Technology Transfer Through Industrial Capacity Expansion Projects: Developing Countries Case

by

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ABSTRACT:

The purpose of this study is to review the technological development policy and options in developing countries with special reference to the cement industry.

A review of the international cement market, mathematical models for location and demand forecasting, technology transfer and finally a case study undertaken to determine the various options with emphasis on mixing capacity expansion projects with technology transfer activities.

The argument will finally be focused on to a case study where the impact of the hypothesis will be tested. This case study is the result of work undertaken by the author with the Iranian cement industry.

The principal conclusions of the study are that the current situation prevailing in the developing countries are mainly due to problems which are internal rather than external and these problems cannot be solved from outside.

Thesis supervisor: Professor Fred Moavenzadeh

Thesis reader : Professor Donald R Lessard

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1.0 Introduction

Cement and its range of by-products is an important and essential components of contemporary industrialized development. It plays a dynamic role in the expansion and improvement of infrastructure in the developing countries. Cement constitutes a major factor in the national development and it can be considered as a basic commodity on which development programs rely. Its importance is comparable to that of water, energy and fertilizer supply. Shortage of cement in a developing country frequently undermines the crucial construction program and results in great loss in the implementations of the major projects. Therefore self sufficiency in cement production is always given a high priority in development plans.

Availability of cement at affordable prices in developing countries is crucial if the development plans of these countries are to be realized. In many developing countries development planners prefer to install large scale cement plants that involve complicated technology. These factories and related technology have been either entirely imported, or in some cases in countries with more developed industrial sector, combine locally manufactured machinery with cooperation and technology of developed countries.

Economies of scale are substantial in cement plants and the tendency has been towards construction of higher capacity plants. Some of the developing countries, however notably China have developed small scale plants for cement producing. This has given developing countries a choice in selecting appropriate technology for some of their areas with low density of population. This thesis addresses the resulting questions: which technologies are to be employed, and under what circumstances, and what is the better and reliable planning to supply the technologies to the developing countries?

2. Cement consumption and availability

Cement has been known and used for at least two thousand years. The Romans used a great deal of this material in their construction projects, many of which still stand. The cement they used were natural and pozzolan cements, made from naturally occuring mixtures of limestone and clay and from a mixture of slaked lime and volcanic ash containing silica.

Portland cement is the produt of separate and continous operations of one of the largest moving machinery in any industry. Either of two processes, wet or dry, is used to make cement.

Nearly all cement is used to produce concrete. The growth of a cement market is a direct function of the growth in the demand for concrete. The demand for concrete depends on the level of construction activity. Concrete has many attributes that make it an ideal construction material which has a wide and growing range of applications.

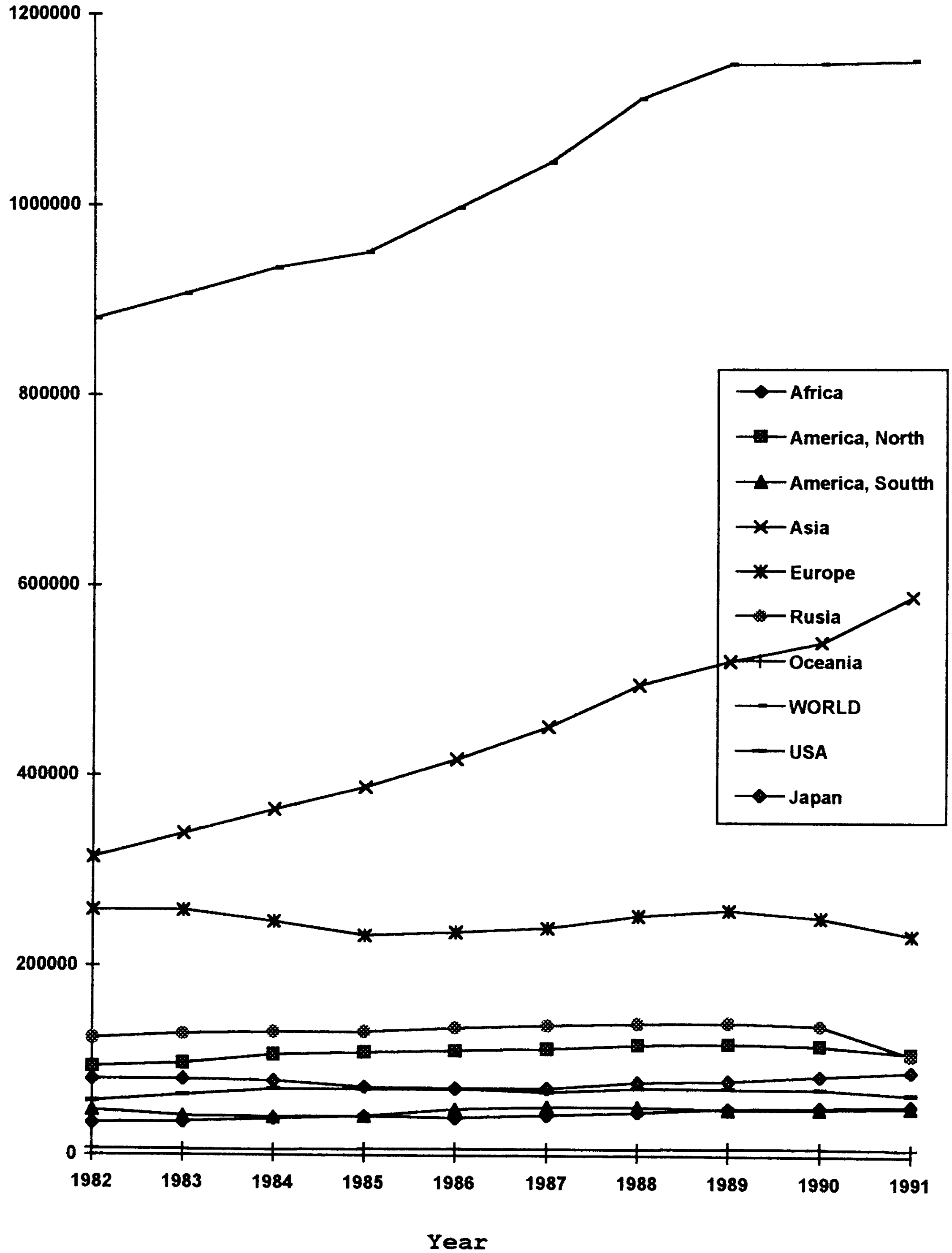
Almost all construction cement manufatured throughout the world is portland cement, although the specifications for finished cement vary from country to country. The production of specialty cements is determined by the market demand for the end use, by the availability of needed raw materials such a fly ash and slag, and by the strength requirements that the cement must meet. The majurity of the cement manufactured in most of the countries being considered is a pure portland cement.

The assessment of the market potential of cement in developed countries must be based on market data for cement and the structure of each country's economy. The demand for cement parallels the demand for concrete, the needs of the construction industry, and the health of the general economy.

The concept of Gross National Product (GNP) is used as a statistical measure of economic activity. Because accounting practices differ among countries, a good internationl measure of economic growth is a country's Gross Domestic Product (GDP). However, the growth of a country's GDP is not sufficient to determine a country's economic progress toward improving its standard of living. A country's standard of living is measured by its Gross Domestic Product per capita [1]. As population increases, proportionate increases in the production of goods and services must occur if the standard of living is to be maintained.

The construction industry provided the foundation for economic progress. With increasing construction activity, cement production expands. Rapid ecomic growth in Japan and certain parts of Europe produced substantial growth in the cement production of these countries. The growth rate of cement consumption within three past decade, 1964-73, 1972-81 and 1982-91, are being 4.0, 4.5 and 3.0 percent. Chart 2.1 shows the growth of world's cement production in past decade [2].

Chart 1.1: World cement production (000 tones)



Source: UN (1994), Statistical year book, New York.

2.1 Factors influencing supply

Cement is an extremely bulky item whose transportation, packing and storing is highly expensive relative to its value added. It is common place, particularly for small imported quantities, for transport costs to equal the fob value of cement. Since elasticity of demand with respect to price of imported cement are generally found to be non-zero, freight costs have a major impact on the source of import, and in the long run on decisions to alter production capacity. Packing costs are another consideration, for bagged cement the cost of appropriate packing materials, usually special paper, can be prohibitive. If bulk transportation is used, investment in large special bulk carriers and loading and unloading system becomes necessary. In general, since the raw material and finished product are extremely heavy, cement is for most practical purposes a limited tradable item. Expansion of capacity for production in individual countries with large geographical markets must, therefore, give special consideration to costs of transportation within the country apart from export markets, technology for packing and storage systems [3].

Additional capacity for cement production can either come from improving the efficiency of existing plants or by expanding and building new plants [4]. Given the numerous factors involved it would be inappropriate to provide a standard costing of a cement plant. However, the main physical ingredients of producing cement can be viewed for illustrative purposes. These figures, supplemented by values provided by certain countries, should enable reasonable approximations as to which of the developing countries have the requisite inputs for an economic expansion of cement production.

Approximate efficient production input/output coefficient for cement are given in Table 2.1. Also Table 2.2 is an examples of typical cost breakdowns of medium sized dry process cement plants [5].

Table 2.1 : Main inputs of cement and approximate quantities used for unit production

	Inputs	Unit	Quantity
1.	Raw materials	Ton/per ton of clinker	
	i) Limestone		1.28
	ii) Mare-clay		0.32
2.	Ancillary materials	Kg/per ton of cement	
	i) Gypsum		40
3.	Ancillaries	Kg/per ton of cement	
	i) Balls		0.2
	ii) Sillpebs		0.17
	iii) Plates		0.13
	iv) Magnesite bricks		0.68
	v) Alumine bricks		0.5
4.	Electricity	Kwh/per ton cement	110
5.	Fuel	Kg/per ton cement	
	i) Fuel oil (1 kg = 9500 kcal)		100
	ii) Coal		211

Table 2.2 : Typical cost breakdown for medium sized dry process cement plants

Description	US$/Ton	(%)
Variable cost:		
Fuel-Oil (at $ 120/ton)	10.6	16.0
Electricity (at $ 0.60/kwh)	7.2	10.9
Wages & salaries (50% of the total)	4.0	6.0
Spare parts and other consumable	7.5	11.3
Total variable cost:	29.3	100.0
Fixed cost:		
Capital Related charges (Depreciation, interest, dividends, etc.)	32.0	48.5
Labor and overheads	5.0	7.5
Total	**66.3**	**100**

Although ancillary items also vary between countries, the crucial variable costs which determine the efficiency of a cement plant are the energy and fuel consumption figures. The cost of the main inputs are shown for some countries in Table 2.3. Despite country variations, the main cost of producing cement falls on fuel and electricity consumption with the exception of Iran. This observation applies more so to lesser developed countries, such as Greece, Turkey, Indonesia and Morocco, Where energy costs account roughly 30 to 50 percent of the total value added [6].

Table 2.3 : The relative shares of main inputs in the average total cost of cement

Countries	Wages salaries	Raw Materials	Fuel	Elect-ricity	General	Others
Austria	23.0	14.0	16.0	9.0	8.9	29.1
Greece	13.6	16.6	30.8	19.6	9.6	9.8
Ireland	20.0	3.0	17.0	17.0	22.0	21.0
Sweden	28.0	10.0	11.0	6.0	26.0	19.0
England	19.7	4.3	25.7	11.1	11.3	27.9
Turkey	10.2	8.5	28.0	22.5	15.7	15.0
Indonesia			25.0	6.0		
Morocco	6.0	18.0	14.0	16.0	15.0	30.1
Iran	45.0	6.0	4.0	6.0	14.0	25.0
Jordan	12.0	8.0	15.0	9.0	48.0	8.0

A number of important insights can be drive from table 2.1 and 2.3.

First, the production of cement primarily involves the conversion of limestone through a highly energy-intensive process, with some other additives into an end-user product.

Second, since limestone is as bulky than cement, its transportation costs are likely to be very high. Hence, cement plants have to be located near easily accessible raw materials.

Third, improvements in production technology, such as wet versus dry process, makes a significant difference to energy consumption which suggests that modernization of old plants should be viewed seriously.

Fourth, the location of new plants in the developing countries would essentially involve a trade-off between costs of transportation to points of final consumption and countries with cheap energy resources.

Finally, as the case of Jordan shows, for countries with an expanding cement sector financial charges are dominant in the cost structure, hence the servicing of loans denominated in foreign currencies in an environment of devaluing local currencies should be carefully scrutinized before decisions to invest in cement plants are undertaken.

2.2 Trends in world cement trade

The significance trade of cement trade in overall world consumption has traditionally been low, with the low unit value of the commodity, widespread availability of raw materials, and link between economic growth and cement consumption, all favoring domestic production rather than dependence on imports. Nevertheless the proportion of demand accounted for by imports grew continuously throughout the 1970's, increasingly overall from 3.4 to 7.6% (20 to 66 million t) [7].

2.3 Oil-boom and spurt in world demand for cement

The sudden rise in world cement demand from major oil producing countries following the growth in their revenues after the oil prices rises of 1973-74, boosted by further rises through 1979-81, is well known. It shows that between 1974 when the first OPEC price increases were imposed and 1983 when world cement trade reached its peak, world production of cement grew by 28%. Over the same period world trade in cement increased by 116%. However by 1982, the OPEC-led boom in the cement trade was fading through existing construction projects carried total world trade to its highest level in the following year, but in 1984-85 the demand for cement from the Middle East collapsed and from then onwards the international cement trade has been falling in volume very sharply. There are a number of factors involved. Firstly, the Middle East countries have small populations and most of the construction projects needed to bring their industrial, commercial and social development up to the desired standards have completed. Secondly, many of them have installed domestic cement production facilities which are sufficient to fulfill, most, if not all of their demand. Some of them are now exporting cement to neighboring countries.

2.4 Competition for the dwindling world market

The only booming import market in 1984-86 has been the USA. Since construction activity, there has followed a cyclical pattern for many years. Cement producers have tended to gear their production capacities to average demand throughout each cyclical movement, relying on imports to supply the peak demand periods.

However, the upward phase of the current demand cycle, in which imports have shot up rapidly from 2.6 million tons in 1982 to a total of 16.8 million tons cement and clinker in 1985, has produced a number of new factors. Although a lot of outdated, inefficient plant was scrapped during the 1981-83 recession, there is still a significant proportion of manufacturing capacity in the USA which is outmoded and expensive in its operating processes. Moreover cement production costs in the USA are generally higher than in many other countries and in the case of such a low value product this cost differential acquires a vital significance. Although the USA is by far the biggest market for cement exports at present and no new major source of demands is likely to appear within the foreseeable future to challenge it, other markets will still account for significant demand within the international market.

The North African market for imported cement, unlike that in the Middle East, stayed firm, even strengthening a little in 1984.

2.5 World trends in export and shipping

This trade development has occurred in tandem with significant structural change while shipments to the Middle East have remained of great importance, their actual percentage share of world movements has declined by a massive 20 points over the 1984-87 period to just 15.5% [8]. The other major structural development on the import side of the trade equation has been the increase in significance of shipment to the USA, these climbing from below 14 to 30% of the total as actual tonnage volumes have increased.

On the export side, a relative decline in overall market significance has been noted for the traditional majors of Spain/Greece (down from 32 to 24%), other Europe (13 to 7%) and Japan (21 to just 9%), as actual tonnage levels from each supplier have slumped. In contrast, shipments from South Korea/Taiwan and Latin America have increased in absolute and relative terms, with their associated share of world movements climbing from 12 to 16% for former and from 8 to 15% for Latin America, the latter based on increased shipment level to the USA. The volume of supplies from other exporters has also been increasing, notably shipments by Canada and by the Middle and Far Eastern countries. Allied to this structural trade development, average shipping distance for trade as a whole has declined by around 15% over recent years to below 3000 nm.

Table 2.4 - World seaborne cement trade matrix 1987. (Million tones)

Region	Spain Greece	Other Europe	Japan	S.Kora Taiwan	Latin America	Others	Total
Middle East	1.5	0.5	0.8	0.6	-	4.1	**7.5**
North Africa	3.1	0.8	-	-	-	3.7	**7.6**
West Africa	0.6	0.7	-	-	-	1.4	**2.7**
USA	4.6	0.8	1.0	0.5	6.7	0.9	**14.5**
South/SE Asia	0.1	0.2	2.3	6.5	-	3.2	**12.3**
Others	1.6	0.4	0.2	0.2	0.7	0.8	**3.9**
Total	**11.5**	**3.4**	**4.3**	**7.8**	**7.4**	**14.1**	**48.5**

Table 2.5 - Seaborne cement trade volume & shipping demand 1984-87

Year	Trade Volume (mt)	Av. haul length (nm)	Shipping demand (bn tm)
1984	55.1	3455	190.34
1985	49.0	3145	154.19
1986	49.4	2970	146.69
1987	48.5	2810	136.28

2.6 Development in the 1990s in trade and shipping

The projection of cement demand profiles over anything longer than the short-term is extremely difficult, specially given the high degree of market dynamism witnessed in the past four to five years [9].

Nevertheless, such an exercise has been undertaken and the cement/clinker supply/demand development associated with a range of alternative forward macro-economic scenarios evaluated. In conjunction with the main trends underlying trade pattern movements and the overall development of fob and shipping costs for the major individual exports, the actual likely forward patterns of world cement trade have thus been evaluated.

In terms of overall trade structure, While significant changes have occurred in recent years with regard to the relative importance of individual trades, the main trade flows as evidenced in 1987 are set to enjoy a continued central prominent role in the forward period. Thus, despite declining in tonnage by over 4 million in recent years, the Spain/Greece-North Africa trade is set to remain one of the principal of world cement hauls, increasing in terms of its share of the global seaborne trade from 6.4% in 1987 to between 9 and 10% in latter 1990s. Similarly, with the development of US import and Latin American export levels, the relative significance of this trade is set to increase from the 13.8% level of 1987 (8.0% in 1984) to 16% towards the end of the 1990s.

Against these proportional increases however, relative decline will be such trade flows as the Spain/Greece-USA haul, overall trade significance high from 9.5% in 1987 to 6% in 1990, with a small increase to 6.5 to 8.8% projection low to high scenarios over the 1990s.

In the case of the export trades of Japan, South Korea and Taiwan, despite an increase of aggregate shipments to the Middle East, the proportional importance of intra-regional movements from exporters (i.e. shipments to South East Asia) is projected to diminish throughout the period. From accounting for over 18% of all 1987 seaborne movements in the world therefore, these trades are set to account for not more than 12 to 15% by the year 2000.

American exporter is to the fore, with the projected global trade level to approximately equal to that of 1987. In the high scenario, while these same shipments are again in evidence, the rise of shipments from Spain/Greece, increasingly in proportional overall global significance - by almost 6 percent, despite the global trade level almost doubling over the 1986 to 2000 period.

On the import side, the overall forward development with regard to the relative significance of individual markets is less marked, the main features being a decline for the US and South East Asian markets and a rise for the Middle East and West Africa, this after the widespread tonnage increases of the early part of the 1990s. In the high scenario, while shipment level are forecast to increase markedly during 1986 to 2000 in all the main regional import sectors, no growth is forecast in the late 1990s for South East Asia, and a decline is projected during this time for the Middle East. For the overall, however, a sizable proportional gain in relative significance is projected for West African imports (from 5.6% of total sea trade to 12.6%), while smaller positive movements are projected for the middle East, North Africa, and the USA. On the negative side, overall falls in relative importance are expected in the case of South East Asia (from 25.5 to 19%) and for the 'others' category (8 to 2.3%), the latter a consequence of reduced shipment levels in the wake of increased domestic supply in Latin America, and of reduced exports to West Europe in the face of tightening overall cement market conditions.

For seaborne cement trade overall therefore, the forward period is set to witness a marginal recovery from the depressed levels at present, with that projected for 1990 representing a 2.5% increase on the 1987 level, the latter some 12% (5.4 million t) below that achieved three years earlier. From the 1990 level of just under 50 million t therefore, trade levels are expected to continue to increase over the early 1990s, although in the low scenario the pace of this growth is likely to be slow, with overall 1990 to 1995 growth posited at just 8% to just under 54 million t. The late 1990s in the low scenario are set to see a return of the global trade level to around that of the late 1980S-i.e. 49 million ton per year (tpy).

This profile is in contrast to that of the high forward case where positive growth is projected throughout the study period. Over the first half of the 1990s, world seaborne trade expansion is set to total 25% to over 62 million tpy by 1995, with a marked slowing of growth in later years manifest in overall 1995 to 2000 expansion of just 11% to a 2000 level of 69 million t. These overall high case growth levels thus represent average annual growth of almost 5% for the first half, and just over 2% for the second half of the decade.

Table 2.6 presents a summary of the overall seaborne trade development projected over the 1990s. It is apparent that while the low case does involve trade growth, the aggregate level is not thought likely to approach that attained in 1984 at any time in the forward period. In the case of the high scenario trade growth, the 1984 high is set to be surpassed by around 1993, with the 1995 level some 13% above that of 1984, and the 2000 level higher by almost 26%.

With average laden haul length remaining relatively stable over the forward period, total shipping demand generated by the international cement trade is set to increase only very marginally over the year 1990 to 1995.

Thus after the period since 1984 during which total shipping demand fell by almost 30% from 190 billion tonne-milles to 136 billion tonne-miles, an overall positive movement of almost 3% is expected by 1990 to the 140 billion tonne-miles level. With average shipping distances remaining relatively constant over early 1990s in the low case, shipping demand is set to increase in roughly the same proportion as seaborne trade, with total 1990/95 growth of some 9% to over 152 billion tonne-miles. Thereafter however, with both trade and haul length set to fall, shipping demand is set to decline sharply, with a 10% reduction projected for the late 1990s to 136 billion tonne-milles the same depressed level as that witnesses in 1987.

Table 2.6 - Forecast seaborne cement trade volume to the year 1995-2000

Year		Trade Volume (mt)
1984		55.1
1985		49.0
1986		49.4
1987		48.5
1990		49.7
1995	**Low**	**53.8**
1995	**High**	**62.2**
2000	**Low**	**49.2**
2000	**High**	**69.2**

In the high scenario, the early 1990s is set to be a period of extensive growth, founded by trade expansion and longer average haul length. During 1990 to 1995 shipping demand is set to expand by over 32% to 185.5 billion tonne-miles although this level is still below that witnessed in 1984 despite a far higher level - further evidence of the significant structural changes occurring within the cement trade as a whole. Over the latter 1990s, shipping demand growth will be tempered by a net decline in mean voyage levels, although a rise of almost 10% is expected to be realized, this taking the aggregate to over 200 billion tonne-miles.

The overall characteristic of the forward cement seaborne trade and shipping sector is therefore one of marginal overall growth. Within this aggregate profile however, substantial volumes of structural change is expected - as new domestic capacity becomes operational in current importers, export gearing is increased in many 'new' producers, and the changing cost profile of bulk sea transportation has a marked impact on landed cost competitively. The forward period is thus set to include the reemergence of a significant volume of short-haul intra-area - based partly on changing bulk freight rates but also on changing overall patterns of supply/demand. The extent of this change has already been witnessed with regard to the rise of shipments to Japan, and the evolution of export cargoes from Middle East. The full impact of these developments on cement shipping system - more specifically on the use of specialist cement carriers and of floating transshipment terminals - has yet to be fully realized.

2.7 Overview of cement trade in developing countries

The most striking feature of world cement trade during the past ten years is the predominant position taken by the developing countries in supplying each other's import requirements. For example, a cement plant was built in the Bahamas with a view to exporting not only to the East Coast of USA, but also to other Caribbean countries. The Kenyan cement industry is export-oriented and supplies a large area of the Indian ocean region through its own vessels and cement terminals [10].

It is useful to recall that cement is a low traded commodity. In 1986, only 7% of the world production was traded. According to the transport expenses, the bulky nature of cement makes it economically unfeasible if exports or imports have to travel a distance of over 1500 navigable kilometers [3]. Therefore, cement trade has to be focused on regional basis. In 1988 the Middle East countries imported about 13 million tons of cement. Less than 10% came from regional suppliers, due mainly to their high prices, taking into account overt and hidden subsidies of the main cement exporters such as Greece, Romania, South Korea which had increased its cement exports from 0.5 million tons (1970) to reach 4.8 million tons in 1988. Only Bangladesh and Jordan have made cement trade with their region.

2.8 Opportunities for trade within Middle East Countries

The trade of the cement in the international markets is affected, inter alia, by the relative cost of the product, transportation cost, output subsidies by the state, etc. The high rise in oil prices in the 1970s and early 1980s in oil producing countries greatly accelerated the demand for cement. As a result, massive importation of cement and construction of new cement plants took place in these countries. With the lowering of oil prices the internal demand for cement decreased in these countries and some of them now have even become cement exporters. Moreover, since the cost of transportation in the cement trade is a significant part of the total cost, countries with long borders can be importers and exporters at the same time. Since distance is a major factor in the cement trade will apply in next chapter.

The middle east region has been the scene of increased construction activities during the early 1970s and 1980s. As a result of this increased demand for cement, many cement factories were constructed in the Middle East region. With an effective decrease in oil prices the regional cement industry is approaching a temporary equilibrium with some plants operating at only 45-55 percent of capacity. The region used to import huge amounts of cement from different sources. Now major cement importer have been reducing their import with an increase in the domestic production of cement. However, the overall picture of the region is seen in table 2.7.

Cement producers in the UAE have been trying to export cement to avoid keeping the plants idle for much of the time. Nevertheless they have been able to export to the countries such as Oman, Qatar and Saudi Arabia. However, UAE will have difficulty in exporting to Saudi Arabia in coming years bfcause the eastern coast of Saudi Arabia is rapidly moving to higher capacity of cement production. Turkey has been on of the major exporter. However, a mini-boom in Turkey's construction activities in 1987 forced the country to import cement amounting to 2.04 million tons in 1987. The importation of cement by Turkey continued in 1988 and 89.

Table 2.7: Middle East region's capacity (1990)

Country	Installed capacity (1000 t)	Number of plants	Reliable production (1000 t)
Kuwait	2145	1	1716
Iran	17610	14	14088
Egypt	15500	7	12400
Lebanon	3400	3	2720
Bahrain	200	1	160
Iraq	24380	16	19504
PDR Yemen	0	0	0
Syria	7300	5	5840
Jordan	7410	3	5928
Turkey	23775	38	19020
YA Repub.	800	2	640
Oman	835	2	668
UAE	8100	9	6480
S. Arabia	12713	9	10170
Qatar	360	1	288
Total	**124528**	**111**	**97982**

2.9 Cement plant utilization

As shown in table 2.8 most cement plant in developing countries are operating at abbout 67% of their capacity. This may be due to the reason given below:

Some of the plants that started commercial operation in Middle East regions have faced in some countries, a glut in the cement market. This was due to the effect of sharp decline in oil prices and a depressed state of business activity. In addition, the plants were also adversely affected by the influx of cement imported from South East Asian countries.

Also the increased cost of spare parts, raw material and energy is considered to be imprtant affecting the utilization of those plants. Some plants are also suffering from power shortages that aafect production. Lack of proper maintenance procedures and skilled staff in most developing is also contributing factor. Also lack of a logical planning, technical issues related to the appropriateness of new technologies, skilled labors, and general weakness in infrastrucure are most important problems that affecting utiliazation of cement plants.

Table 2.8: Cement plant utilization in selected developing countries

Country	Capacity (000 Tons)	Production (000 tons)	Utilisation (%)
Algeria	11300	7195	64
Egypt	15500	12119	78
Iran	17610	14088	80

Iraq	19260	9096	47
Jordan	4000	1990	50
Malaysia	7800	3879	50
Morocco	5000	4500	90
Pakistan	8180	4775	58
Syria	5928	3300	56
S.Arabia	13500	10500	78
Tunisia	5250	3470	66
Turkey	23755	19020	80
U.A.E.	7550	3600	48
Average			**67**

2.10 Problems interfacing cement plants in developing contries

This study has identified some major problems faced by the cement industry in developing countries. These are explained in the following sections.

2.10.1 price controls

Price controls, in general, are exercised in two ways. Either the government, as a political decision maker, fixes the price of cement and that of inputs (e.g. Egypt, Iran, Syria, Algeria, etc.) or draws the guidlines to determine cement prices. In the latter case, a cement union or a selected representative body of the industry applies to the government to seek a price revision in cojunction with the predetermined guidlines, e.g. Morocco, Indonesia, etc.

2.10.2 Excess supply capacity for domestic market

Excess supply of domestic market has been a serious problem in most of the cement producing countries. These countries, in the 1970s, had invested heavily in cement plants on the ground of exponentialy growing demand. The construction boom in OPEC and in raw material exporting countries in 1970s had led to optimistic expectations for cement consumption. The decline in the oil and raw material prices and the situation of infrastructural investmens in some of the OPEC countries in 1980s slowed down the growth rate of the demand for cement. The main countries that are facing exess supply of capacity are, Indonesia, Malaysia, Syria, Morocco, Tunisia, UAE and Senegal. Also it is considerable that thia excess supply capacity is not fully utilized by importing countries.

2.10.3 Foreign competition in domestic markets

Foreign competition in domestic markets is mainly observed in some of the oil exporting countries; such as UAE, Kuwait, Qatar, S.Arabia where relatively liberal import policies are followed. As the world market price of cement is widely based on its marginal cost, local manufaturers are not able to meet such a low price as their fixed expenses will not be fully covered. Therefore, a part of the domestic market is evently lost to foriegn copetitors and local prices are driven down to low levels. A typical example of this case is the UAE.

2.10.4 High energy prices

High energy pricing, apart fro m a few of the oil exporting countries, is a major problem in developing countries. As the energy cost (fuel and electricity) accounts for about half of the operating cost of a cement plant, its implications are considerable. Particularly in countries where the price of cement is fixed by the central authority regardless of its cost structure, financial losses for cement plants have become a permanent feature. As the demand for fuels and electricity is highly price inelastic, the governments often tax them to raise public revenue. But the sales price adjustment for cement does not, in general, immediately follow the increase in the price of energy; hence, cement producers continue to bear the extra cost of the energy for a considerable period of time.

2.10.5 Non-availability of raw materials

The required raw materials for cement, mainly, are calcereous limestone, clay, marl, pozzolan,etc. These are abundant resources almost everywhere in the world. However, there are some exceptional cases where these materials are inaccessible or costly for extraction (e.g. Bangladesh, Pahang Cement in Malaysia). It is also possible that some cement plants exhaust the quarries they are built on which raises the transportation cost for raw materials from more distant location (e.g. some plants of Iran).

2.10.6 Deficiency in know-how

Running and managing a cement plant has become a fairly standardized and straight forward process. The most crucial areas are process monitoring, inventory management, and proper maintenance. It is noteworthy to underline the importance of ensuring a regular and uniform supply of raw materials to the preparatory treatment machines in orderto utilize the plant at maximum efficiency and obtain a homogeneous quality of product. It is notable that in some developing countries, foreign management teams have been hired in the relatively new cement producing countries, e.g., S.Arabia, UAE and Libya.

2.10.7 The importance of repair and maintenance for the efficient performance of cement plant is substantial. A plant may embody all the technological innovations and other competitive advantages; but, if it is not maintained properly on a pre-scheduled basis, most of these advantages would be offset due to the maintenance failures and breakdowns. Also lack of good-planning, rational inventory control of spare parts and qualified technicians are part of problems. The shortage of hard currency in many cases is amajor cause of the lack of spare parts, preventing timely repair and maintenance, e.g., Egypt, Iran, etc.

2.11 General problems facing developing countries

In summary, the main problems which developing countries are facing, are:

- The existing system of policies, regulations and standards for national development is very general, at all levels.
- Reduced budget allocated to research, in government and private institutions.
- Shortage of skilled human resources.
- Lack of collaboration between research institutions.
- Lack of proper infrastructure.
- Lack of external competitivity for nationally goods.
- Importing inappropriate technologies.
- Improper technology transfer policy and control.
- Lack of suitable capacity utiliazation.
- Scarce relationship between research programs and problems of production organizations.
- Poor dissemination of scientific and technological information.

3. Capacity expansion planning

3.1 Definition of planning

The lack of a common glossary of the term planning system may in practice mean very different things to different people. The research articles do not always define all planning terms, but the reader should be aware of potential semantic differences.

Corporate planning. Early writing tended to use the term long range planning, largely because the major new element was looking beyond the short-term plan of the annual budget [1]. Modern writers have accepted the planning should be comprehensive, and should embrace the short and long term [2]. Corporate planning, or comprehensive business planning, tends to be favored as a more useful title. So it can define as the formal process of developing objectives for organization and its component parts, evolving alternative strategies to achieve these objectives, and doing this against a background of systematic appraisal of internal strength and weaknesses and external environmental changes [3].

3.2 Planning environment factors

The planner general uses the environment term to refer to total business environment in which the organization operates. It therefore embraces economic, political, social, demographic, technological, legal, ecological and infrastructure factors.

In this thesis we have consider only economic, technological, infrastructure and some legal articles which are involved with transfer of technology.

3.3 Planning time horizon

Time horizon of planning depends on three factors. Lead time from idea to implementation, how long the results of a decision stays in the organization, or how long a decision binds the organization, and predictability of the future.

Short term plan covers above two years with an operational nature, medium range plan covers three to five years with a quantitative and financial nature, and long range plan covers more than five years with more conceptual and strategic nature [4].

3.4 Capacity expansion problem

Capacity expansion planning are made by various agencies of the government, by businesses, and to some extent by private individuals. With respect to the planning, Many decisions are made, small and large, who will spend capital investments and time. Some of these decisions, small or large, are made following months or years of study and deliberation. These decisions add up to a massive commitment of capital. The efficient commitment of that capital depends on making good decisions in individual capacity expansion undertakings [5].

The situations surrounding decisions about expanding electrical generating capacity, telephone network capacity, cement plant capacity or other manufacturing capacity are very complex, but they all share same basic features such economy-of-scale.

3.5 Characteristics of capacity expansion problems

Capacity expansion is addition of facilities to serve some need. The capacity expansion problem is restricted to situation in which the following apply:

a) The cost of the equipment or facilities added exhibits economics-of-scale.

b) Time is an important factor. That is, there is a continuing need for the facilities, and the facilities or equipment added are durable.

Capacity expansion problems arise in a myriad of applications such as Communication networks, gas and oil pipelines, electrical power generation, public facilities and manufacturing facilities [6].

Many different idealized capacity expansion problems can be abstracted from such applications. These are mathematically described problem that can be related more or less to situation that arise in the applications:

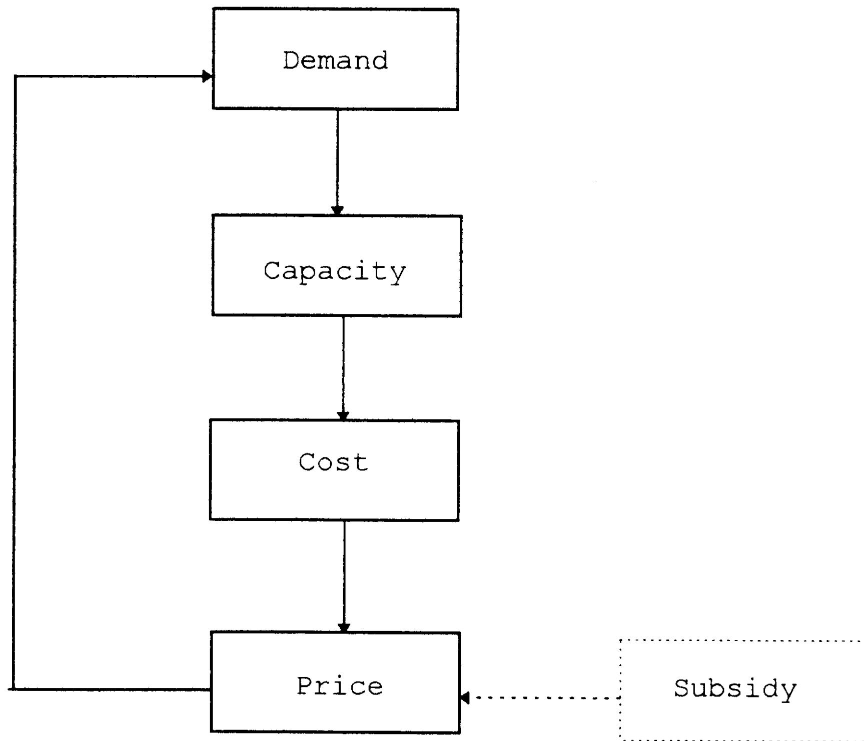
- Additional units of a single type of facility are to be deployed as demand increases over time. Several different types of interdependent facilities are to be added.

- There are other costs, such as operating costs that depend on the capacity expansion decisions.
- Backlogging some demand or importing services is permitted as an alternative to capacity expansion.
- Some existing capacity may have to be replaced due to obsolescence, deterioration, or cost advantages of new equipment.
- A finite set of projects is to be undertaken, and the problem is to determine the optimal sequence.
- The optimal location of additional facilities is affected by transportation costs.
- The link capacities of an interconnected transmission network are to be expanded.
- Demand depends on price, which depends on cost, which depends on capacity expansions, which depend on demand (figure 3.1).

The primary capacity expansion decisions typically involve the sizes of facilities to added and the times at which they should be added. Expansion timing is specially important when operating costs are significant or importing are allowed. Often the type of capacity or location of the capacity to be added are also major concerns. In addition to this primary decisions, there may be dependent secondary decisions involving the optimal utilization of the capacity being added.

All these concerns, size, time, type, location and utilization are what be called the operational aspects of the capacity expansion problem.

Figure 3.1 Interdependence of demand, capacity expansion and price

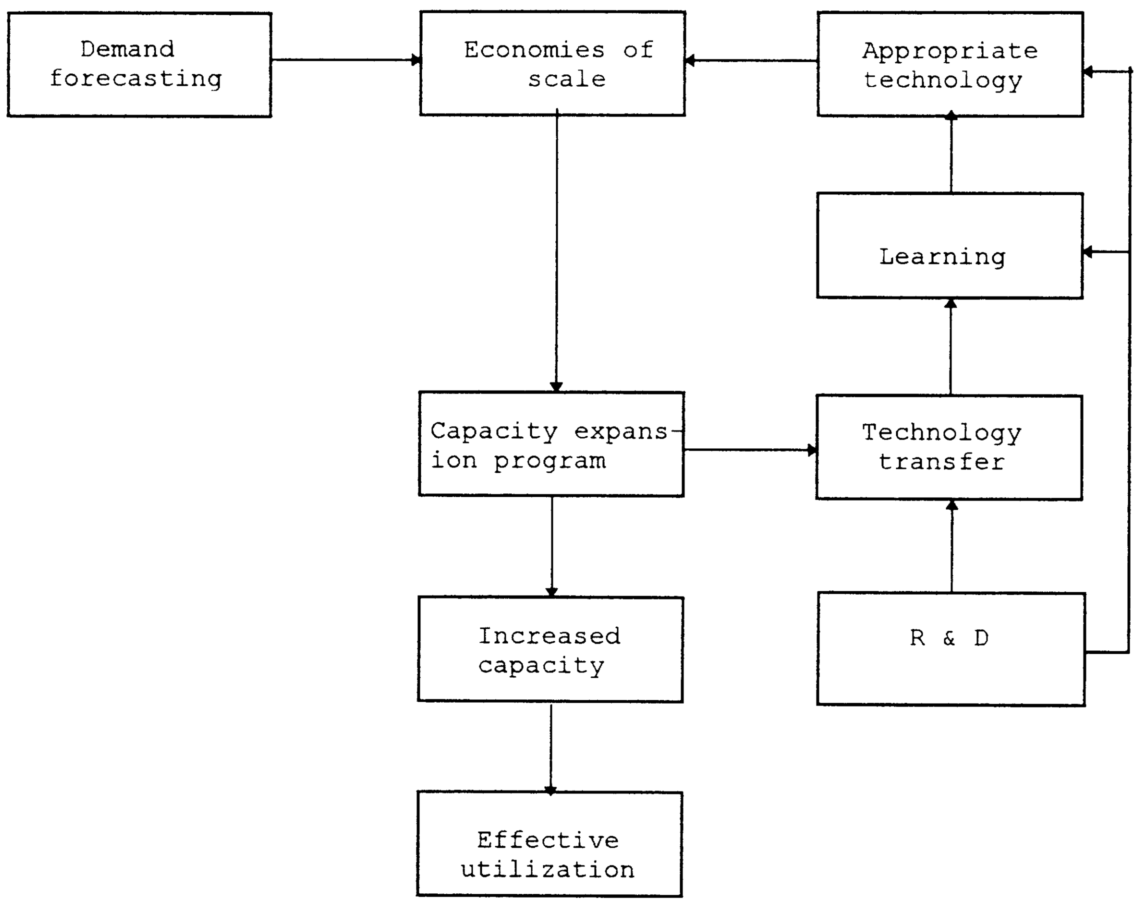


3.6 Objective and proposed methodology

The objectives of this thesis are, the first to describe how the developing countries can expand their production capacity through an optimal decision to avoid of further problems in utilization, and secondly how they can enjoy of the expansions programs to develop their technological capabilities.

The proposed methodology is shown in figure 3.2. According to the this methodology five main factors are influencing a successful expansion programs, demand forecasting, technology appropriateness, technology transfer, research and development, and learning. If these factors consider properly in expansion programs it may lead to an effective and economical utilization of plants and also a better return for investment in industrial projects.

Figure 3.2: Factors influencing successful expansion programs



The contents of this thesis covers a wide spectrum of topics which might appear initially to be unrelated. However, detailed analysis of each topic will show the strong connection between them and their relevance to the subject of this thesis.

These five factors will be explained in ensuing chapters and also we will study a case of expansion capacity in cement industry as a technology transfer oriented project in Iran.

The diagram in figure 3.2 simply indicates the main issue to be discussed. Each issue in the associated block diagram will be elaborated in its respective chapter.

4. Demand forecasting

4.1 Factors affecting cement demand

In principle the determinants of the demand for cement are not greatly different from the demand for any product. These include factors which determine the budget constraint and relative prices of the products which are similar in usage. In aggregate, when estimating a country's demand for product, the most obvious limits on purchasing power are some measure of its national wealth. The usual proxies used in this context are country's Gross National/Domestic Products (GNP/GDP), or some version of it. There is however a great deal of difference between aggregate GNP and individual purchasing power on which a more accurate picture of consumption can be built. The same is true for variables which attempt to measure the cost (price) of cement to the final consumer.

In most studies related to the cement sector several key indicators of growth are normally used to estimate demand for cement [1]. The most reliable estimate are based on the pattern of construction output and cement demand. The former is itself a function of the stage of development of a country. It has been observed that cement is most heavily used in civil engineering, industrial and commercial buildings at earlier stages of development, while demand for housing is mainly a function of a much higher stage of growth. Thus factor which could influence demand for cement may include the rate of urbanization in the country, extent of government involvement in building the infrastructure, etc. However, data, in particular time-series, on these variables is highly irregular and difficult to access. For these reasons, the most commonly used time-series to estimate cement demand are: GNP/GDP; construction expenditure/output; and/or some measure of overall capital formation or investment in the economy.

Apart from variables which can measure a countries wealth, the other main element of the equation is the cost and availability of cement. The impact of the cost or price of cement on its consumption can be viewed in two ways.

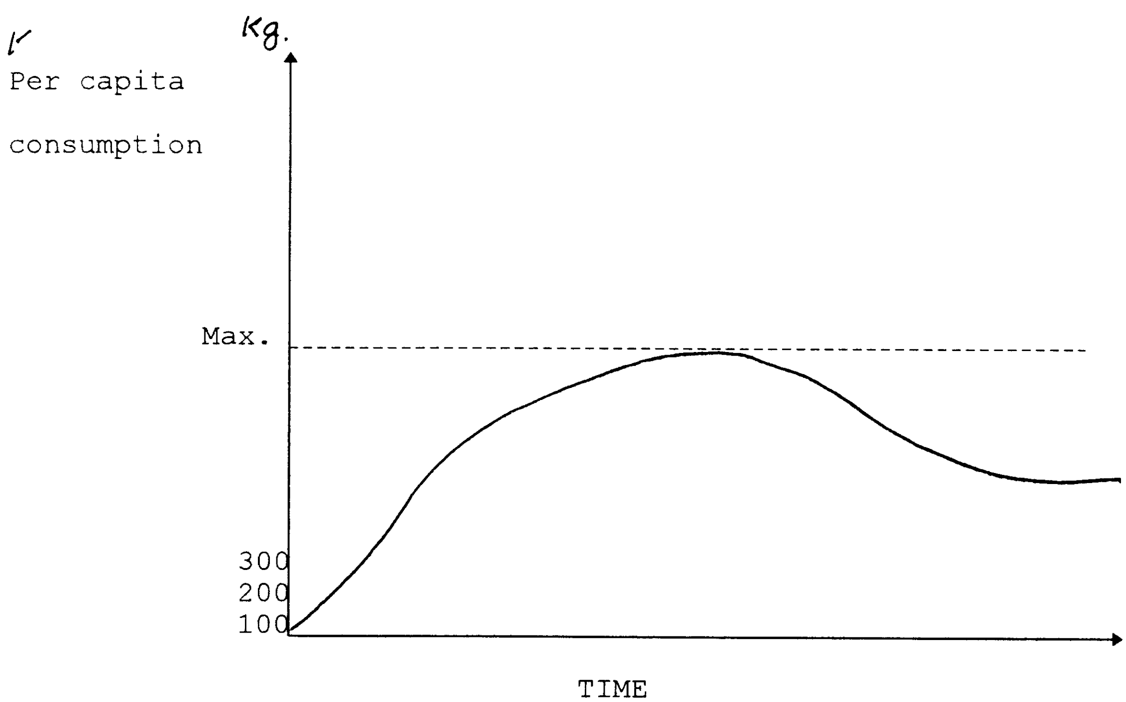
First, the price is important because possibilities of substitutes exit. For instance, instead of cement plastering, gypsum wallboards, specially in commercial buildings, can be used. Another possibility is prefabricated walls in developing countries, particularly with high rural populations. The use of wood, mud, etc., in housing are obvious substitute building materials.

Second, and more important, is the possibility importing cement for higher cost of domestic cement. The important price of cement must of course include transportation, handling costs, tariffs and quotas if any. in most developing countries not only are domestic prices controlled but world market prices do not necessarily reflect the actual costs paid by the final consumers. As we will see, for this reason statistical correlation between cement demand and prices are usually quite spurious.

4.2 Structure of demand

Cement consumption, as observed earlier, is highly correlated with the stage of development of a country. The insights provided by this relationship can have far reaching consequences for a country's investment program in the cement sector. At the earlier stages of development the demand for construction is constrained by a lack of resources, but as growth takes place the demand for cement increases reaching a maximum and then, after falling for sometime is start to stabilize at a lower level.

Chart 4.1 : Stylized trend of cement consumption



The pattern of this highly stylized version of reality is brought out clearly in chart 4.1. The problem with this analysis is that it cannot provide anything more than a general approach. Thus the point of maximum per capita consumption of cement will vary between countries, as will the level at which a stable demand is generated for replacement and a regular level of construction activity. Nevertheless, if policy planners are aware that demand for cement is likely to taper off after reaching a maximum, then the appropriate strategy is to prevent excess capacity at later stages.

However, as explained earlier, the exact points at which a country should accelerate investment and then retrench will require in-depth studies for individual states. As a rule of thumb it appears that countries do not sustain levels of per capita consumption over 1000 kgs per annum. This observation is justified in the light of the experience of some of the Middle East countries. Saudi Arabia reached a peak of per capita consumption of 2186 kgs in 1983, which has been declining ever since. Kuwait having completed its infra-structure earlier has been experiencing falling demand since 1980.

In a recent study on the building material industry, it was found that the elasticity of demand for cement is equal to one when GNP is $390 (in 1965 prices); greater than one when GNP is less than $390; and less than one when GNP is greater than $390 [2]. If these figures were to be applied to the developing countries over 40 percent of them would have elasticity of demand for cement, with respect to GNP, of greater than unity, which implies a considerable scope for expansion of capacity in the developing country's cement sector.

4.3 Mathematical approach

For simplification of models that we use throughout this part is that demand for the capacity in question can be forecast independently of the capacity expansion decisions. Also as stated, the sequence in figure 3.1 illustrates this schematically. We start with a demand forecast and determine a capacity expansion schedule that results in some pattern of costs over time. It is very important that the entire demand, expansion, cost and price problem should be solved simultaneously but such an approach would be very complex. One of the important parameter may come from of governmental subsidies and price controlling that would add to the this complexity.

We avoid these problems by assuming that a demand forecast can be made without knowledge of the expansion schedule. In many practical problems, this is reasonable because demand is simply not that sensitive to price [3]. Also, demand forecasts are difficult to make even for some assumed price structure, without having to estimate sensitivities of the demand in each period with respect to prices in every other period. So the methods that presented here also are useful as a suboptimization within a larger optimization procedure.

4.3.1 Transport model - primal: Given several sources of production, each having fixed production volume, and several consumption points each with a given amount of demand, and the total capacity of the producers in balance with the total needs of the market, determine how the supplies of various plants should be allocated among various demand locations.

Let:

X_{ij} = the deliveries from the i to the point j.

C_{ij} = the transportation cost associated with carrying one ton of cement from production location i to consumption place j.

D_j = the total demand of j.

K_i = the total capacity of the factories located at I.

F = total transportation cost.

(i= 1, ...n) and (j= 1, ...m)

The transportation problem involves the minimization of the total delivery costs:

$$\text{Min } F = \sum_{i=1}^{n} \sum_{j=1}^{m} C_{ij} X_{ij}$$

$$\sum_{i=1}^{n} X_{ij} = K_i \quad , \quad \sum_{i=1}^{n} K_i = \sum_{j=1}^{m} D_j$$

$$\sum_{j=1}^{m} X_{ij} = D_{ij} \quad , \quad X_{ij} \geq 0$$

The problem involves the solution of $n + m + 1$ equations with $n + m + 1$ unknowns.

the equation representing the objective function to be minimized is:

$$F = C_{11} X_{11} + C_{12} X_{12} + C_{13} X_{13} + \ldots C_{1m} X_{1m} +$$

$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

$$C_{n1} X_{n1} + C_{n2} X_{n2} + C_{n3} X_{n3} + \ldots C_{nm} X_{nm}$$

The equations representing the capacity limitation are:

$$X_{11} + X_{12} + \ldots X_{1m} = K_1$$

$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

$$X_{n1} + X_{n2} + \ldots X_{nm} = K_n$$

The equations representing the demand of various location are:

$$X_{11} + X_{12} + \ldots X_{n1} = D_1$$

$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

$$X_{1m} + X_{2m} + \ldots X_{nm} = D_m$$

Given $X_{ij} \geq 0$

Among all solutions for which supply and demand are in balance, the solution which minimizes the transport cost must be selected. This solution provides the optimal utilization of the national transport network.

4.3.2 Market area boundaries - graphical solution: The limited number of the production locations and consumption location make the use of linear programming possible [4]. The model delineates the boundaries of various cement markets for different plants so that the transportation cost to those markets is minimized. To illustrate the model, consider the existence of a linear market with two plants located at distances a and b from their particular ends of the market. Assume that the average cost of the first plant is C_1 and the average cost of the second plant is C_2. The transportation costs are proportional to weight and distance. The total length of the market is L kilometers.

The boundary of the market areas of the two plants has the following conditions:

$$C_1 + f_1 x = C_2 + f_2 y$$

f_1 = the transport cost per unit distance from the location of the first plant to the customer located on the boundary.

f_2 = the transportation cost per unit distance from the second plant to the customer located on the boundary.

x = the distance from the first plant to consumer on the boundary.

y = the distance from the second plant to the consumer on the boundary.

Also:

$$L = a + x + y + b$$

This states that the total length of the market L, is equal to the sum of a, b, x, and y.

The solution will be:

$$x = \frac{c_2 + c_1 + f_2 (L-a-b)}{f_1 + f_2}$$

This equation shows that with increase in the average cost at cement plant 1 or with increase in its freight rate per ton per kilometer, the boundary of the market supplied by that plant should shift inward.

Graphic solutions of the problem are illuminating. Let L represent the length of the market. Assume that the consumers are evenly spread over its length and that their requirements are equal. Furthermore, assume that the length of lines B′, N and B, M represent the average costs at the two plants. The line M, Z′ is drawn in the following manner. For each unit distance the transport cost per ton of cement is calculated and added to the BM, the average production cost. Take a point on line L, for instance r. The distance r from the line MZ′, rr′ represents the delivered cost of one ton of cement to location r. The line MZ′ is referred to as the transport gradient.

It is important to note that when there is no capacity shortage at either production point, the boundary line will be the locus of places at which the difference of transportation cost plus fob average production cost are zero.

Chart 4.2 : Boundary point of market

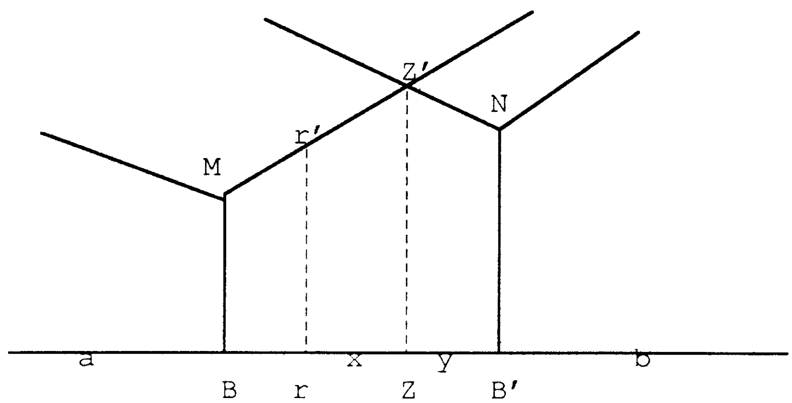
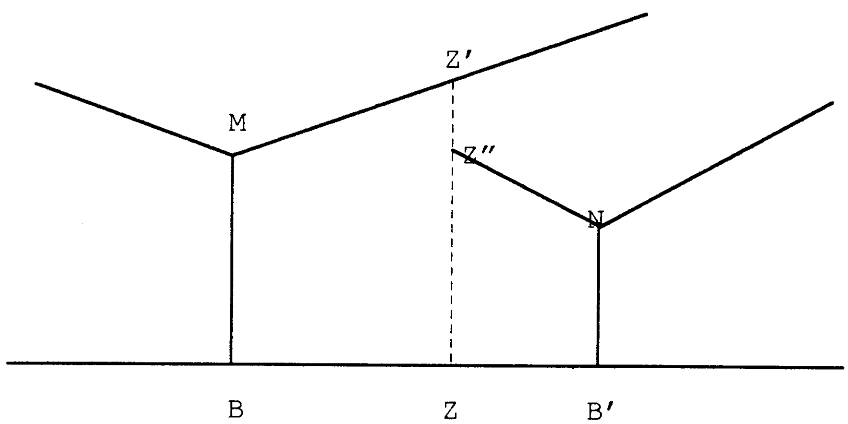


Chart 4.3 : Cost differential at boundary



However, where there is capacity limitation at one location, the market area of the competing producer will expand to fill the that area. Z'Z'' represents the cost differential which will come to exist at location Z.

4.3.3 Market area overlap - stock-out inventory model: When the assumption of linearity of the market is abandoned the same conditions still hold, that is, in the absence of capacity limitation, the boundaries will be the locus of the zero delivered cost difference points and in the case of capacity shortage the boundary lines will be the locus of the minimum delivered cost difference points. Utilizing these concepts the market boundaries can be constructed.

Reduction in cross hauling and market area overlap depends on: First, improved forecasting of the annual seasonal pattern of demand, second, improvement in the timing of governmental and private construction to correspond more to the production cycle and, finally, improvement in inventory policy. The following model indicates the optimum size of inventories.

Let:

$C(Q)$ = the total carrying cost of the inventory, a function of the average number of units in the inventory.

$O(Q)$ = the total ordering cost, a function of the amount of average inventory.

$S(Q)$ = the total stock-out cost, a function of the average inventory size.

The total cost of the inventory decision is given by:

$T = C(Q) + O(Q) + S(Q)$

The total cost function may be minimized by differentiating T with respect to Q and setting the derivative equal to zero and solving for Q.

$dT/dQ = dC/dQ + dO/dQ + dS/dQ = 0$

This implies that $dS/dQ + dO/dQ + dO/dQ = -dC/dQ$. The marginal reduction in the cost of being out of stock and ordering costs which result from adding a single unit of inventory should equal the marginal addition to the carrying costs at the optimum inventory level.

4.3.4 Dual of the transportation model: The problem of allocating available supplies among various demand places may be reformulated in such a manner that the solution to the problem will show what the actual costs are involved in the allocation. In other words, if the market were purely competitive and the supply and demand determined the prices according to the degree of scarcity of various production factors in relation to the local demand, the delivered prices of cement to different location and the profit changes of the various factories would be determined. These prices and profits correspond to the prices and costs determined by the following linear programming model.

Maximize:

$$Y = \sum_{j=1}^{m} D_j V_j - \sum_{i=1}^{n} K_i U_i$$

Subject to:

$$U_i + C_{ij} = V_j$$

$X_{ij} \geq 0$

where:

V_j = the delivered price per ton of cement to location j.

U_i = the cost per ton of cement at plant i.

The constraint indicates that the average cost of the production unit i plus the transportation cost to location j should be equal to the delivered price at location j. The objective function involves the maximization of the profit.

The solution to this dual problem is obtained in the process of solving the prime transportation problem.

4.3.5 Optimal location for new plants: Assume that there is a shortage in the total supply of cement and a need for establishing new factories, how can the location problem be solved at minimum cost? The objective function may be written as:

Minimize:

$$\sum_{j=1}^{m} \sum_{I=1}^{n} C_{ij} X_{ij}$$

Subject to:

$$\sum_{I=1}^{n} X_{ij} = Dj$$

And the capacity of the n production units being:

$$\sum_{j=1}^{m} X_{ij} \leq (K_i + N_i)$$

and:

$$\sum_{j=1}^{m} D_i \geq \sum_{i=1}^{n} K_i$$

$$X_{ij} \geq 0$$

Where:

D_j = the estimated demand for the cement in location j as some future date.

K_i = the present capacity of the cement factories.

N_i = some additional capacity to be built in the future.

Let:

$$\sum_{j=1}^{m} D_j - \sum_{i=1}^{n} K_i = \Delta$$

Where: Δ is the excess of future demand over present capacity.

The problem may be rewritten and solved in the following form:

Minimize:

$$\sum_{i} \sum_{j} C_{ij} X_{ij}$$

subject to:

$$\sum_{j} X_{ij} \leq (K_i + \Delta)$$

$$\sum_{I=1}^{n} X_{ij} = D_j$$

This formulation involves the assumption that the capacity of all production centers may be expanded by an amount equal to the total production shortage which develops in the future. In minimizing transportation costs some of this additional capacity will be used and some will remain idle. Obviously, there is no need to construct capacity which unused. Therefore, to the extent that production is utilized, capacity will expand. Intuitively, it is obvious that the demand of each area will be supplied by the plant in its vicinity, except when the distant location has a cost advantage greater than the additional transport cost involved in purchasing from it.

4.3.6 A dynamic industrial complex model: In the linear programming model regional demand for cement was treated as an aggregate. Planning may be improved when the interrelations between the cement industry and other industries are explicitly recognized. Planning should be multi-regional and multi-industry. In this section criteria for regional and sector division of the cement market will be considered and a dynamic model for cement location will be developed.

Spatially, the demand for cement can be desegregated in different ways. The forms of classification selected by Iran are according two categories, first, specification of the demand in terms of shipment to various urban centers and aggregation of data by province.

This classification corresponds only partially to the location of final consumption. It should be supplemented with further information regarding the amount of cement shipped to other areas from urban centers. It is important to note that demand for cement comes from two types of sources: Distribution center and area location. The distribution centers include major cities. Area locations include minor urban centers and rural areas supplied from major cities. The distinction between the shipment of cement to satisfy the demand of distribution centers and the shipment to satisfy area needs is crucial in determining the optimal scale of operations and the number of plant locations.

Two divergent forces impinge on the location of cement plants. First, there is the centrifugal force of transportation costs and, second, the economics of scale. In order to illustrate the significance of the two forces assume that various cost factors are evenly distributed over space. In this case the problem reduced to a determination of the optimal sales radius, the number and the scale of operating plants.

The real demand can be served only via expenditure of resources to provide the necessary transportation services. The larger scale of operations and the more spatially concentrated the production, the greater will be the average transport cost per customer. The rise in transportation cost counterbalances economies of scale. Let consider the following simple model:

$C = [f(Q) + g(t,D)]/Q$

and:

$D = L(Q)$

Where:

C = average cost.

D = distance, a function of the quantity of sales.

f(Q) = the total cost, a function of the size of output (sales).

$g(t,D)$ = the total transportation cost to area location, an increasing function of the rate of transport cost and distance.

In order to minimize the average cost, the function C may be differentiated with respect to Q and the derivative function set equal to zero and solved for Q.

Production volume and sales radius should expand to the point where the marginal addition to the scale of operations will raise the marginal production and transport cost by an amount equal to the average transportation cost to the consumers, plus the average cost of operations.

For a distribution center the model does not include the variable D and becomes:

$C = [f(Q) + g(t)]/Q$

Where:

t = the average transport cost per ton of cement to the urban center.

With respect to the industrial composition of demand of distribution center the following sectors may be identified as: residential construction (X1), commercial-industrial construction (X2), municipal infrastructure (X3) and, intermediate industrial usage (X4).

For area places the sectors include: rural agricultural-residential construction (X5), rural infrastructure (X6), and national infrastructure (X7).

These sectors may be broken into finer categories:

I.	**dist. cnt. demand**		**Xnm**
	1.	**Residential construction**	**X1**
		Apartment houses	X11
		Small housing units	X12
	2.	**Commercial-industrial construction**	**X2**
		Industrial	X21
		Offices	X22
		Stores, restaurants and parking	X23
	3.	**Municipal construction**	**X3**
		Recreational, educational and social	X31
		Hospital and institutional establishments	X32
		Utilities (Electricity-telephone)	X33
		Gas and petroleum	X34
		Transportation (roads, ports, ports)	X35
		Governmental offices	X36
		Sewer system	X37
		Water system	X38
		Other public structures	X39
	4.	**Intermediate usage**	**X4**
		Ready-made concrete	X14
		Asbestos cement industries	X42
II.	**Area demand**		
	1.	**Agricultural-residential**	**X5**
		Agricultural	X51
		Rural-residential	X52

2.	**Rural infrastructure**	**X6**
	Feeder roads	X61
	Bridges	X62
	Dams	X63
3.	**National infrastructure**	**X7**
	National highways	X71
	National bridges	X72
	Military	X73

The classification suggests the kind of data accumulation which is becoming increasingly indispensable to location planning of cement factories. In the next chapter the significance of various sector to the demand for cement will be evaluated.

The major material inputs into the production of cement include: limestone (X8), clay (X9), gypsum (X10), fuel (X11), and Transportation (X12). Also industries which supply inputs to the cement industry and industries which use cement as raw material are components of the complex. In delineating industries which are tied closely to this complex their input-output relations also should be included.

The fact that the cement industry is an extractive manufacturing operation reduces the number of backward linkages. Also, because cement is primarily used to the construction of fixed asset, it contributes mainly to final demand rather than to intermediate consumption.

4.3.7 The dynamic model: The central problem is to determine the least cost means of meeting the growing demand of various industries. In order to solve this problem the demand of various distribution centers and their subordinate areas should be estimated and different ways of meeting these needs should be explored.

Projection of future fixed capital investment and expected demand of demand of cement using industries, can be drive using capital output or input coefficients. Capital output ratios are used when cement is utilized as an intermediate product.

The demand of distribution center j for cement will be:

$$D^{o}_{jp} = \sum_{i=1}^{n} a_{ijp} \; 0^{o}_{ijp}$$

Where:

a_{ijp} = the input-output coefficient, or the fixed capital output ratio of the particular industry multiplied by the ratio of cement to total fixed capital, for distribution center.

0^{o}_{ijp} = the output of industry i, distribution center at time 0, present time.

Similarly, the cement demand of the subordinate area places of j is given by:

$$D^{o}_{j1} = \sum_{i=1}^{n} a_{ij1} \; 0^{o}_{ij1}$$

j = (1...m)

$i = (1...n)$

The growth of demand in distribution center j and its area places is determined by the following formula:

$$D^t_{jp} = \sum_{i=1}^{n} a_{ijp} \; 0^t_{ijp}$$

and:

$$D^t_{j1} = \sum_{i=1}^{n} a_{ij1} \; 0^t_{ij1}$$

$$0^t_{ijp} = 0^0_{ijp} \; e^{b(i,j,p)t}$$

$$0^t_{ij1} = 0^0_{ij1} \; e^{b(i,j,1)t}$$

$e^{b(i,j,p)t}$ = the exponential growth factor for industry i in distribution center p of location j.

$e^{b(i,j,1)t}$ = the exponential growth factor for industry i in area places of location j.

The increased demand of various industries at different places can be met by expansion of imports or of productive capacity. Since increases in production capacity require lump sum investments, in the short run it may pay to increase import until the growth in demand justifies additions in productive capacity. Alternatively, over capacity may be maintained for a time with exports absorbing the unused capacity. The ultimate decision depends on the export potential of the cement industry and on the cost of imports.

Assuming a fixed productive capacity the differential growth rates of various locations will alter the optimal arrangement of market areas. Given the relatively higher rates of industrial growth in distribution centers, a shortage in cement supplies will be felt most strongly by area market. The reason for this phenomenon is the higher transportation costs to the area markets. As a result there will be greater substitution of the competing materials for cement in those centers.

Import of cement to regions in the vicinity of ports of entry will release supplies for local use. However, growth in demand for cement may outstrip all newly available supplies and imports will have to fill the gap in other regions as well.

In order to indicate the significance of the distribution center and area demand in location distribution and the problems involved in timing the establishment of new productive capacity, let assume that present demand is fully met by domestic production and future additional demand is to be met either by imports or newly established production facilities.

a) The import cost function:

$$C(t) = \sum_{j=1}^{m} \int_{0}^{t} C_{jp}(t)(D_{jp}^{t} - D_{jp}^{0})(e^{-kt}) +$$

$$\sum_{j=1}^{m} \int_{0}^{t} C_{j1}(t)(D_{j1}^{t} - D_{j1}^{0})(e^{-kt})$$

Where:

$C(t)$ = the total cost of imported cement over time 0 to t.

$C_{jp}(t)$ = the delivered cost of imports for location j, over time.

$D^{t}_{jp} - D^{0}_{jp}$ = demand for other industry at location j, over time 0,t.

e^{-kt} = discount factor to covert the costs to present value.

$C_{j1}(t)$ = average delivered cost to subordinate area j,over time.

The C(t) states that total cost of imported cement for a period from time 0 to t years is equal to the discounted present value of the imported cement used in distribution centers and their sub-region areas. It is important to note that prices of imports, $C_{jp}(t)$ and $C_{j1}(t)$ are expressed as a function of time. $C_{jp}(t)<C_{j1}(t)$, that is, the import prices to distribution centers are less than area import prices because the imported cement is first transported to distribution centers and then to the subordinate areas.

b) The domestic cost function:

As the demand for cement builds up to a particular level it becomes profitable to produce cement domestically. The cost of domestic production includes the present value of the lump sum investment in fixed assets I, plus the present value of all operating costs including production and transportation costs.

$$H(t) = I\, e^{-kt} + \sum_{j=1}^{m} \int_{t}^{v} h_{jp}(t)\,(D^{v}_{jp} - D^{t}_{jp})\, e^{-kt} + \sum_{j=1}^{m} \int_{t}^{v} h_{j1}(t)\,(D^{v}_{j1} - D^{t}_{j1})\, e^{-kt}$$

Where:

v = the time when full capacity is reached.

$h_{jp}(t)$= average cost of 1 ton cement at distribution center j.

$h_{jl}(t)$= average cost of 1 ton cement at area j.

The function H(t) is sum of three terms of PV of investment, PV of supplying cost from urban distribution center and, PV of supplying area sub-region.

As an example consider the dismantling a small factory located near a rapidly expanding center and its relocation in a less densely populated area which lacks a nearby supplier. The costs of relocation and the benefits are given by the following function:

$$F = C_0 - \int_0^t Q_0 e^{at} (F_1 - F_0) e^{-bt} dt$$

Where:

F =the total cost involved in plant relocating.

C_0 =the costs of dismantling and reassembling.

Q_0 =the demand at the less density location.

F_0 =the average of production and transport costs per ton before relocation.

F_1 =the average of production and transport costs per ton after relocation.

e^{-bt} =the discount factor.

e^{at} =the growth factor of cement demand.

If average of transporting cost do not change with increased demand and integrating function:

$$F = C_0 + Q_0 (F_1 - F_0) \int_0^t e^{(a-b)t} dt$$

$$F = C + Q (F - F) [e^{(a-b)t} / (a-b) - 1]$$

The cost saving for the new plant will have a similar expression with the only difference that C_0 will be the initial costs of fixed assets and the second term in the F function will present net saving in operating and transportation costs. Let present this function by L. The replacement will occur if $L-F > 0$.

Various modifications may be made in the assumptions of this model to suit particular problems of policy making. Obviously, the question of optimal scale of operation and location under dynamic conditions is a complex phenomenon. If one delays investment it may be possible to establish a large plant with lower average cost, or a plant at a better location in terms of future needs. This type of problem can be studied by simulations as shown in the next section.

4.4 Simulating of cement plant location

The multitude of alternatives available makes analytical solution of plant location problem extremely difficult. Only partial answers for particular aspects of the location problem using linear programming or methods of differential and integral analysis have been developed.

An alternative approach is to design a computer program and scan the cost of various courses of development. The main components of the simulation model are summarized below.

a) Simulating the cement demand: The country can be partitioned into n distribution centers and their subordinate areas. The industrial mix of each distribution center and its sub-region is determined. The input-output and capital-output ratios for various industries are estimated. The output of various industries are projected into the future under various assumption regarding industrial growth rates. Cement requirements are estimated using input-output and capital-output coefficients. These coefficients can be varied over time to examine their impact on cement demand.

b) The cost of supplying cement: Various promising combination of the following factors should be considered in determining the location and size of cement factories.

b.1 The capacity of cement plants may be vary between 150,000 to 1,500,000 tons per year. Also each capacity involves a particular average cost of production.

b.2 N potential centers for locating the new plant are specified. The average transport cost from each existing center to all distribution centers and their subregions is estimated. In this regard the ports of entry of imports should be treated as other production locations with unlimited supply capacity at international prices. And the export markets are treated as any domestic consumption center.

b.3 A planning horizon of H years is specified. The estimates of demand should range over this period.

b.4 The costs of relocating present or future factories to alternative places is estimated.

We have examined the conditions of the Iran cement industry, as a case sudy, in light of the models that discussed in this part.

5. Appropriate technology

5.1 Definition

In recent years the concept of appropriate technology seems to have shown many more complexities than technologists and economists used to think in their early studies and field surveys. The extremely various conditions in which technology transfer takes place in developing countries seems to prevent a clear-cut, absolutely valid definition of "appropriateness", acceptable and applicable in all cases.

Appropriate technology is generally viewed as being the technology mix contributing most to economic, social and environmental objectives, in relation to resource endowments and conditions of application in each country.

Adaptive or appropriate technology are often concepts used in technology transfer, particularly when applied to the introduction of advanced technology into developing countries. As import of technology by developing countries consumes a significant percentage of their GNP (10-19%), technology transfer must be planned as an integral part of development policy [1].

5.2 Technological appropriateness

The nature of the concept is manifold and context-dependent, and the evaluation of technology assessment and impacts must consider technological, economical, social and political dimensions, none of which can principle be easily reduced to the other.

Depending on economic and geographical contexts, more attention should be given either to local factors or to factors relating the region under study to a broader market area in which economic processes take place [2].

Thus criteria for technological assessment should not only assume the appropriateness of technology in terms of flexibility and adaptability to a local context, but also should take account of the possible diffusion effects within an integrated market area [3]. From this point of view the issue of appropriateness has become interesting even for the more developed industrialized countries, affected with serious problems of unemployment, geographic and sector disquilibria.

Nine characteristics are considered to be essential for the definition of an appropriate technology [4]:

- low capital cost per job;
- low capital cost per unit product;
- low capital cost per unit plant;
- simple product manufacturing, use and maintenance;
- simple organization of the production process;
- placed in the traditional sector of the economy;
- placed particularly in the rural sector, comprehending the most part of employed people in the developing regions;

- small scale plants, to make them accessible and operationally feasible in a context with low capital availability and low managerial and entrepreneurial capabilities;

- close self supporting economy, relative financial and technical independence from abroad.

The proposal by Stewart presents two problems:

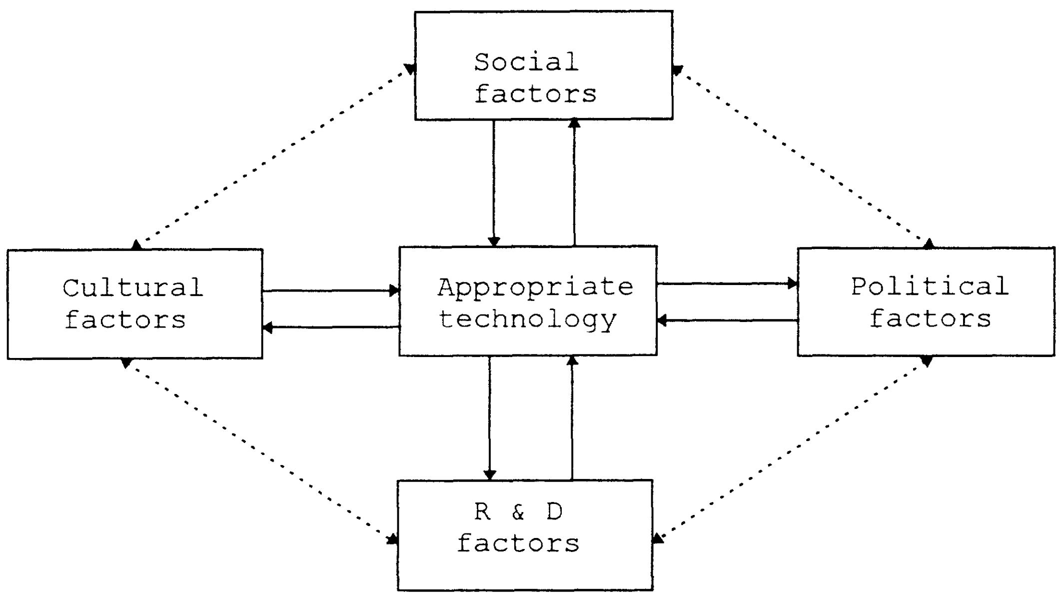
- it is essentially qualitative, and quantification seems to be difficult;

- it is focused on the problems and needs of the Third World.

Significant examples of intermediate technologies, according to this classification are presented by many authors [5].

Appropriate technology can be viewed as a dynamic and flexible concept, which must be responsive to varying conditions and changing situations in different countries. It is also true that different levels of technology are acceptable in the same country, if conditions warrant such variations. Every technology used should be appropriate, that is, it should present the best alternative with regard to the other factors of production. The adoption of such technology should be balanced with social, political, and cultural objectives and constraints (figure 5.1).

Figure 5.1: Factors affecting technology appropriateness in developing countries.



5.3 Factors affecting appropriate technology selection

Although there are many factors affecting the selection of appropriate technology, such as the as know-how availability and infrastructure, but the main competitive advantage in developing countries is cheap labor and in other hand lack of the capital. So if the capital is limited and labor abundant and cheap, then labor intensive technology is appropriate. If such technology does not exist, it should be developed in such a way as to be competitive economically and more acceptable socially and politically than any other alternative technology. In some developing countries, the unskilled labor available does not facilitate application of the technology required. Wages for the needed skills may actually be quite high, but upgrading skills requires programs of education and training which are essential, but fall outside the domain of specific operation. As a consequence, one may have to accept advanced technology as being appropriate under certain conditions. In cases where a social cost-benefit analysis justifies commercial operations, lower efficiency is acceptable as a means to maintain higher employment levels. Also, higher costs could become acceptable as a means to support new industries. Where neither of scenarios exists, it is suggested that the choice should still be labor intensive technology because of its ultimate goal of providing employment for many and raising the standard of living.

Apart from the major considerations with respect to labor and capital intensiveness, several other factors should be taken into account in evaluating technological alternatives.

5.3.1 Cost efficiency:

Production costs and end product pricing will effect the choice of an alternative appropriate technology. Some situation may necessitate higher prices for a limited period until technological efficiency can be achieved. In such cases, the higher costs must be compensated by the realization of broader socio-economic objectives. Long term survival however will depend on achieving technological efficiency and bringing costs down to a competitive level.

5.3.2 Energy consumption:

The energy consumption needs of each alternative also must be evaluated. For example, type of fuel may well determine the future technology employed in cement plants. Energy consumption must be weighted against energy resource availability.

5.3.3 Employment opportunities:

Each alternative must be evaluated on the basis of its ability to provide the maximum employment specially, rural employment to the society. The most direct way of raising the lowest income is to raise the zero incomes of the unemployed. In developing countries, employment of any kind is an advance over no employment since it provide income, however modest.

5.3.4 Renewability of resources:

An important consideration is whether the resources required are renewable or non renewable. The short and long term goal of developing countries should be towards resource economy, which include resource conservation, and waste minimization.

5.3.5 Training and education:

The degree of training and education necessary to implement an appropriate technology must be evaluated in selecting an alternative. The availability of training and education resources must also be taken into account, especially as they effect maintenance and repairs.

5.3.6 Environmental effects:

As in many cases, the effect of environmental conditions on the choice of technology must be considered in evaluating alternatives. The political, economic, and social climate should be evaluated as a prelude to the technology selection.

5.3.7 Availability of raw material:

The availability of raw materials or substitute raw materials in the host country in some cases is an important consideration in evaluating a given alternative.

5.3.8 Infrastructure:

The availability of the necessary infrastructure to support the new technology is of paramount importance. adequately constructed roads, communication, energy and other related infrastructure will facilitate the adoption of new technology.

5.3.9 Others:

Other factors include the availability of the necessary technical expertise, community acceptance, etc.

5.4 Policy formulation for developing countries

Policies should be formulated to encourage industrialization. The type and direction of industrialization should be specified based on the needs of the country. If employment is an objective, then incentives should be provided to increase employment. Each government can set the tone for the technical manpower needs to support new technology and also provide the necessary incentives to foster that cause. Policies regarding excise duties, sales taxes, and other levies imposed on new industries should be formulated in a manner that will enhance the adoption of new technology. Government incentives can include the development of infrastructure, subsidies for hiring more manpower, and loans to entrepreneurs.

While foreign technology inflow and exchange would continue to be necessary, greater emphasis should be paid on the selection of such technologies and the term and conditions under which they are acquired. Although user enterprises should generally select the technology they consider most suitable, governments might prescribe guidelines in this regard and also increase the bargaining capacity of such enterprises through screening of foreign technology proposals. Policy and institutional measures should also be formulated to encourage the rapid absorption and adoption of such technologies to local conditions. The extent to which national policies and programs should be oriented towards technological development would necessarily have to be related to specific country situations.

5.5 Technology level

Technology can be developed either by adapting foreign technologies which are appropriate elsewhere or by producing technologies. In one case, technologies are transferred and made appropriate by adaptation. In other case, it is appropriate by design. But as there are both advantages and disadvantages of modern and intermediate technologies, it is obvious that neither the high nor the low technology, will achieve the desired goals of developing countries [6]. What is necessary is an integrative strategy of selecting and applying both high and low technologies which are appropriate.

5.6 The optimal mix of technology

A developing country needs technologies of different sizes and sophistication. appropriate technology is a mix of modern, intermediate and simple technologies [7]. Appropriate technology should aim at a better balance of the three levels of technology in order that technological contributions to the development process become more effective.

6. Technology transfer

6.1 definitions and concepts

The return effects on an economy are complex and if the effects coming from transfer of technology are more complicated because of the variety of factors involved. Furthermore, transfer of technology covers two separate situations, the transfer of industrial production capacities, and the transfer of capabilities to master, adapt and further develop imported technology. The two sorts of transfers do not necessarily occur at the same time or at the same rate.

6.1.1 Technology

The world "Technology" is derived from the Greek words. "Techne" with meaning art, or more descriptively, craft as implied in the definition of the applied arts and "Logos" with meaning word, discourse or knowledge. Thus in meaning, the word technology is knowledge of the practical or industrial arts, or the knowledge of how craft or industry is wrought.

Apart from very broad definition such as, technology is the body of knowledge that is applicable to the production of goods, the main feature of most definitions is that they highlight one or more special aspects of technology, such as its subject, method and type, whether it takes a material or non-material form, or else its legal or systemic characteristics [1].

This suggests the range of perceptions regarding the nature of technology and the difficulty of finding an all embracing definition. A further point is that while technology is embodied in tangible products such as machinery or industrial complexes, or in legal documents such as patents, licenses or know-how contracts, it may also be expressed in the form of skill, a practice or even a technology culture which finally becomes so diffuse that it is no longer noticed [2]. However, it is on such a culture that the proper functioning of a given technical system ultimately depends. For example, a firm wishing to transfer a particular technology for the first time ever may have to produce a vast set of written rules and descriptions defining its management shop-floor practices [3].

This cultural aspect of technology has led some authors to say that technology is, in fact, the use of scientific knowledge by a given society at a given moment to resolve concrete problems facing its development, drawing mainly on the means at its disposal, in accordance with its culture and scale of value [4]. However, the clarity of this definition has to be set against its applicability. Furthermore, to avoid of restricting and limiting, the definition used here must be confined to commercial and industrial aspects of technology.

6.1.2 Technology transfer

"Transfer" covers a whole range of activities. It may be defined, however, as the process by which science and technology are diffused throughout human activity [5]. This can be either transfer from more basic scientific knowledge into technology, or adaptation of an existing technology to a new use. Technology transfer differs from ordinary scientific information transfer in the fact that to be really transferred it must be embodied in an actual operation of some kind [5].

The transfer concept has subsequently become increasingly identified with the systematically organized exchange of information between two enterprises which may or may not be located in different countries [6]. Obviously, the enterprises may belong to different branches and may be at different levels of technical development [7]. Such an exchange may be the object of a formal cooperation agreement.

6.2 The need for technology transfer

There are a number of specific strategies to achieve economic development. Among these are increased savings, international trade, foreign and technology transfer [8]. Increased savings is what is also known as supply-side economics. Whether an increase in savings is achieved voluntarily or by force, increased saving methods have not been very popular in developing countries.

International trade has been and is a popular development strategy. Newly developed countries such as Hong Kong, Singapore, South Korea and Taiwan in particular have achieved their current economic status through successful international trade. However, most developing countries have not been successful in this area and, in fact, there is a little possibility for many of them becoming successful in international trade.

Foreign aid is a logical development strategy. However, because of its political implications and much mismanagement that existed in the allocation and utilization of aid funds the outcome has been near zero.

Finally, technology transfer, if successful, implies increased productivity and ability to produce. Regardless whether the newly transferred technology is used to substitute imports, to stimulate exports or just to develop new domestic industries, it plays a profound role in the economic development process.

Thus, of all the key strategies, technology transfer is considered to be the most effective alternative in economic development. It is desirable to fill gap, which is widening, between developed and developing countries of the world, it is of the utmost importance that there must be successful transfer of technology to developing countries.

In very broad terms there are two kinds of technology that need to be considered by developing countries. Choosing between the two is one the critical controversies of our time. These two kinds are, the most appropriate technology, and, the most up-to-date technology. Proponents of the most up-to-date technology argument maintain that the gap between developing countries and developed countries is already too wide. If developing countries do not receive the most up-to-date technology then the gap between the two groups will be even wider [9]. After all, developed countries are using the most up-to-date technology and are making significant progress.

Proponents of the most appropriate technology argument, on other hand, would posit that most up-to-date technology is not very good for developing countries [10]. They are not likely to take full advantage of the most advanced technology. However, if developing countries were to receive the technology that is most appropriate for their needs and particularly for their abilities, they will make significant progress. In fact, the progress they may make under these circumstances may create greater synergy than developed countries using the most up-to-date technology. Thus, the gap between developed and developing countries may even narrow if appropriate technology is successfully transferred.

6.3 Key dimensions of technology

There is a need for a general model of technology transfer. before such a model can be implemented, it is necessary to understand the specific dimensions of technology. These dimensions must also be accounted for if a successful transfer of the technology is expected. Six such dimensions are, geography, culture, economy, people, business, and government [11].

6.3.1 Geography

With different parts of the world endowed differently in both natural resources and population, different countries or geographic regions have developed differently. Because of geography, some technologies can not be transferred. Thus, all things being the same, geography influences technology transfer in at least two distinct ways. First, if the natural resources or new materials needed to produce certain products by applying the new technology do not exist because of geographic conditions, this will directly affect the applicable technology. Second, even if the country has the raw materials but it may still lack a certain key ingredient, for example water.

6.3.2 Culture

Culture is the sum total of the values, beliefs, and mores that condition life in general and behavior in particular. It is clear that culture plays an essential role as to the need for and acceptability of specific technologies.

Some cultures are more tradition oriented. They may be closed to new technologies, and they may resist the development and adoption of these technologies.

6.3.3 Economy

The economic condition of developed and developing countries implies at least three key situations regarding technology transfer [12].

Situation 1. The poor countries' needs far exceed their capability of absorbing the transferred technology.
Situation 2. Economically advanced countries, by generating, adopting, and most of all by properly utilizing the most up-to-date technology, expand the economic gap between themselves and developing countries.
Situation 3. Regardless of the degree of economic development, the economy dictates, to a substantial extent, the appropriateness of the technology to be transferred.

With regard to the first situation, the developing countries that need technology are limited by their economies as to what technology they can transfer. Some of the special high technologies which require know-how, resources, and infrastructure can not be adopted because of the deficiencies in these requirements.
With regards to the second situation, economically advanced countries, generally enjoy a momentum in the development and transfer of technologies. This momentum further enhances their economic status and creates a greater gap between them and developing countries.

Finally, as suggested in situation three, there are economic limits to technology transfer regardless of the degree of richness. Many rich but small countries, for example Switzerland, cannot successfully adopt high technological, extensive farming like USA.

6.3.4 People

People's behavior and openness are likely to hinder technology transfer. There is a classification of inner-directed, other-directed, and tradition-directed as indicators of the people approach to technology developed elsewhere [13]. With regard to this classification, three distinct types of behavior can be described.

The inner-directed people may not be closed to new technologies, but they like to develop these technologies themselves rather than adopting transferred technology. The other-directed people will be most prone to adopt transferred technology since they are quite open to other people's behaviors. And finally, tradition-directed people are perhaps most closed to the transfer of technologies developed elsewhere. They will not condone development of technology domestically either. They adopt this attitude because they believe the technologies are radical deviations from the tradition and the tradition is the most important guiding factor of the society.

6.3.5 Business

Business is one of the most important vehicle of technology transfer. In both developed and developing countries, multinational corporations are major vehicles of transfer and diffusion of technology [14]. While multinationals pursue profitable returns for their efforts, they make an effort to improve operational efficiency or produce certain technical products. In other case the multinational companies transfer technology through their multinational production networks. Their impact are [15];

Positive impact:

1. They may supplement the local capital which is needed in the developing countries economic development.

2. Additional national income generated by the multinational's technology transfer efforts may encourage the development of ancillary industries and create jobs in developing countries.

3. Additional revenues may be generated for government expenditures.

4. Technology transfer by multinationals may develop the developing countries export potential by the adoption of highly sophisticated technology which would not have come without the multinational company.

5. The developing countries foreign exchange gap may be reduced or the country's foreign exchange reserve may increase.

6. The multinationals may sell technology at a marginal cost that does not include a large portion of the fixed costs which

would have been incurred if the technology had been developed indigenously.

Negative impact:

1. Outflow of dividends or profits, management and royalty fees, and interest on loans and other remittances can be too costly to developing countries.
2. Too much technology transfer may destroy the local "infant" industries.
3. The multinational firm may use scarce local capital and make it scarcer for local industries.
4. Similarly, other scarce resources, such as trained manpower and raw materials, may also be used excessively by the multinationals.
5. Because of the technology transfer through multinationals, certain parallel industry which is totally unconnected to the rest of the developing country's economy may not develop.
6. A "halo effect" may be created by the multinational being an example and local industry's developing inappropriate methods.
7. For a number of reasons, the transferred technology may not be appropriate.

Thus, technology transfer by multinational companies cannot be allowed without close scrutiny. The recipient country often has a lot at stake. A wrong move may significantly widen the gap between the upper economic level, capital-intensive technologies, and lower economic level, local labor-intensive technologies [15].

6.3.6 Government

Governments, directly or indirectly, play a vital role in technology transfer. Among the direct roles of the government of the recipient are:

1. specifications of national needs or approval of the technology;
2. coercion of the domestic industry or political forces to import the technology;
3. involvement in direct importing of the technology; and
4. participation in direct negotiations about the mechanics of importing the technology.

The indirect role governments play in the technology transfer process is, at least, equally important. In this context, first, instead of importing the technology itself, the government may provide special incentives so that certain specified technologies will be given higher priority by the private sector that will take over the responsibility of importing. Second, the government can assist in the process of making the imported technology successful. For instance, many third world countries will provide protection to aid the imported infant industry. Finally, the government has the authority to allow, approve, or reject joint ventures that can be instrumental in the transferring technology [16].

6.4 The basic model of technology transfer

The model presented here, provides insights into the key components of technology transfer. The way these components interact would facilitate or hinder the successful transfer of technology in question.

Five key components are considered in this model, the sender, the technology, the receiver, the aftermath, and assessment (figure 6.1).

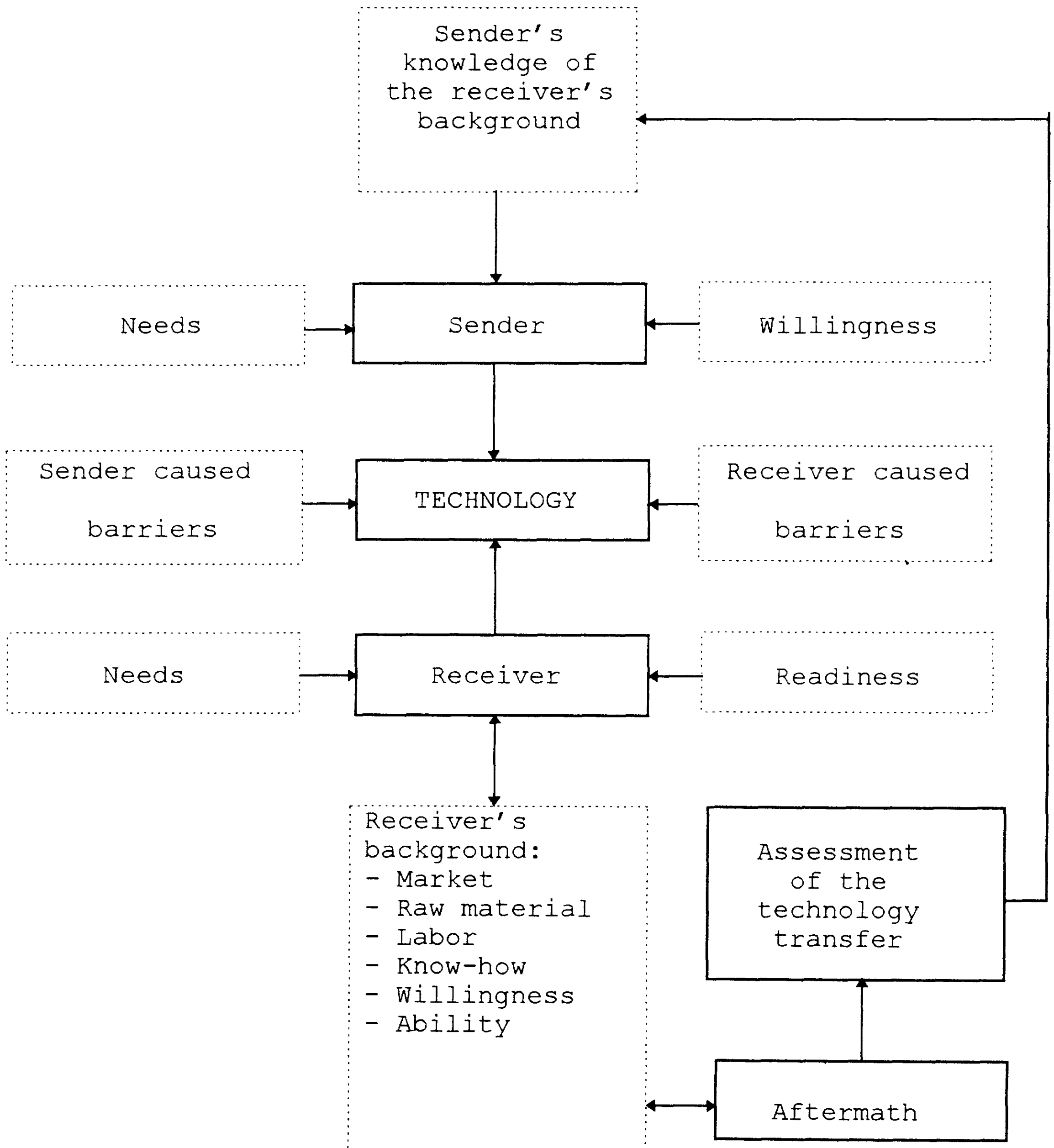
6.4.1 The sender

In addition to being capable of developing the technology to be transferred, the sender must have other qualities. First, the sender must have enough knowledge and sensitivity as to the receiver's background and needs. Second, the sender must have the willingness to send the technology. The sender's needs must coincide with the receiver's needs in such a way that the technology transfer would be a mutually advantageous transaction. Thus, the sender plays a very critical role in the whole process.

6.4.2 The technology

Technology means a variety of things. Many think of it as only the technical heavy equipment aspect of applying modern science to economic activity. It is basically more than just the heavy equipment, however, it is the capability of applying science to economic activity or production. Hence, it includes all the hardware, software, manware, and other supporting activity.

Figure 6.1: The basic model of technology transfer



Determining the appropriate technology that the receiver needs and transferring it effectively are most difficult task. The appropriateness of the technology must be assessed on the basis of all of the factors, five are considered in this model are market, raw materials, economic of scale, labor and machinery [17].

6.4.3 The receiver

The third component of the basic model is the receiver. Each receiving country has different needs, resources, values, and culture. Thus, successful technology transfer implies congruence among the sender's needs and understanding of the recipient's needs. The nature of the technology, and the receiver's priority ordering as to the immediate economic needs. In dealing with the receiver so that a congruence among the sender, technology, and receiver is achieved, three factors can be considered, the receiver's needs, its readiness, and its background.

6.4.4 The aftermath

The direct and indirect impact of the transferred technology must be singled out and evaluated so that future attempts will be more successful. Furthermore, if the aftermath cannot be identified, the overall assessment of the technology transfer cannot take place [18].

Two steps are involved in the total outcome of technology transfer. The first is the aftermath and the second is the assessment. While the aftermath is related to the immediate and mostly the direct impact, the overall assessment is related to long-run and far-reaching outcomes.

6.4.5 The assessment

It is particularly important to assess the outcomes of the transferred technology. The six main areas identified as the key criteria for technology assessment studies are technology, economy, society, the individual, the environment, and the value system [18]. More emphasis is necessary on the development of appropriate structure for social assessment of technology. Without significant progress in this area, total effectiveness of technology transfer cannot fully materialize.

6.5 Barriers to technology transfer

Successful technology transfer implies the technology that is being transferred to a developing country being totally functional. However, there are numerous problems prevailing in the receiving country which are coined barriers to technology transfer [19]. It is identified a minimum of seven such barriers (figure 6.2).

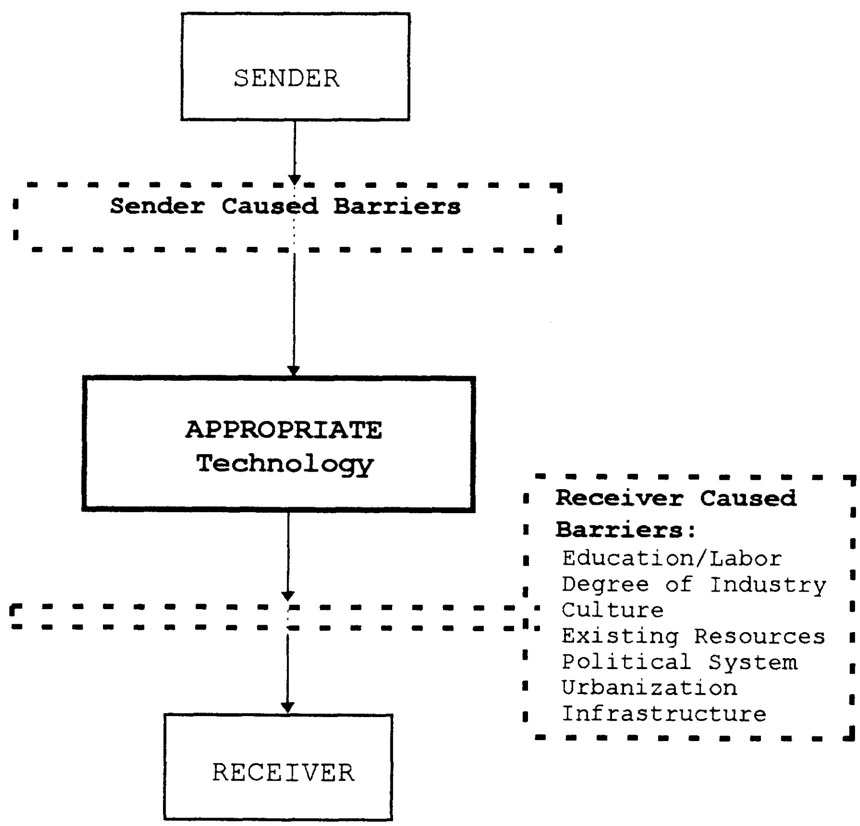
6.5.1 Education / Labor

If the educational level of the receiving country is less than adequate so that the laborers of the country are not informed, technology may not be total impossible the technology cannot be absorbed.

6.5.2 Degree of industrialization

Certain technologies requires a specific degree of industrialization. If receiving country lacks that particular required degree of industrialization, the technology cannot be transferred.

Figure 6.2: Barriers to technology transfer



6.5.3 Culture

Culture-related values and attitudes can be very instrumental in accepting or rejecting new technologies.

6.5.4 Existing Resources

Different countries have varying levels of resource endowments. If the proposed technology requires certain necessary resources which are less than adequate in the receiving country, it will not be very wise to transfer that particular technology.

6.5.5 Political Systems

If the existing political structure is such that those who have the power are not likely to delegate or give it up then technology transfer may be intercepted. This is due to the fact that with the new technology comes new knowledge and power. This situation is likely to change the existing power structure.

6.5.6 Urbanization

The more rural the receiving country, the more difficult it is to transfer the technology in question. If the population is more spread out and very rural, then there may not be adequately concentrated industrial centers which may complement and supplement the technology in question. The conditions therefore could be quite adverse.

6.5.7 Infrastructure

The infrastructure implies the necessary institutional makeup as well as the necessary physical conditions for transferring technology. If the country were to import first generation communication systems but does not have the necessary institutional structure to generate and desegregate the information, the transfer of such technology will be impeded [20].

Thus, even though the most appropriate industry is decided upon, its transfer is not likely to be smooth if any of these barriers exist. As can be seen, almost all of these barriers are long-term related. None of these can be eliminated in very short period of time. However, it is necessary to create certain condition for the technology to be transferred and become effective in short run.

6.6 Technology transfer effectiveness in developing countries

There is a need to continually evaluate the effectiveness of technology transfer with respect to the particular sector in which the technology was applied and with respect to the overall development plan and environment of the developing country. Furthermore the evaluation must include consideration of changes in the external environment to ensure that the continuos trend of technology transfer to a developing country is in line with changes in the internal and external environment. In this manner can we assure that technology transfer will become more effective, and make a meaningful contribution towards closing gap between developed and developed countries.

For technology transfer to a developing country to be effective, it should form part of national, regional, or local development policy, otherwise it forms a small, disjointed technical anomaly which soon disintegrates [21]. Also include effective resource planning and allocation so that follow-up requirements of the new technology, such as spares, are properly provided for. Risk and uncertainties which are involved in technology transfer must be understood. Such risk include the risk of environmental (society, labor, etc.) acceptance of the change.

Also effectiveness of technology transfer to developing countries is subject to a long term and continuos process. Finally, it is important to evaluate institutional constraints as part of technology transfer planning to assure their resolution or acceptance in transfer plan.

7. Research and development

7.1 Definition and purpose of R&D

The classification of R&D, that is used in official statistics in most of European countries and is very similar to the definitions provided by the national Science foundation in the USA, is [1]:

Basic research: is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view.

Applied research: is also original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific aim or objective.

Experimental development: is a systematic work, drawing on existing knowledge gained from research and practical experience, that is directed to producing new materials, products and new devices, to installing new process, systems and services, and to improving substantially those already produced or installed.

Very few organizations can afford to genuinely conduct basic research. Therefore the word "research" will be assumed to refer to "applied research" unless "basic research" is explicitly mentioned.

7.2 Role of R&D in developing countries

The ultimate aim of a national R&D Institute is to help the country achieve sustainable economic growth. This overall aim is translated into specific objectives and targets. Two problems are interface, goals are many, and resources are limited.

The lessons from experiences of developed countries point out to the unassailable conclusion that the R&D system constitutes the core of a nation's technological capability. developed countries spend 2-3% of their GNP on R&D , whereas developing countries spend only 0.1 to 0.8%. In absolute terms, this difference will appear even longer [2].

The plurality of goals is due to the fact that there are so many different activities essential for overall development. Some activities are essential for satisfying short-term wants while others are essential for satisfying long-term needs. The activities also differ when various uses of technology are considered such as for human need satisfaction, for increasing productivity, for gaining competitive advantage in the international trade, for self-reliance, etc.

7.2.1 Dimensions of R&D management

From the viewpoint of developing countries, who have both advantages and disadvantages of being late-starters in producing technologies, the management of R&D activities is a complex task. In order to appreciate the complexity of this task, it is necessary to note the multiple dimensions involved [3]:

- Includes multi-scope options in terms of subject, size, territory, sponsorship, involvement, etc.
- Incorporates multi-constituency or multi-sectoral needs of a wide range of social groups.
- Concerned with multi-ordered risk with wide range of costs and possible impacts.
- Demands multi-frame balancing of immediate wants and future needs.
- Requires multi-criteria optimization of maximizing positive effects and minimizing negative effects. and
- implies multi-disciplinary problem solving approach.

7.2.2 R&D project selection and evaluation

There are two distinct aspects of problems, organizational budgetary allocation, and project selection.

Stochastic programming and stochastic networks are found to be useful techniques to find resource allocation solutions. Studies indicate that R&D ideas are generated and proposed continuously, but funding in industrial and government R&D organizations is made on an annual basis [4].

Measurement of values becomes a critical issue in applying quantitative models for R&D project selection and evaluation [5]. The criteria commonly used for project selection and evaluation are:

- Direct and indirect economic contribution.
- Utilization rate of local resources and people.
- Contribution to the existing technology in the country.
- Chances of successful completion of project in terms of objective, duration and resources required.
- Social contribution. and
- scientific contribution.

7.2.3 Budgeting aspects of R&D

In most R&D organizations, budgeting and resource allocation decisions are made by top management, with R&D project leaders and individual scientist making proposals. Two problems generally encountered are, the lack of awareness of overall organizational and national goals at research level, and the lack of awareness or confidence in the technical capability and project potential at the top management level.

For R&D organizations, generally three basic questions are asked:

- What activities constitute R&D?
- Should R&D be charged against income when incurred or deferred and amortized against future income?
- What R&D information should be disclosed in financial statement?

The control of the R&D process can be financial, technical, or both. The common practice is to focus on cost as well as time and quality control [4].

7.2.4 Role of information in R&D activities

The role of scientific and technical information is central to the success of R&D activities. The R&D process is basically a process in which ideas, rather than physical hardware, are transferred from initiators to users through a variety of user levels. Thus, the ability of the R&D organization in this process to identify, acquire, and utilize scientific and technical information is of paramount importance to the efficiency of the process. The fact that these ideas and knowledge deal with, or are embodied in hard technologies should not obscure the observation that innovation in general, and R&D, in particular, is an information processing and communication activity [6].

7.2.5 Role of technological forecasting in R&D

One of the important elements of future-oriented R&D planning is forecasting technological trends. This involves anticipating technical innovations, and on this basis, initiating new projects and also abandoning obsolete projects [7]. In developing countries, technological forecasting is almost non-existent. Technological forecasting, in general, and forecasting technological substitution, in particular, can be very useful for R&D activities having the objective of gaining the competitive edge in international trade.

Technological forecasting also gives direction to R&D policy and assists in R&D planning by:

- Predicting the rate of obsolescence of existing technologies and products.
- Identifying potential technologies which can, in the future, substitute present technologies.
- Identifying technologies which are profitable in the long run for setting R&D priorities.
- Predicting breakthroughs for preparing to maintain or secure competitive edge against their effects.

7.2.6 Human resources in R&D

The most important R&D resource is the researcher. Also it is very important to understood that the requirement for R&D employees differ from those of most other organizations. Stubborn, strongly opinionated people which are pretty useless in most functions, can be quite useful in a R&D environment. Conversely, easy going but somewhat superficial people are not the kind of employees which bring about technical innovation, although they may perform satisfactory outside of R&D.

7.3 Problems of R&D activities in developing countries

Most developing countries establish R&D institutes with the declared intention of promoting science and technology activities. The common problems of these institutions have been discussed internationally and are well documented in recent years [8]. Some issues are summarized below.

7.3.1 General inadequacies

Inadequate funds, facilities and manpower are recognized as universal problems faced by R&D institutions. The problem of inadequate funding and facilities is aggravated by spreading them thinly over too many research projects. Most of projects are subcritical levels of funding. This is true for manpower as well. Since science related activities far outnumber development and engineering activities in these R&D institutions, the distribution of scientist and engineers is heavily skewed towards the former. Therefore, the problem of subcriticality of manpower is aggravated by the absence of significant engineering inputs into the R&D activities.

Most of the R&D organizations are in the public sector and usually their compensation system is not tied to performance. Consequently, the activities undertaken often do not get the expected intensive application of mind necessary for viable outputs from research efforts.

7.3.2 Lack of gatekeepers

In today's fast moving technological world, monitoring the evolutionary process and locating the point of departure from which the exploitation of a newly available technology may be worthwhile are critical. High technology centers of excellence usually perform the task of such gatekeepers [9]. The lack of technological gatekeepers in developing countries prevent such a critical activity. Their absence in science and technology infrastructure may result in the loss of many opportunities for technology transfer and development.

7.3.3 planning

Weak or non-existent program planning and mechanism precludes effective pre-appraisal and post-evaluation of research projects. No rigorous selection procedures is followed to determine the fields of research in which developing country can afford to specialize and make a significant contribution, both to improve imported technologies and to produce new technologies.

Emphasis has been placed on the research component, while more emphasis should have been placed on the development aspect [10]. Most basic scientists are engaged in pursuing research, with little effort toward commercialization. There are very few engineers employed in R&D organizations to carry on development activities like pilot plant work. Engineer are not attracted to do R&D work, and existing careers system often does not encourage them to join R&D institutions.

Subcriticality of manpower is also caused by too many projects undertaken. No attempt is made too weed out duplicating subcritical efforts, particularly projects with low potential for productive use.

7.3.4 Linkage between R&D and production system

Very weak linkage exists between the R&D organizations and the production sector, down stream, or human resources development programs, upstream. Consequently, R&D efforts are unproductive and often inappropriate. R&D organizations are run more as academic institutions rather than as industrial enterprises [11]. Support to industry is weak and as the source of knowledge for new industry, R&D organizations are inadequate.

7.3.5 Bureaucracy

The organization and management of R&D institutions are frequently modeled on those of government departments. Thus, bureaucratic relationship rather than a collegial atmosphere dominates the R&D scene. Multi-disciplinary task force approach for the solution of a problem is not followed [6]. As a result, the team spirit and the ability to view a problem from all possible angles are absent. Creativity is not encouraged and standard procedures for generating creative ideas are not adopted. Research budget is often not separated from the overhead and salaries budget. As a result, the real input to research cannot measured [2].

7.4 The role of government in R&D

Nature of government intervention takes various forms and is increasingly taking the shape of direct involvement in all countries. Thus, most governments in the developing countries today have taken major roles of formulation, appraisal and implementation of technology oriented projects.

In the developing countries have always considered science and technology development as a government sector activity. Successes and failures in such activities also largely depended on the political commitment of top leadership, and not on the number of public institutions set up to carry out technology development activities.

The success of Japan, Korea, and to some extent India and China, have clearly demonstrated the favorable result of direct government intervention in assessing the needs and capabilities. However, the government in these successful countries also sponsored and promoted fiscal-cum-legal instruments to create an effective demand for technology and providing pull for innovation. In the process, it created an atmosphere of mutual confidence between the private and public sectors, and government bureaucracy itself. It also helped establish mutual confidence between industry and R&D establishments. Initially R&D institutions derived their programs from the trouble-shooting problems of industries utilizing imported technologies. From this stage, they moved on to the adaptation and improvement of existing process. Ultimately, they were able to create and innovate [12]. In technologically successful countries, the investment in national R&D by private industry has been growth significantly over past ten years [12]. This demonstrates that once the R&D process is set by the government on the right track, mutual confidence grows between the concerned institutions and private sector research becomes viable even in a developing country.

R&D efforts in developing countries should be geared toward both generation of new technologies and successful absorption, adoption and adaptation of imported technology. With these objectives in view government can initiate action programs to support R&D activities.

In determining the degree of support, decisions regarding Gross Expenditure on R&D, GERD, as a percentage of Gross Domestic Product, GDP, is a vital factor. Some of the recently developed Asian countries are aiming toward 3% GERD by the end of this century [13].

Government also has to sponsor:

- Large R&D projects for private industry with long gestation periods.
- Research programs concerned with regional equity, and
- coordinated research involving R&D institutions in the public as well in the private sector.

7.5 Role of private sector in R&D

In the private sector, national organizations for technology exploitation may be right within private companies, private R&D organizations and non-profit-based private foundations. In developed countries, the private sector contributes a considerable share of the national R&D expenditure on science and technology. In Japan, the private sector contributes 68% of the total R&D expenditure on science and technology in the country [12].

Most family-run companies in developing countries are mainly small companies. Small companies with relatively small capital are unable to mobilize funds adequate for R&D activities. Their short-term survival wants tend to squeeze out long-term development needs. In addition, they are in a relatively weak financial position and cannot afford to stand if a project fails. On the other hand, large companies can, without any financial difficulty, put aside adequate funs for R&D activities. In addition, failure of a R&D project does not threaten the existence of the company.

The private sector industries of developing countries can play an important role in technological development. However, they need to be organized and properly guided by legal and fiscal policies in order to effectively contribute to technology development.

8. Learning and human resource development

8.1 Learning

It has been established that transfer of right kind of skill and knowledge is essential so that a recipient country can benefit from secondary innovation. This process helps in attaining technological self-reliance and generates technology export potentials. Obviously, successful technology transfer is closely related to, and in fact, is dependent on the existence of a technology which create an innovative environment in a country.
Technology culture, in more practical terms, refers to the existence of a mass of middle and lower level technical and managerial staff down to and including skilled workmen. Specific trained technician of the developing country is quite comparable to the technician for same job in any developed country. What is required is a technologically trained human resource making it possible for a member of the community to use a machine intelligently.

Creation of such a human resource is a prerequisite for the dissemination of innovation and techniques in any community. Trained manpower of higher skills and knowledge can perform and produce only when such a general base of trained manpower exists [1].

8.2 Creation of technology culture

The creation and promotion of technological environment is a prerequisite for technology development, particularly in countries where social and economic pattern and customs are bound by tradition. Without such an environment there would be too many constraint imported technology to be digested or improved. The major goals of this movement may be:

- To encourage the people to develop a habit of applying elementary technical knowledge to everyday life, and
- to encourage everyone to acquire technical skills.

8.2.1 Mass media

Society should realize that technology is the master key of development. This can be by newspapers, radio and television.

8.2.2 Technological exposition

Technological expositions are very useful means of popularizing technology. These can be organized by urban centers. Roving exhibitions can be quite effective in this regard.

8.2.3 popular technical literature

There is a lack of popular scientific and technical literature in almost all developing countries. Organized efforts should be made to encourage the publication of popular literature. Science and technology societies and clubs can also play a leading role in this.

8.3 Basic education

Education at primary and secondary levels are vital in human resource development. In the developing countries, the primary and secondary school levels should lay more emphasis on science and technology, rather than on liberal arts. This would require a deep commitment from government, including additional resources for teacher training in science and technology and necessary physical facilities.

8.4 Technological education system

It should be recognized that this type of human resources development requires a specialized education and training system. The four major tiers of this technological education systems are: vocational, Polytechnic, technological, graduate and postgraduate.

8.4.1 Vocational education system

These are responsible for the formal training of the large number of skilled workers and craftsmen. Short modular courses, aimed at imparting specific skills to enable a person to be employed immediately, may be effectively used.

8.4.2 Polytechnics

These are responsible for producing the technicians who form the intermediate, supervisory level of technological human resources. A common deficiency of this tier of education in many developing countries is its emphasis on theory, rather than practice. This often means that the products of these institutes are neither engineers nor technicians. Consequently, they are unable to play their due role which is so essential in national development.

8.4.3 Technological education

Leading to graduation, this is typically offered in three types of institutions namely: engineering colleges, departments/faculties of engineering forming a part of multi-diciplinary university, and technological universities /institutes of higher learning. While the suitability of a particular set-up is dictated by tradition and socio-economic factors, experience shows that technological universities/institutions do contribute to acceleration of the pace of human resources development.

8.4.4 Graduate and post-graduate education

R&D is a key element in technological growth. Rapid growth of technology implies that under-graduate cannot impart the specialized education necessary for undertaking high-level R&D works. Setting up institutions capable of imparting post-graduate education in an expensive undertaking. It may not be feasible for small developing countries to set up such institutions in many of the fields. However, international and regional institutions of higher learning can be effectively used to train this high level manpower.

8.4.5 Distance learning

This is an important factor that makes development of human resources a very time consuming process. However, the rapid growth of television coverage in many developing countries and easy availability of radios have enabled many countries to introduce the so-called distance education method. This can greatly reduce the number of teachers required.

8.5 Technological training

The different categories of manpower which constitute human resources require constant training to keep pace with modern technological developments.

Formal training of skilled workers and craftsmen can be imparted in the industries as well as the vocational institutes. These may be in the form of part-time evening or full-time course. Non-formal training programs may be organized by government or by semi-government agencies.

The employee may arrange for in-service training or various categories of employees. Sometimes, this may involve sending them out of the country or bringing in trainers from abroad.

Continuing education for professionals is very often neglected in developing countries. This is usually the reason for the professionals gradual decay in ability and the obsolescence of their knowledge. Universities, polytechnics and other institutes of learning should regularly organize short or medium term courses in specialized areas. This will enable the professionals to keep abreast with the developments in their respective fields.

8.6 Managerial training

Industrial management and personnel management are areas which require special education and training. It may be necessary to establish separate institutes to impart management education and training to the various levels of personnel such as workers, supervisors and managers.

8.7 Planning issues for human resources development

In the absence of technology climate, much of the workforce entering industries find themselves in an environment totally alien to them. There is a necessity for a program to enable proper orientation of personnel at their workplaces. Many training programs in developing countries suffer due to lack of adequate training materials. Training in most sectors of technology has to depend heavily on practical demonstration.

8.7.1 Optimum ratio of human resources categories

It has been stated that human resources comprise various levels of personnel. A very important factor is that, depending on technology mix and the level of technological development, there is an optimum ratio of various categories of personnel. In fact, most developing countries of the Asian and Pacific region suffer from a structural balance in the composition of their technological manpower. Based on data in many countries, the relative proportions are, engineers 15%, technician 60% and others 25%. This implies that for every engineer or higher technologist, there should be 4 technicians [2]. However, the figure is found to be around 1:2 in many developing countries of the region. This imbalance should be rectified by proper planning.

8.7.2 Training by foreigners

In imparting training on newly developed technologies, there are two ways opening to developing countries: foreign training, and in-country training by foreigners. Unless these are properly organized, there can be a gross wastage of valuable resources. Selection of trainees for foreign training should be done with great care, so that people with the right background are sent abroad. Ideally, a person should have a few years of experience in related fields so that he can appreciate better the problems within the context of his own country.

In-country training by foreigners is another method. But care is necessary in selecting the right type of trainer with the requisite background. The trainees should be made to realize the unique opportunity of knowledge and skill transfer. They should be encouraged to acquire as much information as possible in order to rapidly reduce dependence on foreign training in that particular field.

8.7.3 Work environment

This has a great influence on the productivity of workers. A small investment in upgrading the work environment may pay rich dividends not only in form of increased output, but also in boosting the morale of the workforce.

8.7.4 Retaining human resources

The developing countries of the region find it extremely difficult to retain qualified science and technology personnel within the country. In fact, exodus of trained manpower from developing countries is creating a very big vacuum in different levels of technological manpower. It should be recognized that while developed countries are prepared to pay the originating countries the price for natural resources or produced resources purchased from them, they are obtaining human resources from these countries almost for free.

Therefore, the large amount of investment which a developing country has made to produce human resources is very often sold in the international market without any price paid to the country producing it. In a free society, it would be impossible to stop this migration by legislation. A pragmatic human resources development policy should recognize this leakage at various levels, and production targets for different categories of manpower should also be set accordingly.

8.7.5 Remuneration

Experience in many developing countries shows that with proper incentives and recognition, it is possible to attract many nationals working abroad back into the country. The example of South Korea may be cited. It has been found that the feeling for one's home country is so strong that a person is very often prepared to come back. In some cases, science and technology personnel are willing to come back. But lack of decent human treatment in their own country often forces them to go abroad again.

8.8 Role of engineering and consultancy

The aim of the developing countries should be to achieve design and engineering and consultancy capabilities, at least in those areas which are of strategic importance. Technology intensive industries are by nature consultancy intensive ones. From prefeasibility studies to conceptual elaboration of process, design engineering, preparation of vendor's specification, scheduling, procurement, erection, start up and commissioning, the services of experienced consultants are required.

This requirement is usually met in following ways:

-Developing in-house capability in the public sector enterprise;

-Developing independent public-sector consultancy organizations;

-Developing independent private consultancy firms; and

-Engaging foreign consultant.

Most international financial agencies who appoint foreign consultants in projects funded by them state of efforts would be made to train local consultants and develop indigenous design capability. However, actual practice shows that developing countries are becoming more and more dependent on foreign consultants even for projects requiring simple engineering design. This means that developing countries are not only losing their decision-making capability, the morale of their engineers and technologists is also going down.

Therefore, the developing countries should establish viable engineering consultancy organizations. The experience of countries like India and Mexico shows that the high initial cost of establishing such an organization is worth paying for.

9. Case study

9.1 Background to the country

Iran is situated in south-western Asia and borders the Ex-Soviet Union and the Caspian Sea in the north. Turkey and Iraq in the west, the Persian Gulf and the Gulf of Oman in the south and Pakistan and Afghanistan in the east.
There are few cities in central and eastern Iran, where water is scarce, although lines of oases penetrate the desert. Most towns are supplied with water by natural subterranean water canals, therefore, they are located a short distance from the foot of a mountain.

9.1.1 Population

The latest census taken in October 1986, puts the total population of Iran at 51.7 million person. According to population growth rate it estimates above 60 million in 1994. Of the total population, 45.4% is in the below 14 years age group, 51% in the 15-65 years age group and only 3% over 65 years of age. The literate constitute 61.6% of the over 6-year-old population, of whom 84% is in school age, the ratio being 93.1% for the urban and 75.1% for the rural areas, while 52% of the literate are in the 15-year-old age group.

9.1.2 Economic Damages of the war

A committee comprising the representatives of a number of Ministries, Government and non-Government institutions, formed under the auspices of the Ministry of Plan and Budget is concerned with estimating the economic damages suffered by Iran as a result of the Iran-Iraq war. The committee has published its estimates only up to the March 1984. Critics maintain that a defect of the estimates is their failure to study the damages to the private sector thoroughly. Furthermore, while the four-year-old report has set the total damage at $190 thousand million, the Minister of Economy and Finance announced the loss caused by the war at around $150 thousand million in November 1987.

9.1.3 Housing

Housing has been an acute problem in Iran for long and in particular in the last two decades and the development plans have paid special attention to solving it.

Nevertheless, the problem has persisted as a result of extensive rural migrations to the urban areas and the shortage of housing facilities. According to the studies carried out, nearly one quarter of the families in Iran do not own a housing unit.

A further related problem is the low quality of the available housing units. A sample statistics taken at the March 1984 showed that 39.9% of the total of 14,617 sample families lived in residential units less than 50 square meters in area, 33.8% in units between 51-100 square meters in area, 15.8% in units of

101-150 square meters in area and only 10.5% in residential units larger than 150 meters in area [1].

9.1.4 Oil

The Iranian oil industry is 87 years old (since 1908). Oil is one of the major revenue sources of the Government, a sum of $15,000 million per annum. From then onwards, all the oil industry related operations, ranging from exploration to refining, sales and exports have been directed by the National Iranian Oil Company.

9.1.5 Industry

The Iranian industry has undergone a period full of ups and downs. The main manufacturing in Iran are industrial assembly groups heavily dependent on the West for basic materials, machine, parts and technology. As a result of this characteristic, the economic conditions of the last few years, i.e. the strong fluctuations in foreign exchange revenues and the restrictions caused by the Western economic sanctions, have left direct impacts on the growth of industry and disrupted the Government plans.

The industrial experts maintain that Iran's industrial production has failed to reach a desirable level as a consequence of the factors such as foreign exchange problems, power-cuts, depreciation of machinery, low level of industrial culture, etc.

9.1.6 Industrial policies

The industrial policy making bodies have been trying to resolve the above mentioned problems as much as possible by better planning.

Their efforts have, therefore, been concentrated on:

- Importing technology and reducing the technological dependency on industrialized nations.

To achieve this aim, self-sufficiency study groups have been formed to study and research in the methods of manufacturing the parts and basic materials required by the Iranian industries. Moreover, manufacturing technology has been imported along with importing the required machinery. The industrial policy making bodies have been conditioning conclusion of contracts with foreign companies to importation of technology as much as possible. Efforts have also been made to benefit from experience and facilities of the United Nation Industrial Development Organization (UNIDO).

- Training the needed skilled personnel.

To do this, close contact has been established between the educational centers on one hand, and the Ministries concerned with industry on the other. Courses for training the skilled personnel and specialized managers are organized in coordination between the educational organizations and industrial plants to train the latter required skilled personnel.

- Drawing up a plan to suit the present circumstances and the pertinent problems. This plan has given priority to establishment of industrial plants creating larger numbers of jobs, producing for export, manufacturing the machinery required by the industry, and independence from foreign basic materials. In contrast, establishment of foreign exchange-intensive industrial plants has been opposed [2].

9.2 Background to the cement industry in Iran

The Iranian cement industry has developed since 62 years, starting in 1933 with one kiln with a capacity of 100 tons/day, using wet process technology imported from Germany.

At present there are 15 cement factories operating in the Iran with a total capacity of 17.4 million tons pre year. Table 9.1 shows the growth of cement industry and related capacity and utilization of these factories on the basis of 300 working days from 1972-91.

9.2.1 Consumption

Iran has experienced severe shortages in cement during the past 25 years. A continuous and growing shortage has developed since 1973, estimated to have been at least 100% of current cement availability. There are back market in which prices are at least 300% higher than official prices and much higher in urban areas.

Table 9.1: Growth of cement industry of Iran (000-tones/year)

Year	Capacity installed	Growth (%)	Production	Growth (%)	Utilization (%)
1972	2598	-	2831	-	109
1973	3228	24	3308	17	102
1974	3228	-	3375	2	105
1975	4803	33	4529	34	94
1976	5523	15	5366	19	97
1977	5823	5	6076	13	104
1978	5823	-	6228	3	107
1979	7413	27	6140	-1	83
1980	11358	53	8253	34	73
1981	11358	-	8101	-2	72
1982	15576	37	10103	25	65
1983	15576	-	10655	6	69
1984	15576	-	12064	13	78
1985	16200	4	11954	-1	74
1986	16823	4	12148	2	72
1987	16823	-	12852	6	76
1988	16823	-	11926	-7	71
1989	17446	4	12587	6	72
1990	17446	-	14429	15	83
1991	17446	-	15000	4	86

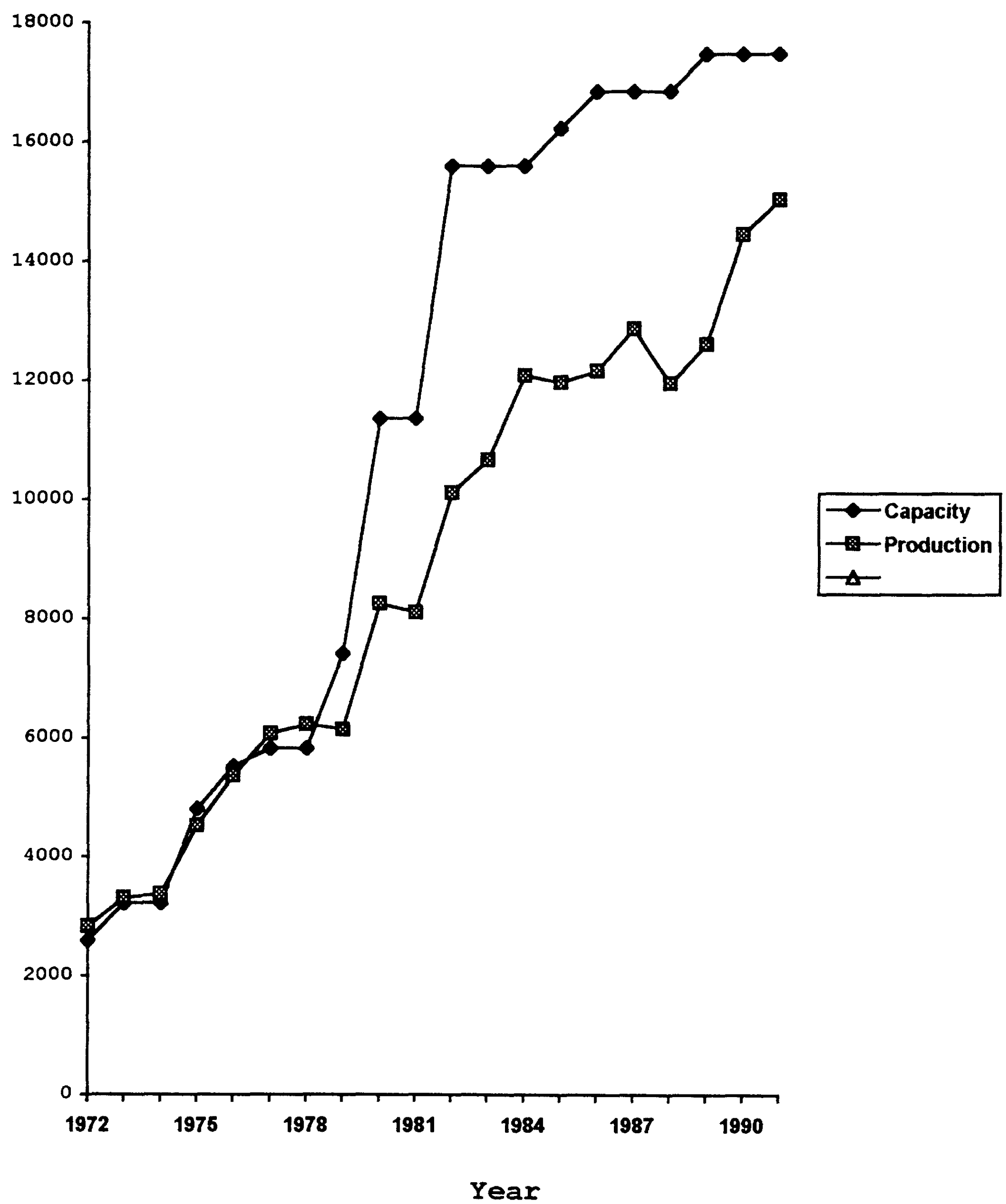
Cement is rationed under a three-tiered system. Public sector users have first priority; users earmarked by government have second priority; and the reminder is allocated to the states for sale in the open market at a semi-controlled prices. The handling of residual open market supplies varies from state to state with some controlling or directly undertaking distribution even in this part of the market. The cement shortage is felt most heavily by private users, but also by high priority users. The present shortage is caused by strong demand growth, slow growth in installed capacity for the last several years and inadequate utilization of existing capacity. The main reason for the recent deterioration in the rate of capacity utilization are power, spare parts, refractories, and skilled labor shortages.

9.2.2 Capacity utilization

Cement industry's past and current record of capacity utilization is somewhat unimpressive (table 9.1). Expect in years 1972-1978, its performance is characterized by a declining trend with occasional spurts now and then. Apparently partial decontrol measures effected in 1990 have had little impact on capacity utilization. The industry just reached a figure of 86% in 1990, suggesting perhaps that prolonged control had extensively crippled the industry and it is yet to spring back to health.

Such a wide variation in capacity utilization is indicative of some problem which may be locational, technological or managerial origin. However, one major factor on which the industry has blamed its low capacity utilization in the past was the controls on the sale prices of cement. After full decontrol

Chart 9.1: Cement capacity, production and utilization in Iran (000 tones/year)



Source: UN (1994), Industrial statistics year book, New York in 1990, the blame has now been shifted to the inadequacy of the government controlled infrastructure facilities like power, labor wages, fuel, transportation and mainly foreign currencies. Beside, there are a host of other causes which can be said to responsible for low capacity utilization. Most of these are within the control of the plant management. Some of the more important ones are:

- Poor industrial relations
- Spare parts
- Operational inefficiency
- Technological constraints
- Managerial competence

9.3 Case of technology transfer through capacity expansion projects

As stated the Iranian cement market has experienced severe shortages during the past 25 years. To cover the shortages, in 1988, the government decided to execute a capacity expansion program above 11.8 million tone per year, in other meaning a total growth above 68% (table 9.2). Also to enjoy such of these high investing projects for savings in foreign currencies expenditure, through performing technology transfer in kiln department. We are going to explain the result of this decision as much as possible in a summarized following steps.

Table 9.2: New cement plants projects (000 tones/year)
Estimate utilization in 1997

Project name	Province	Capacity	Product
Gharb (expansion)	Kermanshah	600	Gray cement
Neka (expansion)	Mazandaran	600	"
Shargh (expansion)	Khorasan	600	"
Khash	Sistan & Baluch.	600	"
Kordestan	Kordestan	600	"
Ghaen	Khorasan	600	"
Hormozgan	Hormozgan	1800	"
Ilam	Ilam	600	"
Ardabil	East Azarbayjan	600	"
Bojnourd	Khorasan	600	"
Yazd	Yazd	600	"
Shahrud	Semnan	600	"
Hegmatan	Hamadan	600	"
Ekbatan	Hamadan	600	"
Abadeh	Fars	150	"
Esfahan (expansion)	Esfahan	300	"
Khouzestan	Khouzestan	1800	"
Total capacity	_	**11850**	"

9.3.1 demand forecasting and plant location

The first method applied here is to use past consumption trends to generate future demand. The main virtue of this approach is the simplicity and frugality of requisite data. Two important objections should be noted. First, the use of past consumption to forecast future demand does not take account of unsatisfied demand. In most developing countries such Iran, imports are restricted by quotas and non-price rationing is common.

An alternative technique to predict demand is to use regression analysis. Due to the lack of suitable data which can accurately measure economic concepts, such as real disposable income and appropriate relative prices, proper regression forecast equation are a matter of trial and error.

To find the optimum points for location new plants or expansion capacity of existing factories we have used the geographical latitude and longitude. The distance on the geographical latitude is run with the same method to minimize the objective function to determine in order to specify the optimum geographical latitude. The summary and some calculation are attached as appendix 9.1.

The result of our calculations to forecast and shortages (surplus) is shown in table 9.3, and also best location for future plant in table 9.4.

Table 9.3: Demand forecasting (000 tones)

Province	**Estimated production in 1997**	**Shortages (surplus) in 1997**	**Shortages (surplus) in 2002**	**Shortages (surplus) in 2007**
Tehran	3818	1286	2156	3175
Markazi	780	(140)	(31)	97
Gilan	727	494	703	946

Mazandaran	1248	771	1115	1518
E. Azarbayjan	2203	244	661	1150
W. Azarbayjan	811	809	1464	785
Kermanshahan	1248	287	436	(68)
Khouzestan	1758	1062	1331	409
Fars	1406	484	806	1184
Kerman	1241	(306)	(146)	41
Khorasan	2384	725	1256	1876
Esfahan	3234	(1293)	(961)	(574)
Sistan & Baluch.	624	82	202	343
Kordestan	624	514	669	251
Hamadan	780	117	271	450
Charmahal & Bak.	0	373	436	511
Lorestan	1451	(649)	(513)	(352)
Ilam	624	(223)	(185)	(316)
Kohkiloyeh	0	483	566	663
Bushehr	0	339	396	464
Zanjan	2340	(1403)	(1244)	(1057)
Semnan	624	(379)	(338)	(259)
Yazd	624	(283)	(225)	(157)
Hormozgan	1560	(1115)	(1039)	(950)
Total		**2279**	**7783**	**10100**

Table 9.4: Locations for starting new cement projects for 1997 (000 tones/year)

Province	Capacity needed	City
Khorasan	1256	Neyshabur
Mazandaran	777	Amol
Gilan	703	Lahijan
Tehran	627	Tehran
E. Azarbayjan	661	Mianeh
W. Azarbayjan	1464	Naqadeh
Kordestan	669	Sanandaj
Kohkiloyeh	566	Dehdasht
Khouzestan	424	Ahwaz
Fars	581	Jahrom

9.3.2 Technology transfer

The primary purpose of technology transfer agreement attached to the machinery and engineering contract of kiln department was:

a) To make available to, and put at the disposal of buyer the basic technical documents with the right to use and utilize such documents for the design and engineering of 2000 tpd cement plants and carrying out other related services in Iran.

b) To receive and train buyer's experts at the supplier's design office in conjunction with carrying out the project services and design work under the contract.

c) To review and approve the drawings and documentation prepared by buyer in its own design office in relation to the project(s) services and design work undertaken by buyer during the project phases.

d) To cooperate with buyer in exchanging information and experience in the field of design, engineering, operation and maintenance of plant(s) and any substantial improvement relating thereto according to the provisions of contract.

9.3.2.1 Phases of cooperation

The objective outlined, here of shall be three phases described below:

a) The first phase shall be implemented in conjunction with the carrying out the project services and design work under the contract(s). This phase also included:

- The provision of the basic technical documentation for cement project(s).
- The receiving and training of buyer's experts at the supplier's design offices and at the facilities and workshop in which the equipment are being manufactured.
- To supply the complete basic technical documentation prepared by the supplier under the contract(s).
- The provisions of technical assistance including the dispatch qualified experts to supervise the manufacturing of the local manufactured machinery and rending technical assistance during their manufacturing.

b) The second phase shall commence within 5 years after the effective date and shall run for a period of 5 years thereafter. During this phase, the supplier and buyer will exchange experts in order to exchange information, knowledge, expertise and experiences in relation to the project(s). Also during this phase the supplier shall, if requested by buyer, assist buyer with, and render the required services for the modification, converting, or renovation of the existing cement plants in the Iran and the project services and design works in connection with up three cement plants.

9.3.2.2 Evaluating the results

We assess the result of this contract at 1994. The buyer saved 55% in foreign currencies needed for supplying machinery for such of these project and now, has ability to produce kiln department machinery equal to 55% of value and above 85% of weight (table 9.5).

Table 9.5: Technical results of technology transfer agreement of cement kiln department according to the machinery weight

Machinery	**Foreign supply (%)**	**Local supply (%)**
Preheater Pr-type	5	95
Preheater fan	25	75
Elevator	0	100
Compressor station	50	50
Rotary kiln	15	85

Kiln main drive	70	30
Kiln auxiliary drive	100	0
Tertiary air line	30	70
Kiln burner system	90	10
Calcination burner system	80	20
Thermal oil system	45	55
Heavy oil supply and preparation	100	0
Grate cooler	15	85
Upper housing	10	90
cooling fans	75	25
Hammer crusher	60	40
Cooler dedusting	60	40
cooler exhaust fan	50	50

Appendix 9.1

Iran cement Distribution & planning
Scheduled for year 1997

CAPACITY TON /YEAR	ZANJAN	ILAM	LORESTAN	MARKAZI	SEMNAN	ESFAHAN	YAZD	KERMAN	HORMOZGAN BY ROAD	HORMOZGAN BY SHIP	PROVINCE DEMAND	FUTURE DEMAND
	1244000	185000	513000	31000	338000	961000	225000	146000	1039000			
HAMADAN				31000		240000					271000	
DISTANCE	567	397	337	188	564	479	792	1179	1561	99999		
TEHRAN	1244000					285000					2156000	627000
DISTANCE	93	733	576	289	329	491	677	1064	1501	99999		
MAZANDARAN					338000						1115000	777000
DISTANCE	343	983	826	538	201	664	927	1314	1751	99999		
KHUZESTAN			264000							643000	1331000	424000
DISTANCE	1209	515	305	593	1109	765	1008	1365	1169	390		
CHAHRMAHAL BAKHTIARY						436000					436000	
DISTANCE	614	887	397	398	749	107	422	810	1189	99999		

Iran cement distribution & manufacturing
Schedule for the year 1997

	ZANJAN	ILAM	LORESTAN	MARKAZI	SEMNAN	ESFAHAN	YAZD	KERMAN	HORMOZGAN BY ROAD	HORMOZGAN BY SHIP	PROVINCE DEMAND	FUTURE DEMAND
CAPACITY TON /YEAR	1244000	185000	513000	31000	338000	961000	225000	146000	1039000			
KOH KILOYE BUYERAHMAD											566000	566000
DISTANCE	1246	969	759	1030	1381	739	698	1055	859	99999		
BUSHEHR										396000	396000	
DISTANCE	1308	1141	931	1092	1443	801	760	1117	921	307		
FARS.							225000				806000	581000
DISTANCE	988	1083	811	772	1422	481	440	797	601	99999		
SYSTAN BALUCHESTA								146000			202000	56000
DISTANCE	1698	2024	1534	1535	1541	1244	928	541	1039	99999		
KHORASAN											1256000	1256000
DISTANCE	1017	1657	1330	1212	696	1338	1306	919	1417	99999		

Iran cement distribution & manufacturing
Schedule for the year 1997

	ZANJAN	ILAM	LORESTAN	MARKAZI	SEMNAN	ESFAHAN	YAZD	KERMAN	HORMOZGAN BY ROAD	HORMOZGAN BY SHIP	PROVINCE DEMAND	FUTURE DEMAND
CAPACITY TON /YEAR	1244000	185000	513000	31000	338000	961000	225000	146000	1039000			
AZARBAYJAN SHARGHI											661000	661000
DISTANCE	531	786	690	803	852	1038	1301	1688	2125	99999		
AZARBAYJAN GHARBI											1464000	1464000
DISTANCE	853	804	878	824	1174	1112	1428	1815	2194	99999		
GILAN											703000	703000
DISTANCE	232	904	744	611	551	737	1000	1387	1824	99999		
KORDESTAN											669000	669000
DISTANCE	507	344	418	364	740	652	968	1355	1734	99999		
BAKHTARAN		185000	249000								434000	
DISTANCE	643	208	282	320	753	665	1091	1368	1748	99999		

Iran cement distribution & manufacturing Schedule for the year 2002

CAPACITY TON /YEAR	ZANJAN	ILAM	LORESTAN	BAKHTARAN	SEMNAN	ESFAHAN	YAZD	HORMOZGAN BY ROAD	HORMOZGAN BY SHIP	PROVINCE DEMAND	FUTURE DEMAND
	157000	316000	352000	68000	289000	574000	157000	950000			
HAMADAN		133000	255000			62000				450000	
DISTANCE	567	397	337	189	564	479	792	1561	99999		
TEHRAN	1057000					1000				3175000	2117000
DISTANCE	93	733	576	525	323	481	677	1501	99999		
MAZANDARAN					239000					1518000	1229000
DISTANCE	343	983	826	775	201	664	927	1751	99999		
KHUZESTAN									409000	409000	
DISTANCE	1209	515	305	509	1109	755	1008	1169	390		
CHAHRMAHAL BAKHTIARY						511000				511000	
DISTANCE	614	887	397	772	749	107	422	1189	99999		

Iran cement distribution & manufacturing Schedule for the year 2002

CAPACITY TON /YEAR	ZANJAN	ILAM	LORESTAN	BAKHTARAN	SEMNAN	ESFAHAN	YAZD	HORMOZGAN BY ROAD	HORMOZGAN BY SHIP	PROVINCE DEMAND	FUTURE DEMAND
	1057000	316000	352000	68000	289000	574000	157000	950000			
AZARBAYJAN SHARGHI										1150000	1150000
DISTANCE	531	786	690	578	852	1038	1301	2125	99999		
AZARBAYJAN GHARBI										784800	734300
DISTANCE	853	304	878	596	1174	1112	1428	2194	99999		
GILAN . .										946000	946000
DISTANCE	232	804	744	596	551	737	1000	1824	99999		
KORDESTAN . .		193000		63000						251000	
DISTANCE	507	344	418	136	740	652	968	1734	99999		
MARKAZI . .			97000							97000	
DISTANCE	281	585	118	320	516	291	607	1373	99999		

Iran cement distribution & manufacturing Schedule for the year 2002

CAPACITY TON /YEAR	ZANJAN 1057000	ILAM 316000	LORESTAN 352000	BAKHTARAN 68000	SEMNAN 289000	ESFAHAN 574000	YAZD 157000	HORMOZGAN BY ROAD 950000	HORMOZGAN BY SHIP	PROVINCE DEMAND	FUTURE DEMAND
KOH KILOYE BUYERAHMAD										663000	663000
DISTANCE	1246	969	759	963	1381	739	598	859	99999		
BUSHEHR									464000	464000	
DISTANCE	1309	1141	931	1135	1443	801	760	921	307		
FARS.							115760	77000		1184000	991240
DISTANCE	988	1083	811	1077	1422	481	440	601	99999		
SYSTAN BALUCHESTA										343000	343000
DISTANCE	1698	2024	1534	1909	1541	1244	928	1039	99999		
KHORASAN										1876000	1876000
DISTANCE	1017	1657	1330	1449	696	1338	1306	1417	99999		
KERMAN							41240			41240	
DISTANCE	1157	1483	923	1368	1292	703	287	498	99999		

MAZANDARAN PROVINCE

LINEAR PROGRAMMING RESULTS SUMMARY

THE NEW CEMENT MANUFACTURING FACTORY AT THE RATE OF 2000 TON/DAY IS AT OPTIMAL LOCATION , IN THE GEOGRAPHICAL DIMENSIONS OF

3145' LONGITUDE & 2190' LATITUDE (NEAR AMOL CITY)

CITY	POPULATION	LONGITUDE	LATITUDE
1- GONBAD KAVUS	534775	55,10'	37,15'
2- BABOL	495213	52,44'	36,34'
3- SARI	371673	53,05'	36,34'
4- GORGAN	353343	54,22'	36,49'
5- AMOL	336508	52,21'	36,25'
6- GHAEM SHAHR	284622	52,53'	36,23'
7- BEHSHAHR	219385	53,33'	36,43'
8- NOSHAHR	208173	51,33'	36,39'
9- TONEKABON	160041	50,52'	36,43'
10- KORD KUY	103618	54,02'	36,45'
11- BANDAR TORKMAN	95703	53,59'	36,47'
12- NOOR	78403	52,00'	36,35'
13- ALI ABAD	75077	54,53'	36,54'
14- SAVAD KUH	71616	53,05'	36,10'
15- RAMSAR	60209	49,30'	36,53'

THE RESULTS OF THE PARAMETRIC PROCEDURES USED FOR FINDING THE OPTIMAL LONGITUDE AND LATITUDE OF THE NEW CEMENT FACTORY LOCATION ARE AS FOLLOW :

LONGITUDE (MINUTES)	OBJECTIVE FUNCTION
3120	90053549
3130	88163969
3135	87219029
* 3140	86274139 ***
3145	86891029
3150	87898239
3160	89912309

LATITUDE (MINUTES)	OBJECTIVE FUNCTION
2170	23931370
2175	25462350
2180	21992330
2185	18523310
* 2190	17666334 ***
2195	18550276
2200	22435238

AZARBAYJAN GHARBI PROVINCE

LINEAR PROGRAMMING RESULTS SUMMARY

THE NEW CEMENT MANUFACTURING FACTORY AT THE RATE OF 4000 TON/DAY IS AT OPTIMAL LOCATION , IN THE GEOGRAPHICAL DIMENSIONS OF

2725' LONGITUDE & 2220' LATITUDE (NEAR NAGHADEH CITY)

CITY	POPULATION	LONGITUDE	LATITUDE
1- MAKU	173134	44,30'	39,18'
2- KHOY	267795	44,28'	38,56'
3- SALMAS	123443	44,46'	38,11'
4- ORUMIEH	548946	45,04'	37,32'
5- PIRANSHAHR	60776	45,08'	36,42'
6- SARDASHT	75343	45,13'	36,05'
7- MAHABAD	232205	45,43'	36,46'
8- NAGHADEH	133763	45,22'	36,57'
9- MIANDOAB	314514	46,06'	36,58'

THE RESULTS OF THE PARAMETRIC PROCEDURES USED FOR FINDING THE OPTIMAL LONGITUDE AND LATITUDE OF THE NEW CEMENT FACTORY LOCATION ARE AS FOLLOW :

LONGITUDE (MINUTES)	OBJECTIVE FUNCTION	
2640	111834902	
2660	92555022	
2680	64427634	
2700	59092573	
2710	55636693	
2715	54153026	
2720	53179126	
* 2725	53144106	***
2730	53735006	
2740	54916306	
2760	65100430	
2790	107764198	

LATITUDE (MINUTES)	OBJECTIVE FUNCTION	
2160	143405973	
2200	90793518	
2210	81495264	
2215	78892629	
* 2220	73647558	***
2225	81156433	
2230	83665308	
2250	93700308	
2270	97941563	
2300	105944182	
2350	137876896	

KHORASAN PROVINCE

LINEAR PROGRAMMING RESULTS SUMMARY

THE NEW CEMENT MANUFACTURING FACTORY AT THE RATE OF 4000 TON/DAY IS AT OPTIMAL LOCATION , IN THE GEOGRAPHICAL DIMENSIONS OF

3530' LONGITUDE & 2170' LATITUDE (NEAR NEYSHABOR CITY)

CITY	POPULATION	LONGITUDE	LATITUDE
1- MASHAD	2038388	59,37'	36,16'
2- SABZEVAR	363923	57,43'	36,12'
3- NEISHABOUR	365599	58,50'	36,13'
4- BIRJAND	352687	59,13'	32,53'
5- TORBAT HEIDARIEH	406645	59,13'	35,17'
6- BOJNOURD	332935	57,20'	37,28'
7- KASHMAR	216662	58,27'	35,11'
8- GHUCHAN	255681	58,30'	37,07'
9- TORBAT JAM	219349	60,37'	35,13'
10- GONABAD	93503	58,41'	34,21'
11- FERDOS	76233	58,10'	34,01'
12- GHAENAT	123727	59,10'	33,43'
13- ESFARAIEN	102827	57,16'	37,07'
14- TAIBAD	146012	60,45'	34,44'
15- SHIRVAN	98960	57,55'	37,27'
16- DAR GAZ	65697	59,09'	37,28'
17- TABAS	54103	57,43'	36,25'

THE RESULTS OF THE PARAMETRIC PROCEDURES USED FOR FINDING THE OPTIMAL LONGITUDE AND LATITUDE OF THE NEW CEMENT FACTORY LOCATION ARE AS FOLLOW :

LONGITUDE (MINUTES)	OBJECTIVE FUNCTION	
3510	68169440	
3520	63797440	
3525	62114368	
* 3530	60557028	***
3535	61457658	
3540	62358238	
3550	64247886	

LATITUDE (MINUTES)	OBJECTIVE FUNCTION	
2160	76274450	
2165	74985950	
* 2170	73697450	***
2175	74860153	
2180	80511324	

AZARBAYJAN SHARGHI PROVINCE

LINEAR PROGRAMMING RESULTS SUMMARY

THE NEW CEMENT MANUFACTURING FACTORY AT THE RATE OF 2000 TON/DAY IS AT OPTIMAL LOCATION , IN THE GEOGRAPHICAL DIMENSIONS OF

2825' LONGITUDE & 2245' LATITUDE (NEAR MIANEH CITY)

CITY	POPULATION	LONGITUDE	LATITUDE
1- TABRIZ	1566933	46,17'	38,05'
2- MARAGHEH	419552	46,16'	37,24'
3- ARDEBIL	492820	48,17'	38,15'
4- MARAND	262130	45,45'	38,26'
5- AHAR	337027	47,06'	38,28'
6- MIANEH	249973	47,42'	37,20'
7- MOGHAN	247182	48,03'	39,01'
8- MESHKIN SHAHR	160525	47,01'	38,23'
9- KHALKHAL	139935	48,31'	37,38'
10- SARAB	135939	47,34'	37,57'
11- HASHTROUD	153260	47,00'	39,17'

THE RESULTS OF THE PARAMETRIC PROCEDURES USED FOR FINDING THE OPTIMAL LONGITUDE AND LATITUDE OF THE NEW CEMENT FACTORY LOCATION ARE AS FOLLOW :

LONGITUDE (MINUTES)	OBJECTIVE FUNCTION	
2780	80101313	
2820	56792178	
* 2825	55393345	***
2830	57043662	
2840	60259352	

LATITUDE (MINUTES)	OBJECTIVE FUNCTION	
2240	37648110	
* 2245	36610675	***
2250	37852720	
2260	40716950	

KOH KILUYEH PROVINCE

LINEAR PROGRAMMING RESULTS SUMMARY

THE NEW CEMENT MANUFACTURING FACTORY AT THE RATE OF 2000 TON/DAY IS AT OPTIMAL LOCATION , IN THE GEOGRAPHICAL DIMENSIONS OF

3050' LONGITUDE & 1840' LATITUDE (NEAR DEHDASHT CITY)

CITY	POPULATION	LONGITUDE	LATITUDE
1- BOOYER AHMAD	144544	50,22'	30,38'
2- KOH KILUYEH	166091	51,41'	30,50'
3- GACH SARAN	102461	50,47'	30,21'

THE RESULTS OF THE PARAMETRIC PROCEDURES USED FOR FINDING THE OPTIMAL LONGITUDE AND LATITUDE OF THE NEW CEMENT FACTORY LOCATION ARE AS FOLLOW :

LONGITUDE (MINUTES)	OBJECTIVE FUNCTION	
3020	22619520	
3030	20129250	
3040	19429160	
3045	17579515	
* 3050	17572396	***
3055	18126701	
3060	18631016	

LATITUDE (MINUTES)	OBJECTIVE FUNCTION	
1835	5973059	
* 1840	5339104	***
1845	5893419	

KORDESTAN PROVINCE

LINEAR PROGRAMMING RESULTS SUMMARY

THE NEW CEMENT MANUFACTURING FACTORY AT THE RATE OF 2000 TON/DAY IS AT OPTIMAL LOCATION , IN THE GEOGRAPHICAL DIMENSIONS OF

2320' LONGITUDE & 2120' LATITUDE (NEAR SANANDAJ CITY)

CITY	POPULATION	LONGITUDE	LATITUDE
1- BANEH	70786	45,53'	35,59'
2- BIJAR	115839	47,36'	35,52'
3- SAGHEZ	163472	46,17'	36,14'
4- SANANDAJ	412078	47,00'	35,19'
5- GHORVEH	175763	47,48'	25,10'
6- MARIVAN	153126	46,11'	35,31'

THE RESULTS OF THE PARAMETRIC PROCEDURES USED FOR FINDING THE OPTIMAL LONGITUDE AND LATITUDE OF THE NEW CEMENT FACTORY LOCATION ARE AS FOLLOW :

LONGITUDE (MINUTES)	OBJECTIVE FUNCTION	
2815	20518443	
* 2320	19548738	***
2325	21105733	
2830	22662728	

LATITUDE (MINUTES)	OBJECTIVE FUNCTION	
2110	15770640	
2115	13503365	
* 2120	11741430	***
2125	12000355	
2130	12260280	

KHUZESTAN PROVINCE

LINEAR PROGRAMMING RESULTS SUMMARY

THE NEW CEMENT MANUFACTURING FACTORY AT THE RATE OF 4000 TON/DAY IS AT OPTIMAL LOCATION , IN THE GEOGRAPHICAL DIMENSIONS OF

2915' LONGITUDE & 1880' LATITUDE (NEAR AHWAZ CITY)

CITY	POPULATION	LONGITUDE	LATITUDE
1- AHWAZ	834528	48,41'	31,19'
2- DEZFUL	365087	48,24'	32,24'
3- BEHBAHAN	203860	50,16'	30,35'
4- MASJED SOLEIMAN	224883	49,17'	31,59'
5- BANDAR MAHSHAHR	236112	49,13'	30,33'
6- SHUSHTAR	169204	48,50'	32,03'
7- EIZEH	212241	49,52'	31,51'
8- RAMHORMOZ	142681	49,37'	31,16'
9- ANDIMESHK	87736	48,22'	32,29'
10- SHADEGAN	96297	47,49'	30,38'
11- DASHT AZADEGAN	75195	48,10'	31,33'
12- KHORRAMSHAHR	2592	48,11'	30,25'
13- ABADAN	2117	48,17'	30,20'

THE RESULTS OF THE PARAMETRIC PROCEDURES USED FOR FINDING THE OPTIMAL LONGITUDE AND LATITUDE OF THE NEW CEMENT FACTORY LOCATION ARE AS FOLLOW :

LONGITUDE (MINUTES)	OBJECTIVE FUNCTION	
2880	80101818	
2900	56792178	
* 2915	55893345	***
2920	57043662	
2925	60259852	
2930	60259852	
2940	60259352	

LATITUDE (MINUTES)	OBJECTIVE FUNCTION	
1870	38591901	
1875	36471936	
* 1880	35168243	***
1885	37129638	
1890	39091033	
1895	41115856	
1900	43235821	
1905	45355786	

FARS PROVINCE

LINEAR PROGRAMMING RESULTS SUMMARY

THE NEW CEMENT MANUFACTURING FACTORY AT THE RATE OF 2000 TON/DAY IS AT OPTIMAL LOCATION , IN THE GEOGRAPHICAL DIMENSIONS OF

3220' LONGITUDE & 1715' LATITUDE (NEAR JAHROM CITY)

CITY	POPULATION	LONGITUDE	LATITUDE
1- ABADEH	177122	53,40'	31,11'
2- ESTAHBAN	56422	54,04'	29,09'
3- EGHLID	70775	52,38'	30,54'
4- JAHROM	174397	53,34'	28,33'
5- DARAB	174759	54,34'	28,36'
6- SEPIDAN	76941	54,00'	32,19'
7- SHIRAZ	1126091	52,32'	29,26'
8- PHASA	160889	53,41'	28,58'
9- FIRUZ ABAD	169308	52,36'	28,52'
10- KAZERUN	220720	51,40'	29,36'
11- LAR	231339	54,17'	27,41'
12- MARVDASHT	238496	52,49'	29,51'
13- MAMASANY	173605	50,27'	32,08'
14- NEIRIZ	79964	54,20'	29,12'

THE RESULTS OF THE PARAMETRIC PROCEDURES USED FOR FINDING THE OPTIMAL LONGITUDE AND LATITUDE OF THE NEW CEMENT FACTORY LOCATION ARE AS FOLLOW :

LONGITUDE (MINUTES)	OBJECTIVE FUNCTION	
3090	73149459	
3150	64503759	
3170	54166171	
3210	43669331	
3215	42570332	
* 3220	42323757	***
3225	42445754	
3230	42764349	
3250	43592573	
3270	47567021	

LATITUDE (MINUTES)	OBJECTIVE FUNCTION	
1680	53096543	
1700	48354603	
1710	45998533	
* 1715	45241360	***
1720	45998533	
1740	51795505	
1750	57385307	

TEHRAN PROVINCE

LINEAR PROGRAMMING RESULTS SUMMARY

THE NEW CEMENT MANUFACTURING FACTORY AT THE RATE OF 2000 TON/DAY IS AT OPTIMAL LOCATION , IN THE GEOGRAPHICAL DIMENSIONS OF

3085' LONGITUDE & 2145' LATITUDE (NEAR TEHRAN CITY)

CITY	POPULATION	LONGITUDE	LATITUDE
1- TEHRAN	6037656	51,23'	35,41'
2- DAMAVAND	32177	52,04'	35,43'
3- RAY	433833	51,26'	35,34'
4- SHEMIRANAT	40739	51,25'	35,47'
5- KARAJ	1181715	50,58'	35,43'
6- VARAMIN	317222	51,40'	35,17'
7- GHOM	626133	50,52'	34,38

THE RESULTS OF THE PARAMETRIC PROCEDURES USED FOR FINDING THE OPTIMAL LONGITUDE AND LATITUDE OF THE NEW CEMENT FACTORY LOCATION ARE AS FOLLOW :

LONGITUDE (MINUTES)	OBJECTIVE FUNCTION
3060	23227232
3070	22822992
3080	17418752
* 3085	17051472 ***
3090	13557476

LATITUDE (MINUTES)	OBJECTIVE FUNCTION
2130	40686652
2135	41399258
* 2140	38264279 ***
2145	40103728
2150	43155632

GILAN PROVINCE

LINEAR PROGRAMMING RESULTS SUMMARY

THE NEW CEMENT MANUFACTURING FACTORY AT THE RATE OF 2000 TON/DAY IS AT OPTIMAL LOCATION , IN THE GEOGRAPHICAL DIMENSIONS OF

3000' LONGITUDE & 2240' LATITUDE (NEAR LAHIJAN CITY)

CITY	POPULATION	LONGITUDE	LATITUDE
1- ASTARA	54925	48,51'	38,26'
2- ASTANEH ASHRAFIE	100324	49,58'	37,15'
3- BANDAR ANZALI	112066	49,28'	37,28'
4- TALESH	230915	48,50'	37,45'
5- RASHT	619076	49,36'	37,16'
6- RUD BAR	127359	49,24'	36,47'
7- RUD SAR	201373	50,18'	37,03'
8- SOMEH SARA	127504	49,19'	37,17'
9- FUMAN	180695	49,21'	37,12'
10- LANGRUD	110671	50,10'	37,11'
11- LAHIJAN	221252	50,00'	37,12'

THE RESULTS OF THE PARAMETRIC PROCEDURES USED FOR FINDING THE OPTIMAL LONGITUDE AND LATITUDE OF THE NEW CEMENT FACTORY LOCATION ARE AS FOLLOW :

LONGITUDE (MINUTES)	OBJECTIVE FUNCTION
2990	20496925
2995	19739190
* 3000	19251847 ***
3005	20660392
3010	22069937

LATITUDE (MINUTES)	OBJECTIVE FUNCTION
2220	40956081
2235	30411156
* 2240	30203445 ***
2245	31037330
2250	32173255
2255	33762240

10. Conclusions and recommendations

10.1 Conclusions

There is the fundamental premise that the primary responsibility for developing technological capabilities and the proper use of technologies for rapid socio-economic advancement in the developing countries rests with those countries themselves.

If one accepts this premise, it becomes obvious that the integration of technological considerations national planning and in the decision making systems.

The current situations prevailing in the developing countries are mainly due several problems which are internal rather than external. These problems cannot be solved from outside.

It is therefore the greatest challenge to the managerial level in the developing countries to face the situation in their related sector boldly, and initiate measures which would reverse the current trend of increasing technology gap between the developed and developing countries.

10.2 Recommendations

This study clearly shows that there is a great opportunity for transfer technology and know how for developing countries throughout purchasing technology, machinery and other related project materials. Also there are a variety of choices in the equipment and options available for selecting the type and level of technology.

There are doubts as to whether large-scale cement plant technology is appropriate in all circumstances, but on account of economies of scale and technology development the developing countries have to find a better way to enjoy of more developed technologies.

Under Iranian conditions the 2000 tpd rotary kiln cement plant does represent a viable alternative to other capacity kiln plant given appropriate technical and institutional conditions.

The Iranian case study shows that developing countries can have a large foreign currency savings while performing new projects that essentially in point of technology are dependent to the importing technology of developed countries, with a mixing purchase of machinery and technology.

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