td>16</td>
<td>29</td>
<td>28</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>1975</td>
<td>53</td>
<td>31</td>
<td>49</td>
<td>12</td>
<td>21</td>
<td>34</td>
<td>28</td>
<td>26</td>
<td>10</td>
</tr>
<tr>
<td>1980</td>
<td>60</td>
<td>42</td>
<td>51</td>
<td>19</td>
<td>21</td>
<td>39</td>
<td>41</td>
<td>29</td>
<td>18</td>
</tr>
</tbody>
</table>


¹¹⁷. UNIDO, n.101, p.17.

However, the growing involvement of the oil companies in primary petrochemicals has not been fully offset by chemical firms pulling out of this market. The imbalance caused by these two developments (undue optimism about demand prospects and the compensated stronger vertical integration of oil companies) was made even worse by several other factors. Firstly, the pre-existing causes of instability were incubating prior to the 1973 oil crisis. The building of many new plants had begun in the late 1960s and early 1970s including an inflow of American investment in Europe and the new facilities were of a larger capacity making the supply structures increasingly rigid. Secondly, the COMECON countries emerged as a major petrochemical production area which soon started exporting to Western Europe. Thirdly, the first wave of large scale petrochemical investment projects in developing countries, especially in Latin America, decreased the OECD countries' export potential. 119

In Europe and Japan, there was a marked divergence between production capacity and petrochemical consumption trends throughout the 1970s and early 1980s accompanied by serious under utilisation of capacities during most of the period. In the US, apart from the 1975 recession, the

119. OECD, n.82, p.82.
situation was more balanced up to 1979 but it deteriorated badly during the following three years. The supply and demand imbalance has had catastrophic consequences for the finances of petrochemical enterprises. Low capacity utilisation raised unit costs whilst prices have dropped steeply owing, among other things, to self-destroying competition that many producers were reduced to, in the hope of better capacity utilisation. Moreover, changes in the structure of production costs had made strategies for maintaining profitability or increasing market shares by lowering prices at a time of prolonged recession more dangerous. 120

All these factors resulted in the restructuring of the petrochemical industry in three different but interrelated dimensions: organizational, technical and geographical. 121 So far as organizational restructuring is concerned, the giant oil companies closed their marginal facilities. The beginning of 1980s has seen a period of significant capacity reduction in the US, Western Europe and Japan, as the industry responded to a situation of severe overcapacity and stagnating demand growth. 122 The net capacity closures

120. Ibid., p.84.

121. UNIDO, Petrochemical Industry in Developing Countries: Prospects and Strategies, IS. 572, 24 October 1985, p.46.

122. Ibid., pp.49-51.
between 1980 and 1983 in these regions are given in the table - 1.7.

The table shows that the ethylene capacity has been reduced the most and low density polyethylene the second most. However, by 1985 HDPE would be the most affected and PVC the second most affected petrochemical in Japan.

The regional shares of world production and consumption of petrochemicals changed considerably during the 1970s and are in the process of further changes. For example in 1975, the developing countries accounted for 8 per cent of the world consumption of basic petrochemicals and 15 per cent of that end products but they produced only half of the amount they consumed. During the period between 1975 and 1981, the production and consumption of petrochemicals grew by 50 per cent world-wide whereas in the developing countries it more than doubled. Another peculiar feature is that the share of developed market economies, with the exception of Canada, are generally declining while the developing countries and Eastern Europe are increasing their shares. The following table provides a detailed picture of ethylene capacity adjustments between 1983 and 1985 and also a comparison between the share of the various regions in ethylene in 1975 and 1985.

---

Table 1.7 Capacity Reductions in the United States, Western Europe and Japan 1980-1983

<table>
<thead>
<tr>
<th></th>
<th>Plant Closures</th>
<th>Plant Idling</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>'000 tpa</td>
<td>% of total capacity</td>
</tr>
<tr>
<td>ETHYLENE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>United States</td>
<td>1700</td>
<td>10</td>
</tr>
<tr>
<td>Western Europe</td>
<td>3570</td>
<td>21</td>
</tr>
<tr>
<td>Japan</td>
<td>2250&lt;sup&gt;1&lt;/sup&gt;</td>
<td>36</td>
</tr>
<tr>
<td>Total</td>
<td>7520</td>
<td></td>
</tr>
</tbody>
</table>

PVC

<table>
<thead>
<tr>
<th></th>
<th>'000 tpa</th>
<th>%</th>
<th>'000 tpa</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>200</td>
<td>6</td>
<td>500&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>Western Europe</td>
<td>860</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td>490&lt;sup&gt;1&lt;/sup&gt;</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1550</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

LDPE

<table>
<thead>
<tr>
<th></th>
<th>'000 tpa</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>830</td>
<td>21</td>
</tr>
<tr>
<td>Western Europe</td>
<td>1820</td>
<td>27</td>
</tr>
<tr>
<td>Japan</td>
<td>270&lt;sup&gt;1&lt;/sup&gt;</td>
<td>27</td>
</tr>
<tr>
<td>Total</td>
<td>2920</td>
<td></td>
</tr>
</tbody>
</table>

1. The plant closure figures for Japan include the planned closures up to August 1985.
2. Postponed.

Source: UNIDO, n.101, p.41.
The following table brings out changes in the ethylene production in different regions of the world. The emergence of the new producers i.e. Saudi Arabia, Kuwait and Qatar on the scene in the 1980s, is also clearly seen. The following figures also show the other side of the restructuring process. As mentioned earlier, one of the developed country that is expanding its share of world capacity in commodity petrochemicals, Canada which is exploiting its plentiful feedstock resources in Alberta. Among the developed centrally planned economies, the USSR is seen to be expanding its capacity considerably. Among the developing countries, China, Brazil, Mexico and Saudi Arabia show the most expansion and a significant increase is expected from other developing countries.

All these changes in the petrochemical industry led to changes in technology development associated with it. The main emphasis in technology development was directed towards developing alternative feedstocks, feedstock flexibility, energy saving measures and improvement in existing processes as a response to the increase in oil prices, decline in demand and subsequent decline in profitability.124

124. UNIDO, n.101, p.23.
<table>
<thead>
<tr>
<th>Country or Region</th>
<th>1985 (10^3 tonnes)</th>
<th>Percentage change over 1983 total</th>
<th>Percentage share in 1985 world total</th>
<th>Percentage share in 1975 world total</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>17,298</td>
<td>-1.4</td>
<td>31.1</td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td>2,242</td>
<td>43.6</td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td>North America</td>
<td>19,540</td>
<td>2.4</td>
<td>35.1</td>
<td>37.8</td>
</tr>
<tr>
<td>Germany (fed. Repub. of)</td>
<td>3,990</td>
<td>-4.3</td>
<td>7.2</td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>2,270</td>
<td>-12.4</td>
<td>4.1</td>
<td></td>
</tr>
<tr>
<td>United Kingdom</td>
<td>2,270</td>
<td>0.2</td>
<td>4.1</td>
<td></td>
</tr>
<tr>
<td>Netherlands</td>
<td>2,260</td>
<td>0.0</td>
<td>4.1</td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>1,485</td>
<td>-25.0</td>
<td>2.7</td>
<td></td>
</tr>
<tr>
<td>Western Europe</td>
<td>15,291</td>
<td>-5.4</td>
<td>27.5</td>
<td>35.9</td>
</tr>
<tr>
<td>Japan</td>
<td>5,581</td>
<td>-12.5</td>
<td>10.0</td>
<td>15.1</td>
</tr>
<tr>
<td>Australia</td>
<td>420</td>
<td>0.0</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td>South Africa</td>
<td>150</td>
<td>0.0</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>USSR</td>
<td>4,200</td>
<td>40.0</td>
<td>7.6</td>
<td></td>
</tr>
<tr>
<td>Eastern Europe &amp; USSR</td>
<td>6,622</td>
<td>1.8</td>
<td>11.9</td>
<td>7.2</td>
</tr>
<tr>
<td>Brazil</td>
<td>1,427</td>
<td>5.9</td>
<td>2.6</td>
<td></td>
</tr>
<tr>
<td>Mexico</td>
<td>932</td>
<td>-0.3</td>
<td>1.7</td>
<td></td>
</tr>
<tr>
<td>Puberto Rico</td>
<td>413</td>
<td>0.0</td>
<td>0.7</td>
<td></td>
</tr>
<tr>
<td>Argentina</td>
<td>253</td>
<td>0.0</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Bolivia</td>
<td>230</td>
<td>0.0</td>
<td>0.4</td>
<td></td>
</tr>
<tr>
<td>Country or Region</td>
<td>1985 (10^3 tonnes)</td>
<td>Percentage change over 1983 total</td>
<td>Percentage share in 1985 world total</td>
<td>Percentage share in 1975 world total</td>
</tr>
<tr>
<td>-------------------</td>
<td>-------------------</td>
<td>----------------------------------</td>
<td>-------------------------------------</td>
<td>-------------------------------------</td>
</tr>
<tr>
<td>Venezuela</td>
<td>150</td>
<td>0.0</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>Colombia</td>
<td>115</td>
<td>0.0</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>Chile</td>
<td>60</td>
<td>0.0</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>Latin America</td>
<td>3,580</td>
<td>2.3</td>
<td>6.4</td>
<td>2.1</td>
</tr>
<tr>
<td>Saudi Arabia</td>
<td>1,611</td>
<td>100.0</td>
<td>2.9</td>
<td></td>
</tr>
<tr>
<td>Republic of Korea</td>
<td>505</td>
<td>0.0</td>
<td>0.9</td>
<td></td>
</tr>
<tr>
<td>Singapore</td>
<td>300</td>
<td>100.0</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Qatar</td>
<td>280</td>
<td>0.0</td>
<td>0.5</td>
<td></td>
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<tr>
<td>India</td>
<td>252</td>
<td>0.4</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Asia</td>
<td>3,982</td>
<td>120.4</td>
<td>7.2</td>
<td>1.7</td>
</tr>
<tr>
<td>Africa</td>
<td>120</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Total North</td>
<td>47,628</td>
<td>-3.4</td>
<td>85.6</td>
<td>96.1</td>
</tr>
<tr>
<td>Total South</td>
<td>7,682</td>
<td>41.8</td>
<td>13.8</td>
<td>3.8</td>
</tr>
<tr>
<td>Total(world)</td>
<td>55,610</td>
<td>2.9</td>
<td>..</td>
<td>..</td>
</tr>
</tbody>
</table>

Figure 1.1: The Share of the Emerging Producers of the World Capacity

ETHYLENE

1970
1980
1990

Source: UNIDO, n.123, p.23.
Figure 1.2: The Share of the Emerging Producers of the World Capacity

PVC

Source: See Figure-1 P.65.
Figure 1.3: The Share of the Emerging Producers of the World Capacity

LOW DENSITY POLYETHYLENE

Source: See Figure 1 p. 65
The petrochemical producers were greatly concerned with the supply of feedstocks and energy after the sharp increase in the oil prices in the 1970s and the consequent shortage and uncertainty of the feedstock supply. The countries with ample hydrocarbon reserves were an exception here. The alternative feedstocks for the petrochemical industry can broadly be classified into two categories: those based on conventional hydrocarbons such as natural gas and oil refinery products (light and heavy ends) and the feedstocks derived from non-conventional hydrocarbons such as those produced from coal, tar sand, oil shale and biomass origin. 125

This situation has promoted increased attention to the development of new feedstocks which could be summarized but not limited to the following technologies:

* Technologies for utilizing "heavy end of the oil barrel" such as hydrocracking;
* Production of synthesis gas from heavy oil fraction such as partial oxidation with concurrent development of downstream technologies for the production of oxygenated hydrocarbons as well as olefins, such efforts also comprise the utilization of tar sands and

125. Ibid., p.43.
oil shade which are particularly abundant in the US and Canada;

* The direct cracking of crude and heavy residues for the production of ethylene (UCC - Kureha - Chiyoda high temperature stream infection process, the Lurgi and BASF sand and coke based cracking processes);

* Direct liquification of coal through a diversity of hydrogeneration technologies (British Gas Corporation, Lurgi Kelloggs, Institute of Chicago, etc.);

* Indirect liquification of coal resulting in higher alcohols, methanol etc. depending on the process route;

* Biomass-based technologies for the production of oxygenated hydrocarbons, principally ethanol;

* Biogenetic mechanism for the direct production of petrochemical intermediates such as ethylene and propylene oxides, ethylene glycol, etc. (standard oil, Monsanto, Dupont). 126

The two oil price shocks resulted into higher cost for petrochemical industry not only due to expensive feedstocks but also because of expensive energy. This created new trends in energy conservation in the industry. Measures were

126. Ibid., pp.24-25.
taken towards more rational use of energy. To a certain extent, the industry successfully adjusted to the changed conditions in the relative availability of the various energy products by changing the kind of feedstocks used. 127

The restructuring process had caused the diversification in feedstocks and also diversification in products. The producers in the developed countries felt that the market of most of the commodity petrochemicals became mature, the margin was narrow and the fields of new applications could hardly be expanded enough to encourage remaining happily with them. Hence, attention was forwarded towards specialities where value added was higher and the area of applications was still not mature. For instance, the standard plastics (PE, PP, PVC and PS) that account for 95 per cent of the total market and have a value of under US $ 2 per kilogram and have reached market maturity. The higher value engineering and high performance polymers are likely to experience above average growth because they are characterized by high performance high strength/stiffness and heat resistance. The prices of engineering plastics are considerably higher, ranging from US $ 2 to US $ 5 per kilogram. This is clear not only from production figures but also from the research and development activity. 128

127. Ibid., p.25.
128. Ibid., pp.51-52.
Technological Issues

The international petrochemical industry is dominated by two dozen giant MNCs. Five of these are petroleum companies and the rest are chemical firms often linked together through joint ventures or controlling different sections of the same petrochemical complex independently. All of them have their headquarters in West Europe and North America though lately a few Japanese MNCs have become significant in the industry. The key to this dominance lies in the R & D carried out in the research laboratories of the petrochemical MNCS and their ability to harness science and technology for the purpose of capitalist accumulation. The data in the following table is fairly old yet it gives an idea of the concentration of major companies in the case of synthetic materials.

The control over the very process of scientific production and its integration with the process of capitalist accumulation underpins the domination of the industry by transnational oligopolies and the source of profits and technology payments. In 1976, the US based petrochemical transnationals brought back $1.4 billion in profits, royalty, and know-how fee and earned an export surplus of $5 billion for US. However, large royalty and licence incomes

129. Khanna, n. 73, p. 1321.
Table 1.9: Concentration and Technological Accumulation in Chemical Innovations 1930-55

<table>
<thead>
<tr>
<th>Type of innovations and companies</th>
<th>Synthetic Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top 5 Companies</td>
<td></td>
</tr>
<tr>
<td>Bayer</td>
<td></td>
</tr>
<tr>
<td>BASF</td>
<td></td>
</tr>
<tr>
<td>Hoechst</td>
<td></td>
</tr>
<tr>
<td>DuPont</td>
<td></td>
</tr>
<tr>
<td>ICI</td>
<td></td>
</tr>
</tbody>
</table>

Percent of all innovating companies: 5%

Per cent of all product and process patents: 30%

Per cent of all new products: 58%

Per cent of all radical innovations: 60%

Per cent of major market successes: 66%


should not lead us to conclude that there is extensive transfer and diffusion of technologies outside the MNC system because two-thirds of all royalty and technical fee in the US flows from foreign subsidiaries and affiliates of the MNCs. 130

130. Ibid., p.1322.
The control over the technology and markets is enhanced by the use of patents which grant monopoly rights to patentee. Hence, patents provide a reasonable possibility of return on investments in research and development and production by granting an exclusive position for a limited time encouraging prompt and adequate distribution of new technology.\textsuperscript{131} The bulk of the patents in the petrochemical industry are held by the MNCs, though over the years, the engineering firms too have come to hold important process and equipment patents in the industry.\textsuperscript{132}

On an average, patenting is weaker in base chemicals than at the finished products stage. Pure licensing is more widespread in base chemicals and intermediates through transnational engineering contractors from developed countries than in case of finished and specialty products. Patents in case end products are more tightly controlled and infringements are not encouraged.\textsuperscript{133}

In general, higher the financial involvement of the foreign collaborator in a technology transfer agreement, the stricter are the terms and conditions. Therefore, the terms

\textsuperscript{131} For details on patents see UNCTAO, \textit{The Role of Patent System in the Transfer of Technology to Developing Countries} TD/B/AC 11/19/Rev. 1 (New York, 1975), pp.1-13

\textsuperscript{132} For details see p.52, section II of chapter I.

\textsuperscript{133} For details see p.70, chapter I.
and conditions are strictest in case of a subsidiary while easiest in case of a technical agreement.\textsuperscript{134} Hence, a pure licensing agreement in case of base chemicals and intermediate means less terms and conditions ultimately leading to less constrained technology transfer. However, the problem tends to be severe in case of end products.

Since every plant in the petrochemical industry requires several licences, cross licensing and patent pooling has been common practice in the petrochemical industry. Such pooling has often led to higher royalty rates for those outside the pool, complete denial of licences to others or restrictions on licences. Sometimes, such cross licences provide for market sharing arrangements, the most famous example being the cross licensing arrangement between ICI and Du Pont, under which the two firms divided the chemical product market between them before the 1952 anti-trust ruling struck down the agreement. Several such agreements are still in existence especially for dyestuff, agrochemicals and finishing chemicals.\textsuperscript{135}

**Engineering and Construction MNCs**

A substantial and important component of the petrochemical technology consists of design and engineering,

\textsuperscript{134} Kewal Ram, n.35, p. M-75.

\textsuperscript{135} Khanna, n.73, p.1326.
plant construction and erection. The effective linkage of the engineering sector is the sum of the requirements for expansion (at any given growth rate) and for replacement.136

Before the end of Second World War, chemical firms normally designed their own plants and procured their "hardware" piping, pressure vessels, tanks, columns, heat exchangers, compressors, pumps etc. - directly from component markers. However, once an oil refinery or a chemical plant began to be viewed and designed as an integrated system, it opened the way to a new type of design and contracting company. The petroleum firms in US pioneered this change and many of the contractors like Kellog and Power Gas are now leading contractors for the petrochemical industry.137

A major part of the engineering work undertaken by these independent companies in the petrochemical industry is related to the production of basic chemicals and intermediates. Though the technology for bulk chemicals is much less patented, given the special skills required to design and construct the plants, large engineering MNCs like

137. Khanna, n.73, p.1326.
Stone and Webster, Lummus and Kellogg have a virtual monopoly over the market all over the world.138

The close nexus between the petrochemical firms and the independent engineering contractors has been an accepted practice in the petrochemical industry. Thus ICI uses only six chosen contractors to license its naphtha steam reforming process. Du Pont provided Peter Brotherhood (UK) with the design of a melt spinning plant for the synthetic fibres on the condition that it would not be sold to any other party.139

This nexus ensures that even when the technology matures and becomes standardized, the license fee can be kept at a high level due to the oligopolistic nature of the industry. Secondly, the restricted licensing of the technology of MNCs ensures that it is not pirated and the costs of developing a basic engineering and process package would be prohibitive. Thus, ICI uses its links with Sim-Chem to deny license to any independent producer in countries where it has a subsidiary already producing LDPE or likely to produce in future. Thirdly, most of the engineering firms use manufacturers of plant and equipment in their 'home

139. Ibid.
countries' with whom they have close relationship. Any project licensed and engineered through these firms enables large engineering exports and more profit to engineering contractors in the form of commission.¹⁴⁰

Undoubtedly, the MNCs in the petrochemical industry have shown greater willingness to license their technologies without direct investment over the years.¹⁴¹ But close links between petrochemical and engineering MNCs mean that the technology transfers are "packaged" indicating a very high cost of technology transfer. Moreover, it makes sure that the supplier MNCs can deny technology to producers or certain markets without any fear of their technology being commercialised by independent engineering firms.

The relevance of the above discussed technological issues in case of the petrochemical industry in GCC countries has been evaluated in the later part of this study. The next chapter provides an insight into the rationale of GCC petrochemical production and also a profile of the various petrochemical projects in the GCC countries.

¹⁴⁰. Ibid.