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Industrialization through the import of technology and local technology development in LDC's: the case of Algeria

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INDUSTRIALIZATION THROUGH THE IMPORT OF TECHNOLOGY

AND LOCAL TECHNOLOGICAL DEVELOPMENT IN LDC'S

(THE CASE OF ALGERIA)

submitted by A. HEMAL
for the degree of PhD
of the University of Bath

1986

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A handwritten signature, likely of the author A. Hemal, consisting of a stylized, cursive letter 'H' followed by a flourish.

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ABSTRACT

Technology is important to the process of development and is as essential an aspect of the process of investment as the accumulation of financial resources. LDCs typically obtain this technology from advanced countries rather than by creating it themselves. This thesis examines both the short and long term effects of imports of industrial technology on LDCs' economies, the impact of state intervention on the demand and supply of technology in these countries, and the effects of local conditions on the process of assimilation (ie. absorption and diffusion) of imported technologies. These problems are discussed in the light of Algeria's industrialization experience in general, and cement and flour-milling development in particular.

The thesis has four major conclusions. These are that:

- The straightforward application of the concept of comparative advantage to the transfers of technology to LDCs is simplistic and inadequate for two reasons. The first is that it leaves out the fact that there are important external economies of learning-by-doing in the technological field. This means that if market forces are left alone to determine the extent to which foreign technologies and skills are used, there will be less accumulation of technological experience than is socially desirable. Second, on top of this inherent characteristic of the market, there is the question of 'technology monopoly' which tends strongly to

influence the way the market operates and makes it difficult for locals to even get involved in the learning-by-doing process. Both of these, in addition to the direct costs of technology imports, are arguments for direct state intervention to restructure the demand for, and supply of, technology. However, empirical evidence available so far shows that the explicit technology policies adopted by many LDCs have been often ill-conceived, inconsistent with each other and with the implicit technology policies contained in the overall strategy (see below), and not properly implemented.

- The overall industrial strategy of the country strongly influences the kind of and terms of technology imports and local technological development. The characteristics of the economic system and of many government policies contain an array of implicit technology policies which are often more important than the explicit ones, and which frequently work against the objectives of local technological development.

- The accumulation of technological capacity is not accomplished through costless, automatic learning-by-doing, or simply by acquiring ready-made skills. Evidence shows that absorption and diffusion of imported technologies require conscious effort on the part of the recipient firm or country to develop a technological strategy, to invest in resources for technological change, and progressively to accumulate technological capability. Unless carried out with the explicit objective of learning,

technological transfers do not necessarily provide the experience which is critical to the development of an indigenous technological capacity. Empirical evidence shows, for example, that turnkey contracts did not provide mastery by the recipient in any of the tasks involved in project execution and that they might fail even to transfer an adequate understanding of operational technology.

- Firms' attitude towards selection, absorption and diffusion of foreign technologies under very similar macro-economic conditions differ substantially. Empirical evidence shows that state owned firms which are run according to a common set of regulations act quite differently from each other in the way they select, absorb and diffused imported technologies.

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ABBREVIATIONS USED

- AD: Algerian Dinar (Algeria's currency)
- C.E.I.AL: Centre d'Equipement des Industries Alimentaires (food industry machinery centre).
- C.E.R.I.AL: Centre d'Etude et de Recherche Alimentaire. (Food Industry Research Centre).
- C.R.E.A: Centre de Recherche en Economie Appliquée (Centre of Applied Economic Research)
- ENDMC: Entreprise Nationale de Developpement et de recherche des Industries des Matériaux de Construction. (National Enterprise for Development of Construction Materials).
- E.N.I.AL: Entreprise Nationale des Industries Alimentaires (National Enterprise for Development of food industry).
- FLN: Front de Liberation National (Algeria's unique political party).
- I-S: Import Substitution
- LNG: Lequified Natural Gas
- MPAT: Ministere de la Planification et de l'Amenagement du Territoire (Ministry of Planning and Land Reclamation).
- NICS: Newly Industrialized Countries
- R & D: Research and Development
- R-D & E: Research-Development and Engineering
- SEP: Secretariat d'Etat au Plan (Planning State

Secretariat).

- SN-Sempac: Societé National de Semoulerie, Minoterie, Pâte et Couscous. (National Corporation for flour milling, pasta and couscous).
- SNMC: Societé National des Materiaux de Construction (National Corporation for Construction Materials).
- SN-Metal: Societé Nationale des Industries Metalliques (Metal-Working National Corporation).
- SNS: Societé Nationale de la Sederurgie (National Iron and Steel Corporation).
- SONATRACH: Societé Nationale pour la Recherche, la Production, le Transport, la Transformation et la Commercialisation des Hydrocarbures (National Oil and Gas Corporation).
- Sonelgaz: Societé National d'Electricité et de Gaz (National Corporation for Distribution of Electricity and Gas)

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INTRODUCTION

Conventional wisdom in the past has had it that "capital is the engine of growth". There has, however, been a growing recognition of the pervasive role of technology in the process. Thus even if the productive system of a country could generate a surplus on which to base a viable economic growth it would be necessary to count on the capacity to transform it into reproducible capital goods with the appropriate technical and economic characteristics. In turn, this capacity is determined by the scientific and technological level of the country, by the existence of the capital goods sector, and by the effective combination of the two. Without this capacity, the accumulated surplus must be used to import technology in both embodied and disembodied form. Most LDCs lack this capacity and consequently rely heavily on technologies developed in the industrialized countries. This heavy reliance often results in two major problems. The first is a short-run one: it is the problem of international income distribution effects which are likely to reduce the surplus available for reinvestment and so curtail the ability of the economy importing the technology to be self-generating. The second is a long-run problem: it is about the methods used to import technology which may limit the opportunity for the locals to develop their skills. Thus if technologies are transferred in a way that substitute for local skills and so effectively inhibit their development, the chances of both coming to terms with the first problem (discussed above) and effectively

absorbing and diffusing imported technologies, will be reduced. In this sense, the latter problem has a certain priority over the former. This thesis is mainly about the second problem which is discussed in great detail in the light of Algeria's experience in cement and flour-milling industries. However, both problems are considered in Chapter One, where the technology market, the transfer of technology and the various policies devised by many LDCs to regulate technology imports and to promote local technological capacities, as well as the unique role of the capital goods sector in the generation and diffusion of technology, are examined.

Since technology issues are often strongly influenced by the overall industrial strategy because the latter usually contain an array of implicit technology policies, Chapter Two is devoted to the examination of the basic-industry strategy followed by Algeria in the 1970's. The main technology implications of the strategy are examined in great detail both conceptually and in the light of Algeria's recent experience.

Chapter Three focuses on the concept of "technology assimilation" and examines the various technological capacities and efforts required to select, absorb and diffuse an imported technology locally. It also discusses briefly the strategies which may be followed to assimilate an imported technology in the light of experience of some countries. It provides a theoretical background to the two case studies which are discussed in

Chapters Four and Five.

Chapters Four and Five examine in great detail the process of acquiring, absorbing and diffusing cement and flour-milling technologies in Algeria. The empirical studies discuss the determinants of technology assimilation at the firm level and of inter-firm differences, factors that facilitate or inhibit the process of assimilation of technology and the influence of macro-economic conditions on that process. Both industries have been given a major priority in the Algerian strategy of industrialization because of their vital importance both economically and politically. In terms of investment, their combined share in total industrial (excluding hydrocarbons) investment implemented between 1967-1984 amounted to over 8% with the cement industry absorbing around 5% of the total.

Chapter 1:INTERNATIONAL TECHNOLOGY TRANSFER TO AND TECHNOLOGICAL DEVELOPMENT
IN LDCs

Science and technology are as important to the development process and as essential an aspect of the process of investment as the accumulation of financial resources. Thus, even if a country's productive system could generate a surplus on which to base a viable economic growth strategy it would be necessary to count on the capacity to transform this surplus into reproducible capital goods with the appropriate technical characteristics. This capacity, in turn, is determined by the country's scientific and technological level, and by the effective combination of both. Without this capacity:

1. The accumulated surplus must be used to import capital goods and know-how from advanced countries. Two main problems are often associated with LDCs' reliance on imports of technology from advanced countries. The first is a short term problem: the leakage of the multiplier effect which in turn result in reducing the surplus available for re-investment and so curtailing the ability of the economy to be self-generating. The second problem is that the mechanisms that are used to transfer technology may limit what Skitovsky called "technological external economies": if technologies are transferred in such a way that limit the opportunity for learning on the part of the local people, the economy will

forego some of the important 'external economies' which are often used to justify the policy of industrialization in LDCs. This is a long-run problem: because if technology is transferred in a way which substitutes for local potential suppliers of goods and services, the chances of coming to terms with the short term problem which we have discussed, will be reduced.

2. The country cannot make independent technological choices, operate efficiently, adapt and improve upon imported techniques and products, and generate new ones. "A country without an indigenous scientific and technological capacity has no means of being aware of its own needs, nor of the opportunities existing in science and technology elsewhere, nor of the suitability of what is available for its own needs. Thus, far from being substitutes, the obtaining of technology from advanced countries and the building of a scientific and technological capacity are, in fact, complementary".¹

Attitudes towards the role of science and technology in the development process have evolved over the last three and a half decades in the developing countries as well as among academics and UN agencies. In the 1950's and early 1960's the role of science and technology in the strategy of national development was largely underestimated. The availability of production technologies from the advanced countries seemed an unqualified blessing - though some development economists drew attention to the incompatibilities of factor endowments and capital intensity.

Despite these qualifications there was a more or less general agreement at the time that developing countries could quickly industrialize by applying the technologies which had been generated and used in the advanced countries. This view was largely based on neo-classical assumptions about access to technology. Conventionally technology was assumed to be a "free good" and accessible to all potential users. Consequently LDCs could draw "from the shelf of world technology".²

As time proceeded it emerged that the indiscriminate flow of technology and heavy reliance on scientific and technological knowledge generated elsewhere, had led to dualistic patterns of development, had involved high costs, had increased the degree of reliance on foreign technology and had inhibited learning effects. Consequently both the approach to and policy towards technology transfer have evolved. Some of the assumptions about access to technology have been put into question. The idea that technology is a potential source of monopoly, and is therefore itself monopolized by private capital and that the overwhelming international concentration of scientific and technological potential in the advanced countries have adverse socio-economic effects in the LDCs as well as their position in the international economy have been emphasized. New attitudes towards the role of science and technology in development had subsequently evolved in the mid-1960's; in particular many policy-makers in LDCs and academics as well as UN agencies called for the regulation of the inflow of technology and promotion of an indigenous scientific and

technological capability. This new attitude towards the role of science and technology in LDC's had contributed to a mode of naive optimism particularly among science and technology advocates³ who viewed science and technology as a panacea that would solve all the Third World problems and might even eliminate all the "ills of underdevelopment". Not only it seemed at the time that it is easy to introduce science and technology in LDCs, but it also seemed that a bit more science and technology would both open new production possibilities and might even eliminate backwardness. The only difficult problem to solve was a merely technocratic one: how to establish scientific and technological institutions and train personnel needed to operate them? What is the kind of activities they should carry out and the amount of R & D expenditure required? and the like.⁴

By and large these prescriptions were founded on the most superficial kind of diagnosis. One cannot argue from the success of science based innovation in the advanced countries to the imperative of science and technology development in LDCs. The economic and social organisation of the latter are different from the former and consequently research institutions established in LDCs might serve rather different social functions from those of the advanced countries. Hardly anyone at the time asked why science and technology are, in the first place, acutely backward in LDCs. After all the "underdevelopment of science and technology" could be regarded as a particular aspect of the general phenomenon of underdevelopment.

In the early 1970's a more critical approach to the role of science and technology in LDCs had emerged. It is argued that the establishment of research institutions, the training of labour force required to operate them and the allocation of financial resources to research activities do not necessarily ensure economic and social progress, as science and technology advocates had suggested. This, they argue⁵, is primarily due to the fact that socio-economic organisation in LDCs inhibits the application of scientific knowledge to the productive sphere. Furthermore, they argue that the particular form which scientific and technological institutions take in developed countries, the way they are linked to production via a network of machinery, producers, engineering consultancy firms and the like, and the type of research they carry out are contingent upon the process of historical development of the advanced countries. The notion that the content and form of research activities and their links with their socio-economic environment are a result of a particular form of economic and social organization has played an important role in research on the social function of scientific and technological activities in developing countries. Additionally, more attention has been paid to some problems associated with the transfer of technology to LDCs. In particular the negative effects on the balance of payments because of monopoly pricing of technology and the effects on "learning-by-doing" which is relevant to the development of local scientific and technological activities.

This chapter provides an interpretive survey of many of the issues

related to both development of local scientific and technological activities in LDCs and transfer of technology to LDCs. The first section focuses on social functions of scientific and technological activities in DCs and LDCs. The main argument which runs through this section is: in contrast to DCs where R & D activities are closely linked to their socio-economic activities, these activities in LDCs are often, for a number of reasons, divorced from their environment. The second section deals with technology transfer to LDCs and its direct and indirect effects. Special emphasis will be put on the mechanism of transfer and their effects on LDCs' balance of payments and learning-by-doing. It is argued that some of the mechanisms used to obtain technology from DCs are costly and have adverse effects on the process of learning-by-doing which are relevant to the development of local skills. The third section deals with the role of the state in both regulating technology inflow and promoting local scientific and technological activities. While there is a more or less general agreement that the State has a major role to play in this field, empirical research findings about the effectiveness of some state policies implemented in some countries differ substantially. The fourth section focuses on the role of the capital goods sector in the process of technological change and diffusion. It is argued that the capital goods sector occupies a unique role in the process of technological change. Having said that, two crucial questions should be taken into account: the first is related to the decision whether or not to import or manufacture locally, and the second is related to design capabilities of capital goods

producers as technical change associated with the capital goods sector depends heavily on the existence of this capacity. There is no general agreement among economists on these two issues.

1. Social Function of Science

Technology and technological change are not autonomous forces exerting uni-directional effects on society and neither are they neutral. The belief in the contrary⁶ stems mainly from the mistaken view that regards technology as the mere application of science and scientific discovery, itself the result of the ingenuity of certain thinkers transcending existing socio-economic circumstances. The recognition that science and technology interact in many ways and that both are affected by, as well as affect, the prevailing socio-economic circumstances has important implications for the way we examine the social function of science in relation to the development of production in developing countries.

Although the social function of science was well acknowledged and discussed by the classical economists, the neo-classicists neglected it almost totally. Marx and Adam Smith in particular were interested in the origins of new forces of production as well as in their effects. Both were well aware of the important role of science⁷ in promoting technological development. Thus Smith spoke of "men of speculation" who, in cooperation with machine-builders and workers, were

responsible for many technical "improvements". However, it was Marx who explored at length the relationship between science and production and this earned him the title of "technological determinist".⁹ The essence of his argument can be summarized in the following:

1. New forces of production change, not exogenously or as the result of some mysterious deux ex machina, but rather as a dialectical outcome of a historical process in which the forces of production and relations of production play an essential role. As he put it: "It must be kept in mind that the new forces of production and relations of production do not develop out of nothing, nor drop from the sky, nor from the womb of the self-positing Idea, but from within, and in anti-thesis to the existing development of production and the inherited, traditional relations of production".¹⁰ The importance of socio-economic organization in establishing the link between science and production was dealt with in great detail in Marx's writings. Thus he argued that this link was only established after craft-based production system was superceded by the machine-based one. He showed that science itself can never be extensively applied to the production system so long as the handicraft system continues to be its basis. In other words, science must incorporate its principles into impersonal machinery and this was achieved in the machine-based factory system. When this stage has been achieved, Marx argues that:
2. Technology becomes for the first time capable of indefinite

improvement¹¹ as the requirements of production eventually begin to have an effect on the direction of scientific development itself. For example, technological advances generated new specialized skills at the interface between science and production. This is reflected in the emergence and development of engineering specialists who are able to interpret the needs of the entrepreneurs to the scientists and subsequently economic requirements begin to affect the direction of science;

3. The driving force in his model of technological change is the search for profit. He states quite clearly that the technological changes associated with the two stages of capitalist development he studied - the manufacturing system and Modern Industry - were responses to an expanding universe of profit-making opportunities¹². This line of thought was further explored by Schumpeter who demonstrated how competition in a free market economy leads to a sustained demand for "new innovations".¹³ Furthermore, Schumpeter argued that such "new innovations" confer quasi-monopolistic advantages over those who command them.

The social function of science was further explored by J.D. Bernal.¹⁴ He analyzed at length the reciprocity of the relationship between science and society as well as the effects of economic demands, including those of the military, on technological innovations. In his view, the manner in which society was organised influenced technological change

and vice versa. He maintains that "the machinery of the Industrial Revolution was not the simple gift of inventors - there has been ingenious men in plenty in earlier times - but ... grew in response to the availability of capital and labour and the opportunities the market offered for profit".¹⁵ Furthermore he stresses that: "successful application in war or profitable applications in peace have been the only criteria for technical advances.... Considering the available technical skill and intellectual capacity at different periods, it is apparant that these were rarely if ever the major limiting factors in industrial progress... It was lack of anticipated profit that kept short-sighted and tradition-bound capitalists from embarking on new enterprises long after they were technically feasible".¹⁶ In other words the link between science and production is best stimulated by socio-economic organisation and conditions conducive to technological development and economic demands.

Bernal distinguishes two phases in the development of relations between science and production. In the first phase, i.e. the early stage of capitalism, technological development was mainly achieved through the accumulation of small improvements on the shopfloor, spreading out in space and communicated from generation to generation over time, and from time to time through the invention of a new process or product. During this phase technological advances were often the source of scientific discoveries, if scientists were

interested in these advances which had been developed by machine-builders and craftsmen, so as to learn from them. In the second phase, i.e. modern capitalism, technology production has become increasingly a moment in the capital accumulation process as entrepreneurs began to directly invest in scientific research as a potential source of profit. The research laboratory, whether public or private, has become the major source of technological innovations.

To summarize, the particular form which scientific activities have at present in the developed countries, the way they are linked to production through a complex network of machine-builders, engineering institutions and the like, and the kind of research they are engaged in, are the outcome of the process of historical development of the advanced countries, and the increasing demands on innovation in various sectors of their economies.

The notion that links between science and production are a result of particular forms of socio-economic organization and, especially, of economic demand for new techniques and products has been the cornerstone of recent analysis of the social function of science in LDCs. According to this new approach the main weakness of those who argue from the success of science-based innovations in the advanced countries, to the imperative of strengthening scientific activities in LDC's lies in their failure to recognize that underdevelopment is an

historically particular form of socio-economic organization which cannot be identified with the early stages of development in today's advanced countries.

"Underdevelopment..." Furtado argues, "calls for an effort at autonomous theorization".¹⁷

A great deal of effort at 'autonomous theorization' about underdevelopment in general and underdevelopment of science in particular, has mainly come from South America. Essentially this approach uses particular aspects of the structuralist analysis to demonstrate how the dynamics of the underdeveloped economy operate in such a way that local scientific activities are alienated from production ('marginalization of science' as it is often referred to). This 'marginalization of science', it is argued, was the result of economic policies implemented by the dominant classes in these countries. "For example, the implicit science policy contained in the import-substitution industrialization of many Latin American countries has often reinforced technological dependence".¹⁸ The process of industrialization through import-substitution has been heavily influenced by the fact that income distribution is skewed in favour of a minority which therefore dominate consumer goods markets. Since this affluent minority demand goods similar to those produced in DCs, industrialists (both foreign and local) prefer to import technologies already in existence in DCs. Consequently, foreign technology tended to be a substitute for technologies that might have been developed locally by

scientific and development institutions. The argument is also extended to explain why engineering activities are both underdeveloped and underutilized in many LDCs.

Similar arguments apply to countries which switched to export-oriented industrialization in the late 1960's, as their markets are located in the DCs, which implies that productive techniques and know-how have to be imported to cater for the consumption habits, tastes and standard requirements of these markets. As for the "traditional" sector (for example handicrafts and subsistence agriculture) of these economies, it generates very little demand on local research and engineering imports partly because this sector is not organized in a way which is favorable to scientific and technological advances and partly because it is deprived of resources which are preferentially channelled to the 'modern' sector. The result is that scientific activities are alienated from the production system and consequently their orientation is in the main determined by individual decisions of research workers. Meanwhile engineering activities in these countries are either underdeveloped or underutilized as individual enterprises, local and foreign prefer to use foreign technology and skills (which are proven commercially) than local variants of technology and engineering skills.

Recent studies of scientific activities in LDCs emphasized the existence of a serious discrepancy between the needs of

national development and the orientation of scientific research in these countries. Analyzing the reasons for this situation, India's National Committee on Science and Technology pinpointed the existence of bias in the allocation of resources¹⁹, inefficient assimilation of research results due to the absence of links between scientific institutions and the production system and underutilization of existing capabilities.²⁰ Meanwhile the Indian scientist A Rahman argued that because of this bias in resource allocation and the availability of and accessibility to foreign technology, Indian scientists and engineers oriented themselves towards research topics which contribute to the growth of scientific potential in the DCs with very little regard to the specific research needs of the country. By not using the country's scientific potential to solve immediate problems of the country, he argues, India is not helping to increase the country's wealth or expand employment. That is why there is substantial unemployment among highly skilled personnel, a "brain drain" to the DCs and continued reliance on imported technology.²¹

Studies on Latin American scientific activities point out problems similar to those observed in India. It is argued that most scientific activities in this region bear little relation to its most severe problems and needs. With few exceptions most research projects have no relation to the needs of the economy and society. Thus Sagasti argues that:

"Because the productive sectors of the economy exert little pressure on the local scientific and technological communities, scientists and researchers orient themselves toward the international community, choosing research topics in fashion, seeking to contribute to the advancement of science as an international undertaking, and disregarding the specific research needs of their countries".²² The following quotation from a joint report of the UN Commission for Latin America and the Organization of American States summarizes the situation of scientific activities in Latin America:

"Up to now, in Latin America, in the government vertex, recognition of the importance of science, technology and innovation has been merely rhetorical. This sector is absolutely isolated from the productive structure with the exception in some countries of some contacts with the agricultural sector.... However, they (Councils for Scientific and Technological Research) are not very efficient in using their infrastructure for the solution of the specific problems of society, the same may be said of the Universities and Institutes of higher education ...science and technology are still components divorced from the production process".²³

In sharp contrast to both the optimistic view that emphasizes the contribution of science to development and the widespread belief among science and technology advocates that the key to rapid economic development is massive investment in R & D

activities²⁴, recent research on scientific activities in LDCs suggests that these activities appear to contribute very little to socio-economic development of these countries. This is not to deny that science can contribute to development, nor to suggest that it is more efficient from the social point of view to rely on the technologies which have been developed in the industrialized countries, than to use resources to develop local innovative capabilities. Science and technology can contribute to development. However, the present socio-economic structures of the LDCs and the orientation of their scientific activities as well as the structure and orientation of those located in developed countries, are such that this potential is not being fully utilized to solve the immediate problems of LDCs. Rather, they appear to reinforce and perpetuate the conditions of underdevelopment. Meanwhile there are a number of reasons for rejecting the view which suggests that it is more efficient from the economic point of view to draw "from the shelf of world technology"²⁵ (what is the point of re-inventing the wheel!) than to use resources to develop local scientific and technological activities in LDCs. First of all, foreign technology can never be a total substitute for a local innovative capacity. The latter plays an important role not only in generating new technology and improving the imported one, but also and above all, to ensure the successful transplantation of foreign technology. The successful transplantation of foreign technology requires the ability on the part of the recipient to search, evaluate,

select, effectively use and adapt it to local conditions and eventually to improve upon it. An economy which possesses this capacity is in a position to draw upon foreign knowledge in ways which can have positive results. Without this capacity, the recipient is most unlikely to make a successful use of innovations developed elsewhere, and can be subject to many important adverse effects. In particular, the negative effect on the balance of payments because of 'monopoly pricing' of technology and the effect on "learning-by-doing" which is relevant to the development of local innovative (like R & D activities) and engineering (like project design) activities. The following section focuses on these two effects of technology imports by LDCs.

2. Technology Transfer to LDCs and its Direct and Indirect Costs

The international 'transfer of technology' refers essentially to the process whereby knowledge related to production of goods and services is acquired by entities within a country (for instance research institutions, firms, etc.) from sources outside that country. In examining international technology transfer, several questions related to the subject emerge. These include the sources of technology and their motives for its transfer, modes of technology transfer and their effects on the recipient and the price of knowledge transferred and its consequences on the recipient country.

The international transfer of technology is dominated by private capital and it is thus, by and large, subordinated to the requirements of profit-oriented decisions. This notion of predominance of private capital does not preclude the possibility that the public transfer of technology might outrank or at least equal private transfer in certain sectors or at least with regard to certain functions. In most cases the former plays a complementary role to the latter by helping to establish some of the necessary pre-conditions such as infrastructure and personnel training. However, private firms, especially the big multinationals, are by far the most important actors in the field of technology transfer both within developed countries and between developed and developing countries.

The main motives behind technology transfer by private firms to LDCs are:

1. Extending the product life cycle: international technology transfer is a means of extending the product life cycle of technologies which are either at their latest stage of maturity or are going to be soon obsolete, "...the strategy of multinationalization may be regarded as a substitute for innovation through the method of geographic extension of the life of the product".²⁶ There is ample evidence that such technologies and even obsolete ones were transferred to LDCs. It was also reported that low technology industries rank highest in terms of royalties.²⁷ However, this does not mean

that only mature or obsolete technologies are being transferred to LDCs, as Vernon's product life cycle model seems to suggest. Indeed, some new technologies have been transferred to LDCs before they have been applied in the country where they were originally developed.²⁸ Meanwhile the 'export stage' of the product life cycle has often been truncated and sometimes eliminated. It has also been reported that new products are commonly introduced by US-based MNCs within one year of US initial introduction.²⁹

Whatever success the product cycle model may have had in accounting for empirical data on the sequence of events in some industries³⁰, it turns out to be inadequate as an explanation of technology transfer to LDCs. This is largely due to certain assumptions on which the model was based as well as to certain changes which have taken place since the late 1960's. In the first place, the model assumes that there is some relationship between the age of the product and the extent of quasi-monopoly. It may be true that quasi-monopolistic control over 'new' products is more frequent than over 'mature' ones, but it is nevertheless possible that many products will be firmly controlled by the innovating firm long after they have become 'mature' according to criteria used in the model. One must remember that extra-technology types of monopolistic advantages (such as firm-specific skills in marketing and management, trademarks and brand names) are often used by firms to support their quasi-monopolistic

position, and consequently extend the period of quasi-monopoly. Secondly, the model takes given factor endowments in LDCs as the ultimate determinant of when technology will be transferred to them. Like other theories, it leaves the movement of factors across countries out of the picture. Once this assumption is lifted, and it is hard to see how this can be avoided, it becomes difficult to perceive the relationship between the age of the product and the moment at which production will be transferred to LDCs.

Meanwhile there has been a considerable change in the structure and behaviour of firms, in particular the MNCs. Firstly, the emergence and development of consultancy engineering firms whose business is mainly based on the sale of their services and whose profitability depends on extensive sale of technology and related services. Secondly, most big and medium firms have come to take a worldwide view of their operations. Many of them have in place both extensive overseas production facilities and sometimes even substantial R & D activities located abroad. Given the existing worldwide network of facilities and personnel, firms are trying to use as fully as possible their resources.

These developments led Vernon to acknowledge that: "By 1970, the product cycle model was beginning in some respects to be inadequate as a way of looking at the US-controlled multinational enterprise. The assumption of the product cycle

model...was beginning to be challenged by illustrations that did not fit the pattern".³¹

Even if new technologies are transferred to LDCs, there are other ways of planning their obsolescence by the supplier, such as retaining the essential elements of the know-how of the technology transferred or by developing new technologies to replace the exported ones. As J. Baranson observed: "This Strategy (of measured release of core technology) is common within the process design and engineering industry where the company is interested in selling newly designed technology as extensively as it can and reinvests a portion of profits in developing new generations of technology. In most cases, a deliberate attempt is made to retain an essential element of the know-how, without which the purchasing enterprise is unable to develop a more comprehensive version or to become self-sufficient in the technology".³²

2. Penetrating closed markets: commercialization of technology is an efficient means of penetrating markets closed to products. As Thomas A. Callaghan, Jr., President of Ex-Im Inc., observed: "Markets closed to products are invariably open to technology. Even extremely closed markets will open to Western technology...as long as the United States is the predominant technological power, closed product markets will always be open to American technology".³³ Exports of technology are often accompanied by exports of equipment, materials and components. There may be even follow-on exports

of goods and services. Consequently, technology exports provide the exporter with the longest and surest means of market penetration available.

3. Internationalization of production: international technology transfer is a necessary precondition for the internationalization of production. Since the 1960's, the way technology is transferred internationally has greatly changed. The role of licences and patents has declined in favour of transfer based on the TNCs activities, whereby technology crosses national borders but remains essentially inside the TNCs economic system. Supply of technology by the parent company to its affiliates is essentially restricted to production functions assigned to them within the framework of the TNC global strategy.

Internationalization of production is very often accompanied by a highly centralized organization of technology production. The role of the affiliates, especially those located in LDCs, is confined to that of an executant at the production level. Thus it was reported that out of the 8% of US-based TNC's expenditure on R & D undertaken in 1970 outside the USA, only 0.5% of this expenditure was undertaken in LDCs.³⁴ As Michalet argues: "The subsidiaries' main concern is...to keep a strict check on possible openings for the external dissemination of technology. This must be limited to the technological elements embodied in the finished product sold on the market".³⁵

4. Recovering the costs of R & D and other follow-on costs:

international commercialization of technology is an efficient means of shifting the burden of costs of technology production to others especially those with weak bargaining power.

Technology has become a costly production function not only to enterprises engaged in R & D activities, but also to other enterprises which wish to introduce the new technology through either imitation³⁶ or licencing. Whereas in the early phases of capitalism, technology was mainly produced through the accumulation of small improvements on the shop floor and from time to time through invention of a new product or process, then diffused with very little cost³⁷, at present technology production has become an important factor in the overall strategy of both individual institutions and states.

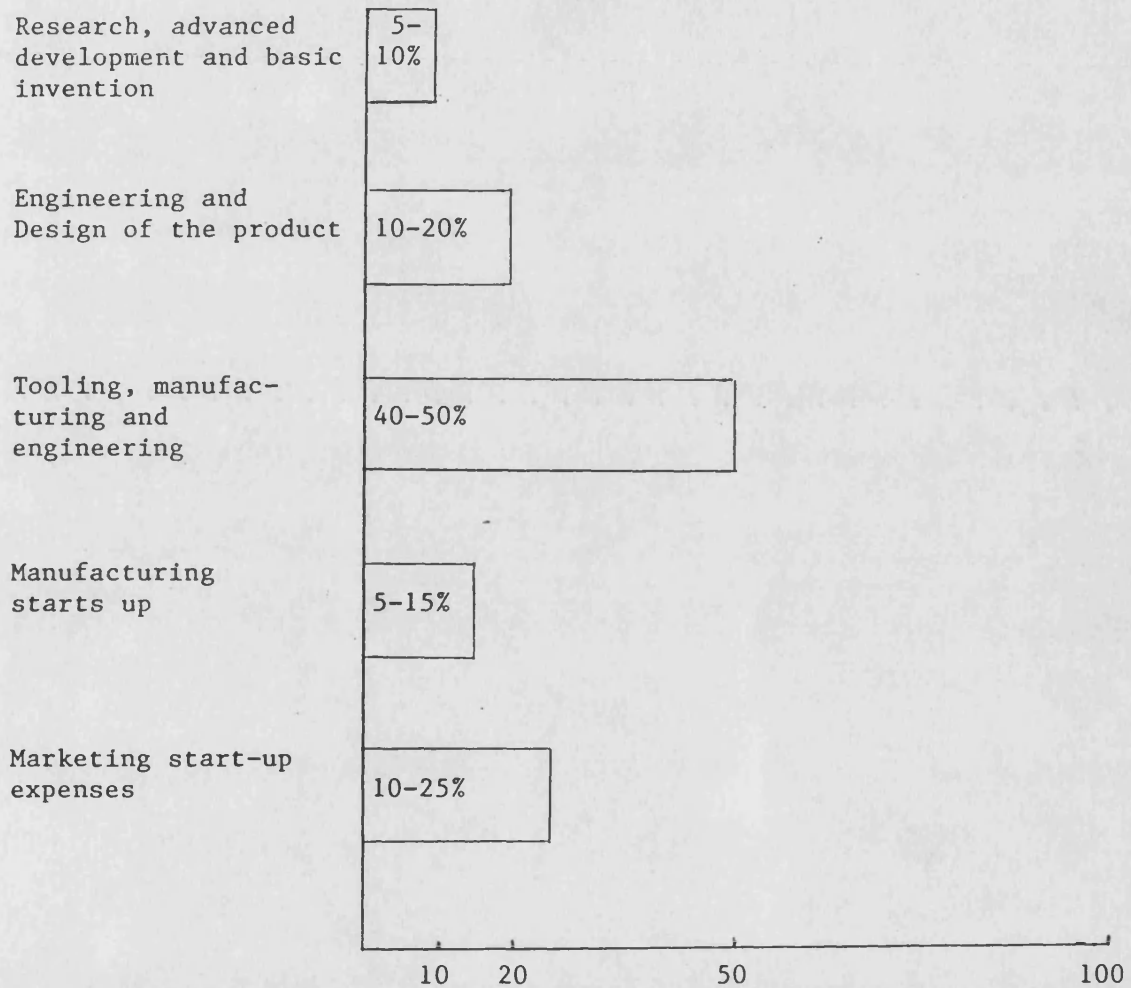
Technology is not produced only to be consumed by the same institution and within a particular country, but also to be transacted internationally. Meanwhile there are nowadays specialized institutions whose main function is production of technology for exchange.³⁸ Additionally, the way technology is at present produced is radically different from those in the early stages of capitalism. Decisions on R & D are decided upon by top-level management of big firms and specialized institutions, and their application is not anymore a spontaneous operation, but based upon direct and programmed effort.³⁹ This does not suggest that invention/innovation is the exclusive domain of the big enterprise and specialized institutions. Small firms and individuals still participate

in this field. But a large proportion of their achievements still end up into the hands of the big enterprises through various channels, including absorption of the inventors or innovators themselves.

Expenditure on R & D by both private and public institutions has witnessed a rapid increase in recent years. Thus: "According to data supplied by the German Chemical Industry, its R & D expenditure have been increased by at least 100% over the last 10 years".⁴⁰ However, a large proportion of R & D expenses have been entrusted to the state as the "general capitalist". In the US, for example, federal spending on R & D "had risen by over 50% in the last four years".⁴¹ It must be emphasized that the costs of R & D are often minimal compared with follow-on costs as the diagram on page 25 shows. The diagram shows that follow-on costs exceed the direct costs of R & D by between 10 and 20 times. To summarize, expenditure on R & D as well as on other activities related to technological innovation is rapidly increasing in developed countries both at the micro- and macro-level. Consequently, the need to export technology so as to recover at least a part of these costs will continue.

Modes of Technology Transfer to LDCs

The possibility of skill formation and acquisition of specialized information are likely to be influenced quite strongly by the type

Typical Distribution of Cost in Successful Product Innovation

Source: R.A.Charpie: Technological Innovation. Its Environment and Management, US Department of Commerce. Quoted in: G. Jones, (1971): The Role of Science and Technology in Developing Countries, Oxford University Press, p. 9.

of transfer mode which is used. The supplying firm often has a direct interest in preventing others from learning about its core technology which may be a source of "quasi-monopoly" to the firm and an essential factor in maintaining its competitive position. This suggests that the choice of mode of technology transfer is important to the recipient. These modes can basically be categorized as being passive or active, market- or non-market-mediated. The diagram below presents this categorization.

Role of foreigners in the transfer process

	Active	Passive
Market-mediated	Direct foreign investment, turnkey projects, joint ventures, licencing and various management contracts	Purchase of machinery and equipment
Non-market	Learning through exporting and training of personnel	Personal contact, scientific exchange, trade Journals and manuals, and imitation

The mode of technology transfer is described as active if foreigners assist the buyer in acquiring and/or applying the technology transferred. If, on the other hand, the technology is acquired and applied without assistance, then the technology transfer mode is said to be passive. It should be noted that in the later case, the buyer is presumed to have competence in the acquisition and application of technology concerned. The capacity for searching, selecting and applying efficiently foreign technology, is not present in most developing countries. This at least partially explains why the active modes of transfer are the most widely used in LDCs. It also explains why most literature on technology transfer to LDCs has been devoted to the examination of those modes included in the North-West of the rectangle. These include turnkey projects, direct investment, joint ventures, licencing, management contracts and other technology agreements. In all these foreigners play an active role in the transfer process, influencing the quantity and quality of technology transferred, and the circumstances and conditions under which it is transferred, including factors such as restrictions on the use of technology transferred and consequently its assimilation and diffusion and the price of technology.

Imports of machinery and equipment is market-mediated, but foreigners often play a passive role and usually do not exercise much control over the way in which technology, embodied in them is used by the buyer. Imports of machinery and equipment is an important source of technological knowledge in developing

countries. Imported machinery and equipment could also potentially play an important role in generating technological knowledge through "reverse engineering" and imitation.

In learning by exporting, foreigners play an active role in providing information which can result in improvements in products exported. The mode of technology transfer is said to be active because the transfer depends on foreigners' willingness to feed back information to the exporter. This mode was examined in great detail in the case of South Korea, where it has been argued that an 'important' source of technological knowledge involved in the export sector has been supplied by sellers and users in their export markets.⁴² In learning by training, foreigners play an active role in transferring scientific and technical knowledge to the recipient's personnel. The mode is active because the transfer of knowledge, in particular knowledge specific to the core technology transferred depends on foreigners' willingness to train the recipient's personnel adequately, so as to acquire the capacity to effectively assimilate the technology in question.⁴³

In the last category (scientific exchange, published materials and personnel contacts in meeting and conferences), foreigners usually play a relatively passive role. Undoubtedly, these modes of technology transfer can potentially play an important role in augmenting technological capacities in developing countries. However, the exploitation of knowledge transferred through these

channels depends largely on the recipient's financial resources, technological capability and the environment in which the recipient operates.

In any particular case, the mode of technology transfer depends on the willingness of the supplier to provide the technology in different forms and the desire and the ability of the recipient to buy it in a particular form. There are considerable variations in the way different LDCs acquire technology reflecting differences in national policies, in their financial and technological capacities and in the industrial composition of the technology transferred. In some countries, for example historically Japan and currently Algeria, the most packaged mode of technology transfer in the form of direct investment is strongly discouraged.

Costs of technology transfer

Recent research on technology transfer puts in question the assumptions that economists conventionally make about access to technology. In contrast to the conventional notion that technology is a 'free good' and accessible to all potential users in time and space, it is today commonly accepted that technology is a source of quasi-monopolistic advantages⁴⁴ and the market for technology is highly imperfect. Consequently the transfer of technology does not take place because some purchasers in developing countries draw from the accumulated stock of world

technology but rather is the outcome of a process in which the technology-owning institutions in the advanced countries exploit their quasi-monopolistic advantages in the recipient country through the most profitable channel available to them.

On the supply side, technology has the character of a 'social good', in the sense that its use by others does not reduce the magnitude of it available to the owner/developer so that optimality requires that it be made available to all potential users without charge. Moreover the marginal cost of communicating it to others is usually very small compared with the initial cost of development. However, in the actual world, legal and other protection means are provided to the owner/developer of technology so that they may acquire some monopolistic control over their technology, and consequently sell it at a price above marginal cost. This has been the system adopted for much technological development in DCs. It is often justified as necessary to secure a continued flow of R & D.

On the demand side, the buyer is usually confronted with what Arrow called "a fundamental paradox in the determination of demand for innovation".⁴⁵ This 'fundamental paradox' arises from the fact that the buyer is forced to make a bid for the information before being able to assess its value fully. In order to make a complete evaluation, the buyer would have to have the information before purchasing it, thus having access to it without cost.

Under these circumstances, the technology market is highly imperfect: price determination tends to be oligopolistic, and consequently there is a considerable scope for abuse, and potential for bargaining on the part of the purchaser, as the price may vary between a maximum level determined by costs of reproducing the technology and a minimum price determined by the purchaser's estimate of the cost of the second best alternative including going without it. Generally, the price of technology is determined by the relative bargaining powers of the seller and the buyer; which in turn, depend on their respective resources, knowledge and other alternatives. However, the supplier has usually the stronger position, if only because the buyers cannot know all there is to know about what they are buying until they have purchased it. Of particular importance in this context is the fact that most LDCs lack the ability to search, assess and select among the alternatives available. Because of their strong position, the sellers of technology are often not only able to dictate the price, but also to maintain control over the use and development of technology supplied to the purchaser. This control can be exercised either directly or indirectly; the former through ownership and/or appointment of personnel to key positions in the recipient enterprise, and the latter by imposing various restrictions during the process of transfer and/or after it on the use and development of the technology supplied.

A great deal of attention has been paid in the literature on technology transfer to LDCs to the direct costs of market-

mediated technology where foreigners play an active role. Direct costs can either be overt or hidden. The former refers to costs which appear in the contracted price (such as the price of a management contract, a licence or an engineering consultancy). The latter refers to estimated costs due to restrictive clauses and transfer pricing. It is commonly accepted that overt costs of technology transfer need bear little relation to real costs where the supplier provides more than one service, as the seller may choose the form in which to receive payment.⁴⁶ In view of this problem, it is not surprising that none of the quite numerous studies on technology transfer to LDCs have come up with satisfactory estimates of costs.

An attempt to systematically estimate overt costs of technology transfer to LDCs was made by UNCTAD in 1975. For 1968, it was estimated that overt costs to LDCs of technology transfer were around 1.5 billion dollars for patents, licences, know-how, trademarks and management and other technical services. This amount was estimated to be equivalent to 5% of exports and approximately 0.5% of GDP. The UNCTAD also estimated that these payments were likely to grow at around 20% per annum on the basis of questionnaires sent to recipient countries.⁴⁷ Algeria's official estimates⁴⁸ for technology transfer payments for the period 1973-78 were much higher than those estimated by the UNCTAD. The average annual payments⁴⁹ for technology, at current prices, over the period 1973-78 were estimated at over 4,766m AD (or approximately 1,200 million US dollars at the official rate

of exchange). Official statistics also show that these payments grew at over 50% p.a. over the same period, rising from 1,000m AD in 1973 to 6,600 in 1977 and 8,600m in 1978. As a proportion of total exports these payments were equivalent to 15.2, 25 and 33% for 1973, 1977 and 1978 respectively. For 1978, technology payments amounted to over 9% of GDP, compared with 1.6% in 1973.⁵⁰

In addition to overt costs, technology transfer is usually associated with additional hidden costs as a result of restrictive clauses and transfer pricing. In the case of wholly-owned subsidiaries, restrictions on the use of technology transferred are implicit. For technology contracts between independent parties, they are an explicit part of the contract. These restrictions include tied purchases of inputs, machinery and parts, limitation (or total ban) on exports, limitation on competing suppliers both local and/or foreign, clauses guaranteeing stable profits, royalties and remittances against adverse effects of changes in monetary and fiscal policies and the like. Detailed studies of technology transfer to the Andean Pact, Argentina and India, as well as preliminary findings on Algeria reveal that restrictions on the application, use and development of technologies transferred are widespread.⁵¹

Meanwhile, the evidence collected so far reveals that transfer pricing is a common practice and a significant source of international income flow in intra-firm transactions.⁵²

Manipulation of transfer prices does not only occur in intra-firm trade, but also occurs in transactions between autonomous firms, where local firms have strong connections with foreign suppliers of technology, or where purchasers of inputs are effectively tied to the supplying firm. Part of the technology costs may appear as inflated prices of imported inputs other than technology.

It would be interesting and useful to have an accurate estimate of these hidden costs, but even without these it is evident from the Algerian case that costs of imported technology are very significant both in absolute and relative terms. Consequently LDCs could make significant foreign exchange savings if they were willing and able to conceive and apply policies which result in reducing the cost of technology transfer.

In addition to direct costs, technology transfer can also have adverse social effects. The most important of these are related to 'appropriate' technology and 'learning-by-doing', which is relevant to local scientific and technological activities in the recipient country. For some observers it seems almost axiomatic that LDCs would benefit from the use of the stock of scientific and technological knowledge which is developed, tested and tried in the advanced countries.⁵³ These observers appear to confuse, or overlook the difference between the physical presence of technology and its availability. There is no question that the existing pool of scientific and technological knowledge at present is sufficient to provide a decent level of existence for

all inhabitants of the world. But due to the existing nature of property relations, the existence of this valuable knowledge cannot automatically be equated with its availability for use; that it exists does not mean that it is accessible.

Secondly from the point of view of social context, i.e., short and long term requirements of development in LDCs, there are important reasons why this view should be qualified, if not questioned. First, technology is not neutral: the characteristics of any technology are heavily influenced by the economic and social conditions in the economy in which it is generated.⁵⁴ Thus technology developed for advanced countries often has characteristics which are inappropriate for LDCs. Consequently any attempt at straightforwardly replicating advanced countries' technology is precluded. Indeed, many LDCs found it difficult to match local skills, materials and scarcity relations with the requirements of technology developed for advanced societies. Technological development in the DCs tends to be increasingly capital- and skill- intensive, designed to produce products to meet the requirements of high-income consumers who demand high-quality goods, and of increasing scale production. If imported unadapted by LDCs, these technologies could have undesirable social and economic effects such as unemployment, income maldistribution and inefficiency. Second, this view overlooks the adverse effects of unrestricted imports of technology on the process of 'learning-by-doing' in the recipient country. Japan's experience illustrates the way in

which selective technology imports may enhance the local development of technological capacity. Third, technology imports often involves the transfer of marketing rights, which are not worth acquiring from the social point of view.

These qualifications are made from the social point of view of the recipient country, and do not directly apply at the level of the individual enterprise, whether private or public. This is due to the fact that social needs and interests do not often coincide with those of the individual decision-makers. Even where local research effort generate viable technologies, there is a strong tendency for these to be rejected in favour of foreign ones⁵⁵, often largely due to the market power bestowed by foreign marketing rights, which is in turn due to the consumer's belief in the superiority of foreign goods. Individual decision-makers, eager to make profits and enhance their competitiveness on the local and/or foreign markets, prefer foreign technologies and skills. For example, local firms may be concerned with construction and lead times and consequently opt for foreign experienced engineering and machinery-supplying firms in preference to less experienced ones. Although these decisions may be rational from the point of view of the individual decision-maker, they may not be optimal from the rational point of view. Clearly there are social benefits to be gained in the long-run by restricting technology imports while at the same time enhancing the development of local technological capacity. Unregulated technology imports may operate so that opportunities

for 'learning-by-doing' both in innovative (like R & D) and design-engineering (like project and capital goods) activities are precluded. This in turn leads to weak links or the absence of links between local research institutions, engineering firms and machine-builders; such links which play a determinant role in linking scientific activities to the production system in advanced countries.

However, a selective approach to the import of technology though necessary is not sufficient by itself to ensure the development of local technological and scientific activities. While selective measures may be required to protect and encourage local innovative and learning activities, promotional policies aimed at stimulating local scientific and technological activities are also required. The most successful examples of technology promotion have combined selective imports of foreign technology with many positive promotional measures at the macro- and/or micro-level. At the macro-level, Japanese experience illustrates how technology was imported with the explicit objective of using it as a basis for local technological activities; rather than a substitute for it. Its policies have been designed to achieve the objective: "the first machine by import, the second by domestic production". This seems to have been achieved through the establishment of complimentary relationships between foreign technologies imported and 'learning-by-doing' by local technologists. The State financed R & D spendings in those industrial branches which made most use of imported technology.

Most of these spendings were concentrated on improving and adapting the technologies which were imported.⁵⁶

The promotion of local technological capabilities are not only required to generate new technology, but also and above all, to ensure the success of imported technologies. As Rosenberg has argued: "Perhaps the most distinctive single factor which determined the success of the transfer of technology has been the early emergence of an indigenous technological capacity. In the absence of such a capacity, foreign technologies have not usually flourished. Countries which had successful experiences usually learned at an early stage that the successful importation of foreign technologies required some minimum level of technological skills - not only to modify and adapt the foreign technology to local needs...but to provide the basis for an intelligent selection among the wide range of potential suppliers to begin with. Intelligent choice among the alternative technologies available abroad presupposes a considerable amount of technical knowledge".⁵⁷

3. The Role of the State in the Development of Local Technological Capacity.

Technological capacity means the ability to make independent technological choices, to adapt and improve upon chosen techniques and products and to generate new ones locally. This capacity is essential not only to generate new

technologies but also to ensure the success of transplantation of old ones. Any technology transfer requires a certain degree of technological capacity and effort on the part of the recipient, if only because of the 'implicitness' and 'tacitness' inherent in any technology transfer⁵⁸, as a result of which the transfer of knowledge cannot be achieved in its entirety. Indeed, one of the characteristic features of knowledge is its lack of permeability; it is often acquired in bits and pieces even when the supplier is willing to provide all the information required.⁵⁹ The result is that the recipient always acquires a less complete set of information than possessed by the supplier. Moreover, a great deal of knowledge is generated through hands-on experience in design and production activities. Unlike scientific knowledge, technological knowledge is largely product-, firm- and context- specific. Accordingly technology transfer from one country to another is inherently uncertain and problematic, and its success depends largely on the recipient's technological capacity and willingness to allocate the necessary resources, both human and material, in order to acquire this knowledge and make effective use of it.

The relationship between the import of technology and the development of local innovative and project construction capacities is complex and involves complementarities and conflicts. Whereas local technological capacity may always

be required to make effective acquisition and use of imported technologies, account must be taken of the possible existence of substitutabilities and complementarities between local and foreign technological knowledge; the former may undermine local technological effort and the latter may stimulate it. Thus while the import of technology may be a necessary part of the learning process - either by providing the critical input into the learning process or by allowing the recipient to bypass the process of 're-inventing the wheel' - nonetheless an unregulated and nonselective inflow of foreign technologies may severely marginalize local innovative and engineering activities and/or inhibit the learning process.

There may be different paths to the achievement of a sustained process of local technological information. Both the historical experience of successful 'late-comers' technologically⁶⁰ and actual differences in technological levels among LDCs make it difficult to pinpoint a common set of necessary and sufficient conditions which have to be met so as to achieve a sustained process of technological innovation. However, the following may be the types of policies likely to be conducive to local technological development in LDCs:

1. Policies which remove legal restrictions on local technological development and enhance the bargaining power of local enterprises. These particularly apply to patents and

trademarks. The patent system as it operates at present seems to work against the interests of LDCs. Over 90% of patents issued to foreigners in LDCs are not exploited and thus they tend to prevent competition and local technological innovation rather than stimulate it.⁶¹ Trademarks tend often to favour the well-established and reputable foreign suppliers, thus making it difficult for less well-known alternatives to compete. While the private benefits of acquiring trademarks to a particular enterprise, in terms of market power, may be great, they are not socially beneficial in terms of both direct and indirect costs.

2. Policies which protect indigenous technological development through selective imports of technology. Most successful 'late-comers' technologically have been selective in acquiring foreign technologies. Although in the 19th century, the US Government intervention in this context was minimal, American firms were highly discriminatory in importing technology.⁶² However, it was the Japanese and the Soviets who were consciously and deliberately selective in acquiring foreign technologies.⁶³ The State in both countries played a determinant role in both regulating technology imports and promoting local technological capacities.

Regulation and selection of the inflow of foreign technology involves some form of State control over technology imports.

A number of LDCs have begun to intervene actively in the inflow of technology through various means. The most common way of control is compulsory registration of technology imports, with the aim of both increasing the bargaining position of local technology buyers, protecting local technological effort and increasing the learning effects of imported technology. Other countries, such as Algeria use very specific methods to control the transfer of technology. In principle, the Algerian State determines directly, through its control of the economy, the country's technological needs as well as the terms and conditions of its transfer. Many Algerian laws and regulations can be applied to the transfer of technology, but they usually do not only serve this purpose. In addition to these laws and regulations there are model agreements established by the various technical ministries for State enterprises under their control. These model agreements constitute the basic text for discussion during the negotiations between national enterprises and foreign technology suppliers. Two forms of these agreements exist: turnkey and production guarantee agreements*. These contractual forms aim to force the foreign supplier to bear the risk for industrial operations (including sale of capital goods, trademarks in some cases, licencing patents, supply of know-how, training of Algerian personnel, technical

* their equivalent in French are: 'clé en main' and 'produit en main'

assistance and engineering organization). However, in some cases, exemptions of provisions of these model agreements are possible and have been obtained by suppliers, usually by inserting additional clauses.

The aim of selective policies is to import technologies that are both appropriate to local conditions and complementary, rather than substitute for local ones, so as to learn from them and eventually improve upon them. The success of this policy, from the technical point of view, depends largely on the recipient's ability to acquire technology in an unpackaged form⁶⁴ so as to assess each element of the package and decide which parts are available locally and which are not. The acquisition of this capacity in turn depends on the degree of development, and promotional effort given to local consultancy firms, information centres, R & D institutions and capital goods industries.

Historians of science and technology and economic historians have been puzzled for some time about the precise origins of a basic indigenous technological capacity in a given country.⁶⁵ However, research on this point is in agreement that this capacity is to some extent related to the general literacy level, especially in the agricultural sector, and the educational system's emphasis on empirical problem-solving and on general cognitive processes. Meanwhile most research on developing countries is in agreement that the

general cultural level in most of them, in particular those in Africa, does not match the requirements of most imported technologies.⁶⁶ In other words, there is not only a shortage of highly skilled technical and managerial personnel who can make effective acquisition and use of foreign technologies, but also and above all a shortage of the mass of middle and lower echelons of managerial and technical personnel, down to and including semi-skilled workmen in these countries. This lack of coincidence between the general cultural level of the country's population and skills requirements and imported technologies may result in the technological graft becoming an excrescence that is quite impossible to assimilate and diffuse, in particular in the short run.⁶⁷

While no government can legislate against the initial low level of local technological capacity, they can however play a determinant role in both overcoming supply-side constraints and stimulating demand for local technological innovations and consultancy engineering. This could be achieved through promotional policies.

3. Policies to promote indigenous technological capacities. They are an essential counterpart of policies towards technology imports. On the supply side, they include provision of general and technical education and training, promotion of local consultancy and applied research activities as well as of capital goods industries and

information screening institutions. On the demand side, they include government procurement policies, tax incentives and direct subsidies to various kinds of technological efforts, and promotion of the use of local suppliers of technology.

Past experience with respect to promoting local technological activities reveals that the success of these explicit policies depends on the following:

- a) Whether or not these promotion policies coincide with the general economic strategy of the country: The general economic strategy strongly influences technological development. This is most obvious in relation to the question of 'appropriate' technology, where policies towards trading strategy, income distribution, investment and credit allocation, factor prices and sources and modes of technology transfer are all critical in determining the choice of products and techniques. The general economic strategy is also of great significance in relation to local technological development. Thus most import-substitution policies have tended to be accompanied by full-scale protection of consumer goods industries; which in turn tended to promote a passive attitude towards the utilization and development of local learning process during the early stages of industrialization.⁶⁸ Thus, instead of protecting local learning process and technological effort, which extends to those goods which embody technology, I-S policies tend to protect the market for consumer goods, thus discouraging

local technological effort as managers become complacent within their protected structures;

- b) The establishment of links between the production system and the various educational and research institutions. Such links may be created through various means including contractual arrangements and in-house training and applied research, as well as through informal relations. Past LDCs experience reveals that these links are weak and this led to the 'marginalization' of the educational and research activities. The 'marginalization' of the former led to overemphasis on general education at the expense of technical and vocational training and to attention being given to quantitative expansion rather than to the quality of knowledge and skills acquired and their utilization in the work place.⁶⁹ The 'marginalization' of the latter led to the tendency to overdo basic research against applied research. Underlying the promotion of education and training and research activities was the belief that these links would automatically take place. Subsequent empirical evidence has shown that this belief was misplaced, and these educational, training and research activities have very weak, or no links with the production system.
- c) Specialization. LDCs are not expected to excel in all fields of scientific and technological fields. Consequently, a conscious and deliberate selection of the areas, which they tend to develop, is essential so as to concentrate their promotional efforts and import selectivity in these areas.

This specialization may be accompanied by determination of the level of technological mastery required in each area, and consequently the technological effort required to achieve it, according to the objectives of the general economic strategy of the country. The experience of some countries suggests that the acquisition of production engineering capacity can be sufficient for the efficient use of some imported technologies. "Korea's experience...demonstrates that a high level of technological knowledge in all aspects of the use of technological knowledge is not required for sustained industrial development. This is evident from the fact that its mastery has progressed much further in production engineering than in project execution".⁷⁰

The technological capacity required in each area chosen may range from mere production engineering to more complex operation in the form of basic research through information screening, adaptation and improvement of imported technologies, and the development of new ones as well as project execution. Detailed analysis of these various capacities and technological effort needed to acquire each of them is reserved for Chapter 3 dealing with the assimilation of imported technologies.

Empirical evidence on the impact of these explicit policies on terms of technology imports by, and promotion of local technological capacities, in LDCs is still sketchy and

inconclusive. Their proponents assert that they have reduced the overt costs of technology imports, have helped to reduce, and in some cases even eliminate, undesirable restrictions without inhibiting the inflow of foreign technologies⁷¹, and have helped local purchasers in obtaining "full information on technological alternatives and conducting a careful evaluation and selection of products and processes".⁷² In the case of Mexico Graham pointed out that: "Critics of the Registry* claim that the opportunity cost to Mexico of the screening effort has been substantial because of the reluctance of foreign companies to bring to Mexico or sell to Mexican companies technologies that are unique and closely held... Critics of the Registry have included some academic economists in Mexico as well as a number of prominent Mexican businessmen".⁷²

As for the impact of the policies on the development of local technological capacities, empirical evidence available provides no clear conclusion. Whereas Lall and Katz and Alpin⁷⁴ assert that these policies have generally had positive effects on deepening the learning process, a cross country study carried out by the Science and Technology Policy Instrument (STPI)⁷⁵ concluded that explicit policies had less effect on technological development and technical change than other implicit policies (for instance related to

* 'The National Registry of Technology'

trade, investment licencing, credit allocation and the like).

On the Indian experience Lall argues that: "The present evidence...supports [the first hypothesis]...that the protection of domestic 'learning' (comprised of protection of local manufacturing, particularly of capital goods and the protection of local technological effort by restricting access to imported technology) leads to a diverse and deep technological capability which spills over into technology exports...Thus [in] India...government intervention, almost unique in the newly industrializing countries group for its inward-looking obsession with self-reliance has been largely responsible for its accumulation of technical capabilities". However, he also adds that India "may also have generated a certain amount of socially wasteful technological effort which would have to be written off in a more open, competitive environment" and asserts that: "The costs of pushing technological effort too far leads to high costs, technological lags and various distortions which are very difficult to remove". Lall's ultimate conclusion was: "Some intervention is clearly needed to promote technological deepening. Such intervention may enhance both the production process (on classical infant industry grounds)...and the technology generation process (on protection of 'learning' grounds)".

In contrast to Lall's findings, the STPI Study concludes that

explicit science and technology policies (with the exception of personnel training) had very little impact on the development of local technological capacities in the countries surveyed, particularly at the early stages of industrialization. Nevertheless the study asserts that these policies appear to assume increasing importance as industrial development proceeds. The study did not explain why the explicit policies of technological development in these countries appear to be relatively ineffective. It is possible to infer that their ineffectiveness was a consequence of other findings of the research, which were that these policies were inconsistent with other implicit policies contained in the strategy of industrialization⁷⁶ or they were not adequately applied, and often appear to work at cross-purposes.⁷⁷

Many of the policies described above involve challenging very powerful interests, some of which are external; others have been internalized and are well represented within many LDCs. The history of attempts by a number of LDCs' governments to control the terms and conditions of technology imports as well as to develop local scientific and technological activities is strewn with failure of 'will', which is somewhat a metaphorical way of describing successful resistance, on the part of interests involved, to attempt to control them. The following examples may provide some indications of what happened in some countries.

In Mexico, the near monopoly of a technologically successful local firm in the steroid hormone industry, which led in R & D worldwide, was broken as a result of pressure from US firms and the US government. As a result the industry was soon after dominated by foreign subsidiaries. Later government attempts to regain control over the industry for local firms failed mainly because of opposition from external and internal vested interests.⁷⁸

In both Brazil and Sri Lanka, government plans to replace brand name drugs by generic drugs were diluted as a result of strong political opposition which had powerful foreign support.⁷⁹ Meanwhile, the Brazilian government's recent attempt to protect the local information industry has led to a strong opposition from US firms and administration which appears to have at least been partially successful as the Brazilian government decided to lift control over some areas of the industry.⁸⁰

The experience of the Andean Pact countries with respect to the implementation of Decision 24⁸¹ illustrates some aspects of political economy of each member country. Since its inception in 1969, Decision 24 has been controversial even among parties to the Pact. Venezuela, for example, did not sign the Treaty of Cartagena until 1973, one of the reasons being that Decision 24 would discourage foreign investment and technology from coming into that country. However, after

the oil price hike of 1973-4 the Venezuelan government began to re-evaluate its position on FDI and, by 1978, it had swung to a hard-line position on Decision 24. By contrast Peru, with a stronger national bourgeoisie, succeeded in divesting the Decision between 1970 and 1975 but began to soften its position after experiencing severe balance of payments deficits after that. As for Ecuador and Bolivia, where foreign interests were relatively stronger, they expressed concern over Decision 24 almost from the beginning, and both de facto did not stick rigidly to its provisions. While embracing the principles of Decision 24, the Columbian government, under pressure from local and foreign interests, has not in practice enforced provisions of the Decision rigidly.⁸² Finally Chile has experienced the widest swings in its official and practical position with respect to Decision 24. Under Allende, the official and practical position was that Decision 24 presented a de facto minimum policy on inflow of foreign investment and technology, so that some actions which were taken went even beyond Decision 24. Following Allende's overthrow, the policy was radically revised to a virtual repudiation of Decision 24.

Certain conclusions are suggested by taking into account the political economy aspects. First, certain types of policy may be easier to secure from the political point of view, than others. For example, general promotional policies are likely to be less subject to opposition than those dealing

with regulation and selection of imported technology. This is not just because they are likely to be less effective (although undoubtedly this is part of the story) but also because their effects both depend on the effectiveness of control of inflow of foreign technology, and are normally more widely dispersed and therefore specific opposition is less likely to be aroused. Secondly, from the political point of view the ability to control the terms and conditions of the inflow of foreign technology is likely to be greater the more arms length and the less previous relationship with foreign technology suppliers. Third, discretionary policies are more subject to abuse (e.g., through bribery) than general policies.

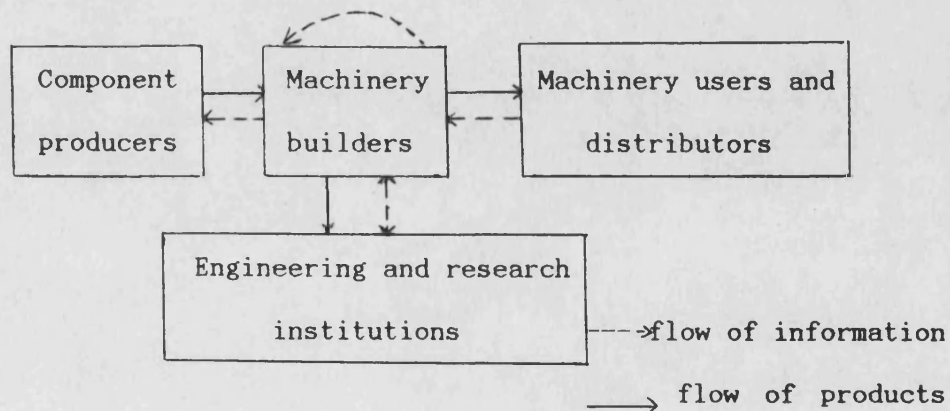
The political economy aspects of technology transfer and technological development in LDCs does not provide a reason for not attempting to control the inflow of foreign technology and foster local technological development. However, they suggest that political forces should be taken into account in formulating such policies and the need for strong 'will' to carry them out, needs to be emphasized. Indeed, most research on technology aspects in LDCs is in agreement that the state has a major role to play in the process of development of local technological capacities and in the diffusion of both international and local technological knowledge. However, there is a difference of opinion on the extent, duration and forms of this

intervention.⁸³

4. The Role of the Capital Goods Sector in the Process of Technological Change

The capital goods sector occupies a unique role in the process of technological change. The reason is that it lies at the heart of the process of technology diffusion and generation. All technical change, whether in the form of product or process, requires the development of improved or new machinery. Meanwhile the diffusion of improved or new machinery enhances the process of technological change in using sectors.

In view of the central role of the capital goods sector in the process of technological change, it is worth analyzing the sources of technical change within this sector as well as the way they are diffused. The following diagram illustrates the sources of technical change and the way they are diffused:



As mentioned above, the most important function of machinery-building sectors lie in the adaptation, modification and innovation of machinery. To achieve this aim, machinery producers require information on the basis of which they can make these changes. One of the important sources of this information comes from the interaction between producers of machinery and users and distributors of machinery. A number of authors analyzed the importance of this interaction in shaping the kind of technical change produced in the capital goods sector.⁸⁴ Another source of technical change in this sector is the machinery producer industry itself. As Rosenberg pointed out, the capital goods sector has a unique feature in that it is both a user and producer of some machinery it produces.⁸⁵ This is particularly true in the case of machine tools whose producers are at the same time users of some of what they produce. The result of this production-use is that information flows are at least partially internalized within the firm producing the machinery and thus possibly facilitating the flow of information and their subsequent utilization for technical change. Another source of information internal to the sector but external to the individual firm is other producers of machinery whose innovations may be obtained either formally or informally.

A third source of information is the components producer industry who supply information in both embodied and

disembodied form to, and receive information from, machine-builders. The fourth source of information is the engineering and research institutions which provide disembodied knowledge to, and receive both embodied and disembodied knowledge from, machine producers. Long ago, Marx provided the most substantial analysis of the two-way link between science and production. As Rosenberg⁸⁶ argued, Marx observed and analyzed the way in which the link between science⁸⁷ and production via the development of machinery created the necessary condition for infinite technological improvement.

In view of the central role of the capital goods sector in technology generation and diffusion, it is not surprising that there is a general consensus on the importance of an indigenous capital goods sector for facilitating technological change in the LDCs. The reason, it is often argued, is that production conditions are to a large extent location-specific and consequently they are in many respects different from one country to another and particularly different in LDCs from those prevailing in DCs. Katz⁸⁸ listed a number of factors, such as scale of production, market size, factor prices and the degree of competition and skill availability, which may make the kind of capital goods that are required in LDCs different from those in use in DCs.

In addition to the function of adapting technology to local

conditions, the capital goods sector plays a major role in linking research institutions to the production system, in responding to the production requirements of local users and in diffusing technology through improved and/or new machinery. It is the 'black box' in which information received from various sources are transformed, and simultaneously the main centre for the diffusion of technology. In its absence, new information which may be supplied by the various formal and informal sources, is either transferred to machinery builders abroad or simply shelved. Indeed, a considerable proportion of new ideas to improve products and processes in the Algerian industry, have been shelved for many years as a result of the underdevelopment of the local capital goods sector and bias in the allocation of scarce foreign exchange in favour of new projects (at the expense of refurbishing existing ones).⁸⁹

For the reasons discussed above the capital goods sector has a potentially important role to play in the process of technological development and economic growth in LDCs. A crucial question, therefore, relates to the decision whether or not to import or manufacture locally. There are diametrically opposed opinions on a number of related policy questions in developing this sector in LDCs: while most writers agree that an indigenous capital goods sector provides the necessary conditions to adapt, improve and generate new products and processes, the consensus abruptly

ceases in cases where, at least in the short run, the local production of specific capital goods is inefficient relative to world best practice. In such cases, some argue that, if competing imports were to be inhibited this would place the users of these capital goods at a disadvantage. Others argue that protection of any kind and over any length of time will impair long-run progress which may be achieved through the effects of international competition.⁹⁰ On the opposing side, there are those who emphasize the possibility of a long-run learning process which may eventually result in the attainment of international competition, thus justifying the short-run costs.⁹¹ Indeed, all LDCs, except perhaps Hong Kong, are establishing their capital goods sector through direct government intervention and some of them such as South Korea, India, Argentina, Brazil and Taiwan are competing on the world market. But even with this success, a number of complex policy issues arise. For example, is there a case for selective government intervention to promote the protection of certain capital goods that will not be produced otherwise? If the answer is in the affirmative, as some argue, what forms of government intervention are best? and for how long?. Conventional economic theory suggests that externalities, infant industry learning effects and training of skilled manpower may be taken into account in addressing the issue, but in practice the evaluation of these factors is problematic because of the uncertainty of what may happen in the future. For example, it is not possible to be certain

that successful learning will take place. A likely danger is that local managers may become complacent within their protected structure and lose, or never develop, the ability to be competitive, and may even block any attempt by the government to lift its intervention. As for the duration of the state intervention, it is theoretically a function of the lead time which separates the level of technological development of local capital goods producers from the world technology frontier: the larger the short run costs and the longer the period during which this intervention is required as local producers attempt to 'catch up'.

Some empirical evidence on these issues has recently been published. Some case studies concluded that there was a substantial increase in productivity and a considerable technological change in parts of the capital goods sector that were initially protected.⁹² Thus, while it is often argued that heavy protection and distorted factor prices remove incentives for local technological change, empirical evidence reveals that there are a number of cases where local technological innovation occurred in a generally protected environment. Thus India and Argentina have been exporting technology, including whole industrial plants, to other LDCs and some capital goods to both LDCs and DCs.⁹³ The sort of pressures which lead to local technological innovation were of many kinds, e.g., absence of particular raw materials, local users' requirements and the like, and not confined to

cost pressures associated with exchange rate policies and prices.⁹⁴ Still it is not possible to conclude from these findings that the long-run benefits outweigh the short-run costs. Furthermore, Fransman argues that considerable learning took place in the capital goods sector in Hong Kong under conditions of near-free market. However, he concludes that under these conditions some potential protection-related gains may have failed to be realized.⁹⁵ Again, it is difficult to be certain whether the learning process would have improved by selective government intervention. These empirical findings illustrate some of the practical difficulties in attempting to plan the development of the capital goods sector in LDCs.

Conclusion

This chapter has provided a survey of many issues related to industrialization, technology transfer to, and technological development in LDCs. Perhaps the most important points to emerge from the discussion are that the overall economic strategy of the country strongly influences local technological development, that unregulated technology transfer can have undesirable effects on the recipient country (short term negative effects in the form of transfer of surplus available for re-investment and long term ones in terms of foregoing 'learning-by-doing' effects) and that the state and the capital goods sector have an important role to play in fostering technological development in LDCs. Although

some empirical evidence suggests that the state intervention had very little impact on terms of technology imports and technological development, these findings do not provide a reason for not trying to introduce desirable changes. In fact what they suggest is that political economy aspects should be taken into account in formulating policies and the need for strong commitment to carry them out, needs to be emphasized. Most of the issues raised in this chapter will be discussed in the next chapter which focuses on Algeria's experience.

FOOTNOTES TO CHAPTER 1

- (1) UN, (1971): p.31
- (2) This view is still prevalent in the literature, see e.g. Fei and Ranis, (1970) and Emmanuel, A., (1982): Ch.2.
- (3) See e.g., various documents published by UN Conference on the Application of Science and Technology in the Developing Countries, 1962.
- (4) UNESCO, (1969): p.24
- (5) [India's] National Committee on Science and Technology, (1973): pp 14-15; Sagasti (1979): Chapters 1 and 2 and Harerra in C. Cooper (Ed.), 1973: pp 19 and 38.
- (6) See e.g., Leslie A. White who argues that a social system is a "function of the technological system" and furthermore "technology is the independent variable, the social system

the dependent variable, social systems are, therefore, determined by systems of technology, as the latter change, so do the former". (1971: pp 365f).

- (7) Though science in their context meant the application of scientific principles to production in a wide sense, and not a specific search for new inventions in laboratories.
- (8) Adam Smith, (1964): pp 9ff.
- (9) For a defense of Marx (explaining why he is not a technological determinist) see Rosenberg, (1982a), Ch. 2.
- (10) Marx, (1973): p. 278.
- (11) Marx and Engels, (1951): p.34
- (12) Marx, K., (1967): pp 713-28
- (13) Schumpeter (1961): Ch. 4
- (14) Bernal (1968)
- (15) Ibid., p. 1236
- (16) Ibid., p. 1246
- (17) Furtado, (1964)
- (18) Sagasti, (1979): p 10
- (19) "Thus in 1979-1971, while agriculture contributed to roughly half the gross national product the central and state R & D allocation for this sector was about 21% of the total, whereas the Atomic Energy and Space programme alone accounted for 20%of the total expenditure on R & D in the central sector, medical research and family planning absorbed only about 5% while R & D expenditur on defence was 12%, irrigation accounted for less than 8% of the total expenditure on scientific activity of the central sector".

[India's] National Committee on Science and Technology, op. cited., pp 18-19.

- (20) Ibid.
- (21) Rahman, "Problems of Science Policy", Citizen, 12 (1), pp 12-13.
- (22) Sagasti, 1979, op. cited., p.10
- (23) UNECLA/OAS, 1969: p.14
- (24) For example, The UNESCO's call on LDCs to raise their expenditure on research activities to at least 1% of their GNP "as soon as possible but not later than 1980", UNESCO, 1969: op. cited., p. 24. In response to such advocates, India's National Committee on Science and Technology pointed out: "There is a body of opinion on science and the economy which...suggests that the key to rapid development is massive investment in R & D. Were it but so! Our own experience, and the wide variation of the growth rates of different industrialized countries with similar investment in R & D teach us that there is far more to gearing science and technology to the national purpose than a mere expansion of education and an increase in R & D expenditure...", op. cit p. 8.
- (25) See for example, Fei and Ranis, 1972, op.cit., and Emmanuel, (1982) Chapters 2 and 3.
- (26) Michalet, (1976): pp. 161-162
- (27) See for example Baranson, (1978): pp. 5-10
- (28) For example, the technology for transforming natural gas into Liquefied Natural Gas (LNG) was first applied in

Algria in the early 1960's.

- (29) See for example, Davidson and Harrigan, (1977): pp. 15-23.
- (30) See, for example, Vernon (Ed.), 1970
- (31) Vernon, (1971): p. 108
- (32) Baranson, 1978, op. cited., p. 6
- (33) Quoted in D. Enst, (Ed.), 1980: p. 13
- (34) Dunning, 1981: p. 336
- (35) Michalet, 1976, op. cit., p. 167
- (36) In examining imitation costs and time of innovations in a number of industries Mansfield concluded that: "...imitation cost averages about 65% of innovation cost, and imitation time averages about 70% of innovation time". E. Mansfield in Z. Griliches (Ed.), 1984, p. 142.
- (37) "Until very recent times", writes Galbraith, technology "was in all countries, a nearly absolute social good" in Williams, B.R., (Ed.), 1973: p. 39
- (38) Sabato and Mackenzie speak rightly of "factories" of R & D. (1979; pp. 31 ff)
- (39) Sabato and Mackenzie (Ibid.), refer to this new form of technology production as "new mode of production of technology", so does A. Emmanuel (1982, op. cited, pp. 25-26).
- (40) Quoted in D Ernst (Ed.), op. cited, p. 13
- (41) Financial Times, February 11, 1984, p. 84
- (42) Westphal, L.E. et al in Fransman and King (Eds.), 1984: pp. 279-314
- (43) Specialized training of the recipient's personnel (e.g. in

process and product design engineering and R & D) depends heavily on the supplier's willingness to depart with such know-how specific to the technology in question. It is reported that some foreign suppliers were unwilling to train Algerians in such specific tasks. See e.g., Benachenhou, (1976)

- (44) The notion that possession of a particular technology confers monopolistic advantages on its owner is not new to economics. Long ago, Ricardo pointed out that: "He...who made the discovery of the machine, or who first usefully applied it, would enjoy an additional advantage, by making great profits for a time...", Ricardo, 1970: p. 378.
- (45) Arrow, K., in Rosenberg (ed.), 1971: p. 171
- (46) See for example Vaitzos, (1971), Sercovich, (1974), Subrahmanian, (1972) and El Hindis No. 5, (1979), pp. 54-67
- (47) Quoted in the World Bank, No. 344, (July 1979), pp. 30-31
- (48) MPAT, (May 1980): pp. 304-10
- (49) These payments were for patents, licences, know-how, management and technical services and training of Algerian nationals abroad. It was estimated that the share of royalties and labour training payments amounted to around 20% of the total. The main recipient of foreign technology was industry (including hydrocarbons and energy) with around 95% of the total.
- (50) Compared with imports of capital goods, total payments for technology amounted to 28.3% in 1973, 50.3% and 52% in 1977 and 1978 respectively. Official statistics also revealed

the predominance of Western countries in technology transfer to Algeria: they accounted for around 93% of the total. Ibid.

- (51) See footnote 46
- (52) See for example UNCTAD, (1977) and Jenkins, G., and Wright, B.D., (1975).
- (53) See for example Greschenkron, (1962); Kuznets (1966) and Spenser (1970)
- (54) This point is analyzed in great detail by Stewart, F., (1977), Chapters 1 and 3.
- (55) See for example Subrahmanian, op. cited.
- (56) See for example Peck, M.J., and Tamura in Patrick, H., and Rosovsky, H., (eds.), (1976); and UNCTAD, (1978).
- (57) Rosenberg, N., in OECD, (1982): p. 42
- (58) This point is discussed in great detail by Nelson, R., (April 1979).
- (59) This is not often the case as technology suppliers usually practice what may be called a measured release of information to the recipient. In other words, they tend to withhold the essential elements of the core technology which are necessary for the recipient to reproduce the technology.
- (60) See for example, Rosenberg, N., in Beranek and Ranis (eds.), 1978, and UNCTAD, 1978, op. cited.
- (61) Vaitzos, C., in Cooper, C., (ed.), 1973, op. cited, pp. 71-98 and Delmore, J., in OECD, 1982, op. cited, pp. 88-167.
- (62) Rosenberg, N., in Beranek and Ranis, (eds.), op. cited.

- (63) See for example UNCTAD, (1978), op. cited.
- (64) For example Mytelka's research into the Andean Pact country experience suggests that the development of local capacity to choose and generate technology may require unpackaged technology transfer. Mytelka, L., (1978) and (1977).
- (65) See for example Roseberg, N., in Beranek and Ranis (eds.), 1976: op. cited.
- (66) There are some exceptions to this view. See for example Patel, J. who argues that Third World "is now more prepared from the educational point of view than the developed countries at the beginning of their industrialization". (1976: p. 210)
- (67) This point was discussed in great detail by Lambert, D., [(1979): pp. 130-140]. The author refers to such technological grafts as "technological cysts".
- (68) For more detail, see N. Lee (1975) and Sagasti, 1978, op. cited.
- (69) See for example King, K., in Fransman and King (eds.), 1984: op. cited, pp. 31-64.
- (70) Dahlman, C., and Westphal, L., in F. Stewart and James, J., (eds.). 1982: pp. 129-30
- (71) See for example F. Stewart in Streeten, P. and Jolly, R. (eds.), 1982, and Vaitzos, (1971): op. cited.
- (72) UNIDO, 1978, op. cited, p. 53.
- (73) Graham, E.M., in OECD, (1982): op. cited, pp. 73-74
- (74) Lall, S., (1984): pp. 471-480; Katz, J., and Alpin, A., (1979) and Katz, J. in Fransman and King (eds.), 1984: op.

- cited., pp. 113-136
- (75) A summary of the study is published in Sagasti, (1979): op. cited.
- (76) See for example, Sagasti, (1978): Ibid, Herrera, op. cited, and Ch. 2 of this thesis.
- (77) Ibid., Agarwala, A., (1978): pp. 442-3 and Gereffi, G., (1978).
- (78) Gereffi, Ibid.
- (79) Agarwala, op. cited.
- (80) Financial Times, October 27th, 1986.
- (81) Decision 24 pertains to regulation and control of foreign firms operating in and selling technology to member nations. Articles 18 through 26 of Decision 24 pertain specifically to technology transfer.
- (82) A detailed analysis of political economy aspects with respect to Peru, Columbia and Ecuador, following their common policy of Decision 24, can be found in Mytelka (1977) op. cited.
- (83) For more details, see the various views expressed in the essays published in Fransman and King (eds.), 1984: op. cited.
- (84) See for example, Freeman, C., (1974)
- (85) Rosenberg, N., (1976): op. cited.
- (86) Rosenberg, N., (1982): Ch. 2
- (87) See footnote 7.
- (88) Katz, J., in Fransman and King (eds.), 1984: op. cited. Evidence is now accumulating showing that local capital

goods sectors in the more industrialized LDCs, provide machinery that is significantly different from those supplied by DCs. See for example, Jacobson, S., (1984) and UNCTAD (May 1982).

- (89) During my visit to a number of mechanical and electrical production units in Algeria, a number of cases where the design of improved or new products were shelved, were pointed out by executives. Among these was the design of a small agricultural machine, which although exhibited to a number of Algerian ministers and foreign delegations visiting the plant, was shelved as the Ministry in charge decided not to extend the plant so as to produce the new machine. Instead, the Ministry was said to be negotiating with foreign firms with the objective of building a new plant producing similar equipment on a turnkey basis and using foreign technology. Until the end of 1986, no final decision was taken in this respect.
- (90) See for example Doore, R., in Fransman and King (eds.), 1984: op. cited, pp. 65-80 and Ranis, G., in Ibid., pp. 95-112.
- (91) See for example Stewart, F., Katz and Dahlman's essays in Fransman and King (eds.), 1984, op. cited.
- (92) See for example Katz, Dahlman and Lall's essays in Ibid. and Lall's other publications on technological change in and technology exports of India, as well as Katz, J., (1984): pp. 13-37 and Teitel, S., (1984): pp. 39-61.
- (93) See Lall's various essays on India's exports of technology,

Hug, M.M. and Prendergast, C.C., (1983), UNCTAD, (May 1982), various essays in World Development, 13 (3), 1985, Chudnovsky, D. et al., (1983) and Katz and Alpin, (1979): op. cited.

(94) See footnote 92 and 93.

(95) Fransman, M., in M. Fransman and K. King (eds), 1984: pp. 301-316.

Chapter Two

ECONOMIC STRATEGY AND TECHNOLOGICAL POLICY: THE CASE OF ALGERIA

Introduction

In the previous chapter we argued that the general economic strategy of a country strongly influences local technological development. This is mainly because the general strategy contains an array of implicit technology policies which are sometimes more important than explicit policies, and which frequently run against the objectives of local technological development. Identifying these contradictions are of great importance for local technological development. For example, the explicit technology policies contained in the basic industry strategy¹ followed by Algeria in the 1970s, reinforces technological dependence at least in the short and medium term. While its main long term objective is to reduce both market and technology dependence by emphasizing investment in the producer goods sectors, the strategy contains an inherent contradiction between medium term heavy reliance on foreign technology, and long term technological independence².

There is no doubt that the basic industry strategy, if it is successfully implemented, will reduce both market and technology dependence by creating an integrated industrial productive system that features a capital goods sector, and thus provides a

necessary handle on the problem of development of indigenous innovative capacity. However, it requires investment in basic and producer goods sectors with advanced technologies that are unlikely to be mastered by the developing country, at its initial stage of industrialization, in the short run. Consequently it is inevitable that the implementation of such a strategy in the initial stage will heavily depend on foreign technology and management. This is only part of the learning process, a necessary but not sufficient step towards technological independence. The real question therefore is whether the initial heavy reliance on foreign technology and management will eventually give way to local ones. Proponents³ of the basic industry strategy argue that there is bound to be friction between the introversion and extroversion tendencies inherent in the strategy, but they tend to emphasize the former and play down the latter, by emphasizing investment in the capital goods sector in order to end the dependence on raw material exports as a means of affording a necessary intermediate and capital goods imports. They also emphasize the importance of reorienting consumption and of reallocation of resources by channelling available resources towards the producer capital goods, the expansion of which would provide the necessary conditions for the development of a local technological capacity.

It appears that proponents of the basic industry strategy underestimate the effects of both the gap between local knowledge systems and the imported technology and internal and external

constraints which may inhibit the process of local technological development; and they overestimate the role of the capital goods sector in the process of technological development. the implementation of the strategy requires heavy concentration of investment in producer goods and basic industries with advanced technologies that are unlikely to be mastered in a short time. These industries will have to be started and maintained for some time by using foreign patents, capital goods, engineering and foreign technical assistance. This is only part of the learning process, a necessary but not sufficient step towards local mastery of technology. The real question is whether the learning process envisaged will take place and eventually result in the development of a local innovative capacity capable of sustaining itself. In reply to this question, the basic industry strategy's proponents argue that these problems are foreseen and can be managed both with conscious efforts of resource deployment on manpower training and institution-building and with protection while local technical and managerial personnel learn-by-doing.

It is doubtful whether LDCs could create in the short, and even in the medium run a system of knowledge comparable to that of DCs even if all their resources have been put into the effort. Development of the system of knowledge takes a much longer time than the establishment of a productive sector through the import of technology. This is a fact which is underestimated by both proponents of the basic-industry strategy and policy-makers in LDCs, where there is a pressure to deliver goods to people as

fast as possible. As for the protection of the learning process against the pressure of international competition, it may be necessary but not sufficient, to ensure the emergence and development of a local innovative capacity⁴. There is a likely danger, though not a necessary outcome of the strategy, that managers may become complacent within their protected structure and lose, or never develop, the ability to innovate.

Furthermore, proponents of the basic-industry strategy argue that both diffusion of technology and innovation would take place through the establishment of an integrated productive system that features a capital goods sector. This argument underestimates the difficulties of establishing an integrated productive structure and overestimates the importance of the capital goods sector in the process of technological innovation and diffusion.

The 'blackening of the matrix', or integration, is not only complicated in itself for reasons inherent in the planning and execution of a very detailed system of inter-sectoral and inter-industry linkages. It is also restricted because of the terms imposed by the extrovert policy of seeking foreign assistance in solving these problems of introversion. Thus when foreign engineering firms and machinery suppliers are called upon to design, equip and construct industrial projects, they often tend to apply norms, specifications and technical coefficients familiar to them without taking into account the internal application and linkages, thus making the envisaged coupling a practical impossibility. It may be doubly difficult for local

institutions to catch up and adapt un-linked production units if they, as it seems to be the case in Algeria, continue to act independently of each other⁵.

There is no doubt that the establishment of a local capital goods provides conditions necessary to adapt and improve as well as diffuse products and processes, however its existence alone is not sufficient to fulfill these functions as this depends on the producers' design and manufacturing capabilities as well as on interactions between them, potential users of capital goods and engineering and research institutions. Recent case studies carried out in some NICs reveal that the design capabilities of the most sophisticated capital goods producers in these countries are still limited. Examining the results of these case studies, Chudnousky concluded that "evidence is far from conclusive about the progress made by firms surveyed in mastering design and manufacturing technology... [B]asic design and, in some cases, even detailed designs are not yet mastered by leading producers in the countries studied. Accordingly, they suffer from a major handicap which affects their ability to fulfill their role as eventual generators of technological innovations".⁶

In addition to design and manufacturing capabilities of capital goods producers, the role of the capital goods sector in technological development depends to a great extent on the flow of information between producers and users of capital goods and on the competence of engineering and research institutions which

often play a major role in translating the problems of users (particularly those lacking technological capability) into engineering solutions, as well as on their interactions with manufacturers of capital goods. Analysis of research activities in LDCs reveal that their links with the productive system are either non-existent or very weak. (See Ch. 1).

Having briefly analyzed technological implications of the basic-industry strategy, we will examine in this chapter in great detail the points raised above, in the light of both de Bernis' Theory of 'industrializing industries' and Algeria's experience. Both de Bernis' theory and Algeria's Strategy of industrialization contain implicit policies which aim to allow the country to attain a certain technological autonomy in the long run. Both argue that technological autonomy is not an immediately accomplishable goal but must be approached in the context of a transition from dependence to autonomy. This transition was to be achieved through the combination of rapid industrialization based initially on imported technology and extensive education and training programmes. Industrialization (based on 'industrializing industries') through imports of technology was expected to provide the necessary input in the learning process and outlets for the education system; which was expected to provide the necessary skilled labour. The combination of the two was expected to provide a pool of skilled labour which, in combination with engineering and research institutions building would lead to the mastery of imported

technology and eventually to the generation of new technology. According to Algeria's policy makers, Algeria would be able to master production by 1980, to have the necessary technological capacity to do most of applied research by 1985 and to be a relatively autonomous nation in scientific and technological fields by the year 2000, by being able to do R & D as well as basic research work in a comprehensive way.

Although insititutions for training local manpower and accumulating scientific and technological capacity have expanded considerably, it seems that they lag far behind the needs of the established productive system. This growing gap was partially due to rapid industrialization and the extrovert policy of seeking foreign assistance in solving the problems of introversion and partly to the initial low level of development, the established system and the education and training policy. The consequence of the imposition of these external and internal constraints was that the system of knowledge in its broadest sense, could not keep pace with the development of the productive system which was established through imported technology. This in turn resulted in a great waste of scarce resources both during projects' implementation and after.

The discussion is organized as follows. The rest of this section provides an introduction to the next four sections and sets the study in its historical context. The first section focusses on the main objectives of the Algerian strategy of industrialization

and the means to achieve them. The second provides a summary of the underlying theory of the strategy, ie, de Bernis' theory of 'industrializing industries' and its implications for technology. It focusses particularly on contradictions inherent to the theory with regard to the role of 'industrializing industries' in economic integration and technological development. We shall argue that although the author was aware of frictions between introversion and extroversion tendencies inherent to the strategy he advocates, he seems to have underestimated their adverse effects on the implementation of the strategy. The third section deals with the implementation of the Algerian strategy of industrialization, its achievements and problems. Although Algeria could hardly have done without realizing its hydrocarbon resources through exports, the question is whether the policy of rapid industrialization through massive imports of technology, with emphasis on the end product of an integral chain of scientific and technological activity, on competitiveness and thus on meeting the standards of the world market, is not making its long term objective of introversion through extroversion a practical impossibility. In addition to external constraints emanating from the policy which attempts to make use of the international circulation of technology, products and finance, other problems relate to the initial low level of development, the economic system and rapid industrialization, have resulted in great distortions and waste. The strategy's achievements are to be analyzed from the point of view of economic growth, integration, employment and provision of a skilled labour force.

The fourth section focusses on the education and training policy. The main conclusion to be derived from this analysis is that the inherited educational system which was essentially kept intact until the mid 1970s was irrelevant to the country's priorities and needs and resulted in great waste.

Having outlined the contents of this chapter, it is helpful to situate the study in its historical context. When Algeria became independent in 1962, its economy was heavily dependent on France. Nearly all its industrial producer and consumer goods were imported from France. In exchange, it exported raw materials and agricultural cash crops, particularly wine, as well as unskilled labour. Its industrial sector was scarcely developed, its contribution (including mining, energy and construction) to GDP in 1958 accounted for just over 27%. In addition to this structural dependence, Algeria's independence coincided with a massive exodus of European settlers. Among them were most of Algeria's managers, administrators, technicians, teachers and skilled workers. This was accompanied by a tide of disinvestment and capital outflow which continued freely until the beginning of 1964.

The historical experience of the war of liberation, the structural dependence of the inherited economy and the events which took place during the first years of independence have decisively contributed to economic independence becoming the main objective of development policy. Industrialization was regarded

from the beginning as necessary for agricultural modernization, the creation of jobs and exploitation of the country's raw materials. The 1962 Tripoli Programme adopted by the National Liberation Front (NLF) a few weeks before independence, states that: "the true and lasting development of the country depends on the establishment of the basic industries which are necessary for the modern agricultural sector. In this respect, Algeria has huge possibilities for promoting petroleum and steel industries. In this field, it is up to the state to create the conditions that are necessary for heavy industrialization"⁷. The Algerian planners regard "industrialization" as "the sole remedy to the problem of underdevelopment" and the only strategy "capable of promoting economic and social development in poor countries"⁸. For de Bernis, it is a "means to abolish economic dependence"¹⁰.

Although much remains to be learned about the nature of these goals, the tradeoffs between them, and the possibility of achieving them given both internal and external constraints, the economic literature has substantially analyzed in great detail these goals, and their investigation has become a fairly straightforward matter. The following chapter is a contribution to this investigation.

2.1 Objectives of Industrialization

Though launched in 1967, Algeria's strategy of

industrialization had been until 1971 lacking both practical and doctrinal justification. It was only in the early 1970s that the consolidation of the state apparatus and state control of the leading sectors of the economy were accomplished, thus making a centrally planned strategy of development feasible. The doctrinal justification of the strategy was outlined in an official document published in 1971¹¹. This document was a synthesis of contemporary theories of development as well as the historical experience of certain countries. Ample reference was made to many contemporary economists such as Perroux, Hirschman and above all to de Bernis as well as to the historical experience of certain Socialist countries.

The long term objective of the strategy was to create an integrated productive system capable of ensuring both full employment and utilization of the country's national resources and economic independence. This objective was expected to be achieved in the course of the 1980-1990 decade by which time an integrated national productive system based on a powerful industrial sector would have been set up. A powerful industrial sector was regarded as the means to achieve economic independence, introversion and integration.

The construction of a national independent economy explains largely the priority given to heavy industry in the process of industrialization. As A. Marchal pointed out, the

industrializing effort "concerns essentially the strategic branches of production in economic, political and military terms"¹². From the economic point of view industrialization in general and heavy industry in particular, was regarded as the only means capable of ensuring independent expanded reproduction. Thus, President Boumediene stressed in 1965 that: "The main objective of industrialization is to manufacture locally the necessary means of production so as to ensure the establishment of a solid base for our economic development"¹³.

Introversion¹⁴ implies the reorientation of a dependent, disarticulated and disintegrated economy producing cash crops and raw materials for exports to a balanced and articulated national economy producing manufactured goods primarily to satisfy national demand. The objectives of industrialization according to President Boumediene were: "the increase of the national income, the improvement of the workers' technical level, the increase of employment and the widening of the national market, ie. less dependence on foreign markets"¹⁵.

However, neither economic independence nor introversion imply total autarky. Consequently there is need for specialization and trade. This exchange must be based on both self-reliance and dynamic comparative advantages. This implies rejection of both import-led industrialization and static comparative advantage¹⁶. Algeria aims at replacing its exports of raw

materials and labour with manufactured goods. However, these exports are primarily regarded as a vent for surplus from industries producing for the home market. Moreover, given its low level of development, Algeria regards economic independence as not an immediately accomplishable goal but a long run objective. While rejecting the existing status quo, the Algerian Strategy recognizes the need for trade in the initial stage of industrialization. As an exporter of hydrocarbons of average importance and with limited reserves, Algeria aims at using its foreign exchange earnings from hydrocarbons to set up an industrial and technological base capable of self-generation and self-expansion. Algeria's policy-makers and their followers appeared to see no incompatibility between the long term objective (ie. economic independence) and the means to be used to achieve it (ie. heavy reliance on foreign markets for imports of capital goods and technology and for exports of hydrocarbons). Thus they expected that the country would reach the innovative stage (once a relatively integrated industrial structure and a pool of highly skilled and experienced personnel were created) in the course of the 1980-90 decade¹⁷.

Industrialization and agricultural development were seen to be closely connected. It was argued that industrial development would provide agriculture with the necessary machinery and other inputs required for its modernization and consumer goods for its population. Meanwhile, it is the

expansion of agriculture which provides industry and its labour force with inputs and food. Thus President Proumediene stressed this agriculture development-industrialization inter-dependence: "Industrialization will realize a symbiosis between the industrial and agricultural sectors and achieve a real complementarity within our national economy... With this industrial-agricultural complementarity we are not only going to be able to develop our agriculture and ensure our industrialization, but we shall also be able to save the foreign exchange needed to import machinery and equipment"¹⁸.

Industrialization was regarded by Algerian policy-makers as a cumulative process which tends to integrate all aspects of the economy. For such a process to be cumulative, industries required at the beginning of the industrialization programme must provide the basis for further industrial development. Consequently, the priority in the initial stage of industrialization must be given to what de Bernis calls 'industrializing industries'¹⁹ or 'integrating' industries. In the Algerian case these are essentially chemical, petrochemical, steel, metal processing, mechanical, electrical and construction materials. These branches were expected to transform the country's raw materials (such as oil, iron ore, gas and phosphates) as well as to provide the whole economy with necessary means of production and intermediate products which would stimulate the rest of the economy.

Since economic integration is measured by the degree of satisfaction of total national demand, it requires the creation of intersectoral complementarities through backward and forward linkages so as to prevent the leakages and multiplier effects and thus ensure a rapid overall development of the national economy. In other words, industrialization aims at what de Bernis calls "a systematic darkening of the input-output matrix"²⁰. This implies that the decisive factor in the process of industrialization is to build up industries which would speed up the process of articulation of the economy through their 'industrializing effect', ie. industries which provide capital and intermediate goods.

2.2 De Bernis' Theory of 'Industrializing Industries'

The concept of 'industrializing industries' departs from F Perroux' concepts of industrialization and the leading propulsive industry²¹. For Perroux, industrialization is "the restructuring of the whole economy and society by employing machinery in order to increase accumulatively and with decreasing human effort, the power of human groups in obtaining goods which are essential for their well being. Thus industrialization is the establishment of a process which consists of producing machines by using machines such that the number of machines increases at an increasing rate and results in a decrease in human physical effort, therefore a greater liberation of man from the negative impact of the natural environment".²²

For de Bernis, industrialization is a 'total and complex phenomenon' where the technical, the economic, the political and the socio-psychological interact and influence each other²³. However, development of the forces of production (ie. the economic and the technical) predominate because the idea of the economy and its development are seized and understood through the input-output matrix whose transformation indicates the industrializing effect²⁴.

Leading propulsive (in French 'motrice') industries according to Perroux are relatively new ones which operate at a technically advanced level and exert a considerable influence on their environment through forward and backward linkages. The concepts of leading propulsive industries and the multiplier effect constitute the corner stone of de Bernis' concept of "industrializing industries". Thus he defines 'industrializing industries' as those which "indicate a systematic darkening of the input-output matrix, its transformation, or transformation of the production function through provision to the whole economy of new machinery and equipment which raise factor productivity or global productivity and, in any case, increases man's mastery over his production and product..."²⁵. This is a purely technical-economic definition: it ignores social and cultural environment and the level of development of the country (or region) where they are going to be set up. In other words, they are neutral: wherever they are set up, their

industrializing effect will take place automatically. We shall come to this point later.

Amongst the multiplier effects computable to industry (technical, economic, social, political and psychological) de Bernis indentifies the industrializing effect of certain branches of industry. Thus he argues that although all industries have the multiplier effect, only certain industries belonging to the capital goods sector have the industrializing effect²⁶. For LDCs to achieve real industrialization they have to avoid both import-substitution (based on consumer goods) and export-led industrialization: "For under-developed countires, the decisive factor in the industrialization process is the establishment of capital goods industries which are capable of feeding the economy with basic industrial products. Therefore one has to start with the industries which produce the means of production and not those that produce consumer goods"²⁷.

These industrializing industries according to de Bernis are:

1. machine-building industries which produce capital goods required to equip other sectors: machine-tools, turbines and engines;
2. the main branches of chemical industry which produce major basic and intermediate products required by both industry and agriculture;
3. energy (though not industrializing in itself, it can have

positive effects on other sectors through interindustry linkages as well as through innovations which may occur in this sector).

Moreover, he divides the category of industrializing industries into those which produce what he calls 'non-specific capital goods' and those which produce 'specific capital goods'. The former produces "essentially machine-tools, turbines, engines and computers"²⁹. He stresses the importance of this sector because of its ability to initiate and sustain a circular process of its own as well as to innovate and to diffuse technology³⁰. This implies an explicit reference to industrialization strategy advocated by Feldman, Mahalabonis, Dobb, Sen and Raj who emphasize the decisive role of capital goods sector and within it the machine-tool sector in the process of industrialization. They regard the machine-tools sector as the key to 'breaking out of the determinism' laid upon the economy by the existing structural relations³¹. Thus Dobb argues that "There is a peculiar ability of branch M2 (ie. the machine-tools) namely that it can constitute a circular process of its own, turning machines capable of reproducing themselves, and also of reproducing, if need be, improved types of themselves"³². However, one may add that this decisive role, attributed to the machine-tools sector in economic and technological terms, is only potential. The realization of this potential depends on a number of other factors especially managerial and

technical skills, investment and trade policies of the country concerned. The Algerian experience reveals that the role of this sector (though small in size) is extremely weak largely because of lack of demand for its products³³ as well as of skills and incentives.

The main features of the industrializing industries are first, they are often large scale and require important outlets. Second, they are capital-intensive and hence require a high rate of investment. Third, they are highly sophisticated technologically in relation to prevailing technological levels in most LDCs.

While liberal economists use these features to discredit and discourage such industries in LDCs, de Bernis, in contrast, argues that: "It is, indeed, because of this fact that underdeveloped countries have to use their available capital assets to produce more"³⁴. Having said that, he imposes certain conditions for the success of this strategy:

- a) rejection of the market as a principal criterion for industrial development and resource allocation, particularly in LDCs where the economy is disintegrated and disarticulated. He advocates planning so as to ensure the 'interiorization' of the industrializing effect. As for the smallness of the market, de Bernis insists on taking into account the potential market rather than the existing one. In fact, the development of the capital goods sector can

perform the dual function of expanding both the productive capacity of the economy and the internal market. This latter function, too often disregarded by liberal economists, was emphasized by Lenin, who argued that the widening of the internal market is possible despite restricted consumption and/or lack of external outlets, because "to expand production, it is first of all necessary to draw into it workers who create a demand on articles of consumption..."³⁵. Therefore consumption develops after accumulation, ie. 'the accelerator in reverse' as Dobb calls it³⁶. The Algerian experience reveals that when a relatively high rate of investment is sustained for a while, the internal market expands very fast even if a disproportionate share of investment is allocated to basic and capital goods sectors³⁷. Moreover, the basic-industry strategy allows for and even encourages exports of manufactured goods, but primarily as a vent for surplus from industries producing for the internal market. The real question which is often omitted by its advocates is whether the initially imported technology could be efficiently maintained and/or improved upon, to compete on the world market. As an inward-looking strategy, it provides for protection while local managerial and technical personnel learn by doing, and by doing so, it could result in creating an environment not conducive to technological innovation. In other words, there is a likely danger, though not necessarily inherent to the basic-industry strategy, that local managers may become complacent within their protected structures and

lose, or never develop, the ability to innovate, produce efficiently and react to changing conditions.

- b. Because of their often large scale and capital-intensive character, the establishment of industrializing industries in LDCs require financial and managerial capabilities which are beyond the reach of local private capital. Only the state, de Bernis argues, is capable of both mobilizing the necessary resources to establish such industries and ensure their full utilization and expansion³⁸. While emphasizing the role of the state and planning in the process of industrialization, de Bernis defines neither the nature of the state nor the social forces that are supposed to carry out this strategy and ensure its success. Consequently, planning is conceived of as a purely technical and economic operation rather than a political process that aims at transforming the existing socio-economic structures.

Furthermore, his analysis refers to the limits imposed by the external constraints without including their adverse effect on the implementation of the strategy he advocates. Thus LDCs' attempt to build independent national economies requires imports of machinery and technology as well as capital from the very powers whose control they intend to break. After all economic independence is not a matter of choice, but a matter of how feasible it is given the distribution of wealth and power in the world. It is inevitable that given the low level of industrial and

technological development of most LDCs, the establishment of 'industrializing industries' requires massive imports of machinery and technology from the advanced countries. The real question therefore is whether the early dependence on foreign technology and management will give way to local control and result in the development of a local innovative capacity. de Bernis is aware of this contradiction between this inevitable medium term dependence and the long run objective of technological independence, but he does not address the question of how to solve this contradiction so as to ensure the success of the strategy. The main weakness of the strategy, he advocates, lies precisely in its inability to address the question of transition from dependence in the initial stage of industrialization to technological independence. While stressing the idea that technological independence is not an immediately accomplishable goal but must be approached in the context of a transition from dependence to autonomy and emphasizing the role of the state and planning, he neither explains how this transition could be accomplished, nor defines the nature of the state and social forces that may ensure this transition. Furthermore he does not appear to foresee the dynamics of technological change in the advanced countries which may render imported technologies obsolete before they are even assimilated by the recipient country. De Bernis appears to support the Algerian view that industrialization coupled with extensive education and training would ensure this transition.³⁹ This view

appears to underestimate both the duration of the assimilation process and the dynamics of technological change taking place in the advanced countries⁴⁰.

Concerning the employment constraint, de Bernis calls for a distinction between what he calls "central processes" of production which have to be mechanized and "auxiliary processes" which do not have to be mechanized so as to save investment resources and to create more jobs⁴¹. In other words, he implicitly refers to the USSR's early experience which, according to Ellman consisted of "labour-intensive variants of capital-intensive techniques⁴². It is doubtful whether the use of labour-intensive techniques in peripheral activities would result in the elimination of un- and underemployment in countries where the population increases very quickly⁴³. The argument in favour of the use of capital-intensive techniques in core production processes runs as follows: they result in higher labour productivity and consequently a higher surplus available for re-investment; which in turn would lead after some time to a higher level of employment than the more labour-intensive techniques. The argument therefore is based on a number of rather unrealistic and restrictive assumptions. It assumes that plants using capital-intensive techniques are operated and maintained by local personnel; that their capacities are fully utilized; that each technique pays the same wage rate, and that all savings are reinvested. Each of these

assumptions is challenged empirically⁴⁴, whilst the emergence of a dualistic economy, with its associated problems of chronic employment in Algeria has re-created emphasis on the need for labour-intensive technologies.

To the question whether the priority given to industrializing industries runs against the principal objective of development which is the improvement of living standards of the population, de Bernis argues that "the transformation of the structure of production will, at the same time, enable the amelioration of the living conditions of the workers and generate surpluses which are susceptible of being reinvested in the process of production"⁴⁵. As pointed out above, this argument is based on unrealistic assumptions that installed production capacities are fully and efficiently utilized so as to maximize the surplus to be generated, and that all surplus generated is efficiently re-invested. The Algerian experience reveals that neither of these assumptions are true. Furthermore the argument underestimates the adverse effects of a shortage of consumer goods and social amenities on labour stability, the incentive to produce efficiently, and consequently on labour productivity.

- c. Agricultural reorganization and modernization so as to increase agricultural productivity as well as to avoid large-scale influx of peasants into the towns during the initial stage of industrialization. Success of industrialization depends on agricultural development. de Bernis views the

dilemma-agricultural development or industrialization as meaningless because both are closely related.

- d. An extensive educational and vocational training programme to provide skilled and semi-skilled labour required by both agriculture and industry. This point will be discussed in the last section of this chapter.

Having outlined the main objectives of the Algerian strategy and its underlying theoretical foundation as well as some of its inherent contradictions, we will examine in the next section some of the more specific problems that adversely affected the implementation of the strategy as well as its achievements. The first sub-section deals with investment allocation and realization with special emphasis on the priority sectors. The second sub-section analyses the strategy's achievements in terms of employment, production and economic integration.

2.3 Implementation of the Industrial Strategy: achievements and shortcomings

Until 1969, Algeria had not elaborated a national development plan. Up to 1967, its development was mainly based on a follow-up to the Constantine Plan launched by the French Government in 1959 and primarily financed through foreign, essentially French aid. The main sectors of the economy were in the hands of foreign capital. In 1967, a 3-year

investment programme was launched during which an inventory of national resources and reorganization of the colonial economic and administrative system was carried out. The aim was to pave the way for a centralized development strategy. The administrative system was reorganized so as to gear it towards development. New communal and departmental councils were set up to increase the participation of local communities into economic and social development.

Reorganization of the administrative system was accompanied by a tide of nationalization of foreign capital. By the end of 1971, the state imposed its control over the leading sectors of the economy: mining resources including hydrocarbons, banking and insurance, the import-export trade and key industrial sectors. By the end of 1974, "there was no foreign firm operating in full contact, but only mixed firms"⁴⁶. This state control of the main sectors of the economy has enabled it to appropriate available surpluses to implement its strategy of industrialization.

The state industrial sector was entrusted to national corporations which were set up to manage existing production units and to develop their branches of activity according to overall development plans. In most cases each national corporation had total monopoly over a branch of industry including import-export activities related to its branch. They enjoyed financial autonomy. Cooperation among various

national corporations was expected to take place by mutual arrangements. The organs of central administration, notably the National Planning Secretariat, the Finance and Industry Ministries were expected to monitor and allocate priorities among various corporations according to overall national development plans.

In practice, neither centralized monitoring, nor cooperation and coordination among national corporations really functioned as envisaged. "The position of the state individual companies vis-à-vis central organs of the state bureaucracy is, if not of complete independence, so at least of considerable leverage"⁴⁷. Subsequently, a network of informal connection among enterprises and bureaucracies similar to that found in East European countries has rapidly developed. This created a system that is neither a true bureaucracy nor a true market, but rather a "regime of bargaining" among the various entities in the system, in which informal relationships between bureau-technocrats are the real keys to economic decision-making. In these circumstances neither priorities nor incentives are respected regardless of what the rules may specify.

At the micro level coordination among various national corporations with respect to the sequence of investment, techniques of production and acquisition of technology and other inputs, was almost non-existent. Left to themselves

each national corporation strove to develop its branch independently⁴⁸. This resulted, among other things, in:

1. Each national corporation striving to achieve integration within itself, instead of strengthening inter-industry linkages through sub-contracting. A high 'make/buy' ratio means in-house provision of goods and services that are technologically dissimilar to the corporation's major technological activity. This in turn means lower technical specialization, and many more difficulties concerning production planning, capacity utilization ⁴⁹ and industrial organizations;
2. long delays and high cost overruns in implementing investment projects and difficulties in bringing new production capacities to their full capacity utilization;
3. duplication of technology purchasing from abroad⁵⁰;
4. distortion in the planned structure of investment and the structure of the economy and lack of horizontal flow of information between various entities⁵¹.

By the end of the 1970s, most national corporations had developed into extremely large, diversified and highly centralized institutions, attributes which hampered their efficiency and ability to coordinate their actions. This weakness became a source of concern to Algeria's policy-makers and planners in the late 1970s. Consequently reorganization of the industrial sector was launched in the early 1980s.

A. Investment Allocation and Implementation

The primacy of capital accumulation over consumption was opted for in 1967. Austerity was repeatedly stressed and heavy restrictions were placed on imports of luxury goods. It was also stressed that the sources of investment should in the main be generated internally, only assigning external sources an auxiliary role. The following table shows the increasing share of investment in GDP between 1967 and 1978.

Table 2.I Gross Fixed Investment/GDP (%)

Pre-plan 1967-1969	1970-1973 Plan	1974-1977 Plan	1978	1974-1979*
26.4	33.5	46.8	54.7	50.5

Source: MPAT, 1980; Synthese du Bilan Economique et social de la Decennie 1967-1978, Algiers, P.2 and my own calculation for the last column.

NOTE *: 1978 and 1979 were not included in any plan.

Table 1 reveals that it was in the 1970s that Algeria made the transition from the kind of investment ratios characteristic of most Third World countries to the much higher ratio characteristic of the state socialist countries in their initial stage of development. this gigantic

increase in the ratio of investment did not take place at the expense of consumption in absolute terms. While the share of consumption in GDP had drastically declined between 1967 and 1978, the absolute amount of consumption in constant terms had annually risen by 8.5%. However, the annual rate of growth of investment during the same period was almost twice that of consumption: it amounted to 15.5%.

In fact both investment and consumption grew faster than GDP whose annual rate of growth during the same period was 7.2%. Consequently the main source of increase in the share of investment in GDP in the 1970s was external, primarily in the form of non-concessional loans⁵³. Indeed the proportion of external resources in total investment had risen from 9% during the pre-plan period 1967-9 to 22 and 33% during the first and second 4-year plans respectively. In general over 65% of investment funds were appropriated by the Algerian state from value either created (in the form of external resources) or realized (in the form of exports) abroad. This high ratio demonstrates the high degree of dependence of the process of accumulation on the world market.

The saving capacity is not the only constraint to rapid economic growth. Some underdeveloped countries have no saving capacity constraint, yet they are unable to transform their savings into productive investment mainly because of their limited domestic absorptive capacity. Institutional

rigidities, shortage of managerial, administrative and technical capacity, shortage of capital goods, lack of adequate infrastructure and the need to carry out investment projects sequentially rather than simultaneously may limit the number of investment projects at any time, in many Third World countries. Some of these constraints cannot be overcome solely by rapidly expanding the saving capacity. Efficient use of savings requires adequate institutional arrangements and means of realization.

In an open economy, domestic absorptive capacity constraint can be expanded through imports of goods and services up to the limit set by the country's foreign exchange earnings. However, foreign exchange may not be a limiting factor as is the case in some oil rich countries. Yet institutional factors may limit the rate of expansion to which society is able to adapt itself over a given period of time to accommodate such investment. In the Algerian case the expansion of the absorptive capacity through massive imports of goods and services; which amounted to over 50% of investment expenditures undertaken between 1967 and 1979⁵⁴, was not enough to ensure efficient use of savings.

Long ago, the Yugoslav economist, Hovart, drew attention to the possibility of wasteful over-investment. The reason, he argued, is that an economy has a maximum absorptive capacity⁵⁵. It seems that wasteful over-investment occurred

in Algeria during the 1970s. This is manifested in high cost overruns, long delays in investment project implementation and capacity underutilization.

Official statistics show that actual costs (calculated at the end of each plan period) of investment projects planned between 1967 and 1977 amounted to 2.75 times the planned costs⁵⁶. These cost overruns are generally attributed to rising prices of imported goods and services, to increases in the construction costs and delays in the initiation and execution of projects due to deficiencies in the administrative apparatus, lack of adequate infrastructure and shortage of qualified and experienced personnel. A study carried out on a sample of manufacturing projects revealed that cost overrun affected every stage of project implementation⁵⁷.

Meanwhile, investment projects were rarely implemented in time. A survey of projects included in 1970-73 plan revealed that 62% of them were subject to delays of two and a half years or over⁵⁸. These long delays and cost overruns were accompanied by capacity underutilization which was enormous in some industrial branches⁵⁹.

These cost overruns and long delays have resulted among other things in great distortions in the structure of planned investment allocation. The privileged position of industry

(including hydrocarbons) in planned allocation of investment was further strengthened during the phase of implementation at the expense of other sectors notably agriculture and infrastructure. More and more human and material resources, external and internal, were channelled to industry thus depriving other sectors of the necessary resources to adequately develop.

Table 2.2: Planned and Realized Distribution of investment in absolute and proportional terms

Plan	Sectors	Planned		Realized	
		Million AD	%	Million AD	%
1970-73 Plan	Agriculture, fishing and irrigation	4950	18	4350	12
	Industry (inc hydrocarbons)	12400	44.7	20800	57.3
1974-77 Plan	Agriculture, fishing and irrigation	16720	15	8900	7
	Industry (inc hydrocarbons)	48000	43.5	74100	61.2

Source: MPAT, 1980: Synthese..., op cit, p 5 and 7

Despite this gigantic increase in the share of industry in total investment, the rate of realization in physical terms was extremely mediocre. While financial targets were largely exceeded, the rate of realization (the ratio of investment realized to actual costs of planned projects) between 1967 and 1978, amounted to just over 50%. The rate of realization was above this average in priority sectors, ie. hydrocarbons (57%), 'basic and integrating industries' (57%) and energy (56%)⁶⁰.

Although most of industrial projects included in the 1974-77 plan were carried out by foreign firms on a turnkey basis, the rate of realization had drastically declined demonstrating the limiting factor of absorptive capacity. Thus, whereas the rate of realization was 57% during the 1970-73 plan, it declined to 44% during the 1974-77 plan as the volume of investment had sharply risen⁶¹.

Within the industrial sector itself, the planned structure of investment had drastically changed during the implementation phase, with the share of the hydrocarbon sector having considerably increased at the expense of inward looking industrial sectors⁶². (See table 2.3 on page 105).

- I. Hydrocarbons: They were expected to play a multiple role in the Algerian strategy of industrialization according to their uses as a source of capital accumulation and foreign

Table 2.3: Planned and Realized Distribution of Industrial Investment (%)

	1967-1969		1970-1973		1974-1977		1967-1977	
	Planned	Realized	Planned	Realized	Planned	Realized	Planned	Realized
Hydrocarbons	43	51	37	47	40	48.6	40	48.3
'Basic and Integrating' industries*	41	32.5	42	37	46.2	38.4	44.4	37.5
Mining and energy	7	9	11	10	5.4	6.2	7.1	7.4
Others	9	7.5	10	6	8.4	6.8	8.5	6.8
Total	100	100	100	100	100	100	100	100

Source: Compiled by the author on the basis of data published by: MPAT, op. cit., p. 22.

* 'Basic and integrating' industries refer to steel, chemical, metal, mechanical and electrical and construction materials industries.

exchange, as raw materials and as intermediate products in the form of energy.

- a) As a source of capital accumulation: Hydrocarbons were primarily regarded as a source of foreign exchange needed to import machinery and technology to build up an industrial base and technological capacity capable of self-generation. Therefore they are on the one hand a means of achieving integration and introversion of the economy and on the other a means of increasing the country's dependence on world market. Adepts of the Algerian strategy are aware of this problematic, but they tend to play down dependency, while stressing the idea that "Algeria is planting its oil" by using its returns to set up a self-generating industrial sector. This line of argument is valid only if, first, development of hydrocarbons, an export-orientated sector par excellence, is firmly made subject to the requirements of development plans. Otherwise, as a dominant sector of the economy, they may subject the rest of the economy to its own logic of reproduction which in turn is determined by the world market. Second, if its returns are efficiently utilized.

In practice neither of these two conditions were satisfied in Algeria before 1980. The actual organization of the economy conferred on various national corporations autonomy in developing their branches of activity, marketing and concluding contracts with foreign firms. This autonomy was

further strengthened by the weakness of central organs of the administration which were supposed to supervise and monitor various corporations. Consequently, the national corporation SONATRACH which had a monopoly over hydrocarbons had developed into a huge institution with financial and economic weight which earned it the title of 'a state within a state'⁶³. The dominant position of hydrocarbons coupled with lack of adequate central control had considerably attributed to distortions in the planned allocation of investment in favour of hydrocarbons. Moreover, returns from hydrocarbons were not efficiently utilized. This is clearly demonstrated by long delays, cost overruns and capacity underutilization.

- b) As a source of foreign exchange: hydrocarbons provided approximately 90% of the country's foreign exchange earnings. At the same time they absorbed 30% of total gross investment and 50% of the country's foreign borrowings⁶⁴. Over 75% of these investments were spent on expanding the export capacity of hydrocarbons. Moreover, a considerable proportion of investment allocated to other sectors were primarily intended to meet the increasing demand of hydrocarbons. Apart from cost overruns, two other factors had largely attributed to both heavy concentration of investment in hydrocarbons and its increasing reliance on foreign borrowings. Firstly the need to honour contracts signed with foreign firms. It was the exploitation of natural gas that absorbed the lion's share of investment especially in the period 1975-9. Secondly, there was a decline in the share of internal

savings due to the inability of both agriculture and manufacturing to release any significant surplus. Faced with competing demands for the available foreign exchange, SONATRACH turned to the international financial market. The aim was to use foreign borrowing to expand its export capacity while releasing a proportion of its foreign exchange earnings to meet increasing demands of other sectors. This resulted in further externalization of hydrocarbons.

This heavy borrowing abroad allowed the state to continue its industrialization strategy over the period 1975-9. By the end of 1979, the state was faced with heavy debt service exceeding 25% of total exports earnings, and it consequently decided to cancel a number of projects in the hydrocarbons sector. The aim was to save foreign exchange needed to pay debt service as well as to switch resources to other sectors that had been largely neglected such as housing, infrastructure and light industry.

- c) As raw materials: Hydrocarbons are the principle base product of over 300,000 chemical and synthetic products. According to Chevalier the plastics industry is gradually tending to replace both steel and metallurgy in the hierarchy of 'industrializing industries' and therefore construction of an economy oriented towards this - without necessarily passing through steel industry - is envisageable.

Oil and gas can certainly be the basis for a sound national

petrochemical industry whose establishment can play a decisive role in both modernizing agriculture and inducing industries with strong forward and backward linkages with petrochemicals. The Algerian state is indeed determined to set up a national petrochemical industry geared primarily towards satisfaction of increasing local demands⁶⁶, but also for exports to gradually replace crude oil and LNG. However, in the absence of regional cooperation, Algeria is forced to search for outlets in the world market which at present is both saturated and firmly under control of transnational corporations. A concerted effort by OPEC members in the near future may be necessary to gain access to Western markets, particularly as most of them are investing heavily in petrochemicals⁶⁷.

- d) As a source of energy: Hydrocarbons were expected to stimulate industry by supplying them with cheap energy. According to de Bernis, industries with strong industrializing effects are precisely those which use a large proportion of energy as inputs. Consequently, the existence of relatively abundant sources of energy provides Algeria with a considerable advantage in this sphere at two levels:
- 1) There is no need to import oil and gas hence saving foreign exchange;
 - 2) Energy costs are relatively low due to the fact that world market prices of gas and oil are much higher than their production costs. Consequently Algeria could exploit this 'natural advantage' by setting up highly competitive

industries. This implies discrimination between export and domestic prices at all stages of processing. Thus, according to de Bernis "...disposing of hydrocarbons sold on the domestic market at prices below world market prices, basic industries can be highly competitive on the world market, and therefore provide an adequate possibility, from the beginning, for outlets on the world market. This allows for the establishment of large scale production units and therefore result in low costs of production thanks to economies of scale. Furthermore, Algeria can export a proportion of production at world market prices, while exchanging the rest domestically at marginal costs. Nearer and nearer, the process will continue along the chain of production until its final link. Therefore prices of goods produced locally will remain low thanks to the internalization of external economies and the retention at each stage of processing of export possibilities"⁶⁸.

The model is based on a number of unrealistic assumptions. It assumes that both investment and production activities are carried out as efficiently as in other competing countries; that once basic industries are established, they provide a comparative advantage to the country in question and that dumping will be permitted by competing countries. The existence of cheap energy alone does not automatically result in development of such industries, nor is it sufficient to ensure their competitiveness on the world market. For

example, while possessing massive gas reserves, Algeria has been for many years using imported coal in steel processing even though the direct reduction process was developed in the 1950s⁶⁹. As for the competitiveness of such industries, it is doubtful whether low energy costs would be sufficient to offset high costs emanating from the conditions of underdevelopment and learning by doing. Thus, the model appears to both underestimate the conditions of underdevelopment and their adverse effects on investment and production, and overlooked the very great cost reductions (which are the result of energy saving as well as of other technological change) that have been made in the developed countries in the last ten years. Emperically, the assumption that both investment and production activities are carried out as efficiently as in competing countries, is not supported by the Algerian experience, where neither investment nor installed productive capacity was efficiently utilized, resulting among other things in high costs of production⁷⁰.

II. Manufacturing: The share of manufacturing in planned industrial investment between 1967 and 1977 amounted to just over 53%. High priority was given to 'basic and integrating' industries, ie. iron, steel, metal processing, basic chemicals, construction materials and mechanical-electrical engineering. The aim of giving priority to these industries

was to create a solid basis for both a broad industrial development and agricultural modernization. Their share in planned manufacturing investment amounted to just over 83% whereas industries catering immediately for consumption had to be satisfied with the rest. Despite this apparent bias in favour of the former set of industries, it is misleading to conclude that absolute priority was given to capital goods industries once we take into account:

- a) the difference in capital-output ratios: the average capital coefficient for 'basic and integrating' industries was expected to be 3 to 3.5 times that of those immediately catering for consumption;
- b) the fact that basic industries' products such as steel and cement can just as easily be used for consumer goods as for investment goods production;
- c) the allocation of investment devoted to capital goods industries between investment goods for consumer goods and investment goods for expanded reproduction such as machine-tools and heavy machinery to equip various sectors.

In practice neither the structure of planned industrial and manufacturing investment nor the priority within branches was respected. Firstly, the share of manufacturing in industrial investment declined from 53 to 44%. Secondly, the share of 'basic and integrating' industries in manufacturing declined from 83% to just under 80%. Thirdly, a considerable proportion of investment in priority branches such as

electrical engineering were devoted to luxury consumer goods at the expense of investment projects producing capital goods⁷¹.

Although official data do not reveal the proportion of investment allocated to the capital goods sector as a whole and within it the machine-building branch, for the whole period 1967-1979, official data for 1974-9 show that this proportion was relatively low. Thus the share of the capital goods sector as a whole amounted to 23,000 MAD or 10.6% of industrial (including hydrocarbons) investment programmes for 1974-79. Compared with the proportion of investment allocated to intermediate industrial sectors as well as to the country's needs for capital goods, the share of the capital goods sector was very low. Thus 21.6% of new investment programmes for 1974-79 concerned intermediate industries*. Although these industries play a major role in increasing the degree of integration of the economy, they neither ensure expanded reproduction of the economy nor directly satisfy consumers' demand. As such they increase the country's propensity to import both capital goods and consumer goods. Whereas the latter was compressed through various means the former had rapidly increased as a result of the country's increasing demand to meet its investment programmes.

* See Table 2.5 on page 116

The share of capital goods in Algeria's imports had rapidly risen both in absolute and relative terms between 1967 and 1977. In absolute terms they increased almost eightfold.

Table 2.4 Imports of Capital goods at 1978 prices (in m. AD)

	1967	1967-69	1970-73	1974-77	1978
Value of imports of capital goods	2200	9300	22400	51000	16500
as % of total imports of goods	30	35	41	46	48

Source: compiled by the author on the basis of data published by MPAT, 1980: Synthèse..., op. cited, p 30.

In contrast to China which was able to produce locally 85% of the machine-equipment needed for its Second Plan, Algeria's domestic production in 1978 amounted to just over 10% of its industrial investment needs for the same year⁶⁵. This was primarily due to the fact that China had given priority to the machine-building sector at the very beginning of its development⁷⁴. In Algeria the machine-building sector began

to emerge only in the late 1970s and its full development was expected to take place in the 1980s. Preliminary studies carried out in the late 1970s showed that the size of the internal market was not any more an obstacle to import-substitution in many areas of the machine-building sector⁷⁵.

Within the capital goods sector itself, there was heavy concentration of investment in branches producing capital goods for construction, public works, transport and communication. The proportion of investment allocated to these branches amounted to approximately 70% of the amount allocated to the capital goods sector as a whole for 1974-9.

Figures in table 2.5 reveal that the proportion of investment allocated to the capital goods sector as a whole in the 1980-1984 plan had considerably declined relative to that for 1974-1979 and the share of intermediate industries had considerably increased. Meanwhile, over 50% of investment allocated to the capital goods sector were devoted to branches producing capital goods for construction, public works and communication. This reflects the priority given by the plan to housing and socio-economic infrastructure which were largely neglected before 1980.

Compared with both the size of the existing capital goods sector and the volume of investment set for the plan, the proportion of investment allocated to the capital goods

Table 2.5 Distribution of Investment within the Capital Goods Sector : 1974-84

Branches	1974-1979		1980-1984					
	Invest. Programmes		Completion of earlier projects		New projects		Investment in period	
	Million AD	% of ind invest.	Million AD	% of ind invest.	Million AD	% of ind invest.	Million AD	% of ind invest.
Capital Goods for reproduction	1587	0.7	959.0	1.2	1400	1.1	1256	0.8
Capital Goods for industry	3320.4	1.6	1784.1	2.2	840	0.6	2114.1	1.4
Capital Goods for construction and public works	5234.5	2.4	3054.1	3.7	870	0.7	3204.5	2.1
Capital Goods for agriculture	1585.2	0.7	512	0.6	104	0.1	616.0	0.4
Capital Goods for infrastructure	2055.9	0.9	1041	1.2	2060	1.6	2181	1.4
Capital Goods for transport and communication	9143.6	4.3	4191	5.1	406	0.3	3813	2.5
Total	22924.3	10.6	11541.6	13.9	5680	4.4	13212.6	8.6
Hydrocarbons				33.9		37.1		40.8
Intermediate industries (excluding hydrocarbons)		21.6	15586.4	18.8	57568	43.4	43290.4	28.1

Source: Compiled by the author on the basis of data published by: MPAT, 1980: Rapport Sectoriel.

sector as a whole was extremely low. This proportion does neither ensure future reproduction of the economy nor meets the country's needs to capital goods. Consequently, massive imports of capital goods are required to implement the 1980-1984 and 1985-1989 plans.

Table 2.6: Sectoral Allocation of Investment and the Corresponding Share of Investment in the Capital Goods Sector in 1980-4 Plan (in million AD)

Sectors	Total Investment in each sector (1)	Investment in capital goods (2)	2/1
Farming	20 000	600	3%
Industry (inc hydrocarbons)	154 500	5 600	3.6%
Transport	13 000	3 000	23%
Housing and Consulting firms	80 000	3 200	4%
Telecommunications	6 000	600	1%
Total	273 500	13 000	4.7%
Total investment in the 1980-4 Plan	400 600		

Source: Compiled by the author on the basis of data published by MPAT, 1980a: Rapport sectoriel: industrie, Algiers

Since 1980 there has been a radical change in policy. The priority has been given to social sectors rather than to "primitive accumulation"⁷⁶. This change in policy is reflected in the pattern of investment allocation during the 1980-84 plan and above all in the pattern of allocation of new industrial investment (table 2.5: column 3). The share of industry (including hydrocarbons) in total investment set for the 1980-84 plan was considerably less than in the previous period. It amounted to 38.5%⁷⁷. Meanwhile, industrial investments were geared towards satisfying social needs, that is for building materials, plastics, consumer durables, electric fittings, processed foods and other essential economic requirements, like those of agriculture.

This change in policy is particularly reflected in the pattern of new investment allocation in the 1980-84 plan where the share of industry was drastically reduced compared with the previous period, and the pattern of investment allocation within industry had radically changed. The share of industry (including hydrocarbons) in new investment programmes amounted to 132200 million or 36%. Meanwhile, the share of the capital goods sector as a whole in new investment programmes was drastically reduced to 4.4%, whereas that of intermediate industries was more than doubled. More important is the fact that this pattern of allocation of new investment programmes largely determines the pattern of allocation of investment in the 1985-1989

plan primarily because a large proportion of new investment projects will be completed only after 1984⁷⁸.

Two arguments have repeatedly been advanced by Algeria's policy-makers to justify their decision to defer the development of the capital goods sector until a later date⁷⁹.

These arguments are:

- 1) shortage of financial resources particularly foreign exchange earnings required to expand rapidly the capital goods sector as a whole and within it the machine-building branch. This argument is fallacious because the implementation of most industrial branches as well as other socio-economic projects depends on imports of capital goods and technology. Consequently the main problem lies in the policy's priorities rather than in foreign exchange earning constraint itself. In other words, it is a question of giving priority to either developing the capital goods sector as a whole and particularly the machine-building branch so as to ensure future reproduction and rapid rate of growth or to developing other industrial sectors and consequently increase the country's dependence on the world market for capital goods and technology in the future. Meanwhile, a large proportion of the country's foreign exchange earnings are being channelled into projects which could be easily implemented without foreign firms' involvement, and projects of little social utility⁸⁰.
- 2) access to foreign technology in the capital goods sector is

even more difficult than that in other industrial sectors. This conclusion is arrived at without making enough effort to search for appropriate sources of technology. Moreover, this argument applies only to certain areas of the capital goods industry. Technology for certain areas is available on the world market. Meanwhile, Algeria could make full use of its cooperation agreements with friendly countries to build up its capital goods industry.

The 1980-84 plan gives a major priority to the development of the country's engineering capacity. However, it is not clear how to achieve this aim while at the same time reducing drastically the share of the capital goods sector in total industrial investment. It is inconceivable to develop national engineering capacity without development of the capital goods sector and in particular the machine-tools branch. Without a domestic capital goods industry, Algeria's economy is bound to remain dependent on the world market for its capital goods and technology. "Historical and analytic approaches both conclude that a capital goods sector is essential for innovatory activity. Lacking such sectors, underdeveloped countries have to import not only their machinery, but also their technical progress"⁸¹.

B. Achievements and Shortcomings

Having analyzed the objectives of the Algerian strategy of

industrialization and examined the efforts deployed in terms of investment, we will in the following assess the Strategy's achievements in terms of its main objectives: production and integration, and employment. The analysis will be limited to the pre-1980 period because of lack of detailed data on achievements of the first Five-Year Plan 1980-84.

1. Production and Integration. The average annual rate of growth of GDP in real terms over the period 1967-78 was 7.2%. This relatively low rate of growth was partly due to lagging agriculture and hydrocarbons whose annual rates of growth were respectively 2 and 5.2%, and partly to the slowing down of the rate of growth of the whole economy in the early 1970s. The average annual rate of growth of GDP decreased from 11% during 1967-69 to 6 and 5.5% during the First and Second Four-Year Plan respectively, before it picked up again in 1977-79 when it attained approximately 9%⁸².

The average annual rates of growth of GDP during the First and Second Four-Year Plan were far below the planned ones which were 9.5 and 11.2% respectively. This divergence resulted among other things in a great discrepancy between the implicit ICOR ratios projected, which were respectively 3.2 and 4.5, and the actual ones of approximately 7 and 9 for the First and Second Plan. This divergence in ICOR ratios and

rates of growth of GDP are to be found in cost overruns⁸³, the change in the structure of planned investment and the situation prevailing at the outset of the plans with regard to utilization of productive capacity.

The change in the planned structure of investment during the plans implementation resulted in heavy concentration of investment in hydrocarbons and basic industries which are usually capital-intensive and involve long gestation periods. This in turn resulted in a rise in ICOR ratios and lower rate of growth of GDP.

Meanwhile, capacity underutilization had largely attributed to the rise in ICOR ratios and lower rates of growth of production. 1978 statistics reveal that most industrial (including hydrocarbons) branches were operating far below their full capacity⁸⁴. The proportion of underutilized capacity in hydrocarbons in 1978 was considerable⁸⁵. This proportion has further increased since 1980 when the state shifted its policy from maximizing production for export to energy conservation to meet the country's future demand.

The causes and consequences of capacity underutilization in hydrocarbons differ from those of other industrial sectors. In the former, it was due to lack of demand on the world market as well as to a shift in the state policy.

Consequently, this excess capacity represents a permanent wastage of resources. In manufacturing, capacity underutilization was not due to lack of demand⁸⁶, but rather to organizational and technical difficulties which can be overcome once adequate measures are taken⁸⁷.

The combination of cost overruns and capacity underutilization have partly accounted for the high marginal coefficient of capital and costs of production in the industrial sector as well as for the distortions in the structure of the economy and low degree of satisfaction of local demand. According to MPAT, every additional Algerian dinar generated through industrial production between 1967 and 1978 required 11.2 AD of investment. The figures for hydrocarbons and the rest of the economy were respectively 8.75 and 3.8 AD⁸⁸. Meanwhile a comparative study of costs of production in a sample of French and Algerian factories revealed that costs in Algeria were often considerably higher despite the existence of a large differential in wage rates and energy costs in favour of Algerian producers.⁸⁹ These findings demonstrate that low wage rates and energy costs are not sufficient to render Algerian industrial products competitive on the world market as suggested by de Bernis.

Although over 70% of investment realized between 1967 and 1978 were channeled to productive investment, the share of material production in GDP has declined from 70% in 1967 to

65% in 1978. Meanwhile the combined share of hydrocarbons and manufacturing which absorbed the lion's share of investment over the period 1967-78, in GDP and material production had considerably declined during the same period as the following table shows:

Table 2.7: Change in the Structure of GDP and Material Production between 1967 and 1978

Sectors	1967		1978	
	% of MP	% of GDP	% of MP	% of GDP
Hydrocarbons	50.2	35	44	28
Manufacturing	15.2	11	21.5	14
Construction and Public Works	16.2	11	22.8	15
Agriculture	18.4	13	11.7	8
Material Production	100	70	100	65
Non-material Production		30		35
GDP		100		100

Source: Compiled by the author on the basis of data published by: MPAT, 1980: synthese..., Ibid., pp. 59-60.

Data in table 2.7 shows that the combined share of agriculture and manufacturing in GDP had drastically declined

between 1967 and 1978 due to a rapid decline in the share of the former which was only partially offset by the increase in the share of the latter. Although the average annual rate of growth of value added in manufacturing between 1967 and 1978 was about 10% in real terms, it was far below the planned one. The divergence between the planned and actual rates of growth was particularly large in priority branches, i.e., basic and integrating industries.⁹⁰

The proportion of local demand for industrial products effectively met by local production had drastically declined between 1967 and 1977. It declined from 48% in 1967 to 38.8% in 1973 and 24% in 1977.⁹¹ Thus far from increasing the degree of integration of the economy, Algeria's industrialization strategy had resulted in greater dependence on the world market not only for technology (both embodied and disembodied) but also for semi-finished products and foodstuffs. The growing importance of the last two groups reflects the economy's growing dependence on imports for its very functioning.⁹² Some of the reasons for this increasing dependence on world markets are inherent to the strategy and others are to be found in organizational and technical difficulties encountered. The construction of a highly diversified and integrated economy is a complicated matter and can only be realized in the long-run. The ability to complete the chain of domestic resources to domestic use depends largely on the resource endowment and time. It seems

inevitable that even if the country is richly endowed with material resources, the inherent contradiction remains between medium-term dependence on the world market and the long-term objective of economic independence. In addition to this inherent contradiction, organizational and technical difficulties encountered in the implementation of the strategy considerably contributed to the increasing dependence of the economy on the world market. These organizational and technical problems resulted in long delays in project implementation; in bringing installed capacities to their rating rates, inefficient methods of communicating information on the availability of materials and services and near total absence of interagency coordination and exchange of information. The latter two resulted in importing inputs which are either produced or could be locally produced.⁹³

Cost overruns, long delays in projects implementation and in bringing new production capacities to their full use, and capacity underutilization have been a major source of concern to Algeria's policy-makers since late 1970's. A lengthy investigation into the causes of industrial inefficiency was conducted in 1978-9 and several reforms aimed at speeding up the process of initiation and execution of projects and stepping up productivity were suggested. The most important of these reforms was the reorganization of the industrial (including hydrocarbons) sector. National corporations which had developed into huge and highly centralized institutions,

two attributes that hampered their efficiency and ability to coordinate with each other, were split into specialized and decentralized enterprises. Most services such as housing, transport, consultancy engineering and trade which were previously run by national corporations have been transferred to either local authorities or other specialized enterprises. The aim was to let production enterprises and factories concentrate on production so as to improve their efficiency and financial viability and to promote sub-contracting.

The most significant features of this reorganization are the relocation of a large number of new enterprises outside Algiers, devolution of certain powers to factory managers and the separation of development from production.⁹⁴ Whereas before reorganization all national corporations had their headquarters in Algiers, new enterprises' headquarters have been set up where their main production activities are located. This has been done with the intention of both stimulating regional development and making top management closer to production. Meanwhile factory managers were, in principle given autonomy in day-to-day running of their production facilities within the framework of annual production programmes agreed upon in consultation with their enterprises' management and central administration.

Though it is early to assess this reform, its main weakness lies in its imposition from above without prior consultation

of those directly concerned. This is bound to result in delays in its implementation, wastage and conflicts. These problems appear to have been taken into account in the 1980-84 Plan during which the reform was expected to take place. For example, the annual rate of growth of the economy was expected to be 8.2% which is lower than that achieved during 1977-79. This expected rate can be considered very low if one takes into account the volume of investment planned and the enormous size of slack capacity existing at the time of the launching of the plan. In fact the main objective of the plan was to bring existing production capacities to their full utilization. However, although the plan appears to have taken into account, the short-term adverse effects of the reform on the rate of growth of the economy, it underestimated the full impact of the difficulties related to the implementation of the reform (see below).

First reactions to the reform indicated that the prospect of geographical relocation worried managers and executives who saw their power position and comfort threatened. The lack of social facilities and entertainment in small cities where some of the enterprises are headquartered is another reason for executive managers and highly skilled workers, used to high living standards, to resist the reform. This resistance resulted in the implementation of the reform taking longer than expected and new enterprises lost a considerable proportion of their highly skilled and experienced

personnel⁹⁵. This in turn resulted in lower rates of growth realized during the 1980-84 Plan. Thus preliminary official data published in 1985 revealed that the actual annual rate of growth of the economy, excluding hydrocarbons, was about 5.8% with the industrial sector growing at around 9.5%⁹⁶. Both rates were much lower than those planned and considerably lower than those achieved during 1967-79 period.

Although the degree of autonomy of state enterprises and factories have increased somewhat, many administrative restrictions on their operations have been maintained, thus ensuring their de facto dependence on the central and local bureaucracy. Many product and factor prices are regulated administratively. Wage regulation remained strict, imports, especially 'non-routine' purchases, are strictly controlled and investment decisions are decided upon at the centre. Thus, the system as it actually works cannot foster the interests of management in efficiency and profitability, which the reform aims at achieving. Frictions and conflicts between management and bureaucracy have emerged as the latter tries to impose direct control over the former. Meanwhile the problem related to coordination between various enterprises was not tackled by the reform, except by encouraging them through various and indirect means⁹⁷ to coordinate their activities through contractual arrangements. A likely danger is that enterprises may behave in the same way as the old national corporations, each trying to solve

its problems on its own.

2. Employment: Unemployment has been a major problem in Algeria since the 1930s⁹⁸. The inability of the colonial economy to provide enough employment for the rapidly increasing labour force was recognized by the Gaullist Administration as soon as it came to power. Writing in 1959, R Gendarme emphasized that Algeria's socio-economic problems were due to lack of investment⁹⁹. Soon after independence, unemployment became one of the major political issues. Though there was a general agreement on the necessity of industrialization to increase the potentialities of the economy to meet employment demand, there was no agreement on the immediate priorities of industrialization. On the one hand there were those who advocated social requirements and the satisfaction of the consumption needs of the impoverished masses as the immediate priority of industrialization. This view was criticized by those who advocated heavy industry and regarded the first view as a "fuite en avant" on the grounds that such a policy would not eradicate the causes of underdevelopment and consequently of under-and un-employment.

This debate came to an end in 1966 when the strategy of industrialization was launched. Its employment objective was to provide jobs for the whole male labour force by 1980:

"The principal objective of the chosen long-term development strategy has a central preoccupation which is the radical elimination of un-and-under employment by means of the authentic industrialization of the country... The assessed objective is that from 1980 onwards the causes of unemployment must be irreversibly abolished and that the total annual growth of the labour force must be equal to the new jobs that will be annually created by the development of industries and the activities related to the industrialization of the cities"¹⁰⁰.

According to the 1966 census¹⁰¹ the number of employed and unemployed males in the labour force amounted to 1.72 and 0.58 million respectively. Meanwhile the male labour force was expected to increase annually on the average by 70,000 over the period 1967-73 and by 100,000 over the period 1974-80. The capacity of the economy to generate employment under the prevailing conditions of the early 1960s was estimated at around 30,000 annually. In order to find a solution to this increasing disequilibrium between labour supply and demand, it was argued that: "There was no alternative but to take a radical action"¹⁰² in the light of a long-term strategy of industrialization.

The number of new jobs created over the period 1967-79 amounted to over 1.4 million. They were exclusively in non-agricultural sectors notably hydrocarbons, construction and

Table 2.8: Distribution of New Jobs created during the Period 1967-79 and of new jobs expected during the 1980-4 Plan (in thousands)

	1967-69	1970-73	1974-79	1967-79	1980-4
1. Industry (inc. hydrocarbons)	38	84	270	392	185
of which hydrocarbons	(2)	(14)	(18)	(34)	n.a.
2. Construction and public works	11	108	210	329	300
3. Trade and Other Services	13	21	295	329	305
4. Transport	11	21	50	82	105
5. Administration and Others	12	166	136	314	280
Total	85	400	961	1446	1175
Annual Average	26	100	160	120	235
Industrial Annual Average	12.7	21	45	33	37

Source: Compiled by the author on the basis of data published by: MPAT, 1980: *synthese...*, op. cit., p. 136 and MPAT, 1981: *Plan Quinquennal, Rapport General*, Algiers.

public works, industry and transport, as figures in table 2.8 show. Meanwhile employment in agriculture had decreased in the 1970s¹⁰³

Quantitatively, the expansion of employment over the period 1967-79 did not result in the elimination of male unemployment by 1980 as projected. The rate of unemployment had been reduced on the average during the same period from 25 to 18% of the active population as it is conventionally defined (ie. including male age-groups 18-59 and only a small proportion of women of working age). The rate of unemployment remained extremely high among the youth: 37% of the age-group 18-20 were unemployed in 1978. Meanwhile over 50% of school leavers (age-group 15-17) were neither employed nor integrated into the educational and training system¹⁰⁵.

The failure to achieve male full employment by 1980 was due to:

1. demographic explosion: the annual average rate of growth of the population over the period 1967-79 was estimated at 3.3%, "one of the highest in the world"¹⁰⁶;
2. heavy concentration of investment in highly capital-intensive sectors such as energy, hydrocarbons and basic industries and long delays in investment implementation. The average cost of each job created was extremely high particularly over the period 1974-78;

Table 2.9: Investment per job created at 1978 prices (in thousands AD)

	1967-9	1970-3	1974-8	1967-78
Basic and integrating industries	60	219	475	340
Other manufacturing industries	43	101	347	225
Mining and energy (excluding hydrocarbons)	136	819	722	614
Average for industry (excluding hydrocarbons)	63	220	467	333
Average for the Economy as a whole			302	277

Source: MPAT, 1980: Synthese..., op. cit, pp. 13-14

3. low degree of integration of the Algerian economy: This is reflected in heavy reliance on imports of capital goods, services and semi-finished products produced by labour abroad;
4. non-correspondence between domestic labour supply and demand:

whereas there was a chronic shortage of highly qualified personnel and skilled labour required to plan, design, construct and manage production units, there was over supply of unskilled labour. Already, before independence, Algeria had an inadequate supply of qualified manpower at all levels. At independence, a big gap was created by the massive departure of the European settlers who were Algeria's industrialists, technicians, administrators and foremen. A Tiano estimated Algeria's deficit in qualified manpower required by its non-agricultural sectors in 1963 at over 100,000 of which 5000 concerned the category of heads of enterprises¹⁰⁶.

Official studies carried out in 1966-7 revealed that the economy was suffering from a shortage of 2500 highly qualified persons, yet it was employing 7000 expatriates in the same category. At the middle level of qualification, the deficit was estimated at 11,000 elements with 20,000 active expatriates in the same category¹⁰⁷. With the adoption of rapid industrialization policy, demand for skills at all levels has largely outpaced supply both quantitatively and qualitatively.

This shortage of skills at all levels had a three fold consequence. The first was that poorly qualified Algerians continue to occupy highly responsible positions with its adverse effects on the efficient use of available resources.

Table 2.10: Algeria's deficit in qualified manpower in
1977 (non-agricultural)

	Cadres	Middle level qualification	Skilled and semi-skilled labour
Estimated demand for skills over the period 1970-77	67 140	94 000	243 000
Planned training Targets (1970-77)	(60 180)	(48 700)	(232 000)
Achieved	48 000	27 950	169 000
Expatriates*	14 200	1 500	3 400
Deficit in 1977 (inc Algerianization)	32 400	67 500	77 900
Deficit in 1977 (exc Algerianization)	18 200	66 000	74 500

Source: MPAT, 1980: *Synthese...*, op, cit., p. 192.

Note(*): This number excludes expatriates working with foreign firms contracted by Algerian firms and various administrations.

The second was an increasing demand on foreign technical assistance whose presence exerts an influence over decision-making in many fields, including that of the choice of techniques and sources of technology. J Minces estimated the

number of expatriates working in Algeria in 1978 at 85000¹⁰⁸. The third consequence was labour instability due to wage differentials and other social problems such as housing and transport. The average labour turnover in the industrial sector over the period 1974-80 was estimated at 30%¹⁰⁹.

This increasing shortage of skills despite the exceptional effort undertaken by the state in educating and training manpower both at home and abroad was mainly due to:

1. the fact that training of highly qualified and experienced personnel cannot be achieved overnight particularly in a country such as Algeria where illiteracy was extremely widespread amongst all age-groups and industrial experience was lacking;
2. a heavy concentration of investment in highly skill-intensive industries;
3. inefficient use of the available resources in the educational system.

The structure of non-agricultural employment had considerably changed during the period 1967-77 with the material production sector almost doubling its share at the expense of the tertiary sector. Figures in table 2.11 reveal a tendency towards a rise in the share of productive employment and a decline in the share of the tertiary sector. However, this increase in productive employment was much faster than the increase in value added; which resulted in a decline in value

added per employee.

Table 2.11: The structure of non-agricultural employment (%).

Sectors	1967	1970	1974	1977	1978	1979
Hydrocarbons	0.7	0.8	1.8	2.8	2.0	23.3
Manufacturing	13.4	16.1	17.6	18.8	20.0	
Construction and public works	8.2	11.7	15.3	19.7	20	18.7
Trade	20.4	17.8	14.1	11.6	11	58
Transport	6.0	6.6	6.9	7.6	6	
Other services	16.3	15.0	12.2	11.1	11	
Administration+others	35.0	32.0	32.1	29.3	30	
Total	100	100	100	100	100	100

Source: Compiled by the author on the basis of data published by:
MPAT, 1980: *synthese... op. cit.*, p. 136.

Figures in table 2.12 reveal that there was a drastic decline in value added per employee in the hydrocarbons sector. Whereas the annual rate of growth of employment amounted to approximately 19%, that of value added was only 5.2% over the period 1967-77. The average value added had considerably picked up in 1978 as employment was kept at 1977 level.

Table 2.12: Value added per employee in thousand AD at
1978 prices

Sectors	1967	1977	1978
Hydrocarbons	2,367	562.7	615
Manufacturing	36.8		31
Construction and public works	64.7		32

Source: Compiled by the author on the basis of data published by:
MPAT, 1980: synthese..., op cit, pp 63-4

This decline in the average value added in all directly productive sectors was partly due to overmanning and partly to capacity underutilization. The reasons for overmanning differ from one sector to another. Whereas social reasons were mainly behind overmanning in hydrocarbons and construction and public works sectors, labour instability and 'Algerianization' (ie. employment of Algerians alongside foreign personnel to learn how to operate, maintain and manage the plants) were the main reasons for overmanning in manufacturing. In addition to labour instability and Algerianization there was overmanning¹¹⁰ in auxiliary activities in the manufacturing sector. To tackle the problem of overmanning, the 1980-84 plan called upon enterprises to reduce the level of manning in accordance with technical and economic requirements of their activities, by transferring the existing extra personnel to newly

established activities¹¹¹.

Capacity underutilization was a common feature to all sectors, except a handful of manufacturing branches¹¹².

Whereas most production units were operating far below their full capacity, the level of manning was often kept at the rating capacity. The reasons for this capacity underutilization were multiple¹¹³. The most important ones were:

1. lack of sufficient managerial and technical skills required to operate and maintain the machinery and manage production units efficiently. This resulted in long gestation periods and frequent stoppages due to technical breakdowns and/or lack of spare parts and inputs;
2. administrative rigidities and infrastructural bottlenecks which often resulted in long delays in supplying inputs required to keep machinery and plants operating smoothly;
3. initial mistakes in the design and/or installation of machinery from which a considerable number of plants were suffering;
4. systematic option in some manufacturing branches (such as mechanical and electrical engineering) for large scale and highly integrated production units where most components and parts of (the) final product(s) are produced within the same production unit itself rather than sub-contracted. This option has often resulted in mistakes in the installation and design of certain production units as well as in capacity

- underutilization of certain parts of the plant, and difficulties in managing such large scale production units;
5. high labour turnover and absenteeism (see case studies).

2.4 Education and Training Policies

Algeria's time horizon was to master production technology by 1980, to have the necessary technological capacity to do most of applied research by 1985 and to become a relatively autonomous nation in scientific and technological fields by the year 2000, by being able to do R & D as well as basic research work in a comprehensive way. It was envisaged that the long term objective would be achieved through a combination of rapid industrialization using imported technology and extensive education and training effort. From the technological point of view, the former (ie. industrialization through import of technology) was expected to provide both the essential input for the learning process and outlets for the educational and training system, which in turn was expected to provide the necessary skills to assimilate the imported technology, improve upon it and eventually generate new ones.

As we argued in the first chapter, the relationship between the import of technology and the development of local technological capacity is complex and encompasses both complementaities and conflicts. The import of technology can

be an essential part of the learning process, however, its unrestricted inflow may severely inhibit the development of local technological capacity and may even destroy the already existing one. It appears that the industrialization policy followed by Algeria in the 1970s has generally resulted in turning the imported technology from an investment item (ie. imported for learning purposes with the aim of reproducing it) into a consumption item.

Meanwhile, it is often argued that education is an investment and a means of development and consequently its expansion is beneficial and necessary to development. In fact, education can be regarded as an investment as well as consumption, and as a means of development as well as a product of it, and consequently its expansion has to be considered in relation to the process of development of the economy. Education is an investment if it is geared towards the priorities of the economy and its output matches the requirements of the economy, otherwise it is consumption and its expansion may undermine the country's potential economic development as well as its social stability by producing a mass of educated unemployed. Meanwhile, education is a means of development as well as the product of it. This reciprocity is clearly manifested in LDCs where the school is expected to compensate for the backwardness of the general technological environment, formal training for the deficiencies of the education system, learning on the job for gaps in previous

education and training, and learning-on-the-job of course reflects many of the same weaknesses noticed in informal and formal training and education. Furthermore, weak links between the education system and research institutions, and the productive system have tended to marginalize the former and maintain dependence on foreign technology.

Despite the financial effort¹¹⁴ devoted to education since independence, its output has not kept pace with the range and level of sophistication of imported technology, both quantitatively and qualitatively. The gap between supply of and demand on skilled manpower had considerably increased during the 1970s. This was due to the initial low level of development, the inherited educational system, rapid industrialization and to the fact that it takes longer to produce qualified personnel than to construct a production unit. The inherited industrial sector was very small and limited in range. Before independence, its skilled labour force was mainly provided by European settlers whose departure in 1962 left a large gap which was partly filled by Algerians and partly by foreign technical assistance. The inherited educational system, which had been established mainly to cater for the settlers, became irrelevant to new priorities and needs, yet it was essentially kept intact until the mid-1970s. The gap was further increased in the 1970s as planners approved mammoth investment programmes whose simultaneous implementation was much beyond the ability

of the country to carry out, thus increasing demand on foreign technology and technical assistance.

Although the growth in total number of pupils and students during the 1960s and 1970s was impressive, this expansion was both disproportionate and achieved at the expense of quality.

Table 2.13: Pupils and Students in Algeria's Educational Institutions* (in thousands)

Year	1962/63	1967/68	1977/78
Primary education	750	1460	2900
Schooling rate (%)	30	47.8	72.5
Secondary education	32	143	745
Higher education	3**	17	55
Vocational training	-	9	55

Sources: J Leca in H Defosses and J Levesques (eds): 1975; Socialism in the Third World, Praeger Publishers, New York, p 147; and MPAT, 1980: Synthese..., op cit, p 150

Notes: (*) These figures do not include students sent for training abroad.

(**) Most of the students registered in 1962/3 were foreigners.

Figures in table 2.13 show that the number of pupils and students in 1962/63 was very small and that the expansion that took place in the 1960s and 1970s was disproportionate with regard to vocational training and scientific and technical education. This disproportionate expansion was partly due to the inherited educational system and partly to difficulties inherent to education planning as well as to long delays in implementing investment projects in this sector.

Though repeatedly criticized for its out-of-date curricula, incohesion and high selectivity (and therefore wasteful), the inherited educational system was essentially kept intact until the mid-1970s. Attempts at planning education, so as to match investment in and production of graduates of appropriate types and levels to the progressive levels of development, failed partly because of difficulties inherent to planning education and partly due to delays in reforming the system and in construction and teachers' training. The objective of maintaining a dynamic equilibrium between supply of and demand on skilled manpower is difficult to approximate, let alone achieve, through centralized planning and direction. The task is further complicated by the fact that the individual choice in this field cannot be suppressed through administrative measures. Furthermore, there are socio-economic and psychological barriers which tended to make reorientation of students towards scientific and

technical courses and careers even more difficult. There is a tendency in Algeria to view manual work as inferior compared to other types of work, particularly professional work and civil service. These attitudes are perpetuated by the low status of manual and technical work in the organizational and wage/salary hierarchy. Consequently, any attempt at reorienting the education system towards science and technology requires provision of an adequate system of incentives so as to correct the existing imbalance and to change the existing system of attitudes towards manual and technical work. In addition to the above mentioned problems, attempts at reorienting students towards science and technology in the 1970s were hampered by long delays in reforming the old system and in construction and equipment of technical colleges, universities and vocational training centres planned during the First and Second Four-Year Plans¹¹⁵.

Broadly speaking, the main features of the old system of education were:

- a) The provision of schooling did not meet the demand due to the demographic explosion and delays in implementing projects in this sector, and fell even short of meeting the target of universal primary education. The same is true at secondary and higher education as well as vocational training.
- b) The provision of education for adults was even more inadequate. The 1966 Census indicated that 63.3% of the male

population and 86% of the female population were illiterate. Although a national programme, which originated in a UNESCO project that started with a sample of 200,000 workers in the main industrial zones, aimed at extending functional literacy to 2 million adults in the 1970's was formulated, its realization fell far short of its target. The main effort has been directed at the economically active population and its extent had been very limited as the following table shows.

Table 2.14: Adult Population Affected by Illiteracy Programme

Year	1970/71	1971/72	1972/73	1973/74	1977/78
Adult students	7,500	44,000	140,345	183,115	84,800

Sources: J Cameron and P Hurst (eds), 1983: p 595, and MPAT, 1980; Synthese..., op cit, p 165

- c) Vocational training was largely neglected and its output did not meet manpower requirements; which resulted in an acute shortage of middle level technical and managerial personnel.
- d) A dramatic expansion in the number of pupils and students, which resulted in great pressure on available human and physical resources and consequently in lower quality.
- e) Curricula were based on out-of-date methods, textbooks and

teaching aids were often in short supply, of poor quality and irrelevant in content. Curricula were too academic and too little concerned with the practical application of knowledge. Meanwhile, teaching methods did not favour independent initiative and critical thinking. The system was dominated by qualificationism, ie. the stress was placed on obtaining certificates that had very little relevance to working life, and which were academically inflated. Most schools and colleges were underequipped and overcrowded. At the same time, available resources were not efficiently used: buildings and equipment were allowed to lie idle for too long both during the academic year due to poor maintenance and during vacations which, on average, last four months per year.

- f) Teachers were underpaid and undertrained, hence their morale and skills were low, and the quality of interaction both within and outside the school was very poor.
- g) The system was highly selective and incohesive. Wastage through dropout was enormous and constituted a major problem as most of this waste occurred at the early stage of schooling (ie. between the primary and middle school) which neither prepares the child for working life nor allows him to be integrated into vocational training whose access was only open to school leavers over 14 years old.
- h) Preferential treatment of relatives, friends and highly placed persons was, and still is, rife, and constitutes a major obstacle to improved efficiency.

These deficiencies in the education and training system, coupled with rapid industrialization, resulted in:

- 1) the inability of the former to even meet the immediate needs of the productive system, let alone provide the necessary skills required to develop a 'national' consultancy engineering and research activities. Although institutions for training and accumulating scientific and technological capacity have grown up, they are lagging far behind the increasing demand of the production system. Early attempts made in the mid-1970s to expand consultancy engineering and research activities in parallel to the volume of investment failed mainly due to shortage of skilled and experienced personnel. The total number of those employed by various consultancy engineering firms¹¹⁶ and departments in 1978 was estimated at around 5000¹¹⁷, or approximately one-fourth of the country's needs to implement investment allocated to industry alone during the same year. The same was true with regard to research activities where a dozen of centres were established but their efficient functioning was inhibited by shortage of skilled manpower as well as high labour turnover¹¹⁸;
- 2) increasing reliance on foreign firms and technical assistance as the volume of productive investment rapidly expanded. Foreign firms were not called upon only to implement investment projects but also to provide both technical assistance to operate completed production units and manpower training. However, neither foreign technical assistance nor

manpower training turned up to be satisfactory. Foreign firms have been criticized by Algerian managers and policy-makers for their unwillingness to depart with their know-how¹¹¹;

- 3) the establishment of an educational and training system independent of the traditional system: the inability of the traditional education system to meet the increasing demand of the productive system for skilled manpower led other ministries to establish their own post-secondary technical colleges and training centres in an attempt to make up for the deficiencies of the traditional education system. This, in turn, resulted in almost completely severing the existing weak links between the education system and the production system.

Aware of the deficiencies of the traditional education and training system as well as its economic and social consequences, Algeria's policy-makers finally decided to introduce a totally reformed system which is seen as a means of meeting the trained manpower its developing economy needs and of bringing about the kind of society they envisaged. Its reiterated objectives are democratization, preparation of new generation for working life and scientific and technical bias. The new system was conceived in such a way that the traditionally strong division between education and training is eliminated and wastage through dropout is minimized. The Ecole Fondamentale Polytechnique (EFP) is envisaged as the

cornerstone of the new system. It is envisaged as a comprehensive school which supersedes the old primary and middle schools and offers a nine-year course. During the final year the child should proceed to secondary education (leading to higher education) or specialized training so as to prepare the child for working life. The curriculum was designed in liaison with potential employers and slanted towards science and technology.

Meanwhile, technical education, vocational training and apprenticeship have been given a major impetus since 1980. The curricula for the first two were designed in close liaison with industry, agriculture and worker's organizations, therefore closely linking technical education and training with the production system. Moreover, both private and public enterprises were instructed to provide in-house apprenticeships to school leavers who have been unable to be integrated into the vocational training system or the production system.

Though it is early to assess the new education system as its generalized application took place only in 1984/5, its most positive aspects are the design of the curricula in close relation with potential employers, its experimental approach¹¹⁹, and its potential to limit wastage by extending the schooling cycle so as to prepare the child for working life. However, its success depends above all on the

provision of human and material resources required to implement it. Even before its generalization in 1984/5, its implementation appears to have encountered major problems, the most important of which are:

- 1) overcrowding of classrooms as a result of the extension of the compulsory cycle, coupled with demographic explosion, as well as delays in implementing projects in this sector;
- 2) shortage of qualified teachers, of equipment and various materials required to teach new curricula;
- 3) preferential treatment of relatives, friends and privileged persons, which constitutes a major obstacle to improved efficiency.

Despite the new system's emphasis on technical and scientific education, it is doubtful whether the objective of producing 52,000 engineers, 295,000 technicians and over 1 million skilled workers targeted for the period 1980-90 would be achieved. Indeed the 1980-84 plan estimated that only one-third of the 46,000 students expected to graduate during 1980-4 would do so in science and technology. Aware that results cannot be achieved overnight and the economy's needs for skilled manpower is enormous, Algeria's policy-makers, in an attempt to fully utilize available human resources, decided in 1980-4 to reform engineering and research activities. New national development enterprises and research institutions were set up. The aim of the reform was to pool together existing scarce skills and to define clearly

their priorities and prerogatives. Interdisciplinary teams were set up and research activities were oriented primarily towards priority sectors and applied research. Research teams were formed from university as well as industry and other activities, with the aim of linking research activities to production.

However, a number of problems related to this restructuring remain unresolved. Thus, separation of development from production may result in severing the links which are already weak between development and production enterprises. The reforms did not clearly define how these links could take place. In practice, however, some development enterprises have established formal links with production units by establishing research and development cells, particularly where the latter possess laboratories, so as to ensure continuous exchange of information. Others have very limited interaction with production enterprises and units, and consequently the involvement of the user in development activities could be very restricted. This may, in turn, lead to frictions and wastage. Another problem related to research institutions and their personnel, is that the reform did not include ways of evaluating their activities and sufficient incentives to stabilize manpower as well as to maintain the links between research activities and production. Thus, although economic agents have actively participated in the process of selecting research themes and

priorities, they have no authority over the activities of research institutions as they are financed mainly from the central government. It seems that in order to improve the efficiency of research activities, it is advisable to introduce contractual arrangements so as to avoid the tendency towards 'marginalization' of scientific activities observed in LDCs and minimize waste.

Conclusion

Algeria's time horizon was to establish a relatively integrated productive system that features a capital goods sector by mid-1980s, to master imported production technology by 1980, to have the necessary institutions to do most of engineering work by 1985 and to become a relatively autonomous nation in the scientific and technological field by the year 2000. So far, Algeria's achievements are far behind these targets. Although a relatively diversified industrial base has been established, it remains heavily dependent on the international market for its smooth functioning as well as reproduction. Meanwhile, institutions for training and accumulating scientific and technological knowledge have been growing up but they still lag behind the range and the level of sophistication of the established productive system, and much behind international technology frontiers in all industrial fields.

Overall, the contribution of imported technology has remained

very considerably below its potential because of the mutually reinforcing negative impacts of:

1. The initial low level of industrial and technological development which constitutes a major obstacle to rapid industrialization aimed at yielding an integrated productive system and developing a technological capacity in the medium term. Whereas the industrial base can be established even in the short run through massive imports of technology, this process does not ensure either 'the blackening of the matrix', nor development of a technological capacity capable of assimilating the imported technology. The darkening of the matrix is complicated for reasons of its own, for reasons inherent to the planning and implementation of a very detailed system of interindustry and inter-sectoral linkages. It is also restricted because of heavy reliance on foreign firms for solving these problems, as these firms tend to use technical specifications and standards familiar to them without taking into account their application in the importing country, thus rendering the envisaged integration impossible. Meanwhile, the development of a technological base capable of assimilating imported technology and coupling of unlinked production units, takes time. These problems are often underestimated by the proponents of the basic-industry strategy as well as policy-makers in developing countries.
2. Policy miscalculation, particularly with regard to the priority given to investment over consumption and to certain

industrial sectors over others. First and foremost, the planners undertook and approved in the 1970s a number of mammoth investment programmes whose simultaneous implementation was much beyond the ability of the economy efficiently to carry out. This in turn resulted in increasing reliance on foreign firms, in waste and over-emphasis on project implementation at the expense of production and learning-by-doing. Secondly, over-concentration of investment in a limited number of sectors resulted in bottlenecks which adversely affected efficient use of resources.

3. The numerous shortcomings, even after recent reforms, in the economic and education system, which have many negative effects on the selection, assimilation and diffusion of technology as well as the use of scarce resources. Firstly, Algeria has no independent institutions to evaluate either local technological potential or transfer of technology, nor specific laws pertaining to technology imports. In principle, both enterprises and central organs participate in determining the economy's technological needs and the terms and conditions of technology imports. Many Algerian laws and regulations can be applied to the transfer of technology imports; but they do not serve only this purpose. The most widely used method to control technology imports involve model agreements created by the various technical ministries for national enterprises under their control. They constitute the basic text for

discussion during the negotiations with foreign suppliers. The most widely used are turnkey agreements and production guarantee agreements ('produits en main'). The main aim of these contractual forms is to force the supplier of technology to bear the risks for industrial operations (including sale of capital goods, patent licencing, trade marks, supply of know-how, technical assistance, training or engineering). The main problem confronted in these all-inclusive forms of technology transfer is that tasks that could be performed locally are carried out by foreign firms. This can increase costs and preclude the possibility of local accumulation of human capital through experience-based learning as well as inhibits economic integration. Consequently, the economy is deprived of experience that is relevant to its subsequent development.

Secondly, the quasi-monopoly of an industrial branch by a single national corporation and weakness of central control resulted in duplication of technology purchasing from abroad and in a tendency of each corporation to achieve integration within itself, thus inhibiting specialization and development of the already existing available technological potential. The consequence of this strife by individual big national corporations to achieve integration within themselves was that many small maintenance and repair shops have been virtually cut off from jobs and subsequently disappeared.

Thirdly, although contract negotiation, technology acquisition and financial autonomy was conferred upon national corporations, and recently upon national enterprises, the centre has retained a dominant role in planning investment and imports and a major role in planning production, wages and prices, thus maintaining de facto control over the enterprises' operations. This continued central control over enterprises cannot foster the interests of enterprises in the long-run profitability and economic efficiency. Although the autonomy of state enterprises and production units have increased since recent reforms, so many restrictions on their operations remained intact and subject to red tape and heavy administrative procedures. The most important of these restrictions are import licencing and investment approval, which directly affect day-to-day operation of the enterprise as well as efficient use of imported technology. The influence of these policy and system impacts on technology assimilation will be analyzed in great detail in the following case studies on cement and flour milling industries.

Fourthly, the traditional education system was inadequate and irrelevant to the country's needs, yet it was essentially kept intact until late 1970s, thus resulting in great waste and shortage of skilled manpower, which in turn has had negative effects on efficiency and technology development.

Footnotes

- (1) For more details on the strategy, see section 2 of this chapter
- (2) Technological independence does not imply autarky, but the ability to screen and select foreign technologies which are complementary to local ones and the capacity to substitute imports by local technologies whenever economic or extra-economic conditions dictate such a possibility
- (3) see eg. de Bernis' various essays which are examined in section 2 of this chapter, Thomas, C Y, (1974) and Remeyemamu, J (1983)
- (4) See chapter 1
- (5) Industrialization in Algeria has been accompanied by a proliferation of foreign standards which because of their incompatibility resulted in great difficulties related to sub-contracting. This was due to the absence of a 'national' standards system and to lack of coordination between various firms and institutions
- (6) Chudnovsky, D. in Fransman, M. (ed), 1986: p.85-86
- (7) Front de Liberation National (FLN) in Thomas L, Blair (1970): pp. 258-259
- (8) Algerie Press Service (1975): The title of the pamphlet.
- (9) The Weekly Economic Supplement of the official daily El Mondjahid, October 21-27, 1975
- (10) de Bernis, G in PERROUX (ed), (1963): p 128

- (11) Ministère de la Formation et de la Culture (November 1971)
- (12) quoted in TEMMAR, H, (1974): p 206
- (13) quoted in HAZERA, J-C (1975): p 112
- (14) on the theory of introversion see S Amin's article in Tiers Monde, 13(20), pp 703-726
- (15) quoted in HAZERA (1975); op cited, p 113
- (16) see Ministère de l'Information et de la Culture (1971); op cited, p 10
- (17) this point will be discussed below
- (18) quoted in Benamrane, A (1980); p 69
- (19) this concept is used in the pamphlet published by the Ministère de l'Information et de la Culture (1971); op cit., p 16. However, lately Algerian planners mainly use the term <integrating> industries
- (20) de Bernis, G (1966); p 419
- (21) PERROUX, F (1961); pp 172-193
- (22) quoted in TEMMAR, H (1974); op cit., p 208
- (23) de Bernis (1966); op cit., p 419
- (24) Ibid
- (25) Ibid. A similar definition can be found in Ministère de l'Information et de la Culture [(1971); op cit., p 16] which states that "we opt for capital goods industries, not because Lenin emphasized their importance, nor because they were at the heart of the model of the first socialist country, but because they allow us to overcome disarticulation of our economy..."
- (26) Ibid

- (27) quoted in HAZERA (1975); op cit., p 118
- (28) de Bernis (1971a); p 548
- (29) de Bernis (1970); pp 7-8
- (30) Ibid
- (31) R A J, K N, in Feinstein, C H (ed), 1967: p 218
- (32) Dobb, M (1976): p 68
- (33) this is primarily due to lack of state protection of this sector as well as to lack of coordination between various investment institutions and to generalization of the use of turnkey mechanism in investment implementation; where foreign firms were contracted to construct and Commission plants, and preferences for foreign made machine-tools. Some examples are given in chs 4 and 5 of the thesis
- (34) quoted in HAZERA, op cited, p 123
- (35) quoted in ARRIGHI, G and SAUL, J S, in Bernstein, H (ed) 1981:pp 240-241
- (36) Dobb, M, op cited, p 74
- (37) see Ilman, M C in CREA (1983); pp 115-174
- (38) de Bernis (1962)
- (39) Raj quoting Mahalanobis as thinking that once India had established its basic industries, it would enjoy enormous advantages of lower costs for capital goods. See Raj, K N, 1982 (Jan 26), pp 24-28
- (40) This argument is developed in great detail by Kaplinsky, R, in Fransman and King (eds), 1984; op cited, pp 139-160
- (41) de Bernis (1970a); pp 206-207

- (42) Ellman, M in Feinstein, C H (1967); op cit., pp 285-307
- (43) see next section
- (44) Ibid
- (45) quoted in HAZERA, op cited, p 119
- (46) Jacquemot, P and Raffinot, M (1977); p 379
- (47) HAVEEM, H, in ERNST, D (ed), (1980); op cited, p 456
- (48) this lack of coordination and cooperation resulted in each national corporation having to provide various utilities (roads, transport means, housing and the like) for its new projects, which in turn resulted in cost overruns and delays in project execution
- (49) see ABID, A (1976)
- (50) there is often a likelihood of idle capacity in situations where individual firms are forced by environmental and institutional circumstances to overextend their degree of vertical integration
- (51) this lack of horizontal flow of information led, for example, to imports of certain goods and services which can be procured locally. For more details see chs 4 and 5
- (52) MPAT, 1980; op cited, p 235
- (53) for more details, see OECD (1984); p 85
- (54) MPAT, 1980 (May): PX.
- (55) Hovart argues that the marginal productivity of investment reaches zero well before the share of investment in national income reaches 50%. For more details see Hovart, B (1965); pp 572-5
- (56) MPAT, (May) 1980; op cited, pp 3-4

- (57) See TEMMAR, H (1983); pp 185-186
- (58) for more details see Rapport de Recherche et d'Etudes Universitaires, 1974; Les Tendances Inflationnistes en Algerie, Algiers (memeo)
- (59) For more details see sub-section B.1 of this chapter
- (60) MPAT, 1980 (May); op cited, pp 15-16
- (61) Ibid
- (62) see data in table 2.3
- (63) this view was implicit in the MPAT (May 1980); particularly pp. 65-77
- (64) speech by the Minister of Energy on November 27, 1978, quoted in Mekideche, M. (1979); p.2.
- (65) Chevalier, J.M. (1973); pp. 139-45
- (66) Temmar, H. (1983: p. 163) argues that around 25% of investment in hydrocarbons were spent on expanding their capacity for home consumption. However a large proportion of petrochemicals production is at present exported largely because of lack of downstream processing activities locally.
- (67) European petrochemical producers are already requesting protective measures against OPEC producers. See Financial Times, December 6th, 1984, p. 2.
- (68) de Bernis (1971); p. 587
- (69) for more details on how the direct reduction process was kept unknown for more than a decade to new entrants to steel industry, by big producers of steel in DCs, see P. Judet in Ernst, D. (ed), 1980; op cit., pp. 307-323.

- (70) see next section and ch 4
- (71) see MPAT (1980 May); op cited, pp 20-21
- (72) RAJ, K N, in Feinstein (ed), (1967); op cit., pp 220-221
- (73) Thiery, S, 1980 (September); pp 449-80
- (74) Raj in Feinstein (ed), 1967; op cited, pp 220-224
- (75) a handful of projects related to the machine-building sector were prepared for the 1980-84 Plan. These included the extension of the existing machine-tool plant and construction of a complex to produce heavy equipment for various industrial sectors. For more details see Thiery, S, 1980 (September); op cited, pp 486-89
- (76) "The Algerian Citizen does not anymore support sacrifice in favour of primitive accumulation". MPAT (May 1980a); p 7
- (77) the pattern of allocation of investment in the 1980-84 plan was largely determined by the pattern of investment allocation in the previous period due to incompleted projects started prior to the plan
- (78) the total cost of new investment projects and completion of earier ones was estimated at 560, 500 M compared with investment in the 1980-84 plan of 400,600 M AD. The amount needed after 1984 to complete new industrial projects at 1980 prices amounted to 57200 M AD
- (79) MPAT, 1980a and MPAT, 1980 (May); op cited
- (80) a considerable proportion of the country's foreign

exchange earnings are being spent on grandiose projects which have very little social utility; such as those related to the decoration of the capital as well as projects for durable consumer goods

- (81) Stewart, F (1977); op cited, p 153
- (82) MPAT (1980, May); op cit., 48-50
- (83) on cost overruns and change in the structure of planned investment see sub-section A

- (84) for more details, see MPAT (May 1980); op cit., pp 87-88
- (85) for more details see Ibid, pp 66-67
- (86) for more detailed statistics, see Ibid, p 86
- (87) some reforms aimed at improving efficiency and stepping up production were carried out in the early 1980s. The most important of these are: reorganization of the industrial sector (to be discussed below), harmonization of the wage scale to reduce labour turnover, establishment of productivity bonuses as an incentive to production, stepping up of manpower training, improvement of infrastructure and housing conditions and simplification of administrative procedures with regard to import of essential engineering components and parts as well as raw materials and semi-finished products
- (88) MPAT, 1980 (May); op cit., pp 12-13
- (89) eg. production costs of bricks, tractors, fertilizers, cement, oil refined products, electrical goods and

textiles in Algeria were found to be 125, 130, 125, 130, 100, 100 and 100% those in France. Quoted in TEMMAR, H (1980); op cited, p 187

- (90) for more details see MPAT, 1980 (May); op cit., p 53
- (91) Ibid, p 84
- (92) the share of raw materials and semi-finished was expected to exceed that of capital goods from 1984 on
- (93) a number of such cases were publicized by the official daily El Moudjahid, April 1976
- (94) on the effects of the separation of development from production see chs 4 and 5
- (95) there are no official statistics concerning the number of skilled labourers who did not join their work place after reorganization. However, executives of industrial enterprises I visited pointed out that "some of the highly skilled labour" originally appointed to join their enterprises as a result of reorganization, never turned up
- (96) the official daily El Moudjahid, 26 February 1986; extracts from the speech by the Minister of Planning
- (97) eg. through "sub-contracting" fairs which are periodically organised to encourage horizontal flow of information
- (98) see eg. Benachenhou, A (1976a); op cited
- (99) R Gendarme, (1959); op cited, p 275
- (100) Secretariat d'Etat au Plan, (1974); op cit., p 62

- (101) Commissariat National du Recensement de la Population in Tableaux de l'Economie Algerienne, Secretariat d'Etat au Plan, (1971); op cit., pp 80-83
- (102) Secretariat d'Etat au Plan, (1974); op cit., p 62
- (103) agricultural employment had decreased by over 10% over the period 1970-1979. For more details see MPAT, 1980 (May); op cit., pp 136-137
- (104) Ibid, pp 134-137
- (105) according to MPAT, Ibid

- (106) quoted in TEMMAR, H (1974); op cit., p 525
- (107) quoted in Ibid
- (108) Minces, J (1978); p 50
- (109) Thiery, S, (1980); p 184
- (110) for a detailed analysis of the degree and reasons of overmanning in manufacturing see chs 4 and 5 of the thesis
- (111) this explains why industrial employment was expected to grow during the 1980-84 plan at a much slower rate than those during the 1974-79 period. See table 2.8: columns 3 and 5
- (112) MPAT, 1980 (May); op cited, pp 69-72 and 82-83
- (113) for more details on the reasons for capacity underutilization in the cement industry, see ch 4
- (114) expenditure on education and training amounted on the average to 10% of GNP during the 1970s
- (115) for more details on these delays see MPAT, 1980 (May);

op cited, pp 154-165

- (116) most of these firms were established in cooperation with foreign firms in the form of joint ventures with Algerian partners holding a majority share in equity. In addition to consultancy firms, some national corporations established their own engineering departments through technical assistance where expatriates were recruited often individually. Their activities were mainly limited to feasibility studies, detailed engineering and construction and installation of new facilities
- (117) Thiery, S P, 1980 (September); op cited. It must be emphasized that this shortage of skilled personnel was particularly acute with respect to basic design-engineering. Most local firms did not even attempt to train their personnel in process design and engineering
- (118) a detailed assessment of Algeria's experience in scientific research activities can be found in a speech delivered by the Minister of Higher Education and Scientific Research and published in El Hindis, No. 5, 1979, pp 19-30 and ONRS (nd): Bilan Scientifique de la Recherche à l'Organisme National de Recherche Scientifique de 1975 à 1980 (Algiers)
- (119) the EFB was introduced on a pilot scale in 1974/75 and has been since then gradually generalized.

Chapter ThreeTHE ASSIMILATION OF IMPORTED TECHNOLOGY

Assimilation of technology cannot be achieved by passively importing technology. The term "transfer of technology" is misleading to the extent that it implies that technology can be transferred wholesale and in perfect working order. In fact technology does not come in convenient, self-contained units that can be packaged and shipped for immediate use from one country to another. Technology is derived from a continuum of activities encompassing research, development and engineering, which in turn is closely linked to ongoing production and marketing activities. Furthermore, technological activities are often induced by unique social environments, and closely linked to use environments which provide the signals for what is needed in the way of new or adapted products and processes.

Although both capital goods and technological information can be transferred, the ability to search for appropriate ones and make effective use of them cannot be. This ability can only be acquired through continuing technological effort on the part of the recipient; and it is this ability that leads to technological assimilation by the recipient. Even in developed countries where the technology transferred usually supplements the existing capacity, assimilation of transferred technology requires a continuous effort on the part of the recipient. This

technological effort often takes the form of additional training of the existing personnel, hiring new ones and/or reorganization to accommodate the transferred technology so as to make effective use of it.

The Chapter is organized as follows: section I discusses the meaning of technology assimilation and technological capacities required to achieve it on the part of the recipient. Section II is devoted to a discussion of technological knowledge and effort on the part of the recipient required to achieve assimilation of technology received. Section III is devoted to how field-work was carried out and data concerning the two cases, which will be analyzed in Chapter 4 and 5, were obtained.

I. Technological Capacities Required to Assimilate Technology

Technological assimilation is defined as the effective "appropriation" and use of technological knowledge through continuing technological effort on the part of the recipient to operate and maintain, to adapt, to reproduce, and improve upon the imported technology as well as to generate new technology in the form of new products and/or processes. Effective appropriation and use means the acquisition of the following technological and organizational capacities:

1. Manufacturing capacity: the ability to make effective use of

installed production capacities through mastery of the technology for organizing, managing and executing the factory operations. One basic component of this technology is the engineering knowledge of manufacturing techniques and methods, including quality control, and of how and when to carry out efficiently repairs and preventive as well as protective maintenance of existing machinery and equipment. Broadly speaking, there are two modes of organizing manufacturing production. On the one hand, there are manufacturing plants that use continuous flow processes to produce large volumes of standardized items; on the other, there are factories that apply discontinuous batch processes to produce quasi-standard items, or even custom-made items, in a plant organized as a succession of work-shops. Factories of the first kind, such as cement works, are product specific - i.e., their physical layout follows a sequence imposed by the technical transformation needed to produce a given product. The sequence of technical transformation is always the same and is what decides the physical layout of the plant. The main common characteristics of a factory of this kind are:

- a) The pre-production part of the plant lay-out is detailed and complete and consequently there is very little flexibility in either product design or the production process once construction is completed;
- b) production process sequences systematically follow each other along a direct route, thus minimizing delays and wasted

time;

- c) the handling of raw materials and of work in progress is also minimized;
- d) the product tends to be highly standardized and the production equipment tends to be specific to the industry;
- e) There is very little on-the-job decision-making, therefore direct labour skills and supervisory requirements are relatively less important than in batch production units.

In spite of its advantages, a continuous flow process requires a great deal of engineering experience both during the design and construction stages of the plant and during its operation, as any fault in the first stage or an intended stop during the second tend to be expensive. At the design stage the reliability and maintainability are the important factors to be considered in relation to the plant's performance, capital costs and running costs. At the installation stage, maintainability continues to be an important factor because it is only then that the multidimensional nature of many of the maintenance problems becomes clear. Finally at the production stage, a suitable learning system should be continued to improve techniques and methods of production and maintenance engineering and organization. The function of this learning system is to gather and provide information on production and maintenance problem areas, thus facilitating determination of the plant's optimum operation and maintenance work.

Factories that use discontinuous batch technology are organized in workshops rather than along a 'line' and usually manufacture goods in small runs or in response to individual customers. Different products can be produced simultaneously. The main characteristics of a manufacturing plant of this kind are:

- a) there is a great flexibility in the way a given job is carried out,
- b) the movement of raw materials and work in progress between workshops is the most important element of production organization, and any deficiency in it can be a source of waiting periods and bottlenecks. In this kind of plant, there is usually ample room for reducing the production cycle by careful rearrangement of the physical distribution of jobs in the work area,
- c) given the fact that the output is not highly standardized, on-the-job decision-making is very important. Furthermore workers' skills in setting up the machines, preparing jigs and tools for the job, and actually carrying out the tasks are very important.

Another component of equal if not greater importance is the managerial and organizational know-how, without which the economic viability of the manufacturing operation cannot be ensured. Production management and organization can be considered as the direction, and organization and actual execution of production tasks so as to make effective use of

human and material resources available. Maintenance management can be considered as the direction and organization of resources in order to control the availability and performance of industrial plant to some specified level. The maintenance manager has, generally, two main problems - the determination of the size and nature of the maintenance work-load and the organization and control of men, spares and equipment to meet this work load.

2. The capacity to modify: the ability to introduce technical changes so as to adapt the product or the process to local conditions, or to improve the product or process. As mentioned in the first chapter, technology is always to some extent implicit and location-specific. Accordingly, any transfer of technology will require a degree of adaptation. As Rosenberg pointed out: "New techniques frequently require considerable adaptation before they function successfully in a new environment. This process of modification often involves a high degree of skill and ability, which is typically underestimated or ignored."² A number of local conditions have been found to be particularly important in LDCs. These include the degree of competition in protected markets, the degree of availability of skills, the supply and quality of local resources, the climate and the size and characteristics of the market.³

The capacity to improve means the ability to conceive and

apply technical change with regard to product or process. Here activities go beyond adapting the technology to local conditions and involve introduction of improvements on the product or process in terms of its operating simplicity, technical performance, maintainability. These improvements may be incremental and minor, or they may be major, involving a discrete jump at a point in time. As Rosovsky pointed out: "Improvement engineering reduces the cost of imported technology by making it more productive at the margin...It is largely an activity of 'carefully taking apart and putting together a little better'; it is concrete and directly related to production, especially when compared to basic research. In contrast to the pursuit of core innovations, this type of activity is less risky and much cheaper..."⁴ Recent research on technological activities in some LDCs reveal that such improvements take place and have resulted among other things, in exports of technology in various forms.⁵

3. The capacity to reproduce: the ability to conceive and apply the technology through new investment in the industry concerned. It pertains to the establishment of new production capacities. It involves the mastery of the various tasks required to implement an industrial investment project. These tasks are: the study of pre-investment technical and economic feasibility, basic and detailed design and engineering, procurement and supply of machinery and

equipment, training of the plant's personnel and start-up of operation.⁶

4. The capacity to generate new technology: the ability to conceptualize and define and actually to design and engineer new products and/or processes that are acceptable to the market (or to society) on both technical and economic grounds. Recent research on technological activities in LDCs reveal that Third World countries have rarely produced processes and products that are fundamentally new to the world.

5. The capacity to search: the ability to scan technical and commercial information so as to increase the recipient's technological capacity. Search activity may include relatively 'passive' activities such as the screening of technical and trade journals as well as active testing of alternative products and processes. The importance of search activities in technological development was emphasized by a number of authors. Thus Dahlman and Fonseca emphasized the importance of externally acquired knowledge in technological development of the Usiminas steel plant in Brazil: the firm made major efforts to seek and acquire technical information about technology both through contractual arrangements with foreign firms and outside them.⁷

Several points need to be made about the above categorization of

technological capacities required to achieve full assimilation of technology. To begin with, full assimilation of technology on the part of the recipient is not always necessary, nor is it always socially beneficial.⁸ The local development of local technology is not an objective in itself but rather a means to increase the recipient's ability to produce efficiently goods and services. Underdeveloped countries cannot expect to excel in all technological fields nor should they hope to achieve self-sufficiency in all industrial technological areas. Therefore there is the need for specialization so that the technological capacity required in each area may be defined accordingly. Broadly speaking, two different ideal type technology strategies can be distinguished:

- a) the 'catch-up' strategy which aims at reaching world technology frontier. This strategy requires full assimilation of the technology concerned and its success depends on the ability of the country/firm to generate new technology so as to keep up with competitors in the international market.
- b) the frontier following strategy which is based on imported technology and does not aim even in the long-run to generate frontier technology. Partial assimilation of imported technology may be sufficient to make effective use of it. As Dahlman and Westphal pointed out: "The South Korean experience demonstrates that...high indigenous levels of all types of technological mastery are not necessary for the initial stages of industrial development; in the Korean case,

a mastery which has been mainly confined to production engineering has been sufficient."⁹

Another point which should be made about the above categorization is that it does not necessarily mean that the 'stock' of knowledge required to acquire each capacity increases as we move from (1) to (5), nor should it be identified with sequential technological development advocated by some authors. For example it may be a far more complex matter, in terms of technological capacity and effort, to manufacture an aeroplane engine, than to design a new, but relatively simple machine tool. Nevertheless, there is often a quantitative difference between the first type of capacity and the last four when considered in relation to a given technology. However this quantitative difference does not mean that technological development should proceed sequentially from (1) to (5). Several authors have attempted to identify stages in the development of technological capacities in LDCs.¹⁰ Like other stage theories, these attempts often lack a convincing explanation of the causal mechanism whereby one stage progresses into another, and can be subject to a mechanistic interpretation of the transition from one stage to another. Moreover, a number of case studies reveal that the order implied by the stage description is not always adhered to.

II. Technological Knowledge and Technological Effort

The degree of technological knowledge and technological effort required to assimilate each type of technological capacity listed above differs considerably. To some extent this difference is captured by the distinction, made in this context by Lall¹¹, between knowing how something works, and knowing why it works in the way it does. Generally, within the same industrial branch, both technological effort and technological knowledge increase as we move from (1) to (5). Thus the capacity to operate and carry out corrective maintenance does not require knowledge of the core process and basic design and engineering. However, preventive maintenance usually requires what Lall calls 'know-why': it demands perfect knowledge of the core process as well as design and engineering capabilities particularly in cases where technical breakdowns are due to pre-production design and engineering defaults.

One basic component of manufacturing technology is the engineering knowledge of manufacturing techniques and methods, including quality control and testing as well as maintenance of machinery and equipment. Another component of greater importance is the managerial and organizational know-how which is essential to ensure the economic viability of the manufacturing operation. Manufacturing capacity can be acquired through extensive training of the existing personnel and/or hiring personnel with experience in various aspects of technology operation and maintenance.

The last four types of capacity require knowledge of both 'know-how' and 'know-why' and the technological effort required to achieve them involves the establishment of engineering departments, applied research and development institutions and capital goods industries. Acquisition of these capacities requires a higher degree of knowledge than that required by the manufacturing capacity. Although some minor modifications can be carried out at the shop floor level¹², major modifications often require R & D effort as well as design-engineering capabilities. Referring to a 1962 study by the Japanese Ministry of International Trade and Industry, Peck and Tamura noted that: "One-third of R & D expenditure...were for modifying...imported technology".¹³

The capacity to reproduce a given technology requires various technical and organizational knowledge needed to perform the various tasks involved in product and/or process as well as project design, engineering and execution. It also requires experience in performing such tasks. The types of knowledge and experience required to efficiently reproduce the technology will be discussed in the following chapter on cement technology.

The capacity to develop new products and/or processes requires great knowledge of basic and detailed design engineering. By design capability we mean the ability to conceptualize, define and actually design a product or a process that is acceptable to society and the market on both technical and economic grounds.

Design work is often divided into three main phases: feasibility study, basic design and detailed design. Product or process design is typically a skill possessed by engineers and technologists with advanced training and adequate designing experience. In order to acquire this capacity, these persons need not only to understand elements and fundamentals of product and/or process design, but also to establish their own methodology for creating viable designs. Design work is multidisciplinary and its success depends on the establishment of a harmonious and stable multidisciplinary team.

In addition to design capability, development of new products or processes often requires applied, and even basic research. While there is relatively little research activity in LDCs, it does exist often independently of technical and production activities and consequently it participates very little in solving problems encountered by the production system in these countries.¹⁴

R & D activities are essential not only for the development of new technologies, the reproduction and improvement of imported ones, but also for search activities. As Mansfield pointed out: "R & D provides a window opening on various parts of the environment, enabling the nation or the firm to evaluate external developments and react more quickly to them. In some economic models, R & D is viewed as an invention- or innovation-producing activity. Though correct as far as it goes, this view misses much of the point of R & D, which also is aimed at quick response

to rivals and at clever modification, adaptation, and improvement of their results".¹⁵

A certain amount of knowledge is necessary for the firm or the country to gain additional knowledge through its search activities. Externally acquired knowledge often arrives in the form of 'disembodied' knowledge and information, rather than being embodied in labour or machinery and equipment. In fact, however, such additional knowledge very seldom just arrives. Almost always it has to be sought for, screened and acquired by the recipient. This means that the flow depends on active effort on the part of the recipient, and that in turn requires the prior accumulation and deployment of resources to make such a search effort, as well as to make effective use of acquired knowledge.

Technological effort is defined as the effective use of technological 'know-how' and 'know-why' in combination with other resources to assimilate technology. Its main sources are human capital formation (through training and hiring of ready-made skills) and learning-by-doing, or experience. A number of studies suggest that various kinds of formalized training play a major role in technology assimilation.¹⁶ In particular they stress the importance of active participation of the recipient's personnel in investment implementation, where the recipient's personnel is allocated to work closely alongside the supplier's, with an explicit objective of training to acquire knowledge about the process technology and other tasks involved in project

execution, as well as operational technology. Others stressed the importance of hiring ready-made skills in augmenting the recipient's technological capacity.¹⁷

The second source of technological capacity to assimilate imported technology is learning-by-doing or experience. It is often argued that efficiency in performing tasks increases with the passage of time as greater experience is accumulated, and this is often attributed to doing-based learning. Such efficiency increases with time may reflect reduced labour requirements as tasks become routine through repetition, the effects of learning-by-doing on management leading to better planning, efficient labour scheduling and improved quality control, learning by R-D & E departments, and the effects on increased efficiency of suppliers, who themselves experience the doing-based learning mentioned above and are able to improve quality and delivery dates of their supplies. The implication is that given a period of time doing something, some quantum of learning takes place and automatically results in a regular improvement.

The idea of learning-by-doing has been widely used in the literature in order to conceptually capture the information flows that are generated by the activities of producing, designing, buying and selling. Earlier Arrow¹⁸ and Kaldor¹⁹ had incorporated the concept in growth models where growth is influenced by some indicator of doing, for example, cumulative

output or cumulative investment. The concept has recently been widely used in the literature on technology in the Third World.²⁰

As treated in most economic analysis, doing-based learning has three features. First, it is costless: it is acquired as a free by-product from performing tasks over a period of time. In other words, it does not require expenditure beyond that needed to perform the usual tasks. Second, it arises passively: little or no explicit action is needed to capture the acquired knowledge and/or skills and to make effective use of them. Third, the learning process takes place automatically with the passage of time. In other words, given a period of time of doing something, some quantum of learning will take place.

In the following two chapters, we examine the effects of human capital formation and experience on the assimilation of technology and production performance in cement and flour-milling industries in Algeria. The main reasons for the choice of these industries are, first they have been among the priority sectors in the Algerian strategy of industrialization. Second, a large number of plants in each industry have been constructed since 1969, and a large number of employees have been trained or hired, and this provides the possibility for the firms involved to accumulate a considerable experience in design, engineering and operation of the two imported technologies, and consequently to augment their technological capacity and improve their performance. Third, domestic demand for their products largely

outstrips supply and consequently they face no marketing problems.

Our hypotheses are: first, local content in project execution will tend to increase over time for successive projects as a result of the learning process on the part of Algerians. This is based on the assumption that Algeria would progressively substitute its own internal technical capacity for elements of the engineering and know-how initially purchased externally, to compensate for the local absence of such elements. Second, lead-times of successive projects will tend to be shorter, as a result of the learning process of those involved in project execution, and capacity utilization in completed plants will tend to improve with the passage of time as experience in operating the technology is accumulated. Third, the significance of human capital formation and learning from experience depend, at any level beyond that of the individual task, on the existence of a feedback system to capture and make effective use of acquired skills and experience. Without such a feedback system to generate, evaluate and interpret the skill and experience acquired by individuals, the on-going learning-by-doing and human capital formation will generate little technical activity, and the process of technological development will lack a driving force.²¹

These hypotheses* will be examined in the following two chapters in the light of Algeria's experience in cement and flour-milling technology assimilation. Data needed to test these hypotheses were collected mainly through questionnaire-based interviews with executives of cement works and flour mills. The questionnaire consists of five parts: general information of the technology and the mechanism of its transfer, local content in and lead times of project execution, capacity utilization and manning levels, maintenance and operation of the technology and modifications of the technology imported.**

III. Field Work and Data Collection

Field work was undertaken by the author in Algeria during 1985 and 1986. It took over eight months and three visits to Algeria to collect the necessary data. Major problems were encountered in obtaining access to information and data, particularly during the first visit, which took place at the time when the two industries were going through a transitional period as a result of a reorganization launched during 1982. Before reorganization, each industry was a monopoly run by a national corporation. As a result of reorganization each corporation was split into a number of enterprises. The process entailed a great movement of

* A detailed discussion of these hypotheses is given in Ch. 4, section 3.

** For more details see the appendix

personnel at all levels and dispersion of the data bank concerning the industry. This in turn complicated our mission as ex-executives who had knowledge about projects and the industry, had either left the industry or even though they had been appointed to new enterprises, were still difficult to locate. A second problem encountered was the unwillingness of some enterprises and plants executives to cooperate, even after we had obtained the authorization, which they had initially requested, from relevant ministries. To overcome this problem, an effort was made to gain a prior introduction to potential interviewees in order to avoid negative responses and delays. The main sources were the researcher's personal contacts and the assistance of the already interviewed executives who were generally helpful. However even the application of this procedure was not always successful. Thus, although not a single interviewee of all the ones contacted refused to participate, it became apparent that six of the thirty mills, two executives at one of the flour-milling enterprises and three officials from the Ministries of Planning and Light industry, who acquiesced had done so only nominally. They routinely kept breaking appointments until the researcher stopped pressing them. Third, geographical dispersion of plants and enterprises made field work extremely difficult and time-consuming. An attempt to save time and effort was initially made by mailing questionnaires to far away interviewees to be answered and returned, while visiting only those which are located near the researcher's home town. However, this method proved to be useless, as none of the questionnaires sent during

the first visit had been returned after six months. Consequently, an effort was made in cooperation with individual enterprises to set up a time table of the researcher's visit to each plant. The result was only partially better as most plants did not respect the time table and kept breaking appointments. New appointments were consequently agreed upon with the managers of the plants and copies of the questionnaire were left with them for subsequent completion on the researcher's return. Even then, most respondents were found to be not ready to answer all the questions because they either lacked information or were unwilling to part with it.*

Forty-two questionnaire-based interviews were arranged with executives of all newly constructed cement works and flour mills, of which thirty-six were conducted. Four of these were unsuccessful and the data obtained inadequate for any sort of analysis. Twelve of the remaining thirty-two concerned the cement industry and covered all the newly set up works, and the rest concerned flour mills. All interviews were carried out by the author so that interpretive variance was minimized. In addition each interview took a considerable amount of time as respondents were not allowed the luxury of quick and attractive, but inappropriate, responses where it was felt that the correct situation was not brought out. For example, respondents who

* To complete questionnaire answers and to check their validity two other methods were used. See below.

answered in the affirmative as regards full capacity utilization and technological modifications were pressed for further details and specific examples.

In all cases, respondents were department or sub-department directors and general managers. In the cement industry, each part of the questionnaire was answered by the relevant department director, with the general manager completing the parts which were left unanswered, whenever that was possible. In two cases, the data was supplied by a group of executives in conference format. In the flour-milling industry, data, in most cases, were obtained from the information officer whose responsibilities were gathering information and data at the mill level as well as those emanating from other mills and sources, screening and diffusing them within the mill and outside it whenever that was required. The existence of this information centre saved the researcher time and energy as all information on production, maintenance, manning levels and technical effort carried out at the mill was available in one place. However, most mills lacked information on project execution and lead-times, because this information related to the 1970's and had been kept at the firm's headquarters. After reorganization, some mill managers successfully obtained these documents. Other mill managers suggested that they either did not try to search for them or tried but did not know of their whereabouts.

The questionnaire used is reproduced in the appendix. In all

cases, a copy of the questionnaire was given to the respondent. The researcher and interviewee then went through the document concurrently, with the former providing clarifications if and when necessary, and then noting responses on his copy. This saved time by avoiding the question having to be read out, and also promoted a less rigid setting.

Another method was used with the aim of both completing questionnaire answers whenever possible and to test the data and information collected from works and mills. This consisted of interviewing some enterprises' executives and relevant ministries' officials, and screening some confidential as well as non-confidential reports at the ministries level. Thus, twenty interviews were carried out with some executives of the enterprises and officials at the Ministries of Planning and Light Industry. Although the questionnaire contained an appendix table and questions which were added deliberately to check interviewees' responses, it was observed that some interviewees were aware of them, and consequently tended to point out that such questions had already been answered. Four mills were excluded from the sample because data obtained from them, which was in the first place incomplete, were found to be inappropriate after being compared with those obtained from the enterprises and the ministries mentioned above.

Footnotes

- (1) Hall, G.R., and Johnson, R.E., in Vernon, R., (ed.), 1970:
- (2) Rosenberg, N., (1972): pp. 61-62.
- (3) See e.g., Katz in Fransman and King (eds.), (1984): op. cited, pp. 96-113, and Tietel, S., (1984): pp.39-61
- (4) Rakovsky, H., in Youngston, A.J., (ed.), 1972: pp. 48-49.
- (5) See e.g., Lall S., in Giersch, H., (ed.), 1979; Katz and Alpin, 1979: op. cit., and Dahlman C.J., and Sercovich, C., (1984: pp. 63-99.
- (6) For a detailed discussion of these tasks see the following chapter.
- (7) Dahlman, C.J., and Fonseca, F.V., 1978.
- (8) Lall pointed out that: "deeper" forms of technological knowledge are not always more socially beneficial than those that are "shallow" (1980: pp 24-52)
- (9) Dahlman, C.J. and Westphal, in Stewart, F., and James, J., (ed.), 1982, p. 133 and Katz, J. in Fransman and King (eds.), 1984: op. cit.
- (10) See e.g., Lall, 1980: op. cit; Kim Lee (1980): pp. 254-277 and Katz, J. in Fransman and King (eds.), 1984: op. cited.
- (11) Lall, S., (1980): op. cited.
- (12) According to Lall (1982: p. 170) adaptation can be carried out at the shopfloor level. This is true with regard to minor changes in products, but cannot be sufficient to carry out other adaptations aimed at making the product or

the process appropriate to local conditions. The latter often require the existence of indigenous design capacity, capital goods industries and sometimes even R & D activities.

- (13) Peck, M.J., and Tamura, S., in Patrick, H., and Rosovesky, H., (eds.) 1976: p. 542
- (14) See Ch. 1 of the thesis.
- (15) Mansfield, E., in Sahal, D., (ed.), 1982: p. 16
- (16) See e.g., Seoul National University, (1980), Dahlman and Fonseca (1978) and Baranson, J., (1981) particularly pp. 35-38.
- (17) Katz, J. et al., (1978)
- (18) Arrow, K.J., (1962): pp. 155-173
- (19) Kaldor, N., (1957): pp. 591-624
- (20) See e.g., Teubal, M., (1984): pp. 49-65, Maxwell, P., (1977) and Dahlman, C., and Westphal, L., in Stewart, F. and James, J. (eds.), 1982: pp. 103-137
- (21) This fact was implicitly recognized by the General Manager of the Algerian National Steel Corporation who spoke of what he called "the contradictory effect" of technology transfer on individuals and on the "collective labour force". While the former - limited to the transfer of knowledge and skills from one individual to another - was quite satisfactory, the latter was difficult to achieve. For more details, see Judet, P. et al., (1977): pp. 533ff.

Chapter Four

IMPORTS OF CEMENT MANUFACTURING TECHNOLOGY AND ITS ASSIMILATION

This chapter consists of three sections. The first provides an introduction to the next two sections, which focus on the development of the cement industry in Algeria during the 1970's and early 1980's and the assimilation of cement manufacturing technology. The first section focuses on how cement is produced as well as on technological trends in the industrialized countries and their effects on Algeria's choice of techniques and equipment. Section two looks at how the cement industry emerged in Algeria before independence, and its development since 1969. Special emphasis is placed on investment in the cement industry and the mechanisms used to import technology.

The third section focuses particularly on the assimilation of cement manufacturing technology on the part of Algerian firms and examines the significance of learning-by-doing and personnel training and hiring of ready-made skills on the firm's technological capability and production performance. This involves a detailed analysis of the process of assimilation of various activities related to the generation and application of cement technology. These activities can be grouped into three main categories:

- a) investment implementation which pertains to the establishment of new cement works or the extension of

existing ones.

- b) production and maintenance engineering which pertains to the operation of existing production capacities.
- c) R - D and E which consists of activities aimed at improving the existing technology and creating new technological knowledge related to the technology in question.

1. Cement Manufacturing Techniques and Algeria's Options

This section examines the various techniques used in manufacturing cement and recent technological trends that prevail in the industrialized countries, as well as Algeria's choice of techniques in the industry. The section is divided into two sub-sections. The first describes the process of manufacturing cement and analyzes technological progress which has taken place in the industry over the last three decades. The main characteristic of this technological progress is the introduction of new techniques for capacity enhancement and energy conservation as well as increasing automation. The second analyzes the main factors which determined Algeria's choice of techniques and kilns. As we shall see, this choice was determined as much by the technological and economic trends prevailing in the DCs as by Algeria's local conditions.

1.1 Cement technology and technological trends in the DCs.

World cement production has registered more than a six-fold increase during the last three and a half decades, from 133 million tonnes in 1950 to over 880 million tonnes in 1984. At the same time there has been tremendous technological progress in the cement manufacturing process which is continuously updated through the introduction of new techniques for energy conservation and for capacity enhancement. Recent technological development has involved the development of precalciners and new types of preheaters¹ as well as instrumental control of raw material analysis, blending and burning to make a product with a quality as consistent as possible.

The chemical composition of Portland cement² indicates that the raw material components should be predominantly calcareous with small amounts of silicious, aluminous and iron-rich constituents. Occurrence of rocks which on burning without any admixture, give a cement clinker are rare in the nature. Consequently, the choice of the raw material falls on a variety of naturally occurring rocks or industrial waste. By far the most important raw material for cement manufacturing is limestone which is obtainable from natural deposits. These deposits are relatively abundant and widely distributed in forms which are easy to exploit. Beside limestone, industrial wastes are also used as raw materials

in some industrialized countries, where beside their availability, they fit well with other technical, economic and environmental parameters.

The location of cement works is usually determined by the availability of adequate supplies of raw materials within a reasonable distance of each other. However, relatively small quantities of raw materials, other than lime or industrial waste, may be brought in from a considerable distance to make up deficiencies of silica, alumina and iron oxide. Generally to produce one tonne of cement more than 1.5 tonnes of raw materials must be extracted and transported to the works. The greater the number of components that have to be mixed together, the more expensive is the winning and preparation of the material for obtaining a mixture suitable for burning in the kiln.

The winning and handling of raw materials is a major part of the industrial process of cement manufacturing, and accounts on the average for 10% of net operating costs of manufacture. Whereas the 'soft' materials - clay and chalk - can usually be extracted directly by excavation, 'hard' materials must be blasted from the quarry first and crushed before being transported to the works either by conveyor belts or by high capacity tipper lorries.

Regardless of the production process used to manufacture

cement, the raw materials once they have arrived at the works, pass through the following stages:

- a) crushing and milling: the raw materials are crushed and milled to fine particle size so that they can be correctly mixed,
- b) blending: the crushed and milled materials are blended and mixed to produce a raw meal of uniform chemical composition,
- c) drying: the blended mix is heated to the point where all moisture is driven off as steam or water vapour,
- d) pre-heating and calcining: the mix is further heated to decarbonation or calcining temperature,
- e) clinkering: the mix is further heated to produce clinker,
- f) cooling: the clinker is cooled to a temperature at which it can be handled. Once it is cooled, the clinker is either sent directly to the grinding mill or stored temporarily,
- g) clinker grinding: the clinker is grounded to certain fineness with the addition of small quantities of gypsum to control the setting time of the cement.
- h) the finished product is stored in silos before being expedited either in bulk or in bags.

At present two different methods of cement manufacturing are used: wet and dry process. Beside these two there are two variants of the wet and dry processes: the semi-wet and semi-dry, in both of which the raw feed, prepared either by the wet or dry methods according to the nature of the raw materials, is formed into pellets or nodules with a medium

moisture content.

The choice of process to be used depends on a complex combination of factors. These include the nature of raw materials to be processed, the thermal efficiency of the different processes, fuel and other energy costs. Energy consumption is much lower in the dry process and therefore preferable if the raw material components are not too wet or sticky. The dry process is often recommended for energy consumption especially in cases where the raw material contains less than 15-18% of water.

Since the mid-1970's, the more energy-intensive wet process, once used very widely for all types of raw materials, has been largely superceded in new or modernized works by the dry or semi-dry processes whenever the raw materials are adequate. Definitive predominance of the dry process was established with the application of precalcining whose advantages are multiple: increase of refractory lining stability, reduction of disturbances in the kiln operation, the possibility of utilization of waste fuels, a considerable increase of kiln output and reduction of atmosphere contamination.

The wet process is technically preferable for dealing with 'soft' materials - chalk or clay - as the dry preparation of such materials present technical difficulties. It is always

recommended in cases where the raw material contains deteriorious admixtures which have to be removed by washing. The wet process still plays an important role in some countries, especially in the USA where it accounts for more than 50% of production.³

Technically the wet and dry processes differ in the way materials are processed up to the calcining stage (stage d). In the wet process, the raw materials are milled together with the addition of 30 to 40% water and fed as a slurry into the kiln. 'Soft' materials are converted into a slurry with water in a washmill. Where 'hard' materials such as shale and limestone are still used for the wet process, they are first crushed to a convenient particle size for milling and then, after careful proportioning, are ground in a wet tube mill to a certain fineness. The resulting slurry flows into the storage and blending tanks where it is vigorously agitated both mechanically and by compressed air so as to maintain it thoroughly mixed and in suspension for drawing off to the kiln. Once in the kiln, the slurry passes first through the drying zone where it forms into nodules as a result of the tumbling action of the kiln. As it is thoroughly dried, the material passing through the kiln is raised to the decarbonation temperature of about 800°C at about the mid-point of the kiln. As the temperature continues to rise the dissociation of calcium carbonate into carbon dioxide and calcium carbonate is completed and the

transformation of the oxides of aluminium, silicon, iron and calcium into the active ingredients of Portland Cement begins. This transformation is completed at a temperature of approximately 1400°C in the firing zone, the hottest part of the kiln. The resulting product is cement clinker.

In the dry process raw materials are reduced to a fine powder for feeding to the kiln by a combination of crushing and milling. The raw materials are crushed and put into the stockpiles, often under cover. A considerable degree of homogenization is obtained by laying each of them in layers. There are various systems of storage and recovery in use at present, but they are all designed to minimize variation in the composition of the raw material fed to the grinding mill. After homogenization, the raw material is fed into the milling/drying system continuously by weight. Drying is often accomplished by passing kiln exhaust or hot air through the grinding mill itself. The exhaust heat from the kiln is sufficient to dry material having a moisture content of about 8%, but supplementary firing may be necessary for greater moisture contents. Milling is carried out in either a ball mill or a roller mill. The latter uses less energy for a given product fineness but with very hard, abrasive materials it loses its efficiency and presents a maintenance problem. Where moisty and sticky materials are used, which present problems in crushing, the Aerofall mill is often used. In such a mill the large sized stones are ground

against each other with the help of large steel grinding balls.

From the mill the raw mill is fed to blending and storage silos. Various methods of blending the fine powder are used but all have the same result of producing a kiln feed which is uniform and consistent in composition.

In modern dry-process kilns the blended powder is passed through preheaters before it enters the kiln itself. In the fifties and early 1960's two types of preheaters were developed: suspension preheaters and preheaters with Lepol grates. Progressively the suspension preheaters reached predominance because they are easy to use, mechanically simple and require no raw material pre-treatment, which is necessary in case of grate preheaters, where the granulation of the raw material is necessary. This predominance has become conclusive with the introduction of precalciners in the 1970's.

In a full four-stage preheater installation the raw feed is heated to about 800°C during its passage through the preheater tower, so that it enters the kiln partially calcined. Partial precalcining gives an increase in the kiln capacity of about 30%, with the possibility of utilization of waste fuels. But it has severe effects on the refractory lining of the kiln. With the introduction of precalciners,

the raw meal is entirely decarbonated and calcined before it enters the kiln, thus reducing the thermal load on the kiln. As a result of complete precalcining, the output of the kiln increased 2 to 2.5 times without any increase in the kiln size. Additionally it resulted in reduction of NOx emission, an increase in refractory lining stability and a reduction of disturbances in the operation of the kiln, as well as providing the possibility of using the total amount of by-passing gases, and of producing low alkali cement.

The most important advantage of complete precalcining is lower energy consumption, particularly as energy costs account on average for some 40% of total cement manufacturing costs. The choice of kiln is very important because burning accounts for 40 to 60% of total cement processing costs.⁴ The table on page shows differences in size and energy consumption of various rotary kilns in use at present.

Although dry-process kilns are similar in general construction and operation to those used for the wet process, for the same production capacity they are more energy efficient and smaller in size as there is no drying zone and, in the case of works using a full-scale suspension preheater and precalciner system, the material is already completely precalcined before it enters the kiln. However, complete calcination is justified only in cases where the kiln capacity exceeds 2,000 tpd.⁵

Table 3.1: Main Characteristics of Various Rotary Kilns

Type of kiln	Dimensions (m)		Heat	Kiln load
	length	Diameter	Consumption Average kcal/kg	Tonne/m ³
Long wet process	80-230	3-7.6	1200-1450	0.4-0.8
Long dry process	70-230	3-7	850- 950	0.6-1
short dry process*	40-110	3-6	720- 900	1.4-2.2

Source: J. Mukurji, "Refractories in Cement Making" in S.N. Ghosh (Ed.), 1983: p. 368.

Note (*): short dry process (with suspension preheaters, cyclone and precalciners).

Besides the rotary kiln which dominates cement manufacturing technology, the vertical kiln is still used in some countries. Its part in world cement production (excluding China) in 1974 was estimated at 5%. Since clinker produced in modern automatic vertical kilns is practically equal in quality to that produced by rotary kilns, the choice depends mainly on the factors of space requirement, fuel type and efficiency. Substantial saving in space can be achieved

through the use of vertical kilns, as the rotary kiln is basically horizontal and its length may exceed 230 m. Vertical kilns require a 'lean' fuel and can therefore only be used in places where coke is available. As for rotary kilns, they can be fired with 'fat' coal, oil, gas and waste fuels. Meanwhile processing costs are approximately 20% lower for vertical kilns than rotary ones in small sized plants not exceeding 100 000 tpy.⁷

Despite the significant improvements in the design and operation of the vertical kiln, many technical experts in the cement industry maintain that it is inadequate in terms of efficiency, operation and product quality. In fact the rotary kiln superceded the vertical kiln worldwide largely because the present trend is to have larger and larger kilns and to introduce more and more automation. In industrialized countries the economies of scale, automation and efficient use of energy appear to have compensated for the additional transport costs.

The operation and control of the kiln are the most important part of the entire cement manufacturing process, not only in ensuring the consistent quality of the cement but also in preventing damage to the kiln itself. The rotary kiln operates continuously achieving, under good operating conditions, running times exceeding 93% of available hours throughout the year. Planned shutdown once or twice a year

is necessary to perform essential maintenance and to attend to refractory brickwork lining. An important element in the successful operation of a cement kiln is the selection and installation of refractories lining it.⁸ They have to withstand abrasion, mechanical stress and changes as the kiln rotates, and in the clinkering zone chemical attack by the clinker as well as very high radiant temperatures during part of each rotation, when they are protected by the clinker bed. Additionally to avoid problems in the operation of the rotary kiln, it is essential to maintain very close control over all aspects of the kiln process. This requires a high degree of electrical and mechanical reliability as well as precision in chemical control of the raw meal and in the supply of fuel. Slow initial warm up and good control of the raw composition and feed rate and steady flame, when the kiln is running, all increase bricklife and consequently the running time and life of the kiln.

Until quite recently the control of the kiln operation was mainly dependent on the skill and experience of the kiln operator and his helpers. In recent works conditions in the kiln are monitored by weighters and flow meters, and the readings are displayed alongside the kiln control.

Instrumentation control of the kiln is in fact only part of instrumentation control of the whole flow process that extends from the extraction of raw materials to the discharge of cement into the cement storage. Furthermore, in some

recent works instrumentation and controls are linked to a computer which, when correctly programmed, can continuously monitor a large number of variables and notify the operator of discrepancies and the necessary corrective actions. However, even with this computerized on-line monitoring system, successful kiln operation still heavily dependent on the skill and experience of the kiln operator and his helpers.

Although the cement industry has seen considerable innovation during the last three decades, many gaps in knowledge of cement science and technology are not yet filled largely because of the complexity and multidisciplinary nature of cement.⁹ Consequently successful operation of cement works is still heavily dependent on the skill and experience of those who carry out design, engineering and construction of cement works as well as of those who operate them.

1.2 Choice of techniques and kilns in Algeria

The choice of manufacturing processes and kilns is determined as much by technological and economic trends in the industrialized countries as by Algeria's local conditions. The main characteristics of the former can be summarized in the following:

- a) the wet process is rapidly replaced by the dry and semi-dry processes because the latter are more energy efficient,

- b) predominance of the rotary kiln,
- c) the use of increasingly large scale kilns to save capital through the exploitation of scale economies¹⁰, and;
- d) the introduction of more automation to save labour and improve the quality of the product.

The main local factors that were determinant in opting for the dry process and rotary kilns¹¹ are:

- a) the nature of the raw material available in Algeria, i.e., lime stone,
- b) scarcity of water which excludes the use of wet and semi-wet processes,
- c) sources of energy most readily available at present, which are natural gas and oil.

All newly constructed works use gas fired kilns mainly because Algeria's approved reserves of natural gas are much larger than those of oil, and also because works can be cheaply connected to the existing gas distribution network. Although large deposits of coal exist in Algeria, they are not at present exploited largely because of their distance from the main industrial centres.

Whereas the first two characteristics of the prevailing trend in the industrialized countries coincide well with Algeria's local conditions, the appropriateness of the latter two characteristics to Algeria's conditions is questionable. The

main problems associated with large scale plants and the automation associated with it in cement production are:

- a) long time lag in construction relative to small units which can be built in less than a year,
- b) difficulties over infrastructure required to meet the needs of such large scale works, such as railways, roads, power and the like,
- c) limited number of locations where adequate reserves of raw materials can be found to keep the plant in operation for a 25 to 40 year life of the works,
- d) high costs of transportation to outlying areas and waste incurred as a result of multi-handling and deterioration of the product in transit,
- e) limited number of suppliers of equipment: the larger the works to be constructed, the smaller the number of workshops capable of producing its equipment. This means that for a country like Algeria where heavy workshops did not exist until 1980, the entire plant had to be imported,
- f) difficulties over maintenance and operation of such large-scale and highly automated works which require highly skilled and experienced personnel, and availability of spare parts and equipment. Shortage of spare parts or accidental breakdowns can frequently result in plant shutdowns, thus causing severe losses of production and shortage of cement which in turn adversely affect investment implementation in other sectors. As a continuous flow process industry, a stop anywhere along the production line can bring the works to a

halt and unplanned delays in repair and maintenance operation tend to be very expensive. Consequently large-scale works can be far from economic when a steady rate of full capacity utilization is not ensured. Additionally, unplanned stoppages can result in severe shortages of the product in the market; thus adversely affecting the smooth functioning of cement-using sectors.

Whereas most of these problems associated with large scale production and automation are not encountered in the industrialized countries because of the availability of skilled and experienced personnel, adequate infrastructure and heavy workshops, as well as of high population density, all these problems are encountered in Algeria. Firstly, Algeria is a large country (over 2.2m km²) and sparsely populated. Its infrastructure, particularly railways, is underdeveloped* and high level skills are scarce.** These local conditions adversely affect the effective use of large scale and highly automated cement works. Hence economies of scale expected from large scale plants are often more than offset by delays in project execution, capacity under-utilization and transport costs.

(*) see the map on page 215

(**) see section 3 of this chapter

2. The Emergence and Development of the Cement Industry in Algeria

Cement is one of the most basic of capital goods. It is the cornerstone of civil engineering and building industries and hence a continuing and expanding supply of cement is essential to provide the necessary social and economic infrastructure for development. A temporary shortage of cement can, and often does, completely halt crucial development projects in many LDCs. In countries where cement is imported, construction activities go in cycles depending on the availability of foreign exchange. Because of its vital importance as well as the relative abundance of its raw materials throughout the world, and high transport costs relative to value, self-sufficiency in cement production is usually given a high priority in planning in LDCs. Since it launched its development strategy in 1967, the Algerian state has given a high priority to the cement industry in particular and construction materials in general, so as to meet the development needs of the country.

In order to implement its strategy in this sector, the state first set up in 1967 the national corporation SNMC¹² with the purposes of operating the existing potential and developing the industry to meet future demands. Before its restructuring in the early 1980's¹³, SNMC was entrusted with production, development and distribution of cement and its

derivatives as well as other construction materials such as Quicklime, plaster, aggregates, bricks, tiles and the like. While having monopoly over cement production and distribution, SNMC shared production and distribution of other construction materials with other state corporations, local authorities' enterprises and private firms.

On the eve of the first Four-Year Plan, 1970-3, there were two semi-wet process works in Algeria, each having a capacity of 500,000 t/y, both works having been set up within the framework of the Marshall Plan. Before their nationalization in the late 1960's, both had been owned and operated by foreign firms. Their combined production was, until 1967, sufficient to meet local demand, which was depressed as a result of stagnation of the economy in the period following the country's independence. As soon as investment programmes were launched in the pre-plan period 1967-69, shortage of cement began to emerge and local demand exceeded local production in 1969 by over 0.2 m tonnes despite the fact that the existing production capacity was fully utilized.¹⁴ At the end of the same year the first post-independence cement project with a capacity of 500,000 t/y was launched. The project was expected to be completed at the beginning of 1972.

During the first Four Year Plan three new works with a combined capacity of 2.5 m t/y were planned for construction.

Two of them were expected to start production before the end of the plan thus meeting the projected demand on cement in 1973-4. In practice, only 2 projects were launched and their implementation experienced long delays. In fact neither of them was completed before the end of the plan, thus resulting in a massive deficit in cement supply. Part¹⁵ of this deficit was met through imports which amounted in 1973 to 1.2 m tonnes.¹⁶ As for construction of the third works, it was started during the 1974-77 Plan.

Despite these long delays in project execution experienced during the 1970-73 plan, six new works (one of them was partly a modernization and extension of an old works) were planned for construction during the 1974-77 plan. The main objective of this massive investment in the cement industry was to provide necessary supplies to building and civil engineering activities in the late 1970's and early 1980's. Algerian planners were particularly aware of the existing housing crisis which was the result of both rapid population growth and lack of investment in the housing sector in previous years.

The second Four-Year Plan called for the construction of six new works having a total capacity of 5.5 m t/y and preparation of pre-investment studies of three others. Two of them were planned to start production in 1977 and three in 1978, thus meeting the projected demand of about 8 m tonnes

in 1980.¹⁷ In practice seven projects (the six planned plus the delayed one from the 1970-73 plan) were launched during the plan, but only one was completed in 1977; while four others were completed in 1978. The remaining two were completed in the early 1980's: one in 1980 and the other in 1982. During the 1980-4 plan, two new works each having a rated capacity of 1 m t/y were launched. Both were completed as planned: the first in 1983 and the second in 1986, thus bringing the total production capacity newly installed since 1969 to 10.5m t/y.

Ever since independence, geographical diversification of foreign trade and assistance has been a major element in Algeria's foreign economic relations. However, the application of this policy has been hampered by other policy options such as the scale of investment projects, technology and mechanism of its transfer. 'Small is beautiful' seems to have no place in the hearts of Algerian technocrats. All newly constructed works have been designed on the model of those in the West, and producing Portland Cement and other associated range of products satisfying ISO standards. Thus the smallest works has a rated capacity of half-million t/y. Although there are substantial economies of scale associated with large scale works, these may be more than offset by long construction lead times, transport costs and difficulties over maintenance and operation of such large scale works. Although there are no available data to support this

hypothesis in the Algerian case, there are indications that this may be true. First, construction lead times are relatively longer than those experienced in the DCs.¹⁸ Second, although each works supplies cement to a specific market in its surrounding area, with the aim of minimizing transport cost and waste incurred as a result of multiple handling and deterioration of the product in transit, each works has also to cater for demand of outlying areas which are sometimes thousands of miles away.* Furthermore, transport costs are substantial as most cement is transported by lorries rather than by railroads as the latter is still underdeveloped. Third, none of the new works is at present operating at full capacity due to many difficulties over maintenance and operation of works.¹⁹ Fourth, in contrast to previous large-scale works, the latest completed one comprises two kilns, each having a rated capacity of 500,000 t/y. The primary aim of opting for multiple kilns, according to the project manager, was to minimize the adverse effects of unplanned stoppages. Fifth, the priority given at present to medium-sized works (200,000 - 250,000 t/y) to be located in outlying areas such as the Sahara which used to be supplied from the existing works in the North of the country. Pre-investment studies of a medium-sized works to be located in the Saharan region has recently been given priority over

(*)see the map on the next page

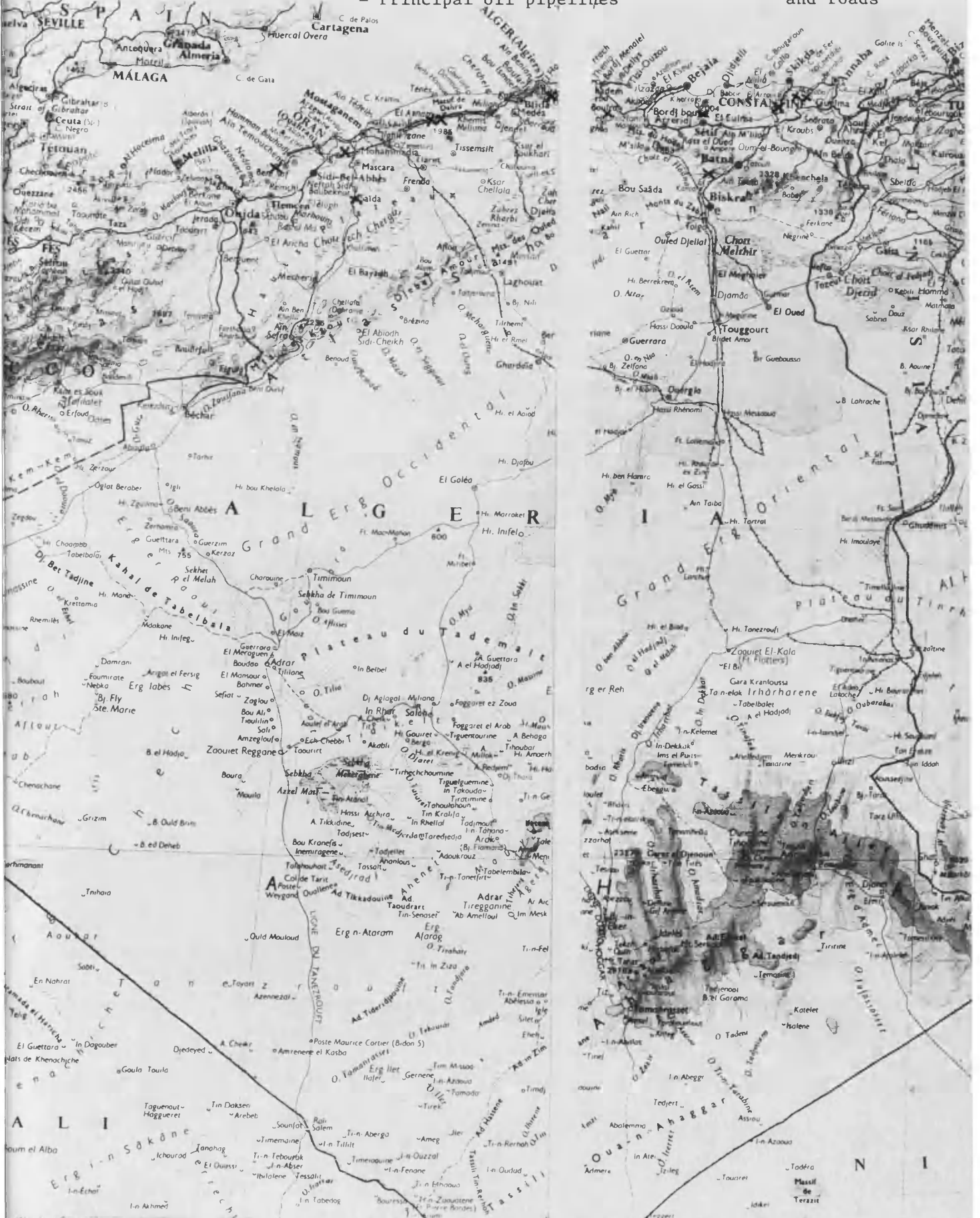
Key:

X = Cement Works

= Principal Railways and Roads

= Other railways and roads

= Principal oil pipelines



other cement projects whose pre-investment studies were completed.

The technology used in newly installed works, is the most up-to-date technology with an extremely high degree of automation. The whole flow process that extends from the extraction of materials to cement expedition is monitored by a control system linked to a computer which, when correctly programmed, can continuously monitor the operation of the plant and notify the operator of discrepancies that may occur. The application of computer controls appears to have caused an alteration in the traditional division of labour. In consequence of the computerization of the control, the knowledge which was formerly concentrated in a multitude of direct workers is shifting to system developers in the user firms and, most importantly, in the control system supplier. Because the control system is the 'nerve system' of the works, knowledge of the control system has become important not only in the development of new processes but also in the operation of the plant and in the application to new equipment and plants. Access to knowledge of the control system is important for the user that is endeavouring to improve the productivity not only of capital but also of the material used.

Consequently, even with this computerized on-line monitoring system, the successful operation of works is

still heavily dependent on the skill and experience of the system control operator and his helpers. The main problem which hinders the optimum utilization of existing installed capacity in Algeria is an imperfect knowledge of both the cement technology and the control system used to monitor the whole flow process.

This systematic option for large-scale projects and up-to-date technology hinders both geographical diversification and participation of small firms in technology supply. It favours both Western countries and big firms at the expense of other potential suppliers. This tendency towards concentration was further strengthened by the decision to opt for a packaged mechanism of technology transfer, which not only hampers participation of foreign small firms but also local ones. This was clearly manifested in the cement industry where all of the completed projects were awarded to only eight firms or consortiums from six Western countries, with France and Japan having a lion's share in terms of both capacity and value.²⁰ Although some East European firms attempted to enter the Algerian cement industry, they failed because the technology they offered was considered to be inappropriate and out-dated.²¹

Two mechanisms of technology transfer were used in developing the cement industry: unpackaged and packaged. The former consists of splitting the project into various elements and

preparing each element for tender separately. It was used during the First Four-Year Plan only. Two works were constructed using the unpacked mechanism. In both projects the principal contractor - a foreign firm - was responsible for basic design and supervision of the work in progress. The rest of work was sub-contracted. Over 70 sub-contractors - Algerian and foreign - participated in the implementation of one of the two works. Apart from the basic design which was carried out by the principal contractor without the recipient's participation, the rest of work was performed in close cooperation between the personnel of the recipient and of the suppliers. The SNMC team, though limited to a handful of technicians, actively participated in detailed engineering and procurement. In the second project the number of sub-contractors was much smaller and local participation in engineering, procurement and installation was very limited. The SNMC team responsible for the project was practically limited to the project manager whose main role was restricted to monitoring works in progress and solving day-to-day administrative problems. In fact all technical functions related to the implementation of the project were performed by the principal contractor.

Since 1972 the SNMC has totally abandoned the unpackaged mechanism of technology transfer. All cement projects launched since then have been implemented on a turnkey basis in which the contractor is responsible for design,

engineering, procurement and erection. The main arguments often advanced by Algerian technocrats for this type of technology transfer can be summarized in the following:

1. Shortage of experienced and skilled personnel required to perform project design and management.
2. The supplier of technology is legally forced to share the risk by guaranteeing to hand over at a given date facilities operating according to contractual characteristics.
3. Shorter construction lead times and cost-effective. These arguments will be analyzed in the light of Algerian experience in the cement industry in the following section.

It is questionable whether geographical diversification really matters. There are several reasons why it may not. First, various firms may coordinate, and in fact they do through sub-contracting and other collaboration arrangements. The following example illustrates this point. Although the main contractor of one of the projects was a Canadian engineering firm, the implementation of the works required the involvement of 20 machine builders and over 100 manufacturers of components and parts in a handful of Western countries including Japan. Secondly the absence of a standardization policy resulted in the proliferation of foreign designs, which in turn has adverse effects on both operation of installed capacity and technological learning on the part of the recipient. Standardization could be effective in cutting down the unit cost of new projects,

speeding up the learning process and construction work, facilitating maintenance operations and the possibility of duplication. From the technological point of view, geographical diversification may be more effective by selecting the best element(s) for most common requirements in the country. To start with a common design could be worked out, by selecting the best design from existing major equipment suppliers - A's kiln may be the best for Algeria's common requirements, B's preheater, C's raw mill, D's precalciner, E's homogenizer and so on. Such rational unification and standardization of cement machinery designs can bring much benefits to the industry. Thus the effort should be to see whether all these could be satisfactorily put together. In fact, this solution appears to be successfully applied to a cement works in Iran where the best equipment from over 20 different manufacturers have been brought and put together.*

3. Assimilation of Imported Cement Technology

Between 1970 and 1986 over 11,000 m AD were invested in the cement industry, more than 6,000 new jobs were created and 12 works were completed. This provided an ample opportunity for Algerian firms to accumulate experience in all aspects of cement technology; process and basic design and engineering,

(*) See Vivesvaray, H.C., (1975): pp. 33-35

detailed engineering, equipment design and procurement, construction, testing, startup, maintenance and operation as well as adaptation and improvement. This section aims at examining the degree of assimilation of cement technology by looking at local content in and lead times of project execution, capacity utilization in completed works and the improvements and modifications introduced.

The discussion is organized as follows: the first sub-section examines the degree of assimilation of the various tasks involved in project implementation through two indicators, namely the local content and lead times. The second sub-section examines the degree of assimilation of operational technology, i.e., maintenance and operation of completed works, and the indicator to be used is capacity utilization levels. The third sub-section is devoted to the description of modifications introduced to improve and/or adapt the imported technology.

Data required for the analysis were obtained through a survey of all works. The survey consisted primarily of questionnaire-based interviews with executives of the works. Most questionnaire answers were not complete for reasons of confidentiality, lack of information at the works level and/or lack of cooperation on the part of some executives. To complete questionnaire answers, another method was used. It consisted of interviewing some executives and officials of

relevant enterprises and Ministries, and screening some supposedly confidential reports at the ministries' level. The purpose of this additional work was not only to complete questionnaire answers but also to test the data obtained from works. Despite this additional search some questionnaires answers remained incomplete.

3.1 Local content in and lead-times of project execution

With data collected in this survey it is possible to test three hypotheses about Algeria's assimilation of cement technology. The first is that local content will tend to increase over time for successive projects as a result of the learning process on the part of Algerians. This is based on the assumption that Algeria would progressively import less goods and services with the completion of each successive plant as Algerian personnel and firms would gradually perform an increasing proportion of tasks involved in project execution and eventually acquire full understanding of the technology concerned.²² The second is that lead times will tend to be longer the larger the size of the project.²³ The third is that lead times for successive projects will tend to be shorter as a result of learning process on the part of those involved in their execution.

3.1.1 Local content in project execution

Execution of an industrial project involves a large number of tasks. The following analysis will be limited to the most important technological tasks which are: basic and detailed design and engineering, supply and installation of equipment and machinery and the startup operation. Examination of local content in each of these tasks is accompanied by the definition of the task and the type of knowledge and experience required to perform it in relation to cement industry.

- a) Basic design and engineering: consists of establishing the process flow through the works, and the associated materials and energy balances and of designing specifications of specific equipment and machinery. Performing this task requires a highly specialized knowledge of the core process. This knowledge can only be obtained through training in process design and engineering or applied R & D including pilot-plant experimentation. So far local content in this task is non-existent. Basic design engineering of all completed works was carried out by foreign firms without any local participation.
- b) Detailed design-engineering: consists of supplying designs of the peripheral technology using data provided by basic design-engineering. It provides the functional specifications equipment, machinery and materials, detailed civil engineering, architectural plans and construction

specifications. Most detailed engineering tasks do not require specialized knowledge of the core process, but instead require other forms of specified knowledge of and experience in, for example, designing materials handling systems, civil works and structures. Before the restructuring of national corporations in the early 1980's, there were at least a handful of local firms capable of performing this task. Meanwhile, the SNMC itself, before its restructuring at the end of 1982, had an "Engineering and Development Department" which was set up with the aim of learning the intricacies of the technology transferred by working closely with foreign suppliers during the process of transfer of technology. In practice, the Department's role was "mainly limited to the preparation of tenders and monitoring of work in progress".* With its restructuring, SNMC was split into a number of enterprises, one of which is the National Enterprise for the Development of Construction Materials (ENDMC) which was entrusted with research,

(*According to a report presented to the 'National Commission for Restructuring', the Engineering and Development Department was employing 215 employees, of which 78 were employed by the subdivisions "Engineering and Supervision of work in progress". However a tentative analysis of the last figure shows that apart from the 14 project managers, technical personnel was limited to 8 persons (of whom 4 were foreigners). The rest were non-technical.

development and engineering related to the construction materials industry. Its executives claimed that their enterprise at present "can carry out detailed engineering and other tasks involved in cement project execution except process design-engineering which is not yet fully mastered". So far detailed engineering of all works was carried out by foreign firms, with one exception where local participation was minimal.²⁴

- c) Supply of production equipment and machinery: consists of designing and manufacturing, using basic and detailed design and engineering specifications, of equipment and machinery. A distinction must be made between equipment specific to cement industry such as kilns, homogenizers and pre-heaters, and peripheral equipment such as materials handling equipment and power generating machinery. Most peripheral equipment to construct a cement works can be designed and manufactured in Algeria. This was achieved as early as 1971-73 when most of the peripheral equipment for cement works A*, constructed on an unpackaged basis, was supplied by Algerian firms. Since then there has been no local participation in the supply of this equipment to successive cement projects.

Concerning specific equipment, so far it has all been imported, despite the fact that the capacity to design most of the mechanical equipment has existed in Algeria for some

(*) See the diagram on page 229 and the note accompanying it.

years. So far, specific equipment was not manufactured locally not because of its technological complexity, but because of:

1. the enormous size of some of this equipment; as the size of mechanical equipment is closely related to the production capacity of the plant. This in turn requires large-scale metal processing workshops which did not in Algeria before 1979. With the completion of a large workshop at the end of 1979, the possibility of manufacturing most of the specific mechanical equipment has existed, and an attempt at participating, in partnership with an East German firm, in the design and construction of the latest completed works, as well as in the supply and installation of specific equipment was made by the Algerian firm owning the workshop. The bid was rejected by SNMC on the ground that the technology proposed by the East German firm was, according to an executive at the works, "inappropriate and out-dated". The contract was eventually awarded to a West European firm on a turnkey basis, and;
2. foreign contractors' preference to sub-contract to firms known or linked to them in order to avoid enlarging their risk, which could happen, if they would rely on relatively inexperienced and unknown Algerian firms, even if the latter are judged to be capable of supplying goods and services

similar to those of foreign firms.*

- d) Installation of machinery and equipment: consists of putting together the various components of the plant using layout specifications and construction plans established by basic and detailed engineering. As early as 1971 an Algerian firm was able to carry out, under supervision of the main contractor, installation of most mechanical equipment of the works A. This experience allowed the same firm to team up with a foreign firm which played the role of a general contractor, and carried out the whole installation of works H.**

(*) This point was made by the chief engineer employed by the main contractor (a foreign firm) of a cement project in Algeria, who told the author that most of the mechanical equipment needed for the project could be locally supplied, adding that the local workshop he visited was "technologically more sophisticated than some of the firm's European subcontractors". He insisted that "the main reason for the firm's preference of European firms was reliability in terms of quality as well as delivery time", two essential factors which he thought the Algerian firm might not be capable of satisfying. [Source: from the interview with some personnel involved in the execution of the latest completed works. The interview was carried out by the author in 1986].

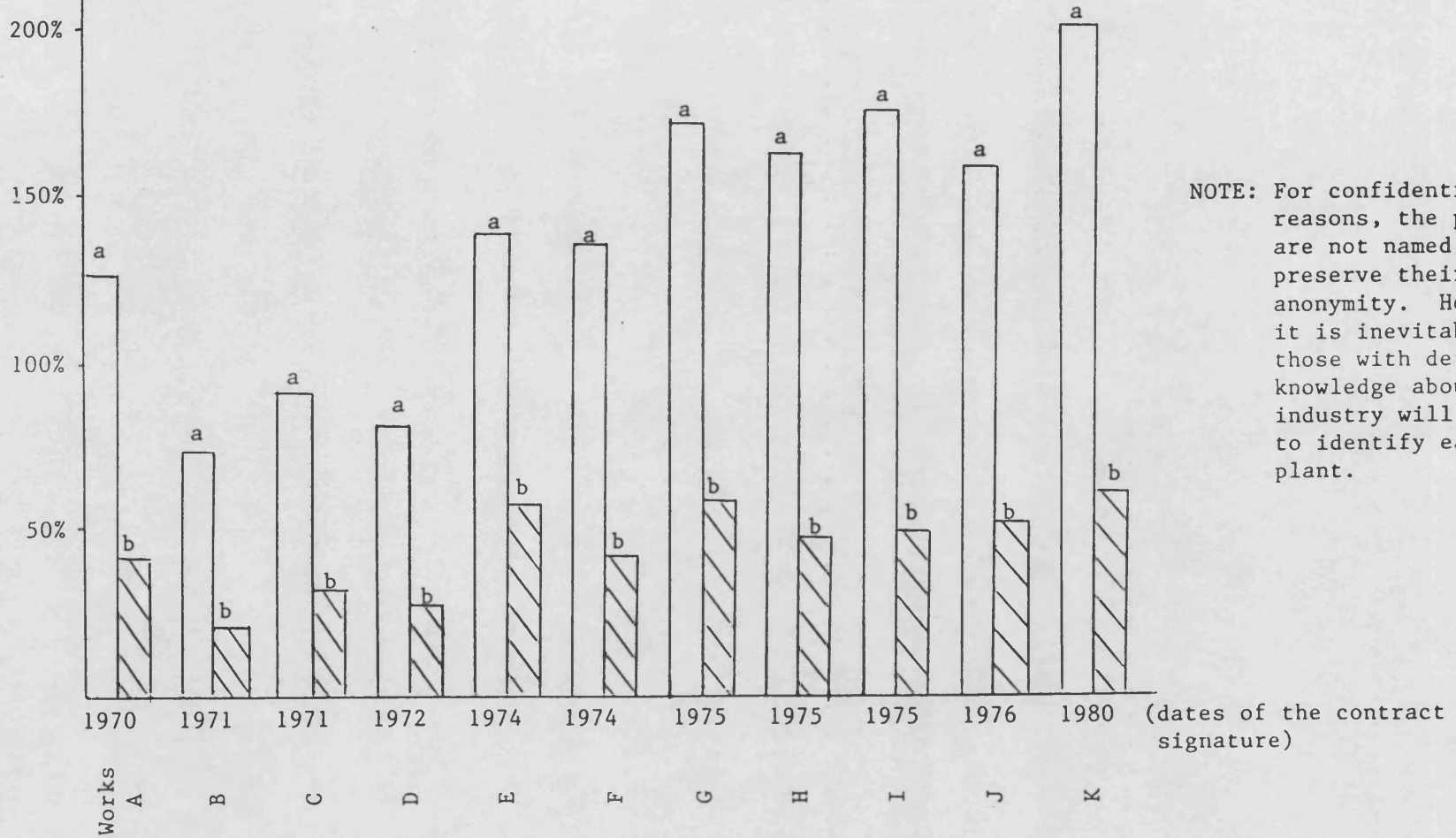
(**)see the diagram on page 229 and the footnote accompanying it.

This experience was not exploited in subsequent cement projects whose installation was carried out solely by foreign firms.²⁵

- e) Start-up operation: consists of test runs of various segments of the plant, minimum load testing of full-scale operation and full test run. Generally this task requires less knowledge of the core process than experience in maintaining and operating similar plants. However, in cases where there are design faults, familiarity with the core process and basic engineering may be essential to overcome design faults. The commissioning stage is not only a period of technical performance testing but also a learning period where primary design faults that might affect equipment availability are located and redesigned. Most executives described the role of the recipient's personnel in start-up operations as that of observers rather than that of active participants. This lack of active participation explains at least in part why some design deficiencies from which certain works are at present suffering, have been discovered only years after start up of their operation.

Another approximative²⁶ estimate of the local content in the execution of each project can be indirectly derived from total import content in relation to both total cost of each project and total cost of production equipment. The following two diagrams show the import content in relation to the cost of production equipment (diagram a) and in relation

Figure I: (a) Total import content in relation to production equipment cost (%).
 (b) Total import content (paid in hard currency) in relation to total project cost.



NOTE: For confidentiality reasons, the plants are not named to preserve their anonymity. However, it is inevitable that those with detailed knowledge about the industry will be able to identify each plant.

to project total costs (diagram b). Diagram (a) shows that the import content considerably exceeded production equipment costs in nine cement works out of the eleven for which data is available. This excess reflects costs of various services (engineering, installation and the like) provided by foreign firms.

The three projects in which the import content was less than production equipment costs were B,C,D. The import content was at its lowest level in works B in which unpackaging was used to its maximum level and local potential in project implementation was fully mobilized. Over 70 sub-contractors participated in implementing this works. This number included 6 Algerian firms which supplied goods and services to the project. Works C was also constructed on an unpackaged basis but local content in various technological tasks previously listed was minimal. Works D was implemented on a turnkey basis, however, it was a combination of extension and modernization of an old works and consequently some old equipment and machinery were maintained. This explains why the import content in relation to both production equipment costs and total costs was much lower than in other turnkey projects.

Diagram (b) exhibits a roughly similar pattern to diagram (a) with import content in total costs falling sharply in Works B then progressively increasing with the passage of time in

successive projects, reflecting the increasing reliance on foreign goods and services in project execution. The slight fall in import content in project H was due to the fact that the installation of production equipment was carried out by an Algerian firm acting as a sub-contractor to the foreign general contractor.

Whatever the parameter used to measure local content in project execution, there is no evidence to support the hypothesis that local content has increased with the passage of time by a learning process. The immediate explanation for this was the mechanism of technology transfer used. The only cement project in which local participation in some technological tasks was considerable, was works B in which maximum unpackaging was used. SNMC's systematic option for the packaged mechanism of technology transfer since 1972 has hindered local participation in project execution and consequently inhibited the process of learning on the part of Algerian firms. Failure to use local suppliers precludes the possibility of local accumulation of experience and diffusion of technology. The economy as a whole is therefore deprived of experience that is directly relevant to the industry's subsequent development. Moreover, the role of the direct recipient's personnel in turnkey projects was often reduced to that of an observer rather than of an active participant in the application of technology. Thus the role of SNMC's teams²⁷ assigned to supervise projects was usually limited to

day-to-day administrative problems leaving all technological matters in the hands of foreign personnel.

In addition, turnkey contracts often deliver a plant together with instructions on how to operate it under the conditions assumed in its design, but fail to provide the recipient with an understanding of the full details of why the plant operates in the way it does. This inhibits the recipient's ability to improve the technology as well as plant operating productivity or to adapt to changes that may occur over time in the circumstances which affect how the plant is best operated.²⁸ As a result, the plant is likely to operate at lower productivity than could have been achieved - with the recipient probably also continuing to depend heavily on foreign technical assistance in troubleshooting - and the recipient may need to make greater efforts to master the technology than would have been necessary had its personnel actively participated in every phase of project implementation.

The SNMC's systematic recourse to a packaged mechanism of technology transfer has in turn to be explained. The main arguments advanced by Algerian decision-makers in favour of this mechanism can be summarized as follows:

1. The supplier is forced legally to handover at a given date a plant in production according to contractual characteristics, and that he accepts part of the risk. Penalties are often

included in such contracts in an attempt to ensure that both parties to the contract respect its contents. For example, around 10% of the value of the contract is often set aside as a guarantee, and only released when the plant is handed over according to contractual specifications. However, the bidder often incorporates contingency allowances in his bid to cover such risks. Furthermore, it is usually difficult to determine who is responsible for defaults, such as delays in project execution or design deficiencies..., which may occur. In fact a number of projects experienced delays in their execution and a number of completed works have been suffering from design deficiencies since their start-up. (see next section).

2. "The supplier is legally forced to guarantee a successful transfer of technology". Those who use this argument seem to confuse technology with its end product which is bound to become obsolete with time. What the supplier offers in turnkey projects is the end product of an integral chain of technological activities which the recipient could only acquire through technological effort in the form of active participation with the supplier in the application of various technological tasks, and training of personnel in all aspects of technology. Without the acquisition of process and detailed design and engineering capacity, the recipient will remain incapable of attaining the desired level of operating capacity in a particular technology and a duplicative and, ultimately, innovative capacity. As

Chaponnière stressed, a systematic application of the turnkey contract will not free the recipient from technological backwardness.²⁹ The end product of the technological chain of activity is bound to become obsolete and the customer is forced to return to the supplier for renewal or extension of the existing capacity.

3. "It is less costly and takes less time to execute projects on a turnkey basis than in unpackaged form": from the data available on project costs and lead times, there is no clear evidence which supports this argument.³⁰ Furthermore, this argument ignores direct and indirect beneficial advantages which may be derived from unpackaging such as experience and training on the part of both the direct recipient and local suppliers. The argument implies that there is no explicit objective of acquiring technological capacity on the part of the recipient.
4. Another common argument is what is often referred to in Algeria as 'contractual convenience', meaning that the rigidity and clumsiness of Algeria's bureaucracy make it necessary to concentrate one project on one contract, because if it is split into multiple contracts the bureaucratic procedures and obstacles are multiplied.³¹ It is true that Algerian bureaucratic procedures are extremely rigid, long and complicated, but these characteristics are not sufficient to explain the firm's behaviour (see below).
5. "Lack of sufficient Algerian skills to carry out project engineering and management". While this argument is

generally true, it requires some qualification. Firstly, the firm did not attempt to establish a permanent team to work alongside foreign personnel so as to learn the intricacies of the technology. Secondly, this argument ignores the fact that the existing human potential³² was largely misused as a result of both high labour turnover and misallocation of tasks.* Thirdly, training of Algerian nationals, which was given a major importance in investment decision was ill-conceived (see sub-section 3).

In fact, the main reasons for this systematic choice of project implementation on a turnkey basis were:

- a) A very rapid rise in the volume of investment which outstripped the absorptive capacity not only of the firm but also of the whole economy. The volume of investment allocated to SNMC during 1974-79 period was almost 8 times that of 1969-73.³³
- b) Deformation in the planning system, which was the result of a combination of a rapid rise in the volume of investment and a change in the balance of power between the central administration which was supposed to orient, supervise and monitor, and various microeconomic entities. The former made the planning and centralized monitoring system unable to cope with the increasing work load and consequently it became unable to supervise and monitor all investment projects

* see sub-section 3

efficiently. This in turn resulted in state corporations becoming increasingly autonomous in the way they implemented their investment projects. The position of the individual corporations vis-à-vis the central organs of the state bureaucracy was, if not one of complete autonomy, at least one of considerable leverage.

- c) Lack of an explicit objective to acquire technological capacity on the part of some state corporations. Indeed, it is this factor which differentiates between those which systematically opted for turnkey projects and those which opted for the unpackaged form of technology transfer or a combination of the two at the same time, although their investment volume was multiplied by more than 10 during the same period.³⁶ In fact most firms' overriding priority was to have their projects completed even at the expense of other socio-economic objectives.

3.1.2 Lead-Times

From contract signature to start-up operation for the twelve works took on the average 47.25 months. This average was approximately 48% higher than those projected by the Planning agency for the same projects. The latter was based on norms prevailing in the industrialized countries and consequently it under-estimated the adverse effects of certain conditions peculiar to Algeria (such as lack of adequate infrastructure, rigidity of certain

administrative procedures and the like) on lead times. Thus it took on the average over 20% of overall lead-time for construction to be started once the contract was awarded. As for construction which involved various tasks such as site clearance, civil engineering and erection, it took on the average 37.66 months. Table 4.1 summarizes the information on lead-times in unweighted arithmetic means.

These lead-times were judged by the respondents to be generally "similar to" those experienced in many LDCs. The Indian experience seems to support this view. Thus it was reported that: "Large new cement plants take nearly 4 to 5 years to complete...".³⁴ However the range between the shortest and longest lead times for very similar projects in terms of production capacity was extremely wide. Whereas the shortest overall lead-time was 35 months, the longest one amounted to almost 7 years. The one project with the longest overall lead-time experienced long delays both before and during the phase of construction. The former was due to changes in location and the latter to the inefficiency of the firm entrusted with site clearance and civil engineering work.

Table 4.2: Unweighted Arithmetic means of lead-times and project cost.

Lead-Times (months)	number of projects				
	n=12	n=10	n=10*	n=11	n=8
Overall lead-time C (from contract signature to completion)	47.25	47.10	49.20	44.10	49.50
Lead-time B (from construction start-up to completion)	37.66	37.80	38.10	36.36	38.37
Lead-time A (from contract signature to construction start-up).	9.60	9.30	11.10	7.73	11.12
1978 project cost	941.83	995.20	936.20	918.36	973.14

Source: Data derived from the survey of works.

Notes: n=12: all works

n=10: all turnkey projects (ie all projects excluding the two executed in an unpackaged form)

n=10*: all works excluding the two launched during 1980's.

n=11: all works excluding one which experienced long delays in its implementation before and after phase of construction.

n=8: all turnkey projects implemented during the 1970's.

The following table summarizes the information on the maximum and minimum lead times experienced at different phases of projects execution.

Table 4.3: Longest and shortest lead times for the sample.

Lead times for the sample (in months)	longest	shortest
Overall lead-time C	82	35
Lead-time B	52	31
Lead-time A	30	1

Data in table 1 show that:

- 1) Once the project with the longest overall leadtime is excluded from the sample (column 4) all average lead-times are considerably reduced.
- 2) Once the two projects implemented during the 1980's are excluded from the sample (column 3), all average lead-times are considerably increased. (As mentioned before, these two projects were the only ones of the whole sample, which were implemented within the time projected by the Planning Ministry). This supports the argument that lead-times tend to be shorter the smaller the number of projects under construction because of the limited absorptive capacity of both the firm and other institutions involved directly or indirectly in project execution.
- 3) There is no clear evidence to support the argument often advanced by Algerian decision makers, that lead-times are shorter for turnkey projects. Comparison of data in column 2

with those in column 1 and 5 reveals that the difference between the two sets of data is very marginal. Once the two turnkey projects implemented in the 1980's are excluded (n=8), average lead-times for the 8 turnkey projects are considerably longer than those of column 2.

All projects in the sample, except the latest two, experienced delays in their implementation relative to lead-time initially approved by the central planning organ and 40% of them experienced delays in relation to contractual lead-times. All respondents emphasized the adverse effects of the Algerian system on lead-times. They drew attention to slow decision-making and rigidity of the administrative system as well as to a lack of coordination between various institutions responsible directly or indirectly for project implementation. Moreover some respondents referred to the inefficiency of certain Algerian firms responsible for providing goods and services related to projects, as well as certain foreign firms involved in project implementation. In one case the delay was judged to be largely due to cancellation of certain sub-contracts initially concluded with foreign firms.

With the cement project data collected it is possible to attempt a test of two hypotheses about Algerian assimilation of imported cement technology. The first is that lead-times will tend to decrease for successive projects as a result of

learning processes on the part of Algerian firms and institutions (and also on the part of foreign firms which were involved in more than one project). the main argument in favour of a possible 'learning curve' is that successive investment in technologically similar projects would result in shortening lead-times, as a result of iterative problem solving and experimentation. This implies that technical and organizational problems encountered in the implementation of initial projects would be overcome in successive projects as experience was accumulated. However, it must be emphasized that learning does not take place automatically. Major financial and human as well as organizational effort is essential to create a learning system capable of gathering, screening and exploiting information about problems encountered and opportunities perceived.

Against the first hypothesis are the following:

- 1) the rigidity of the administrative system and slow decision-making,
- 2) lack of an explicit technological strategy aimed at a long-term objective of assimilating the imported technology both at the firm and national level. Most respondents emphasized the fact that the overriding priority in investment implementation during the 1970's was to get planned projects implemented,
- 3) inadequate supply of skills relative to the volume of investment planned and lack of stability of both management and labour.³⁵

The second hypothesis is that lead-times will tend to become longer, the larger the project. In favour of this hypothesis is the proposition that a project of large value will logically entail a larger volume of work than a similar project of smaller value, and that there will be more technical and organizational problems to solve than there would be for similar smaller projects. Since projects of large value involve a large proportion of infrastructural work, it is expected that work on the project cannot be easily compressed into the same time-scale as for a smaller project simply by allocating more material and human resources to it; the need to carry out some tasks before other for technical reasons would limit the compression of time-scales by such means.

Against the second hypothesis is the fact that the more experience the project manager has with applying the technology concerned, the less the time-scale will tend to be. Lead-times can be reduced through adequate planning of project execution, the choice of competent sub-contractors and coordination and control of work in progress so that certain tasks can be performed simultaneously and according to the time-scale initially established. Against this argument is the view of some (not all) respondents that certain sub-contractors were inefficient and the fact that certain sub-contracts were cancelled during the construction phase for one reason or another.

With data collected in this survey it is possible to attempt a statistical explanation of the variation in lead-times by the variations in (a) the date³⁶ of the contract signature (as an explanatory variable in considering the learning effects) and (b) project size (measured in terms of value in 1978 million Algerian Dinars). Multiple linear regression equations (using ordinary least squares) were calculated with lead-times as the dependent variable and project dates and values as the independent variables. This was carried out separately for various elements of the overall lead-time of all projects in the sample as well as for turnkey projects (i.e., excluding the two implemented in unpackaged way). The results are set up in table 4.3. (see page 244).

Clearly the computed regression equations in table 4.3 provides no support to the hypothesis that larger projects take longer to implement or that lead-times have been reduced with time as a result of a learning process. The overwhelming bulk of the variance in lead-time is unexplained by the variances in project costs and experience. The regression coefficients are in no case significant at the 5% or even the 10% level.

Table 4.4 Lead-times, project costs and experience: Regression results.

Lead Time	Constant Term (in months)	<u>Regression Coefficients</u>		
		Project cost (1978 m AD)	Experience (in years)	\bar{R}^2
<u>Case A: n=12</u>				
Overall lead time C	32 (2.01)	0.023 (1.19)	-0.618 (-0.52)	-0.05
Lead time B	36.12 (4.34)	0.004 (0.37)	-0.21 (-0.34)	-0.20
Lead time A	-5.81 (-0.56)	0.02 (1.62)	-0.59 (-0.72)	0.05
<u>Case B: n=10 (all turnkey projects)</u>				
Overall lead time C	22.6 (0.95)	0.03 (1.15)	-0.43 (-0.32)	-0.08
Lead time B	35.4 (2.77)	0.005 (0.38)	-0.27 (-0.37)	-0.25
Lead time A	-13.23 (-0.9)	0.025 (1.59)	-0.33 (-0.37)	0.06

Source: Data derived from the survey

Notes: \bar{R}^2 is the R^2 adjusted for degrees of freedom. Figures in brackets are t. statistics. Correlation between project costs and experience is insignificant.

engineering firms in order to reduce plant start-up time, and in order to optimize production. The SNMC had no engineering capacity of its own³⁸ to perform this task efficiently and consequently it had to have recourse to foreign technical assistance. However, despite the existence of this technical assistance during the start-up operation of all plants³⁹, none of them has ever operated at more than 78% of the rated capacity.

Although some works were able to achieve an output level as high as 78% of the rated capacity during the first years of their operation, they were unable to improve, and sometimes even to maintain, this level in subsequent years - with and without foreign technical assistance. This was primarily due to either design faults*, or the inability to carry out maintenance adequately, or both. "Major design faults" was suggested to be the "main problem" in three works and an existing but a "minor problem" in three others. In the former cases it was suggested that the "only solution" to the problem was through "substantial investment" to bring about the necessary modifications in the design. In the latter

* Similar problems were also reported in some Mexican cement works. See Ruth Pearson, (Sept 1977) esp. pp. 14-22. Meanwhile design faults were reported to the author by executives of some of the mechanical engineering plants which were visited during 1985.

3.2 Capacity Utilization and Manning Levels

None of the eleven works surveyed³⁷ has ever achieved its rated production capacity. The main problems encountered are: design deficiencies, shortage of skilled and experienced personnel, of spare parts and the non-renewal of obsolete equipment.

1. Design deficiencies: The performance of a production unit (output level, operating costs, quality of product(s) and the like) is partly dependent on the quantity and quality of engineering activity that has gone into its design and construction. At the design stage reliability and maintainability are the important factors and must be considered in relation to equipment performance, capital cost and running cost. At the installation stage, maintainability continues to be an important factor because it is only at this stage that the multidimensional nature of many of the maintenance problems becomes clear. The commissioning stage is not only a period of technical performance testing but also a learning period where primary design deficiencies that might affect equipment availability are located and corrected on the spot, or designed out. Indeed, some design problems are often overcome during the start-up operation of the plant. Others may not be except by carrying out substantial modifications which can only be achieved through further investment in the plant. Industrialists in DCs usually have recourse to either their engineering departments or other

cases it was suggested that "minor modifications" could result in removing bottlenecks and consequently lead to better performances.

Maintenance is another major problem which has a direct effect on output levels. The maintenance department influences availability of the plant directly through preventive and corrective⁴⁰ maintenance. The former can be defined as that which is carried out at predetermined intervals with the intention of reducing the likelihood of an equipment's condition falling below a required level of availability. It can be time- and/or condition-based and may, for its execution, require the equipment to be taken off-line. Determination of a preventive maintenance programme is a difficult management problem and its implementation often requires complete knowledge of the process of production being applied.

Preventive maintenance in modern cement works is a highly complicated matter and requires perfect knowledge of the core process and control system, and adequate resources and organization. The more sophisticated the equipment and the more automated the system, the more important is an adequate maintenance procedure to ensure that the equipment is fully

utilized*. Although maintenance is also necessary with less sophisticated technology, it is only when systems analysis has been, since the early 1970's, applied to cement production that the advantages of a programmed preventive maintenance system have been appreciated. In such a system it is possible to calculate the potential trouble areas which need special maintenance and the minimum frequency with which maintenance procedures must be carried out at all points of the production line. Meanwhile, it may be necessary in modern works to reprogramme the process computer, or work out new rules for the adjustment of the cycle.

So far, Algeria's cement industry has not acquired the process know-how⁴¹ and consequently it relies heavily on foreign firms' "trouble-shooting" flying squads which are called upon whenever major technical problems occur. Even the capacity to carry out regular maintenance work (such as brick lining of the kiln) has not been fully acquired by all works. Some works still rely on foreign technical assistance to carry out this task. This technical assistance is often called upon at planned shutdowns to assist Algerian personnel to perform essential maintenance work and to attend to the refractory brick-work lining.

* To achieve this aim some cement firms in Mexico had recourse to foreign engineering firms to install a preventive maintenance system. See Ruth Pearson (1977): op. cited.

2. Shortage of skilled and experienced personnel: Construction of every works was accompanied by training of some prospective personnel in various aspects of the plant's operation and maintenance at home and abroad, often through experience working temporarily in similar plants. Further training is carried out in the plant itself, particularly during the commissioning stage when prospective personnel are allocated to work alongside foreign workers. Despite this extensive training, executives at eight works reckon that "shortage of skilled and experienced personnel" is "the major problem that hinders the optimum utilization of production capacities". This shortage of skilled and experienced personnel, despite considerable financial efforts to train the necessary personnel, is due on the one hand to the content of training itself and on the other to labour and management instability. During the technology transfer process by which production facilities were established, there was no training across the whole range of technological tasks. Most of the training was provided on-the-job and undertaken "mainly with the objective of acquiring basic operational know-how". Such training provides neither understanding of full details of how the plant operates, nor knowledge of why the plant operates in the way it does. This hampers the recipient's ability to reduce start-up times and to react to post-start-up problems which may occur over time.

Furthermore "a considerable"* proportion of the trainees never joined the industry after completing their training and consequently new recruits have to be trained to replace them. Meanwhile, another proportion of trainees have been allocated to tasks⁴² other than those for which they were trained⁴³, thus depriving the works of their skills, limited though it may have been.

Another major problem which adversely affected technology assimilation and production performance in the cement industry was high labour turnover, both at the shopfloor and management level. The average labour turnover rate ranged from a minimum of 12% per year in one works to a maximum of 25% in another. Some works experienced a turnover rate of over 30% per year during their first three years of operation. Although this phenomenon was not peculiar to the cement industry⁴⁴, its adverse effects on technological learning process and capacity utilization appear to be more pronounced in the cement industry than in other industrial branches. This was due to a number of factors, the most important of which are:

- a) Location: in contrast to most other manufacturing industries which are often located in well established industrial zones near big cities where some ancillary and support activities exist, cement works are often located in isolated areas.

* Sources of quotes: questionnaire answers.

This isolation often makes access to support activities and skilled manpower more difficult than for other industries. For example, most plant executives pointed out that they "find it difficult to attract skilled labour from other industries to replace departed ones because of both isolation and relatively hard working conditions".

- b) Lack of continuous training facilities: in contrast to most other firms which have their own vocational and sometimes even post-secondary training facilities which provide both general and specific training to prospective employees as well as those already employed, SNMC, until very recently, had no such facilities of its own to provide general and specific training to its prospective or old employees. As a consequence, the former find it easier both to retain their employees, as continuous training improves upward mobility, and to replace those who have left. A project aimed at establishing a vocational training centre was launched in 1983, but its operation has encountered serious difficulties related to acquisition of equipment and recruitment of appropriate skilled personnel. Despite these problems, during 1985-6 the new centre provided basic training to a number of prospective employees of the latest completed works.

Although recently both skills supply and labour stability have tended to improve, more efforts are required both at the plant level and outside it to ensure that this trend lasts.

Most works are at present "generally satisfactorily" endowed with qualified technical personnel whose performance depends largely on the improvement of their socio-economic conditions (such as housing, wages and transport) as well as on the efficient labour management at the plant and the enterprise levels.⁴⁵ Meanwhile the rate of labour turnover has tended in recent years to decrease⁴⁶, thus providing the possibility (not the inevitability) of capitalization on experience which will eventually result in optimum utilization of existing installed capacity and technological innovation. However, capitalization on experience of production depends, at any level above that of the individual task, on institutional mechanisms and the allocation of appropriate resources for generating, recording, screening and exploiting that experience. Without such a feedback system, the ongoing operational experience will, for practical reasons, generate little experience, and the process of technical change will lack a critical driving force. Most works appear to have no such feedback system to make effective use of experience accumulated by individual workers and to diffuse it within and outside the works. This perhaps "explains" why executives at some relatively old works pointed out that they have "individual experts" in certain technical areas but they lacked an "integrated team of experts" which has the complete know-how of cement technology. Although most of them blamed the lack of the latter on a "shortage of certain skills and labour turnover", some of them suggested that it was "also

due to a lack of a feedback system and exchange of information between various works as well as within each works".

Other labour-related problems are overmanning and lack of motivation. Overmanning was a common feature to all cement works. By overmanning I mean the excess number of workers in relation to the number of jobs suggested by foreign contractors. The degree of overmanning differed from one works to another: it ranged from a minimum of 8% (in the two works very recently completed) to a maximum of 80% in another works. While recognizing the fact that there was overmanning, all respondents pointed out that manning levels specified by foreign contractors were largely based on prevailing conditions in their countries and consequently tended to underestimate the effects of certain conditions peculiar to Algeria on manning levels. As for the difference in manning levels between various works, it was largely due to employment conditions in their surrounding areas (e.g., recruitment for welfare reasons) and to the amount of employment in servicing departments such as those providing maintenance, medical, recreation and other social services. Some plant executives pointed out that some employees were "imposed on them by those with influence outside the plant for 'welfare' or 'personal' reasons". In two cases, overmanning was, according to works' executives, due largely to high labour turnover and absenteeism experienced during

the first three years of their operation, as departed and absentee employees rarely gave prior notice of their departure or absence. Operating under these uncertain conditions, managers were forced to recruit extra labour to replace those who did not turn up so as to ensure an adequate level of manning.

Meanwhile all respondents cited lack of motivation as an obstacle to technological effort on the part of employees. The Algerian labour law gives more importance to job security and upward mobility by seniority, than to labour productivity and efficiency. Accordingly managers find it extremely difficult to dismiss those who violate work rules or are inefficient, and to encourage those who work hard and are disciplined, through rapid upward mobility and the distribution of other rewards. This lack of motivation applies especially to technological effort. Thus there are no specific incentives to those who may find solutions to technical problems. This lack of incentives hinders technological effort on the part of workers and also discourages the efforts of potential inventors and innovators.⁴⁸

3. Shortage of engineering spare parts and equipment: This is a major problem which adversely affects the performance of imported machinery and equipment not just in the cement industry but in all other sectors of the Algerian economy. Until very recently this shortage was not so much due to a

shortage of foreign exchange, as to mal-management both inside and outside the plant concerned. A large proportion of components and parts can be produced locally, either inside the plant itself or outside it. However, there are major problems which hinder this. Among these problems which were repeatedly emphasized by different works executives are:

- a) lack of technical specifications and plans of these engineering elements, as a result of the initial neglect on the part of the recipient to obtain this information from the technology supplier;
- b) shortage of appropriate raw materials required to manufacture components and parts that could be designed at the plant level;
- c) lack of knowledge on the part of a plant's management of existing workshops which can manufacture such elements. This lack of knowledge was partly due to deficiencies in the flow of information and partly to lack of initiative on the part of some works managers.

Despite the above listed problems the share of locally produced engineering elements in total purchases of some works has recently increased substantially. In some works, this share has increased from nothing in the mid-1970's to over 25% in recent years. This was primarily achieved through "reverse engineering" where the basic design is often carried out at the plant level, and detailed engineering and manufacturing is done by other local firms' workshops. Three

factors have been of great importance to the increase in locally produced spares and components: great effort on the part of management of some works, improvement in design capabilities of their personnel and the state's effort to encourage sub-contracting and inter-enterprise cooperation.

A large proportion of engineering elements is still imported from manufacturers of equipment and machinery incorporated into the plant. There are many problems here as well which result in long delays in obtaining the necessary engineering element; and these delays sometimes cause stoppages of the plants. First each plant is required to plan its yearly import requirements both in quantity and quality before it applies for import licences. However, planning of such imports is an extremely complex matter partly because maintenance planning and management⁴⁹ have not been fully mastered and partly because of unpredictable breakdowns and price fluctuations. Second, obtaining import licences, particularly for non-routine purchases, is a difficult and drawn-out bureaucratic process. Third, the granting of import licences was initially conceived with the aim of obtaining essential engineering elements which cannot be manufactured locally, so as to ensure the smooth operation of existing machinery and equipment. However, this arrangement appears to be misused by most works, which tend to resort to importing replacement parts and needed tools from established suppliers abroad rather than to try to

manufacture them inhouse or to search for potential local suppliers. While this tendency may make perfect economic sense to cement manufacturers, the potential social benefit that could be derived from increased use of local facilities for expanding the country's engineering output and for acquiring more machine-building capacity was lost. Thus, while this arrangement may provide a solution to shortage of replacement parts and components, the problem is bound to be encountered as soon as foreign exchange is in short supply. Fourth, due to a lack of standardization and diversification of designs by initial suppliers of equipment during the technology transfer process, each plant has to deal with dozens of suppliers because Algerian law prohibits recourse to intermediaries. This lack of standardization also hampers:

- a) cooperation between the works so as to find a common solution to maintenance and equipment replacement problems,
- b) efficient import-substitution, as a result of the proliferation of designs,
- c) the learning process as successive works incorporated technological improvements introduced in supplying countries, and equipment designs differed substantially according to the supplier.

Fifth, some relatively old works have already encountered major difficulties in obtaining vital replacement components and parts as a result of technological obsolescence. Some

equipment incorporated in these plants is not anymore produced by the initial suppliers as a result of technological change introduced on such equipment by manufacturers of equipment in developed countries.

4. Non-replacement of obsolete equipment: This is another problem which adversely affects not only the plant performance in the short run but can also cause technical changes in the plant as a whole resulting inter alia in variation in the product quality, accidental breakdowns, increased consumption of energy and other inputs, reduced security of the working place and even pollution of outside environment. For example, some works have been suffering from deficiencies in their obsolete dedusting system for many years. These deficiencies resulted among other things in reducing the efficiency of the plant, a considerable loss of clinker, pollution of the working place and works' surrounding areas, and premature obsolescence of machinery and equipment.

3.3 Improvement of Imported Cement Technology

It was argued in the previous section that lack of complete know-how has hampered the optimum utilization of existing installed capacity. This lack of know-how is particularly acute with regard to process technology and control systems. Learning about how the process 'works' is particularly

important, because an understanding of the nature of process technology, quite apart from its beneficial effects on the productivity of the plant itself (and subsequent projects) through more rational operation of the plant, is also the starting point for further innovation, adaptation and possibly for building up relevant research and development activities. Meanwhile full understanding of the computerized control system is as important to the development of new processes as to its application to new equipment and plants, because the control system is the 'nerve system' of the plant. This lack of complete know-how of the process and its related control system deprives the user of the technology of the necessary knowledge to innovate as well as to efficiently operate existing production capacity. However 'minor' improvements are still possible despite these handicaps. Such improvements often take the form of adjustments in the layout, improvement in peripheral technology and adjustment of certain specific equipment although introduction of the latter may cause unpredictable technical changes in the process. This is exactly what happened in one of the works when certain modifications were introduced without prior knowledge of their consequences on other segments of the plant; which led to a complete shutdown of the plant for a number of days.⁵⁰

At the works level, the overriding preoccupation of management has been the optimization of utilization of

production capacities. Consequently their technological effort has been concentrated on finding technical and organizational solutions to problems encountered in operating and maintaining machinery and equipment. Thus executives at all works seemed to be very much in earnest when stating the reasons for introducing technological modifications, which are "to increase the availability of the plant to the desired level and to ensure security of the working place". This technological effort has, so far, resulted in what they described as, "a limited number of minor modifications".⁵¹ These technical modifications can be analytically divided into two categories: those which were introduced on the peripheral technology, such as the material handling system and those which were applied to the core process such as kilns, homogenizers, dedusting systems and pre-heaters. Examples of the former category are: first, replacement of a pneumatic conveying system which transports clinker from the kiln to storage silos by a metallic one because of the former's low level of reliability, and second, modifications in the control system of the conveyor belt which transports raw materials from the quarry to the works so as to improve its efficiency and reliability. Examples of the latter category include modifications in a) the dedusting system to improve its efficiency and consequently to reduce emission of polluting elements in the atmosphere, b) the blending system with the aim of producing a raw meal of uniform chemical composition, before feeding it to the kiln, and

c) introduction of a new type of refractory kiln lining bricks as well as modification in their installation, with the aim of increasing brick life and consequently the running time and life of the kiln.

The way these modifications were carried out differs from one works to another. In one works all modifications were carried out in close cooperation with foreign machine-producing firms. Two others made use of both foreign and local producers of equipment. The rest used only local workshops. All respondents pointed out that none of these modifications was carried out in collaboration with local research institutes and universities.

At the firm level the SNMC, before its restructuring at the end of 1982, had two organizational units which dealt directly with technology aspects. These were the Engineering and Development Division and the central laboratory. The former's actual functions have already been discussed. The latter's were mainly limited to geological surveying and testing of raw materials required to develop the construction materials industry, and quality control of finished as well as intermediate products.

Since the restructuring of the SNMC, R-D and E activities related to construction materials, including cement, have been separated from production activities and entrusted to

the national enterprise ENDMC. Although the latter was created with the primary aim of promoting technological activities related to the construction materials industry, the idea of separating production activities from R-D and E activities on which the policy of restructuring was based, may prove to be a major obstacle to technological development and efficient application of technological innovations.⁵² Although it is early to provide sufficient evidence to support this view, preliminary empirical information collected from the works suggest that there is at present no direct link between ENDMC and individual works already in operation. ENDMC executives explained this lack of direct links between their enterprise which was supposed to provide consultancy and other services to existing firms and potential investors, private and public, in construction materials industry, was due to the fact that their efforts in previous years had been concentrated on the establishment of the necessary infrastructure and monitoring of projects under construction. They claimed that "now that specialized teams⁵³ are created, more attention will be given to providing technical assistance to production enterprises and prospective investors in the industry".⁵⁴ Still, it remains to be seen how this communication network will be established. As each enterprise is given autonomy in running its business, relationships between various enterprises were initially planned to take place on a contractual basis according to their mutual advantages. However, past

experience shows that Algerian firms tended to have excessive recourse to foreign suppliers of goods and services, sometimes even at the expense of well-established local ones.

Conclusion

This chapter has looked at recent technological developments in the cement industry in DCs and their appropriateness (or lack of it) to Algeria's conditions, and has examined the Algerian experience in acquiring and assimilating cement manufacturing technology. The first section has provided a summary of technological trends in the industrialized countries and examined Algeria's options in the light of these trends as well as of the country's specific conditions. It was argued that some of these trends such as increased use of the dry process and rotary kilns, coincide with Algeria's conditions, while others such as capacity enhancement and automation may not be appropriate to Algeria's recent and present conditions.

The second section has examined the main reasons why the cement industry was given priority in investment allocation and how cement projects were implemented. The main objective of giving priority to the cement industry in terms of investment programmes was to satisfy the rapidly increasing demand on cement as a result of investment in other sectors. While giving a major priority to the development of the cement industry in terms of

investment allocation, the policy lacked the necessary support at the implementation stage. Thus unlike centrally planned economies where priority sectors often enjoyed primacy in terms of material and human resources over other sectors and are put under control of central organs to ensure that planned targets are achieved, priority sectors in Algeria are not treated as such in the implementation phase and consequently they run into major difficulties which, in turn, result in long delays and wastage. Whereas investments are centrally allocated, their implementation is left to individual national corporations or enterprises whose position vis-à-vis the central organs of the state bureaucracy is, if not one of complete independence, is at least one of considerable leverage. In the absence of assistance from central organs and lacking the necessary skills to implement planned investment programmes, state corporations, which appear to be subject to efficiency demand from the centre (or subjecting themselves) often opted for packaged forms of technology transfer with the aim of achieving targets set by the plan. This systematic use of the packaged mechanism in cement technology transfer adversely affected the technological learning process of both the direct recipient and potential local suppliers of goods and services.

The third section has dealt with the assimilation of cement manufacturing technology by Algerian firms and examined the influence of learning-by-doing and of hiring skilled personnel on the technological development of the cement industry. Between

1970 and 1986, twelve new cement works were completed and over 5000 new employees were recruited. This provided an ample opportunity for Algerian firms to accumulate experience in all aspects of cement technology from process and project design to operational technology. It seems that this opportunity for technological learning has not been seized. Indeed, there is ample empirical evidence which suggests that Algeria is far from mastering cement manufacturing technology, including its operational aspects. The reason for the failure to seize the opportunity for technological learning was not so much the reluctance of foreign suppliers of technology to provide technical documentation and training, as the lack of an explicit technology policy on the part of both the recipient firm and the state.

By systematically opting for the packaged form of technology transfer, under which the foreign supplier assumes complete responsibility for project execution, the recipient foregoes the opportunity of acquiring an intimate knowledge of the intricacies of the technology transferred, as training in turnkey contracts is limited to basic operational technology and consequently excludes training in design, construction and phasing-in stages. Furthermore, the turnkey form of technology transfer precludes the local accumulation of human capital through experience-based learning acquired through the construction of the plant. The economy is therefore deprived of experience that is directly relevant to the industry's subsequent development.

The argument often advanced by Algerian decision-makers in favour of the packaged form of technology transfer is that this form is more efficient than the unpackaged one, and that Algeria lacks skills in process and project design-engineering. The data (cost and lead-time) available on project execution provide no support to this argument. Furthermore, a number of cement works executed on a turnkey basis were found to be suffering from serious design faults which hampered the optimum utilization of production capacities. As for the lack of skills, empirical evidence supports the view that Algeria was lacking skilled and experienced personnel, but although other local firms experienced a similar problem, they did not opt systematically for the all-inclusive form of technology transfer. To train their personnel in design and engineering some opted for the establishment of mixed engineering firms (e.g., the national hydrocarbons corporation Sonatrach), others for hiring ready-made skills abroad (e.g., the national metalworking corporation SN-Metal) and others had recourse to foreign consultant firms which were contracted with the aim of examining and supervising design and engineering work carried out by their engineering departments (for example Sonelgaz) or subsidiaries (e.g., Sonatrach). Thus the chosen option of the packaged form of technology transfer in the cement industry was not so much due to lack of skills as to lack of a technology strategy both at the micro- and macro-level.

Concerning the acquisition of operational technology, the cement

industry has not yet fully mastered production and maintenance technology despite considerable investment in training personnel in these tasks and in hiring ready-made skills. Empirical evidence does not support the views that learning-by-doing is costless and takes place automatically with the passage of time, and that hiring skilled labour automatically results in regular improvements in production performance and technological capacity. Without explicit efforts to attract and retain skills and without investment in the acquisition of technological capacity, experience of production would remain limited to the individual task and would lack the critical driving force.⁵⁵ Learning from experienced personnel and hired ready-made one depends, at any level above that of the individual task, on having an institutionalized mechanism for generating, analyzing, interpreting, diffusing and exploiting that experience.

Additionally there are numerous and considerable shortcomings of the economic system even after the restructuring of national corporations. And there have also been policy miscalculations. Examples of the former are lack of motivation, red tape and administrative control of prices, wages and imports which discourage initiative and result in great distortions. The restructuring of national corporations has had only a modestly positive effect on state enterprises because the centre has retained a dominant direct role in planning investment and imports, and a significant role in planning production, and in determining both product and factor prices. Furthermore,

separation of R-D and E from production activities may hamper inter-enterprise communication and could result in inter-enterprise conflicts, instead of promoting the horizontal flow of information and local technological development. This separation could also result in turning R-D and E enterprises into "white elephants". Although it is early to assess the consequences of this separation on local technological capacity, there are some indications that support the argument advanced above. First, although ENDMC employs at present over 200 engineers and technicians, its team responsible for the execution of the latest cement project (awarded on a turnkey basis to a foreign firm during the restructuring of what used to be SNMC) was limited to a handful of engineers and technicians, most of whom has no prior experience in project execution and cement manufacturing technology. Furthermore, in contrast to the foreign contractor who mobilized a team of over 60 engineers and technicians to carry out start-up operations (which were begun in July 1986), ENDMC's effort was limited to sending one engineer from its headquarters to assist the already existing team. Second, so far ENDMC has not provided any technical assistance to already completed works, despite the fact that all of them have recourse to foreign assistance in one way or another.

Examples of the latter are mistakes in investment allocation which has resulted in substantial negative effects on the industry's performance and lack of an explicit technology strategy. First and foremost, the planners undertook in the

1970's an investment programme in the cement industry which was well beyond the ability of SNMC to efficiently carry out. Second, neither the state nor the firm had an explicit technology strategy, and this seriously hampered technological assimilation and resulted in several problems that reduced the impact of imported technology on the industry and the economy.

Footnotes

- (1) on the main functions of precalciners and preheaters see the following pages.
- (2) Portland cement is the most widely used type of cement.
- (3) Gartner, E.M., (1980): p. 713
- (4) Erni, H., in Zement Kalkgips, Special Edition, No. 14, p.11.
- (5) Kurdowski, W., in Ghosh, S.N., (ed.,) 1983: p. 116
- (6) quoted in Stewart, F., (1985): p. 640
- (7) For more details see Otto Labhan, (1965) and Boack, H.C., 1976.
- (8) For more details see Mukurji, J., in Ghosh, S.N. (eds): op. cited pp. 265-286
- (9) See e.g., Idron, J.M., in The Royal Society, (1983): pp. 204-210.
- (10) on scale economies in cement industry see Norman, G., 1979 (July): pp. 317-337.

- (11) Apparently shaft kilns using coal as well as oil as a source of energy were developed in the 1970's, but not introduced in the DCs. For more details see Iyengar, M.S., 1975 (Jan): pp. 36-38.
- (12) SNMC: Societé Nationale des Materiaux de Construction.
- (13) As a result of the 1982 restructuring, SNMC was split into a number of enterprises. Cement production has been entrusted to four regional enterprises. As for development operations of the construction materials, including cement, it has been entrusted to another National Enterprise. In other words, production has been separated from development.
- (14) (MPAT), (1979): p. 245 and pp. 251-252.
- (15) Only partly because many housing projects were delayed and cement imports were not sufficient to meet local demand.
- (16) MPAT, Ibid., p. 252
- (17) It was expected that priority in the post-1977 period would be given to social and economic infrastructure which had been largely neglected in the previous period.
- (18) For more details, see next section.
- (19) See the map on p. 215
- (20) In terms of capacity the combined share of France and Japan in total installed capacity amounted to approximately 57%. In terms of value, the share of each country is difficult to determine because of sub-contracting. However the value of contracts awarded to firms from these two countries, at 1978 prices, exceeds 55% of the total.

- (21) According to some executives, the technology offered was that of the 1950's. Furthermore, they argued that the bidder's technology was "inappropriate from the point of view of standards and norms in application in Algeria".
- (22) For example the contract signed between the Brazilian firm Petrobras and the American firm Kellogg to develop Brazil's ammonia industry, was based on the assumption that the former's involvement in successive projects would progressively increase. For more details see Baranson, J., (1981): pp. 135-138.
- (23) See sub-section 3.1.2 for more details.
- (24) Local content in this task was estimated by the Managing Director of the works at about 30%.
- (25) Some works executives argued that this lack of local participation in this task in subsequent works during 1976-80 was due to the fact that industrial investment was much beyond the capacity of local firms which were called upon to execute projects in other sectors particularly hydrocarbons and petrochemicals. After 1980, these firms were going through transition as a result of restructuring.
- (26) Approximate because not all services provided by foreign firms were paid in hard currency. For example, a proportion of wages paid to employees of foreign firms was paid in local currency. This proportion is not included in the import content.
- (27) These teams were often designated in an ad hoc fashion and assigned the role of supervising work in progress. Once

the project was completed, the team was often appointed to manage the works. These teams often consisted of newly recruited engineers and technicians and other administrative personnel. Their composition sometimes changed completely during the project execution as a result of high labour turnover. There was no attempt on the part of the firm to set up a permanent team responsible for project execution.

- (28) See next sub-section on capacity utilization.
- (29) Chaponnière, R., (1978): p. 36.
- (30) The average cost and lead-time of all turnkey projects are approximately 995.2 m AD and 47.1 months, and those of unpackaged ones respectively 675 m and 48 months. The average cost and lead times for works with equal capacity are respectively 1031.75 m and 48 months for packaged works with a capacity 1 m t/y and 850 m and 53 months for the only unpackaged works. For those of 1/2 m t/y capacity, the average cost and lead-time for packaged projects were respectively 849 m and 44 months and 500 m and 43 months for the unpackaged project. However, if we exclude the two projects implemented in the 1980's, the average cost and lead-time for turnkey projects are respectively 1052.3 m and 51.4 months.
- (31) See for example, Table Ronde: Transfert de Technologie et Industrie Sedérurgique" in Judet, P. et al, (1977): pp. 523ff. The same view was frequently stated by executives of various works studied.

- (32) The number of highly trained personnel registered more than a sixfold increase between 1969 and 1978: from 107 in 1969 to 690 in 1978. MPAT, 1979 (Oct): pp. 256-7.
- (34) "A Special Study - Cement", Science Today, Jan. 1975: pp. 26.
- (35) On labour turnover, see the next sub-section.
- (36) Experience in project execution is measured in years starting from the date the first contract was signed. Experience related to each phase is calculated accordingly. This assumes that there was no experience in cement project execution prior to 1969, which is a logical assumption as Algerians had no experience in this field.
- (37) The twelfth works was completed very recently, in July 1986.
- (38) See footnote (*) on page 224
- (39) The period for which permanent technical assistance was used ranged from a minimum of 12 months to a maximum of 40 months.
- (40) Corrective maintenance can be defined as that which is carried out when equipment fails, or falls below an acceptable condition when in operation.
- (41) It is reported that the Indian cement industry partially suffers from similar problems: "The lack of complete know-how hinders the optimum utilization of existing installed capacity". The Estimate Committee Report, quoted in "A Special Report - Cement". Science Today, 1975 (Jan): p. 26.

- (42) There is a tendency to prefer non-productive jobs to directly productive ones not only because of job conditions but also because of the advantages associated with the former such as wages and other benefits.
- (43) Similar problems were also reported by Hanson in his study of transfer of Western Technology to the USSR. Hanson, Philip, (1981): pp.186-205.
- (44) Although the rate of labour turnover differed considerably from one industrial branch to another, the average annual rate for the whole industrial sector during 1970-1980 was estimated at over 25%. For more details see Thiery, S., (1980): pp. 189-191.
- (45) This was the view of most works executives. Data collected from various plants appear in general to support this view. This is reflected in a considerable change in the composition of the plants' labour force in favour of highly trained personnel such as engineers and technicians.
- (46) The main reasons for the decrease in the rate of labour turnover in recent years are: rationalization and unification of the national wage scale thus eliminating wage differentials between various firms and sectors and improving material conditions of skilled workers, improvement in the supply of skills and other socio-economic infrastructure such as housing and transport, strengthening of discipline to combat absenteeism and introduction of production bonuses.
- (47) By "personal" reasons, I mean those recruited not because

the plant needs their services, or because of their competence, but because of their "personal connections" with those with influence outside the plant.

- (48) This does not imply that no technological effort takes place in Algeria's industry. A number of major discoveries have been reported but most of these have not been applied, either because of lack of motivation on the part of inventors' employers, central allocation of investment which hinders initiative at the enterprise level, or because the discoverers refuse to divulge their details due to lack of material incentives. Some cases were reported in the official daily El-Moudjahid, May 20th 1986, p. 11 and Bernard, C.H., (1982): p. 144.
- (49) Maintenance planning refers to the formulation of a programme for preventive maintenance and guidelines for corrective maintenance. The maintenance plan for a plant is drawn up by selecting for each unit the best combination of the following policies: condition-based maintenance, fixed-time replacement and corrective maintenance. The plan is often based on information supplied by equipment producers, on an operating experience of the plant or similar ones. Maintenance management refers to organization and operation of a pool of resources (men, spares and equipment) directed towards implementing the maintenance plan so as to increase the level of availability of the plant.
- (50) This information was provided to the author by a works

executive who declined to either name the plant in which change was attempted or explain what exactly happened.

- (51) Descriptions used by the respondents.
- (52) This separation was found to be a major blunder in the USSR, see e.g., Berliner, J.S., (1976).
- (53) In 1986, ENDMC was employing 600 workers, of which 200 were engineers, technicians and scientists, and organized as follows: Central administration, geological surveying and prospection unit, and R-D and E unit. The latter is divided into a number of divisions including process design-engineering, detailed engineering and monitoring of work in progress.
- (54) The main tasks of ENDMC are: R-D and E, including project execution activities related to construction materials industry and promotion of local equipment suppliers to the industry.
- (55) As stated by Jean d'Herbes, Director of Total-Corporation Industrielle: "The most competent man, outside his environment, loses his effectiveness: only the expert articulated within a structure upon which he can continue to call, really has operational value". Extracts from an interview in Institut de l'Entreprise, 1978 (Nov), p.11.

Chapter FiveALGERIAN ASSIMILATION OF IMPORTED FLOUR MILLING TECHNOLOGY

Wheat flour is the staple food in Algeria. In 1985 it was estimated that the average annual per capita consumption of commercial flour exceeded 150 kg.¹ It is consumed in a number of ways, but most often in the form of bread and couscous.* In this form it is consumed by the vast majority of the population at least twice a day. Hence development of flour milling has been given a major impetus since the Algerian strategy of industrialization was launched in the late 1960's.

This chapter consists of three sections. The first section focuses on modern flour milling technology and recent innovations introduced in the DCs and analyzes Algeria's choice of techniques. The second reviews the emergence of modern flour milling in Algeria, its development since the late 1960's and its organization. The third looks at Algeria's capacity to assimilate the imported flour milling technology and examines the validity of the three hypotheses discussed at the end of chapter three, using data collected in the survey which covered a sample of modern mills established since 1970.

(*) Couscous is a dish prepared from balls of dough made with durum semolina.

1. Wheat Flour Milling Technology and Algeria's Choice of Techniques

For thousands of years wheat grains have been crushed to produce the powder or flour which was the starting point for further innovations in terms of the wide range of foodstuffs prepared from it. In the earliest times the grain was either pounded to a powder in a particular mortar and pestle or ground by rubbing a large oval, rounded stone over the grains sprinkled over an even larger flat slab of stone. Used in conjunction with a hand seive, the saddlestone method of grinding grain represented the first milling system, albeit a primitive one. Grains were reduced to powder by a rubbing action rather than the pounding action used in the pestle and mortar. The gentle treatment provided for easier removal of the seed coat (bran) and resulted in a more palatable flour.

These early milling methods involved small implements used exclusively in the home to provide for one's family needs. As skill in stone working improved it was found that wheat milling could be made more easily if grooves were cut in the stone to roughen the surface. This improvement was accompanied by using methods of holding a supply of grain in the top grinding stone, while feeding grain onto the lower stone. The lever mill eventually evolved in which the grain was subject to a shearing and grinding action by a flat furrowed stone moving back and forth in a horizontal arc.

Later improvements led to the introduction of circular stones which could be rotated by animals or slaves using bars inserted into radial holes to provide leverage. These rotary stone mills represented a major advance in the development of milling machinery. A rotary stone mill generally consists of two discs of hard, abrasive stones arranged on a vertical axis. In operation one stone rotates while the other is stationary. Gradually, the hand powered rotary mills superseded the saddlestone in the home and were widely used until the end of the nineteenth century. To this day, they are a popular piece of household equipment in many LDCs, where some milling is still occasionally practiced.

It was reckoned that water mills were introduced around 2000 years ago, and eventually superseded animal driven mills. Where water was not available wind was harnessed, and about 1000 years ago the first windmills were built. Water and wind driven mills were eventually superseded, first by steam powered roller mills, and subsequently by the electrically driven mills we know today. By the early nineteenth century bucket elevators and screw conveyors had been introduced in Europe into the mills, making the grinding of grain and sifting of the flour a highly mechanized and automated process. In the latter half of the century when the gradual reduction system evolved, rapid progress was made in the mechanization of the process and in the improvement of the finished product.²

A gradual reduction of the wheat grain is the principle on which the theory and practice of modern flour milling is based, and the introduction of the roller mill was a great improvement on previous processes and spread rapidly worldwide. It made wheat flour cheaper and available to all. Today most countries possess at least one commercial mill for processing grain into some form of flour, but there are still millions of people in the rural areas of LDCs who continue to grow their own cereal crops, store the harvest in granaries and convert their grain by methods other than the roller mill. Some of these methods will be discussed at the end of this section in the light of Algeria's experience.

1.1 Flour milling using modern roller mills

Modern flour milling is a continuous process which comprise the following operations:

- a) Reception and storage of wheat Most modern mills receive wheat in bulk by road or rail. The wheat is sampled and tested for 'dockage' (to determine the amount of extraneous material, such as stones, straw and the like), checked for moisture level and analyzed for protein content. The grain is then 'pinned' according to grade and protein content. The amount of grain received is weighed and transferred to the storage silos by mechanical or pneumatic conveyors. Usually the grain is passed through a machine called a receiving separator where trash and some other impurities are removed

to avoid the bin outlets being blocked or machinery in the plant being jammed. Storage bins are arranged to feed back into the intake elevator to provide for 'turning over'* of the grain from one bin to another. This 'turning over' is essential to keep the grain in sound condition. Provision is also made for controlling dust so as to keep the atmosphere in the elevator relatively free of dust, which is produced whenever raw grain is moved.

The management of a large mill elevator is of considerable importance to the success of the total milling operation. Heavy losses can be caused by incorrect handling or careless blending of the wheat. A well run elevator keeps losses at a minimum and at the same time ensures the proper blending of wheat that is so essential to achieve uniformity in the end product.

- b) Wheat cleaning Blends of the wheat are transferred from the elevator to the wheat cleaning section of the mill, known as the screenroom. This section is one of the most important departments of a modern mill. The extent and sophistication of the wheat cleaning equipment depends largely on the type and range of wheats in the blend (or grist). Because of marked differences in size, shape, degree of hardness and cleanliness of the grains, it is not unusual to find as many

(*) 'Turning over' means conveying wheat from one elevator to another to assist in keeping it in good condition during storage.

as four separate cleaning lines, each equipped with machinery best suited to clean a specific type of wheat. Generally impurities are removed by either wheat washing or dry scoring. In the wheat washing process, wheat is immersed in water, conveyed by means of a warm-screw to a centrifuge, or a whizzer, vigorously agitated and then spin-dried. This process has been abandoned in most modern mills on account of the problem of pollution control as well as the high cost of operating and maintaining the machinery.

In the dry scoring process, wheat passes in succession through a series of machines working on a number of physical principles. No single machine (except the specific gravity separator) can remove all the extraneous matter, but all the machines, considered as a unit, remove practically all the impurities for the loss of very little wheat. Recently electronic, colour-sorting machinery and electro-static separation equipment have been introduced in wheat cleaning.

The efficiency of operation of screenroom machinery depends on the machines' design and on the way they are operated, to determine feed rate and the proportion of cut-off (i.e., reject fraction). As the feed rate is reduced, interference between particles decreases and efficiency increases. As the proportion of cut-off increases, the rejection of impurities becomes certain.

c) Wheat conditioning. Whether washing is used or not, the

wheat must be brought to a specific moisture content to prepare it for milling, and to improve the baking quality of the flour milled. This is achieved by several cycles of damping and resting. In milling technology, this is called tempering, or conditioning, which involves adjustment of the moisture content in the grain and moisture equilibration throughout each grain in order to obtain the desired level of moisture of the grain. The damping is carried out in damping conveyor where a controlled amount of water is sprayed onto the moving wheat as it is conveyed slowly to the tempering bin, where the wheat is kept for a certain period of time to rest. Following the first tempering, the wheat may go through a second tempering cycle. Generally, a two-stage tempering system is preferable to a single stage, as there are occasions when the moisture content must be increased. It is also easier to make this addition in two stages separated by a rest period to allow for proper distribution of moisture throughout the grain.

Optimal tempering is an essential part of the flour milling because it toughens the bran and thereby facilitates its separation from the endosperm without extensive powdering. It also mellows the endosperm and this facilitates its reduction without producing excessive starch damage. This optimum level varies for different wheat types, being higher for hard wheats than for soft ones. To overcome these difficulties caused by variations in moisture content of the

grain and by irregular feed rate, which could entail variation in the required amount of water added, a feedback monitoring system for automatic control of wheat damping has been devised. The moisture content is continuously recorded by measurement of microwave energy, the results compared with the required level, and the difference utilized to control the rate of addition of water to the dry grains.

A number of conditioning methods are used. These are cold, warm, hot and steam conditioning. In cold conditioning, the moisture content of the wheat is increased by adding the desired amount of cold water with frequent turning of wheat and aspiration between successive dampings. After moistering, the wheat is left to rest for at least 8 hours at normal temperature to allow the moisture to diffuse into the grains. Recently, small concentrations of surface active agents or sodium bicarbonate are being added to hasten cold conditioning. On the surface, cold conditioning may appear to be a cheap way of obtaining the desired results, but this is not so, because the bin space necessary to enable carefully controlled damping to be carried out, and the clean wheat storage required after damping is enormous, and so where the rents are high and space valuable, apart from the original costs of storage accommodation, the process is not so cheap as it may appear to be.

Warm conditioning is often applied to avoid the delay of 1-3

days' resting time in cold conditioning. The dampened grains are warm-conditioned for 1-1.5 hours at temperatures up to 46°C and left to rest for some hours before milling. In hot conditioning, wheat temperatures can be raised very rapidly to around 60°C through heat transfer from hot air or radiators, and maintained at that level for a short period of time. This method is used less frequently than warm conditioning because it often results in ruining the baking quality of the gluten by over-treatment.³ In steam conditioning the transfer of heat to the grains is achieved faster than with the other techniques mentioned above, so that even shorter times of conditioning are possible. The method is based on the application of steam to heat the grains and moisten them at the same time. Compared with other methods, steam conditioning is said to require less energy and gives a higher yield of quality flour equal to or better than that obtained by other methods of wheat conditioning.⁴

- d) Milling The objectives in wheat milling are: first, to separate the endosperm, which is required for the flour, from the bran and germ, which are rejected, so that the flour is free from the bran, and of good quality, and so that the digestability and palatability of the product are improved and storage life strengthened. Second, to reduce the maximum amount of endosperm to flour fineness, thereby obtaining a maximum extraction of flour from the wheat.⁵

The milling process requires the use of specific equipment. Essentially it comprises a series of operations involving break grinding, sifting and reduction grinding. Break grinding involves a combination of shearing, scrapping and crushing, exploiting the difference in physical properties between the endosperm, bran and germ. The break system consists of four to six roller mill (or 'breaks') grinding stages, each followed by a sifting stage. The first roller mill is fed with the whole grain, the subsequent stages with the break stock from the preceding stage. Each roller mill is equipped with a pair of rolls, made of cast iron, mounted diagonally or horizontally in parallel alignment along their whole length.

As for the reduction system, it consists of eight to sixteen grinding stages, according to the types of wheat being milled, the extraction rate desired, and the usual moisture content, interspersed with siftings for removal of the grinds. Compared with break rolls, reduction rolls are smoother and the speed differential between the reduction rolls is lower. These two characteristics of the reduction rolls result in the grinding effect being a crushing rather than a shearing or tearing action. The feed to the reduction system consists of the purified semolina and middlings.*

* Middlings are particles of wheat endosperm extracted from the break system which have yet to be ground into farina or semolina.

From time to time it is necessary to renew the corrugations on break and reduction rolls, which become worn with use. It is very important to maintain all rolls in good condition, otherwise both yield and quality of the flour will suffer. Generally, first and second break rolls are expected to give about six to twelve months of continuous service while subsequent rolls (both break and reduction) are expected to operate satisfactorily for several years before recorrugating or regrinding is necessary.

Sifting and purifying consists of classifying mixtures of particles of different sizes into fractions of narrow particle size range, and of separating mixtures of bran and endosperm particles, according to their terminal velocity, by means of an air current. The sieving process is carried out in the plansifter, which consists of a large number of superimposed sieves all rotating together in a horizontal plane. The sieves are arranged in sections each of which may contain as many as twenty-seven sieves. The sieves are clothed with wire mesh for coarse separations while nylon or silk is used for finer separations of middlings and flour.

Purifying is carried out in a machine called the purifier, which consists of a long narrow sieve set at a slight angle to the horizontal, oscillating in the lengthwise direction, and enclosed by a hood. The sieve consists of a number of sections, which become progressively coarser in size of mesh

from head to tail. There is a trend in recent years to eliminate the purifier in modern mills as a result of technological improvements introduced in the industry (see below).

The sieves should be inspected and cleaned at regular intervals to ensure both the efficiency of the plansifter (and purifier) and the quality of flour. Despite the cleaning action of the bouncing balls or pads, the sieve apertures can become clogged with floury or fibrous particles after prolonged operation, reducing the efficiency of the machine. Routine brushing of the covers and repairs to holes caused by wear and tear are essential to keep flour yield and quality at the desired level.

- e) Flour treatment. The milled white flour is enriched with iron, vitamin B, and nicotinic acid or nicotamide to the statutory levels prescribed for these ingredients, and chalk may also be added, according to regulations. Preservatives are also added in some countries where regulations permit their use.*
- f) By-products processing. The by-products of flour milling are often used as a constituent of 'compound animal feed'. Screenings removed during the cleaning of the wheat are often ground at the mill and mixed with wheatfeed, which comprises bran and the accumulated residues from the purifier and

* Addition of preservatives is not permitted in Algeria.

reduction system, to produce a product which is used as a constituent of animal feed.

1.2 Recent developments in milling technology

Flour milling was the first industry to introduce automation by integrating processing and handling systems as early as 1875.⁶ Although the basic process of grinding, purifying and sifting has seen little change in the past century, the machinery has improved in both design and capacity. All three basic machines, the roller mill, the plansifter and the purifier are now far more reliable in operation and efficient than their predecessors. Recent developments in flour milling technology can be summarized as follows: a trend towards 'simplification', automatic control of the whole process and substitution of pneumatic conveying systems for metallic ones.

The trend towards 'simplification' is a process characterized by a decrease in the number of grinding stages, heavier loading on roller mills and plansifters, faster roller speeds and elimination of purifiers. As a result of this process, the grinding capacity of mills has been considerably increased without increasing the size of the mill or the quantity of machinery. Meanwhile, most modern mills use automatic control systems which range from electronic devices to control wheat damping, weighing systems and the like, to

computers which are used to control the whole process. The purposes of introducing electronics are to maintain regularity and to facilitate more effective supervision of the process. However, computers have not yet replaced the miller, but rather assist him in operating the mill and in selecting and blending flour streams and additives to produce the consistent products required by customers. Some large mills use computers to arrive at least-cost blends of wheats which give a flour of the desired characteristics. Additionally, there is a tendency to use pneumatic conveyors rather than metallic ones. For many years, the bucket elevator was used to transport stocks vertically through the mills. For the last 25 years, most new mills have included pneumatic conveying systems in their design to move stocks and finished products through the mill. The versatility of pneumatic conveying coupled with improvements in machine capacities have made it possible to build mills with fewer flour levels. This in turn made supervision of the total process easier and as a result the mills become more efficient in the use of manpower. Moreover the use of air in pneumatic conveying greatly improves the uniformity of grinding and sifting and ensures that mill stocks are cold and easier to handle.

1.3 Choice of technique in flour* milling in Algeria

There are at present a wide range of techniques in use in Algeria. They extend from the traditional, and most primitive method, using hand-operated stone mills, to the modern roller mill of identical design to those in use in the industrialized countries. Between these two extremes there are water mills and grind stone mills which are operated by either electric or diesel engines.

A large proportion of locally produced wheat is not marketed but consumed by those who produce it.⁷ This proportion as well as a small proportion of marketed wheat (produced locally or imported) are processed by methods other than the roller mill. These methods are:

- a) Hand-operated stone mills. The only piece of equipment involved in this method is the use of two discs of hard, abrasive stone, some 50 cm in diameter, arranged on a vertical axis. The opposing surfaces of the two stones are patterned with a series of grooves leading from the centre to the periphery. In operation the lower stone is stationary while the upper one is manually rotated, using a wooden bar

* Flour here refers to semolina and farina. In Algeria, demand on the former is much higher than the latter, largely because a large proportion of bread, couscous and other flour-based products are domestically prepared using semolina.

inserted into a side hole of the upper stone to provide leverage. Grain is fed into the centre ('eye') of the upper stone, is fragmented between the two stones, and the ground products issue at the periphery. The bran is separated from the flour by hand operated sieves. The former is often used to feed chickens while the latter is used to make bread, couscous and other baked foods.

This method is a purely domestic and subsistence activity. It is very laborious and time consuming and consequently does not represent a real alternative to other methods since it can never be practiced commercially. Even domestically, it has given way to other methods. However, it is still occasionally practiced to ground wheat for specific purposes.

- b) Water Mills. These were the first non-manually operated mills to be used. Water provides power which turns propellers, which turn the stones between which the grains are ground. The grinding process is fully automated and labour is only required in handling operations. Water mills were widespread in the northern part of Algeria where water was available and wheat was grown. Most of them have disappeared and even the few which still operate are at present underutilized.

- c) Electric and diesel grind stone mills.* The former exist mainly in small cities and villages where electricity is available. The latter are used in the countryside. The grinding process in both types is fully automated and labour requirements are limited to handling operations. Once the grain arrives at the mill, the miller or servant in the mill weighs it so as to extract the toll which is usually paid in grain. The mill was started (if not already running) and the grain owner's proportion of grain poured into the hopper above the mill stones and milled into meal. As the floury meal pours out the mouth of the stones it is collected in sacks for dispatch.

Aside from honesty, which is a decided advantage when dealing with his customers, a good miller possesses a great deal of technical knowledge and skill that can be summed up as sharp eyes, ears and feel. His eyes not only keep him aware of the conditions of the machinery and customers' belongings, but also ensure his physical safety in a potentially dangerous mill. His ears are constantly attuned to the rythmetical sound of each mill device so that he knows their progress. His sense of touch (or miller's 'thump') is indispensable in discerning the feel that dictates how fast the millstone

* Though the capacity of these mills varies, those which exist in Algeria have daily production capacity of 5 to 10 tons when continuously operated.

should run, how fast the grain should pour and how close, sharp and dressed the millstones should be. In fact adjustments are made on the basis of this feel. Another constant responsibility of the miller is to keep the mill flour and machinery clean.

The main common characteristics of the last two methods are that both cleaning of wheat and sifting of the ground product are carried out domestically and manually, that a small proportion of bran and the majority of germ are not removed, and all mills using these traditional methods are privately owned and their machinery is imported. Wheat cleaning is often carried out through the combination of winnowing and screening. Grain is first exposed to the air so that the wind blows away impurities lighter than wheat such as chaff, dust and straw. This often takes place in the barn. This is often followed by screening to remove other impurities by using hand operated screens, or sieves, of different meshes. Once the grain is cleaned, it is packaged into sacks ready for transport to the mill. The ground product is sifted at home using hand operated sieves which are clothed with wire mesh for coarse separation and nylon or silk mesh for finer separation of middlings and flour.

Both cleaning of wheat and sifting of the ground product are laborious and require space where they can be carried out. Consequently, these two methods do not represent a real

alternative to modern roller mills in urban areas where space is very limited.

Although a large proportion of bran is removed in the sieving process, the majority of germ and a small proportion of bran are retained. These two elements are of great importance nutritionally because they contain a higher proportion of protein and important minerals than the endosperm from which flour in modern roller mills is obtained. The sifting process in modern roller mills involves the removal of the germ and bran and consequently adversely affects the nutritional content of the flour milled. However, even modern roller mills could be adjusted so as to retain the desired level of the bran and germ and even to produce a 'wholemeal' flour where no bran or germ is removed from the ground product. So far 'wholemeal' is not produced in Algeria, "primarily because of lack of demand".*

The predominant flour milling technique in use at present is the roller mill. It is reckoned that the first roller mill

* This is the view of mill executives who suggested that the Algerian customer 'prefers high quality semolina and farina'. However, this preference is based on lack of knowledge on the part of the consumer of nutritional aspects of what is consumed. No effort was made to explain to the consumer the benefits of 'wholemeal' from the point of view of nutrition.

was established in Algeria in the second half of the nineteenth century. Some of those set up at the very beginning of this century are still in operation. Since the 1960's all public investment in flour milling industry has been directed to the expansion of commercial flour using imported roller mills. All newly set up mills are basically similar in design to those in use in the industrialized countries, except that computers are not used and handling of the ground product in some of them is not automated, so as to provide jobs.

The choice of the roller mill is mainly the result of a rapid increase in demand for commercial flour. This rapid increase in demand is, in turn, due to rapid population growth and socio-economic changes that have taken place since the 1960's. Algeria's population has more than doubled since 1963, and this rapid growth took place mainly in the cities as a result of rural exodus. Indeed, it is socio-economic changes that resulted in a radical change in the consumption pattern. Rapid urbanization, monetization of the economy and improvement in living standards led to a change in consumption patterns, which is reflected in increasing demand for commercial flour* at the expense of non-commercial flour.

* A large proportion of commercial flour is at present imported to meet local demand. For more details see below as well as FAO Trade Year Books, 1969, 1977, and 1983.

Whereas in the mid-1960's the urban population amounted to just over 30% of the total, by 1980 it had increased to over 43%.⁸ This rapid urbanization has been accompanied by rapid monetization of the economy through integration of the subsistence economy into the market. Even the most isolated peasants are integrated into the market through their labour (as casual wage earners) and produce. At present it is very common for farmers and peasants to exchange the grain they produce for commercial flour despite the fact that there is a considerable price differential between the two in favour of the latter. As a result of this socio-economic change, average consumption per head of commercial flour has more than doubled between 1967 and 1985⁹, and flour has to be imported to meet demand. Meanwhile some stonemills are underutilized.*

2. The Emergence and Development of Modern Flour Milling Industry in Algeria.

Wheat flour is the main source of energy, protein, iron and vitamins consumed by the vast majority of Algeria's population. Average per capita expenditure on flour and derivatives in 1979 amounted to more than 20% of total

* These mills are underutilized not because of shortage of grain but because of farmer's (as well as other consumers') preference for commercial flour.

expenditure on food.⁹ Compared with the UK, this average was approximately four-fold.¹⁰ Hence provision of adequate supplies of wheat flour is of major importance politically and economically. Because of its vital importance, both state control of the industry and self-sufficiency in flour production have been given a high priority since independence. In order to implement its strategy, in this sector, the state first set up in March 1965 the national corporation, SN SEMPAC, with the purposes of operating the existing potential and developing the industry to meet future demands. Before its restructuring in 1982¹¹, SN SEMPAC was entrusted with production, development and distribution of flour and its derivatives, as well as other related products such as yeast and baby foods. While having a monopoly over production and distribution of commercial flour, pasta and couscous, the SN SEMPAC shared production and distribution of other flour-based food stuffs with local private and public enterprises.

Modern flour milling was well established in Algeria prior to its independence. Modern mills were set up in most urban areas and the installed production capacity in the early 1960's was estimated at about one million mt, and local production was generally¹² sufficient to meet local demand. However, some of the existing mills were very old and their modernization was not carried out by their foreign owners because of the political uncertainty created by the war of

liberation. Despite this drawback, the inherited production capacity was in excess of local demand which was depressed as a result of the massive flight of the European settlers and the evacuation of the French army in the aftermath of independence; who were the main consumers of commercial flour. It took almost ten years, after independence, for local demand to outstrip the existing production capacity. Whereas the installed capacity in 1969 was around one million mt, local demand for commercial flour for the same year was estimated at just over 0.85 million mt.¹³ It was in the same year that contracts for the construction of 6 new mills were awarded to foreign firms. These projects were expected to start production at the beginning of 1973 so as to meet local demand which was expected to exceed 1.2 m in the same year. Most of them were extensions of old mills, some of which were obsolete and were expected to be shutdown in subsequent years.

The actual construction of the six plants was started simultaneously at the beginning of 1970, but only five of them were completed during 1973. The sixth plant was brought into production in the first half of 1974, thus raising the total production capacity to about 1.4 mt. Although the installed production capacity was somewhat higher than local demand, which was estimated at about 1.3 mt for 1974, 51 000 tonnes of flour were imported to meet local demand.¹⁴ This deficit was essentially due to technical difficulties

encountered during the start-up operation of some new mills.

The Second Four-Year Plan called for the construction of 25 new mills. The main objectives of this massive investment in flour milling were firstly to meet the increasing demand for commercial flour and secondly to replace obsolete mills which were marked for shutdown in the near future. Most of these mills were planned to be located in small cities and villages, and in the south of the country, so as to provide employment to those living in disinherited¹⁵ areas as well as to meet demand for commercial flour in these areas.

All new projects experienced long delays in their construction start-up. Only one was launched in 1975, while the rest were launched during 1976-78. This delay was mainly due to the firm's preoccupation, during the first two years of the plan, with:

- a) The standardization of products and milling equipment: SN SEMPAC, in cooperation with foreign firms carried out studies aimed at establishing national norms and standards of ground products as well as standardization of machinery designs to facilitate maintenance operations and subsequently reproduction of milling equipment;
- b) The establishment of repair workshops to provide technical assistance to production units.

This delay in construction start-up was accompanied by long

delays in projects' completion. Whereas all projects were expected to be completed before the end of 1981, only 8 units were actually completed during 1978-81 and three projects are still under construction, two of which are not expected to be completed before the beginning of 1987.¹⁶ These long delays in project implementation, coupled with a rapid increase in demand for commercial flour due to both demographic explosion* and the rapid increase in per capita consumption**, has resulted in massive deficits in flour supply in recent years. Whereas demand for commercial flour amounted to over 1.9 mt in 1978, production capacity remained stagnant at its 1974 level and the deficit had to be filled with imports. An even higher deficit was registered in 1985. Thus it was reported that 0.7 mt of flour were imported in 1985 to fill the gap between demand for and supply of flour.¹⁷ At present Algerian is one of Africa's major importers of both wheat flour and wheat.¹⁸

The following section focuses on the assimilation of modern flour milling technology and analyzes the difficulties encountered in investment implementation in this sector as

* The average annual rate of the population growth over the last two decades is estimated at over 3%.

** Per capita consumption of commercial flour had more than doubled between 1967 and 1985. For more details see note (16) and Revolution Africaine, Nov. 29 - Dec. 5, 1985, p. 28.

well as in operating installed capacities. Emphasis will be put on the technological effort on the part of Algerian firms to master the various tasks involved in the application, operation and reproduction and improvement of the imported technology in this sector.

3. Algeria's Assimilation of Imported Flour Milling Technology

Modern flour milling was well established prior to Algeria's political independence. At the beginning of the 1960's modern roller mills were set up in most large and medium size cities and the industry as a whole employed around 4 000 workers. A large proportion of this labour was Algerian. There was also a specialized school set up near Algiers where millers and other skilled and semi-skilled production workers were trained.* It appears that by the mid-1960's maintenance and production engineering had been mastered relatively well by Algerian workers. This was reflected in the workers' ability to successfully reopen and operate the mills left vacant by their European owners and managers who had fled the country in the aftermath of independence.

* Until the late 1970's, the school provided training in operational technology. Since then the school has been expanded to provide training in the basics of process design-engineering and in maintenance. (This information was obtained by the author from the School's Director.).

Although all the mills that existed at the eve of independence were imported, and Algerians had no experience in their design and installation, four factors could potentially favour assimilation of various tasks of flour milling technology on the part of Algerians in subsequent years. These factors are: the fact that the technology is highly "mature", massive investment in the industry, the existence of a milling school and the experience acquired in operational technology. First, flour milling technology is highly "mature". Although the machinery has improved considerably in design, capacity and reliability, "the basic process of grinding, grading, purifying and sifting has seen little change in the past century"¹⁹. This high maturity potentially makes the task of assimilating technology by late-comers relatively easy. Second, the experience acquired by Algerian workers in operational technology constitutes a potential basis for other technological tasks such as process, basic and detailed design-engineering as well as design and manufacture of specific capital goods and their installation. Third, massive investment effort has been carried out since the late 1960's. Between 1969 and 1986 approximately 6 000 m current AD has been invested and 31 new mills have been either completed or under construction. Although these projects differ in their details, they are very similar in their basics. This provided an ample opportunity for Algerians to accumulate experience in various aspects of flour milling technology. Fourth, the existence

of a milling school which provides specialized training to prospective employees as well as retraining of those already employed to improve their skills.

This section analyzes the degree of assimilation of modern flour milling technology using data collected in the survey. The parameters to be used are local content in project execution, lead-times of project implementation, capacity utilization in a sample of newly completed mills and technological modifications introduced on imported technology.

3.1 Local content in and lead-times of project execution

Data required for the analysis was obtained from a survey of 20 newly set up mills for which data was available. The survey consisted primarily of questionnaire-based interviews with mill executives. Most questionnaire answers were not complete for reasons of confidentiality, lack of information at the plant level and/or lack of cooperation on the part of some executives. In an attempt to complete questionnaire answers and to verify their validity, two other methods were used. The first consisted of screening official reports related to the industry and some contracts signed with foreign firms involved in the execution of the projects concerned. The second involved interviews with executives of some flour milling enterprises, directors of the newly set-up

Food Industry Research Centre, C.E.R.I.AL²⁰ and the Centre for the Design and Manufacture of Capital Goods for the Food Industry, C.E.I.AL²¹, and with a number of officials at the Ministries of Light Industry and Planning. Despite these efforts complete data concerning the local content in project execution was only available for eight projects.

With data collected in this survey it is possible to test three hypotheses about Algeria's assimilation of flour milling technology. The first is that the local content in project execution will tend to increase over time for successive projects as a result of the learning process on the part of Algerian workers and institutions which are directly or indirectly involved in investment implementation in the industry. The second is that lead times will tend to decrease with time as a result of a learning process on the part of those involved in project execution. The third is that lead-times will tend to be longer, the larger the size of the project.

3.1.1 Local content in project execution

Design and construction of a flour mill require the performance of a number of technological tasks, the most important of which are: basic and detailed design-engineering, supply of machinery and equipment, construction and installation, training of prospective

production and maintenance personnel and start-up operations.²² Before its reorganization in 1982, SN SEMPAC had neither an engineering department as such nor R & D facilities. However, it had a multipurpose department in charge of new projects. It was in charge of the selection of engineering firms to be responsible for engineering studies, of drawing up bids, negotiations and supervising²³ of works on site. The firm has also a specialized school where millers and other production and maintenance personnel were trained.

Detailed information concerning local participation in each of the technological task - mentioned above - was obtained for eight projects, two of which are among those completed during the 1970-73 plan. All projects in the sample, except two, were implemented on a turnkey basis. With data collected it is possible to test the first hypothesis by looking at local content in each task*; beginning with:

- a) Basic design-engineering: Local participation in this task was limited to one project which was launched in 1969. This participation took place through a Swiss-Algerian

* For reasons of confidentiality every attempt is made in the following analysis to preserve the anonymity of the plants and individuals involved, inevitably those with detailed knowledge about the industry will be able to identify the plants involved.

engineering firm, in which the Algerian state held a majority capital share. This project was implemented on an unpackaged basis, where foreign participation was limited to the supply and installation of equipment and machinery and, marginally, to the training of prospective production personnel.

- b) Detailed engineering: Local participation took place in one project (the same above). Detailed engineering work of this mill was carried out by a wholly owned Algerian firm.²⁴
- c) Supply of machinery and equipment²⁵: Local participation in this task took place in three projects. It consisted of supplying some handling equipment and machinery for repair workshops. The latter consists of a handful of standardized machine-tools manufactured in Algeria by a state owned firm. In financial terms this local participation was estimated at less than 10% of total costs of machinery and equipment incorporated in the mills concerned.
- d) Construction and Installation: There was no local content whatsoever in the installation of machinery and equipment. Local participation was limited to technically minor tasks such as civil engineering, provision of utilities and construction of administrative buildings and sometimes structures in which machinery is installed and materials stored. Even these tasks were sometimes carried out by foreign firms, and this was the case in three projects included in the sample.
- e) Training of prospective production and maintenance personnel: Although the firm has a specialized training school, it has

continuously had recourse to training abroad of its prospective personnel. This practice was a common feature in all projects. However, whereas in the early projects training abroad was of equal importance for production and maintenance personnel, in recent projects it was essentially limited to the latter. This shift in policy, according to respondents, "reflects the priority given by the firm in recent years to maintenance operations, which aim at both improving the cumulative time of mills' operation and increasing the local content in spare parts, components and equipment". Local content in this task differed from one project to another. It ranged from a minimum of 40-50% in two projects to over 80% in three cases (the parameter used here to measure local content is the number of employees trained specifically for the project inside and outside Algeria). Two of the three projects in which the local content in training was above 80% were those executed in an unpackaged way (i.e., not on a turnkey basis).

- f) Start-up operations: The Commissioning stage is not only a period of technical performance testing but also a learning period where design faults that might affect equipment availability are located and corrected, and prospective production and maintenance personnel are trained on the machinery which they will operate and maintain. Hence active participation of the equipment user in start-up operations is extremely important to subsequent efficient utilization of the equipment. Active participation could ensure design

fault detection and correction as well as effective training of the user's personnel, so as to avoid maloperation and optimize equipment operation once the commissioning stage is over. Local participation in this task was judged by respondents as "relatively ineffective" in four cases. The main reasons for this 'relatively ineffective' participation according to respondents were: "high labour turnover" during the commissioning stage in one case, "unwillingness of the supplier" to fully cooperate with the user's personnel³⁸ in two cases, and "lack of incentive" on the part of the user's personnel to effectively participate in start-up operations. In only four cases local participation was judged to be "sufficiently effective". This "effective participation" was achieved by "posting prospective technical personnel to work closely with the supplier's personnel" during this stage of the plant's life. Two of the four cases happened to be those implemented on unpackaged mechanism.²⁸

The above analysis appears to provide no support to the hypothesis that local content will tend to increase over time as a result of the learning process on the part of the recipient. The immediate explanation of this was the mechanism of technology transfer used. The two projects in which local participation in some technological tasks took place were those in which unpackaging was used. However, this systematic recourse to a packaged form of technology transfer has in turn to be explained.

The main reasons for this systematic recourse to the packaged form of technology transfer are:

- a) A very rapid rise in the volume of investment: the planners undertook and approved a number of mammoth investment programmes whose simultaneous implementation was beyond the ability of the firm concerned and the economy to carry out. Thus whereas the total cost of all projects entrusted to SN SEMPAC to carry out between 1974-78 amounted to over 9 500 m AD at current prices, or more than 43 times that of 1969-73²⁹, the firm's highly skilled technical personnel had considerably decreased during the same period.³⁰
- b) Lack of an explicit technological strategy on the part of the firm as well as of central organs. At the firm level, there was no attempt on its part to set up a permanent team to work alongside foreign personnel so as to learn the intricacies of the technology transferred. Nor did it try to establish a learning system so as to gather and provide information. The firm's "overriding priority was to have its investment projects launched and completed" even at the expense of other socio-economic objectives. The same argument applies to central organs, where no attempt was made to establish design offices at their level à la chinoise³¹ to assist firms responsible for priority sectors to implement their investment programmes and develop their technological capacities. Whereas in other planned economies, priority sectors are given both major priority in resource allocation and special attention from central organs during all stages,

priority sectors in Algeria are considered as such only in investment allocation.³²

- c) "Complexity" of the bureaucratic system and "bureaucratic indifference". 'Rigidity', 'slowness' and 'clumsiness' of the Algerian bureaucracy were repeatedly stated as major obstacles to efficient use of available resources.³³ Thus it is often argued by executives that because of these bureaucratic obstacles managers often prefer to concentrate one project on a minimum number of contracts, and even on one contract, for "contractual convenience" because if the project is split into several contracts the bureaucratic operations and obstacles are multiplied.³⁴ While this argument is understandable from the point of view of the firm (even if state owned), it certainly cannot be in the interest of the country to react to such problems in such a way, not to speak of solving them.
- d) Inadequate information flow between different institutions involved directly or indirectly in investment implementation and lack of coordination between them, and lack of confidence in local skills and products. For example approximately 50% of respondents (out of 20) suggested that there were no engineering firms and capital goods producers capable of supplying services and goods required to implement their investment projects, and stated clearly that they "do not know what C.E.I.AL has achieved so far". In fact there were local engineering firms or departments which were capable of carrying out detailed engineering and supervision of works in

progress, and whose potential was underutilized.³⁵ Meanwhile some handling equipment and most machine tools installed in workshops have been produced in Algeria since 1977 and their producers found difficulties in selling them because of lack of demand. Meanwhile C.E.I.AL has recently manufactured a number of machines specific to flour milling; which according to C.E.I.AL's director are "more appropriate to Algeria's conditions than some of those imported".³⁶ In fact, there is ample evidence that a number of technological tasks could be at least partially performed by local sub-contractors who were not integrated into the process of industrialization largely because foreign contractors generally prefer to sub-contract to firms known to them, than to relatively unexperienced local ones.

3.1.2 Lead-times of project execution

From contract signature to start-up operations of the 20 completed mills for which data were available took on the average 64.15 months. This average was approximately 40% higher than the average lead-time projected by the State Planning Secretariat for the same projects. The latter was slightly shorter³⁷ for projects launched during the 1974-77 Plan than for the six mills launched in 1969. Thus despite long delays experienced in the implementation of early projects, a decrease in lead time was expected to take place as a result of both the experience acquired in previous years and the expectation that contractual

dates would be respected.³⁸ In practice, implementation of projects launched during the 1974-77 Plan experienced delays much longer than those experienced during the 1969-73 period.³⁹ The following table summarizes the information on lead-times in unweighted arithmetic means.

Table 5.1: Unweighted arithmetic means of lead-times and project costs of the sample

Lead times (in months)	n = 20
Overall lead-time C (contract signature to completion)	64.15
Lead-time A (contract signature to construction start-up)	9.06
Lead-time B (construction start-up to completion)	55.09
Average project cost (m. AD at 1980 prices)	164.35

Source: derived from the survey

All projects in the sample experienced delays in their implementation relative to overall lead-times approved by the State Planning Secretariat and 80% of them experienced delays in relation to contractual lead-times. These delays were attributed to a number of factors. All respondents emphasized the "adverse effects of the Algerian system" on lead-times. They particularly drew attention to "slow decision-making", "rigidity" and

"clumsiness" of the Algerian administrative system, as well as to "lack of coordination" between various administrative and economic entities directly or indirectly involved in projects implementation. Moreover, some (not all) respondents referred to "inefficiency" of some Algerian firms responsible for the execution of certain project tasks⁴⁰, as well as of certain foreign contractors. In four cases the delay was largely attributed to changes in location and in three others to modifications in the project.

With the milling-project data collected in this survey it is possible to attempt a test of two hypotheses about Algeria's assimilation of imported flour milling technology. The first is that lead times will tend to decrease for successive projects, as a result of the learning process on the part of those involved in their implementation. The second is that lead times will tend to be longer, the larger the size of the project. The main arguments in favour of the first hypothesis are:

- 1) "Catching-up" objective: the main aim of Algeria's import of modern technology is to catch up with the industrialized countries. This implies that success over time in reducing assimilation lead-times should be important to success in "catching-up",
- 2) "Self-sufficiency" in flour production which implies that new production capacities have to be set up quickly to meet the

rapidly increasing local demand,

- 3) the possibility of a "learning curve": successive investment in technologically similar projects may result in shorter lead-times as a result of accumulated experience. This implies that technical and organizational problems encountered in the implementation of initial projects would be overcome in successive projects as experience was accumulated.

Against the first hypothesis are, first, the point frequently made by respondents that the Algerian administrative system is rigid and clumsy, second, inefficiency of some firms involved in projects execution, and, third, lack of an explicit technological strategy aimed at long-term objective of assimilating the imported technology both at the firm and national level. Most executives clearly stated that their overriding priority during the 1970's was to get planned projects implemented and those completed running efficiently, rather than devote resources to assimilation. This lack of an explicit technology strategy was reflected in a lack of effort to establish a learning system capable of gathering, screening and exploiting information about both problems encountered in project execution and also about perceived opportunities. Fourthly, the supply of skills was inadequate relative to the volume of investment allocated to the

industry.

In favour of the second hypothesis is the proposition that a project of large value will logically entail a larger volume of work, and consequently proportionately more or longer lead-time, than a similar project of smaller value, and that there will be more technical and organizational problems to solve than there would be for similar small projects. since projects of large value involve a large proportion of infrastructural work, it is expected that work on the project cannot be easily compressed into the same time-scale as for a smaller project simply by allocating more material and human resources.

Against the second hypothesis is the argument advanced by respondents that the more experience the project manager has with applying the technology, the less the time-scale will tend to be. Lead-times can be reduced through selection of competent sub-contractors, adequate planning of project execution and coordination and control of work in progress so that certain tasks can be performed simultaneously. Against this argument is the point frequently made by respondents that certain sub-contractors were inefficient and that frequent work stoppages were experienced as a result of delays in payments of work completed and shortage of construction materials.

With data collected in this survey it is possible to attempt a statistical explanation of the variation in lead-times by the variations in (a) the date of the contract (as an explanatory factor in considering the learning effect) and (b) project size, measured in terms of value at 1978 AD prices. Multiple linear regression, using ordinary least squares, was undertaken with lead-times as the dependent variable and project values and years of experience as the independent variables. This was carried out separately for the overall lead-time C, and for each of its constituents A and B. The results are set out in table 5.2.

Table 5.2: Lead-times, Project costs and contract dates:

Regression results

Lead times	Constant term (in months)	Regression coefficients		\bar{R}^2
		project cost (1978 m AD)	contract dates (years)	
Lead time A	6.2 (1.5)	0.05 (1.8)	-0.89 (-2.15)	0.147
Lead time B	42.32 (8.02)	-0.067 (-1.75)	2.44 (5.13)	0.59
Lead time C	52.1 (10.45)	-0.014 (-0.4)	1.34 (3.14)	0.37

Source: Data derived from the survey

Notes: 1) Correlation between project cost and contract dates is negligible.

2) Figures in brackets are t- statistics.

Clearly these tests provide no support to the hypothesis that large projects take longer to implement or that lead-times have been reduced by the learning process on the part of those involved in project-execution. The overwhelming bulk of the variance in lead-times is unexplained by the variance in project size and contract dates, so that the constant terms come out close to the arithmetic means of the lead-times (see table 5.1). The results of table 5.2 support the view of the survey respondents that there is no necessary relationship between the size of the project and lead-times. They also support our argument that doing-based learning does not take place automatically. Rather, it depends largely on the degree of financial and organizational effort allocated to establish a learning system capable of gathering, analyzing and exploiting information about problems encountered and opportunities perceived. Projects were often launched in waves⁴¹, rather than in succession, project managers were often recruited in ad hoc fashion with no prior experience in project management and with no supportive system to back them up.⁴² In such circumstances, project lead-times depended largely on the initiative of the project manager, and his commitment, as well as on the complexity of administrative and technical problems encountered in each case. No effort was made at explicit training of personnel in project management, nor to establish a permanent team responsible for project management, supervision and evaluation of work in progress. These

organizational shortcomings had in turn adverse effects on the learning process of those involved in project execution.

3.2 Capacity utilization in flour milling industry*

Capacity utilization of a flour mill depends on demand for its output, supply of inputs and the plant availability. In practice the first factor has not constituted a constraint to capacity utilization. Demand for flour has been, since 1975, far in excess of local supply. As for the demand for milling by-products, it fluctuates considerably from one season to the next⁴³, but is generally higher than local supply.

It is the supply of some inputs that has adversely affected the capacity utilization of some mills and the quality of flour milled. Both water and electricity supplies were considered by some (not all) respondents to be "inadequate". Inadequate supply of the former adversely affects wheat conditioning, which in turn affects grinding and sifting as well as the quality of flour obtained. As for the inadequate supply of the latter, it usually results in a mill shutdown. Both frequency and duration of power failure differ from one mill to another, and generally they affect mills located in

(*) Capacity utilization is used here as a parameter to measure the degree of mastery of operational technology i.e., production and maintenance engineering and management.

small villages more than those situated in urban ones. The effects of some power failures on the mill operation are not limited to their duration as sudden failures usually result in bottlenecks in the mill. These bottlenecks have to be removed before the mill is brought back to its normal running once the power is restored.

Four respondents (out of 20) considered supply of water as "inadequate particularly during the hot season" and judged its effect as "very minor" on capacity utilization but "very considerable" on the quality of flour milled. As for power failures, it affected eight (out of 20) mills. However, only 2 respondents considered it as having "a considerable effect" on capacity utilization. For 1984, these two mills experienced an average loss of production due to power failure, equivalent to one day of production per month.⁴⁴ However, all respondents claimed that these losses were made up for by intensive use of the plants⁴⁵ with the aim of fulfilling their production targets agreed upon with ministries and marketing agencies concerned.

It is the plant availability which is the determining factor in capacity utilization of flour mills. Availability can be defined by the following formula:

Availability (over a specified time) =

cumulative time of operation in the normal working state

cumulative outage time

The plant availability is mainly dependent on the reliability and maintainability of its machinery and equipment and on its personnel's mastery of production and maintenance engineering and management. The level of maintenance required at the plant operation stage is largely affected by the quantity and quality of design-engineering work put into it at pre-production stage. At the design stage reliability and maintainability are the important factors which should be considered in relation to the plant performance, capital cost and running cost. At the installation stage maintainability continues to be an important factor because it is only at this stage that the multidimensional nature of many of the maintenance problems becomes clear. The commissioning stage is not only a period of technical performance testing but also a learning period during which design defects that might affect plant performance are located and corrected.

All respondents judged machinery and equipment incorporated in their mills to be "generally reliable" and their maintainability "very satisfactory". In only one case some "minor modifications" were introduced, after the commissioning stage, in the installation of some equipment "to facilitate maintenance work as well as to reduce their unavailability".

Since reliability and maintainability were judged to be "very satisfactory", the plant availability becomes predominantly

dependent on the degree of mastery of maintenance and production engineering and management at the operation stage. Mastery of production engineering and management results in the avoidance of maloperation and in the detection of defects while the plant is in operation before breakdowns occur. The mastery of the former results in minimizing cumulative outage time and resource costs. To achieve this aim the maintenance department must work closely with the production department so that an optimum balance between availability and maintenance resource costs could be maintained. This is particularly important where there is a pressure on the production department to maximize output in order to satisfy demand, and where availability costs change greatly with time.

Maintenance can be regarded as a combination of actions carried out in order to replace, repair, service and modify the components, or some identifiable grouping of components, so that the mill continues to operate at a specified availability level for a specified time. The maintenance department influence availability directly through corrective and preventive maintenance. The proper objective of maintenance is the minimization of the sum of unavailability⁴⁶ and maintenance resource costs.⁴⁷

Both maintenance and production engineering and management at the mill level seem to be mastered in almost all mills. This

is reflected in capacity utilization of the mills surveyed as well as in their running-in times and absence of foreign technical assistance. All respondents, except three, claimed that their plants have been regularly operated at the rated capacity or above it.⁴⁸ This view is supported by official macro-economic industry reports.⁴⁹ The three exceptions had experienced considerable yearly fluctuation, but appeared on the average to operate very close to the rated capacity. Hence, the average yearly rate of capacity utilization over the period 1981-84 amounted to 98% for the first mill, 99.2% for the second and 96.5% for the third.

The average running-in time for the mills completed in the late 1970's and early 1980's was less than half of that for those completed in the early 1970's. Whereas the average for the 6 plants completed before 1975 amounted to just over 10 months, the average running in time for a sample of 10 of those completed later amounted to just over 4 months. Meanwhile, all respondents claimed that they had never had recourse to foreign suppliers or other foreign personnel after the stage of commissioning.

Four factors were judged by almost all respondents as being of major importance to mastery of operational technology. These were:

1. Intensive in-house and on-the-job specialized training of prospective personnel. In contrast to the cement industry

which relied almost exclusively in its recruitment of managerial and technical personnel on outside institutions, flour milling industry relied heavily on its in-house trained personnel whose training was not limited to operational technology but also involved some training in most aspects of process technology particularly since the early 1980's. This in-depth training was often accompanied by on-the-job training in specific tasks either at home or abroad, and retraining. Most respondents claimed that specialized in-house training is "much more effective" than formal education because the former "makes the trainee immediately operational once he or she is recruited". Most mill managers judged their technical personnel as highly "qualified and competent", and some managers of relatively old mills drew attention to the fact that some of their technical personnel were "overqualified for the jobs available at the mills" and consequently "underutilized".⁵⁰

2. "A relatively adequate flow of information" both within each mill and between each mill and its neighbouring ones. All mills surveyed had sub-departments in charge of information gathering, processing and diffusion, and some production and maintenance managers judged these sub-departments to be of great importance to their departments' operations. Meanwhile most respondents emphasize the role of information exchange between mills in solving a number of technical problems and in enhancing the learning process, as well as in avoiding

some unprogrammed stoppages, due to shortage of spares, through exchange of engineering components.

3. Labour stability: In contrast to the cement industry which experienced an extremely high labour turnover rate, flour milling industry appeared generally to have enjoyed a great degree of labour stability. Data collected from the 20 mills surveyed showed that labour turnover was relatively high⁵¹ in only two cases during their first two years of operation. However, the rate of turnover dropped drastically in subsequent years⁵², and data on capacity utilization in these two mills suggest that this high labour turnover had minor effects. This very weak correlation between labour turnover and capacity utilization was, according to the two mill managers, due to the fact that the two mills were overmanned and that labour instability concerned essentially semi- and unskilled personnel.
4. Heavy investment in repair workshops and standardization of designs and products. The firm (ex-SN SEMPAC) had invested heavily, during the mid-1970's, in maintenance through the establishment of regional and central repair workshops in addition to the small ones set up at each new mill. The purposes of these regional and central workshops were:
 - a) In the short- and medium run to maintain machinery and equipment of the established mills. This was to be achieved by assisting the mills to establish their maintenance planning, servicing and repairing of equipment which cannot be carried out at the mill for technical or economic reasons,

providing technical specifications and plans of engineering components and parts to the mills' workshops, and designing and manufacturing those elements which cannot be produced at the mills. In practice many problems had been encountered, the most important of which were firstly a lack of technical specifications and plans of the engineering components and parts and shortage of semi-finished products required to manufacture these elements when designs had been successfully worked out. Secondly there was a diversity of technologies and designs particularly with regard to old mills.

Despite these problems local content in spare parts usage has recently increased. Thus according to data collected from some mills, which separate expenditure on locally produced engineering components from those imported, suggest that local content increased from almost nothing in the early 1970's to over 75% in some of the large mills. Most respondents suggested that most of the locally produced engineering components were designed and manufactured by these workshops.

- b) In the long-run to design and manufacture flour milling machinery and equipment, which cannot be produced by other local firms and to encourage sub-contracting by assisting local firms which lack know-how. This switch was expected to take place once maintenance engineering was mastered and skills were improved. The central workshop would then transfer all technical information which existed at its level

to regional mills and workshops so that it could concentrate on the design and manufacture of prototypes of milling machinery and equipment as well as machine-building for the flour milling industry. Meanwhile regional workshops, in conjunction with other local firms, were expected to play the role of sub-contractors to the central workshop and the mills.⁵³ In practice, the shift in function required a definitive option for a particular technology and design, so as to ensure economic efficiency; and executives of SN SEMPAC were aware of this problem and its implications.⁵⁴

Since the firm's restructuring in 1982 regional workshops have been integrated into newly established flour production enterprises, and the central workshop has been integrated into the newly set up National Enterprise for the Development of Food industry, E.N.I.AL. The latter is an engineering firm entrusted with implementation of investment projects in the food industry, including flour milling, and R & D related to the industry. At present E.N.I.AL is investing in the ex-central workshop, which is upgraded into a Centre for the Development of Machinery for the Food Industry, C.E.I.AL, so as to enhance its design, engineering, experimentation and machine-building capabilities. Meanwhile, C.E.I.AL is expected to work closely with the food industry research centre C.E.R.I.AL whose main functions are to develop new products and processes and to train labour force for the food industry. So far mass production of milling machinery has

not yet started, but a number of prototypes have been developed and tested by C.E.I.AL, some of which have already been installed in some neighbouring mills.*

3.3 Manning levels in the operation of the completed mills

Manning levels were obtained for the 20 mills surveyed. In most cases the data covers only recent years (1981-85). Data on early years of operation of relatively old mills were lacking. Generally, all the mills completed before 1975 were overmanned, while those opened since 1980 are generally manned at levels similar to or less than those specified by the technology supplier. By overmanning I mean the excess number of workers in relation to the number of jobs specified by the supplier of technology. The degree of overmanning differed from one mill to another: it ranged from a minimum of 30% to a maximum of 75% in one of the old mills. The main reason for this overmanning was social: to provide jobs for the unemployed and for those who had been employed in closed mills next to the new ones. In one of the old mills where overmanning was highest, the new mill's work force was almost doubled in one day as a result of the closure of an obsolete mill to which the new mill was added in the early 1970's. While recognizing the existence of a certain degree of overmanning, all managers of these overmanned mills

(*) For more details, see sub-section 3.4

emphasized the fact that "manning levels suggested by foreign contractors were based on prevailing conditions in their countries" and consequently they tended to underestimate the influence of certain conditions peculiar to Algeria on manning levels.

Since 1980 there has been a change in policy at the national level and firms were instructed to restrict their manning levels to their necessary operational requirements.⁵⁵ This explains largely why the newly opened mills are operated at manning levels similar to, or even less than, those specified by the technology supplier. Indeed, data collected from these mills reveal that four mills were undermanned and their managers as well as five managers of other mills claimed that manning levels imposed on them were insufficient to meet their units' operational needs, particularly in those mills where handling of milled products was not automated. Meanwhile managers of overmanned mills were instructed to gradually reduce their manning levels.

3.4 Indigenous Technological Change in Flour Milling Industry

Before its restructuring in 1982, most of SN SEMPAC's effort had been oriented towards investment implementation, standardization of products and equipment designs, and assimilation of operational technology. The corporation had neither R & D infrastructure nor an engineering department

capable of developing new products and processes or improving imported ones. The only exceptions which are worth mentioning are:

- 1) The introduction by the firm of a product developed by a local laboratory⁵⁶: Although the product enjoyed great success during its first years of appearance on the local market, the firm has recently found difficulties in selling the product "because of lack of market protection" according to the production manager of the plant⁵⁷,
- 2) Design and manufacture of a handling equipment, which according to a mill manager who introduced it is "more reliable and easy to maintain than those imported",
- 3) Design and manufacture of a large number of engineering components and parts with the main aims of replacing imported ones, and training its personnel in the design and manufacture of equipment specific to flour milling. The experience accumulated played a major role in stimulating technological innovations in subsequent years (see below).

At the mills level, all technological effort was oriented towards efficient use of installed capacities through mastery of production and maintenance engineering and management. In only one mill were some "minor" changes introduced on the installation of some production equipment.⁵⁸

The establishment of C.E.R.I.AL and C.E.I.AL in the early 1980's appears to have stimulated technological effort in the

industry. A number of improved prototypes of production equipment, some of which are specific to the flour milling industry, were locally developed without recourse to foreign licencing or technical assistance. Some of these machines have already been installed in a number of existing mills on an experimental basis. The most important of these machines are:

- A. A specific gravity separator which is used in removing impurities from the grain. Unlike other dry cleaning processes, which require the use of a series of machines working on a number of physical principles, the specific gravity separator alone can remove all the extraneous matter. Compared with other cleaning processes, it is "less expensive to operate and more reliable than other dry processes and more appropriate to Algeria's condition than a wheat-washing process because it does not require the use of water which is scarce in the country"⁵⁹.
- B. A flour grading and purifying machine: this machine is mainly a replica of those installed in newly set up mills. The main aim of its development is "to substitute locally developed for imported machinery"⁶⁰.
- C. A wheat conditioning machine which is used to adjust the moisture of the grain and moisture distribution within the grain in order to obtain the desired level of moisture of the grain before its milling. The main advantage of this locally developed prototype is that its application would result in great saving in water consumption by the flour milling

industry. Thus whereas "imported tempering machinery requires about 150 litres per quintal of wheat, the locally developed one requires only 17 l/q". Indeed, it is claimed that "its application in all existing flour mills [would] result in saving about 3,000,000 m³ of water per year".⁶¹

So far none of these locally developed prototypes has been mass produced, despite the fact that most of them have been "fully tested and approved both technically and economically",⁶² and that "over 90% of components and parts required to produce them, in value terms, have been locally produced". Although some E.N.I.AL and C.E.I.AL executives were confident that production of some of those fully tested prototypes "will be started soon", there is a likely danger that these prototypes may remain display items for a long time, and consequently become out-dated before they have the chance to be introduced on the market. This is because of inadequate market research and information flow as well as central control of investment allocation. Although a great effort was made by C.E.I.AL to publicise the results achieved through local seminars and trade fairs, no effort was made at exploring foreign markets for export possibilities⁶³, which are essential for some of these prototypes to be mass produced economically. Meanwhile the organizational system which is based on vertically separated sectors lacks horizontal cooperation and is characterized by segmentation. This, in turn, resulted in duplication of work⁶⁴ and an

inadequate horizontal flow of technical and economic information both within and from without the economy.⁶⁵ Furthermore, central control over investment in new projects and imports of goods and services usually inhibits initiative at the enterprise level and increases innovation lead-times.⁶⁶

In addition to the development of a number of prototypes, C.E.I.AL has "successfully" carried out the design and engineering work as well as procurement and installation of machinery and equipment in its newly set up workshop in which foreign involvement was limited to the supply of machinery and equipment.⁶⁷ It has also taken part in the start-up operations of a bottle-making and water bottling plant, in cooperation with Algerian employees of the firm owning the plant: C.E.I.AL was requested to assist in start-up operations after the plant was abandoned by the foreign contractor before start-up operations were carried out.

Conclusion

In this chapter we have looked at technological developments in flour milling technology, the various techniques used in Algeria and have examined Algeria's experience in importing and assimilating modern flour milling technology. It was argued, in the first section, that modern flour technology is highly "mature" and despite the many technological changes (such as the

introduction of electronic control systems including computers, changes in the design of machinery to enhance both reliability and capacity and the introduction of pneumatic conveying systems) introduced in the industry in recent years, the core technology has remained basically unchanged. It was also argued that a modern flour milling industry was well established in Algeria prior to its independence, and that the priority given to commercial flour production (using modern flour milling technology) in investment allocation since the late 1960's reflected changes in local consumption patterns, which in turn were due to socio-economic changes such as rapid urbanization and rapid expansion of the monetised sector of the economy. It was also emphasized that imports of flour milling production systems did not entail indiscriminate imports of innovations introduced in the industrialized countries which supplied these systems. Whereas the tendency in the industrialized countries has been towards capacity enhancement, increasing automation through computerized control systems and a proliferation of flour grades to cater for the highly differentiated markets, imports of flour productive systems has largely avoided introduction of these innovations. All newly constructed mills, except two, have been of medium size (relative to those constructed during the same period in the industrialized countries), produce a very limited number of flour grades, do not incorporate computerized control systems, and in some cases do not use automatic handling systems for ground products.

The second section has provided an historical background to the development of the flour milling industry in Algeria, before independence, and examined the Algerian state's effort and objectives in developing a modern flour milling industry. Although a major priority in terms of investment was given to modern flour milling, with the aim of meeting the increasing local demand for commercial flour, the state provided no support facilities, except personnel training, to ensure the efficient implementation of investment projects and the rapid assimilation of imported technology. This resulted, among other things, in long delays in projects execution, heavy reliance on foreign firms in investment implementation and a lack of assimilation of technological tasks related to investment execution.

The third section has dealt with the assimilation of imported technology and has examined the significance of learning-by-doing and by training and hiring skilled labour on technological development in the industry. The assimilation process can be divided into two phases. The absorption phase which involves the successful exploitation of the imported technology in the first production facilities for which it is acquired. The diffusion phase entails the replication of the imported technology in other plants and subsequent innovations introduced in it. Weakness in either phase reduces the impact from the acquisition of imported technology. It was argued that due to policy miscalculations, systemic shortcomings and lack of an explicit technology strategy, investment projects had experienced long delays in

their implementation and local participation in the engineering tasks connected with these projects was not even attempted, except in one case through a joint venture firm. First and foremost, during the 1970's the planners approved a programme of investment in the industry which was well beyond the ability of the economy to efficiently carry out. Second, neither the central organs nor the firm in charge of the industry had made an effort to establish support facilities needed to facilitate the process of assimilation of the imported technology. Furthermore, SN SEMPAC's systematic option for the packaged mechanism of technology imports precluded the active participation of both its personnel and other local suppliers in engineering tasks connected with the projects' implementation. This in turn precluded the possibility of local accumulation of human capital through experience-based learning, and hampered the process of diffusion of the imported technology.

Additionally there were numerous systemic shortcomings which hampered the process of assimilation. The most important of these were central control of decision-making concerning prices, wages, investment and imports, complexity and rigidity of the administrative system, lack of incentives and coordination between various entities, sectoral segmentation, and an inadequate flow of information and of competitive pressure that may stimulate technological effort. Empirical evidence suggests that almost all respondents believed that the Algerian system even after its reorganization in the early 1980's was not

conducive to rapid assimilation of imported technology. We return to this point below.

However, data collected in the survey suggest that a great deal of effort was made, almost from the beginning of the 1970's, to master the operational technology. This effort is reflected in the establishment of a large number of repair workshops, intensive specialized training of Algerian personnel in operational technology, standardization of products and equipment and efforts at establishing preventive maintenance programmes which cover all aspects of the maintenance programme from recording the information about the machinery and equipment installed at the plants, to analyzing the relevant programming, and planning the execution of the programme using mainly conventional techniques. This technological effort appears to play a major role in acquiring operational capability which subsequently spilled over to other tasks such as improvements in the imported machinery and equipment. Data collected in the survey also suggest that existing mills have been generally operated continuously at their rated capacity (and in some cases even above it) without outside technical assistance. However, there was no evidence at the mills surveyed of innovations of the form of modifications being introduced on equipment specific to the industry except in one mill where locally developed production machinery had been introduced on an experimental basis.

Although the restructuring of SN SEMPAC appears to meet certain necessary conditions for technological innovation and the internalisation of the learning process, a number of systemic shortcomings have not been removed and new ones have emerged. Examples of the former are lack of motivation, red tape and administrative control over prices, wages and imports. The restructuring of the economy has had only a modestly positive effect on state enterprises because the centre has retained a dominant direct role in investment allocation and in determining both product and factor prices, as well as in controlling imports of goods and services. Examples of the latter are separation of R & D and E activities from production and the lack of procedures on how coordination between the two activities would be achieved. Although the main aim of establishing an autonomous national enterprise responsible for R & D and E activities connected with the industry, was to stimulate these activities which were previously neglected and consequently reduce the degree of reliance on foreign suppliers of technology, this new organization suffers, in turn, from a number of shortcomings which could hamper technological effort and may result in inter-enterprise conflicts. To start with, both production experience and detailed knowledge of local conditions are essential for the successful design, experimentation and maintenance of new plants, equipment and products. By separating R & D and E activities from production, and by not establishing institutional or other kind of procedures to ensure labour mobility and other types of interaction between suppliers and users, this new

organization could result in a great waste of effort and resources and consequently retard technological progress generally. Indeed, one of the main weaknesses of this new organization is that it does not provide a solution to the problem of the lack of linkages between the production system and research institutions. This shortcoming could in turn result in either inter-enterprises conflicts if R-D and E enterprises attempted to impose their technological results on production enterprises, or a lack of application of the results achieved if the latter decided that they were not adequate or competitive with potential foreign alternatives.

Empirical evidence also showed that doing-based learning and learning by training and by hiring skilled labour played a major role in augmenting local technological capacity when adequate financial and organizational effort was allocated to acquire such capacity. The establishment of various workshops and of an information gathering, screening and diffusing system at the mill and workshop levels have played a major role in establishing preventive maintenance programmes, improving production management and the emergence of the design and manufacturing capability of components and parts, which subsequently formed the basis of C.E.I.AL's activities. The existence of repair workshops and of the feedback system, coupled with intensive specialized training, presumably explain why design and manufacture of specific machinery and equipment have advanced

much faster since the restructuring of the industry than other engineering tasks connected with new investment.

Footnotes

- (1) Calculated on the basis of data published in the official weekly Revolution Africaine 29 November - 5 December 1985, p. 28.
- (2) For more details see Leung, F.L. (1981)
- (3) See Kent, N.L., (1984): pp.84-85
- (4) Ibid.
- (5) The extraction rate varies from one country to another. Since standardization in the mid-1970's this rate has been set at 72%.
- (6) For more details see Leung (1981) and Kent (1984): pp. 101-102
- (7) No statistics are available on the proportion of locally produced wheat which is not marketed. However it was reported that around 50% of hard wheat produced in 1984/85 was not sold to the State Marketing Board. Part of this proportion is often exchanged outside the official channel and milled by methods other than the roller mill.
- (8) Calculated on the basis of data published in MPAT, 1981 (October): Annexes, p. 248 and Revolution Africaine, 29 November - 5 December 1985, p. 28
- (9) D.E.S.E.S; (1984): pp. 38-52

- (10) For the UK's average weekly household expenditure on flour and its derivatives for 1956-1976 see: The Monopolies and Mergers Commission, 1977 (July): p. 13
- (11) In 1982, SN SEMPAC was split into 6 enterprises: five of them were entrusted with production and distribution of flour and its derivatives. The sixth is an engineering and R & D enterprise.
- (12) The quantity of flour imported from and exported to France was very marginal and the trade balance fluctuated considerably especially during the 1950's. For more details see FAO Trade Year Book(s) concerning these years.
- (13) MPAT, 1979 (October): p. 200
- (14) Ibid.
- (15) Due to the high degree of integration of the colonial economy to the French economy, most industrial activities had been established on the northern coastal strip around the main ports. This concentration of industrial activities was further strengthened during the period 1967-73, while the interior of the country lacked the necessary investment to develop. The II Four Year Plan called for concentration of development effort on the interior of the country through light industry in particular to reduce the rural exodus and unemployment in these regions.
- (16) From: MPAT, (1979), MPAT, (1981), Annexes and data collected in the survey.
- (17) Revolution Africaine, November 29 - 5 December, 1985, p.

28

- (18) For details, see FAO Trade Year Book(s)
- (19) Alf Panter in Canadian Interional Grains Institute, 1975 (May): p. 488
- (20) C.E.R.I.AL was set up in 1982 with the objectives of carrying R & D related to food industry, training technical personnel and the provision of technical assistance to the food industry Engineering Enterprise (E.N.I.AL, and other production enterprises on contractual basis. It is an integral part of E.N.I.AL. At present it acts as a consultant to E.N.I.AL, carries out R & D and trains personnel for the food industry.
- (21) Since the restructuring of SN-SEMPAC in 1982, C.E.I.AL (which had been a central workshop) has been entrusted with designing and manufacturing machinery for the food industry, as well as providing assistance to local sub-contractors and production units interested in introducing technological modifications. In 1986 it employed 12 engineers and 30 technicians. On its achievements so far, see pp. 332-333.
- (22) See Chapter 4, section 3.
- (23) This supervision was mainly administrative as technical tasks were carried out by foreign firms.
- (24) The firm employed foreign personnel. For details on its organization and performance see El Hindis, Nos. 7-8, (1981): pp. 29-35
- (25) Excluding transport equipment as well as other equipment

not incorporated in the mill.

- (26) This estimate was given by executives of the three mills concerned.
- (27) One executive, e.g., explained that foreign personnel refused to explain the nature of design faults or to allow Algerian workers to carry out, under their supervision, correction of design faults, on the grounds that it was their job to carry out start-up operations and test equipment performance.
- (28) This effective involvement is perhaps due to the fact that projects implemented in this way are not covered by performance guarantees attached to turnkey projects.
- (29) MPAT, 1979 (Oct): op. cit., pp. 247-248
- (30) Whereas the number of engineers had increased from 11 in 1969 to 19 in 1978, the number of technicians fell from 283 in 1969 to 175 in 1978. MPAT, Ibid.
- (31) On the Chinese experience, see D Chudnovsky, et al., (1983): op. cit., pp. 155-182
- (32) Some executives complained of the increasing pressure on them from central organs which they accuse of being indifferent to difficulties they encounter in obtaining necessary suppliers and in recruiting and retaining skilled workers, required to carry out their managerial tasks effectively.
- (33) The Algerian bureaucracy is not only criticized by Algeria's technocrats but also politicians and the public. See e.g., FLN, (1976) and various speeches of Algeria's

ex-President Houari Bonmedienne. See also J.R. Nellys (1980): pp. 407-422.

- (34) A number of concrete examples can be found in the confidential report written apparently by a number of policy-makers in the Ministry of Industry and Energy, who were dismissed in 1979: L'Industrialisation en Algerie: Echec ou Réussite, Continuité, Infléchissement ou Reversement? Algiers (n.d.). See in particular Ch. 3 and title III.
- (35) See e.g., M.F. Gallineri, in El Hindis, Nos. 7-8, pp. 36-42
- (36) See sub. section 3.4 below.
- (37) About 4 months. Sources: MPAT (1979) and our survey.
- (38) This explanation was given to the author by two officials at the Planning Ministry.
- (39) The average delay time experienced by projects launched during the 1974-77 Plan was more than twice the average delay experienced by the six mills launched in 1969.
- (40) e.g., a partially completed mill remained idle for more than 15 months because of the delay in the construction of its silos, which was entrusted to an Algerian firm. This delay, according to the manager of the firm concerned, was largely due to inadequate supply of construction materials.
- (41) In January 1969 six milling projects were launched. In March 1976, seven new ones were initiated and in January and March 1977 eight and four new milling projects were

started.

- (42) Some of these project managers had no prior experience in flour milling technology. An executive of E.N.I.AL argued that "because of lack of experience in project management, complexity of administrative and technical problems encountered on construction site and lack of support facilities required to back them up at the firm or the ministry level, a number of designated project managers handed in their resignation soon after their appointments".
- (43) e.g., during the second half of 1985 most mills experienced great difficulties in disposing of their by-products and extremely large stocks were piled up at the mills as distributors refused to pick them up because of lack of immediate demand for them.
- (44) This is due to the fact that mills did not have electricity generating units of their own. Their requests to set up their own generating units were turned down on the ground that the national electricity generating board had already undertaken steps to improve the supply, not only to industrial units but also to non-commercial users in these regions. There is evidence to support this argument as one of the two mills discussed above experienced only minor problems as a result of power failure during the first half of 1985.
- (45) This is usually achieved by carrying out maintenance during power failures instead of doing so at programmed

intervals.

- (46) Unavailability costs consist of production loss while in repair, waiting for repair, or while undergoing preventive repairs and loss of in-house service material.
- (47) Maintenance resource costs consist of maintenance labour, equipment, spare parts and holding costs.
- (48) Some respondents (e.g., 8 out of 20) claimed that their mills have been regularly operated at above their rated capacity since the second year of production start-up. This was achieved through intensive use of machinery and equipment. Two mills for which data on yearly running time was available for the whole period, reveal that they were operated much above the specified availability level during their first years of operation. Whereas the average yearly availability level was estimated at 315 days, the two mills were operated regularly over the first five years of their operation, for more than 330 days/year. However, actual availability time tended to decrease with the plant's operating life. This intensive use of installed capacities was imposed on reluctant managers by central organs with the aim of reducing flour imports. Most mill managers claimed that such intensive use of machinery resulted in rapid obsolescence and in the increase in maintenance work and cost.
- (49) See e.g. MPAT, (1980): pp. 82-83 and MPAT, (1981), p. 248. The latter shows that total output of commercial flour was lower than installed production capacity. However this

was due to the fact that a large number of new mills had just been completed during 1980 and were not yet operated at full capacity.

- (50) This point of view was supported by technical personnel of two mills where the author had the opportunity to discuss the matter with a large number of technical personnel. Their suggestion was to establish R & D cells at the mills so as to make effective use of human resources available.
- (51) The average rate of labour turnover amounted to 20% in one of the mills and 15% in the other. The highest labour turnover experienced in other mills was 7%.
- (52) In subsequent years the highest labour turnover registered was 10% in one of the two mills in 1983.
- (53) This obviously would be applicable to those mills whose technology and design is similar to that opted for. Consequently old mills whose technology is obsolete would suffer most as a result of shortage of engineering components which are at the same time difficult to obtain from abroad as their technology is obsolete.
- (54) To opt for a definitive technology and design would ensure future reproduction of the industry through development of local suppliers, but it would at the same time penalize existing mills which used different technology and design. In other words, the firm faced a dilemma on whether to provide assistance to all existing mills while relying on imports for its future expansion or to develop its technological and capital goods design and manufacturing

- capabilities to ensure its future self-expansion. The latter option requires a final decision on the technology and design most appropriate to the firm's conditions. Up to the end of 1982 no final decision had been taken.
- (55) Whereas some mills operated in the early 1970's had a number of auxiliary activities such as canteens, consumer cooperatives and the like, attached to them, newly opened ones had no such activities. At present there are moves to close these activities in old mills.
- (56) The product was developed locally and tested in a number of laboratories abroad before the decision was finally taken to mass produce it. All equipment needed to produce it on a commercial basis was imported. The product is a basic baby food.
- (57) It must be noted here that distribution of the product is entrusted to another firm which, according to the plant manager, played a major role in creating marketing difficulties because of imports of foreign competing markets and their promotion by the firm at the expense of the locally produced product. In 1984 C.E.R.I.AL was requested to either improve the product or develop a new one to replace it.
- (58) A number of technological modifications in plants producing pasta and couscous were successfully carried out. The maintenance manager of a large complex, which incorporates one of the mills surveyed, claimed that a number of "important technical modifications in the design

and operation of some machinery" was successfully carried out with the aims of "improving efficiency and safety".

- (59) This was the view of C.E.I.AL's manager.
- (60) Ibid.
- (61) Ibid., it was also the view of the manager of the mill where this machine had been tested.
- (62) Ibid.
- (63) Until very recently export possibilities were ignored by almost all local manufacturing firms, probably because of lack of competitive pressure on the local market, which is highly protected. This equally applies to C.E.I.AL and E.N.I.AL whose executives argued that market research abroad was not carried out because they were not certain when the decision to manufacture the new products would be taken by central organs. Although this uncertainty exists, export possibilities could also strengthen the enterprise's position when applying for investment in new projects and could facilitate administrative procedure in the light of priority given in recent years by the government to firms with great export potential. In fact enterprises have been encouraged to earn their foreign exchange they need to pay for their imports, through exports of their goods and services. See e.g., the Financial Times Supplement on Algeria published on December 10 1986.
- (64) This fact was admitted by C.E.I.AL's manager who spoke of some "wasteful effort" as some of their design-engineering

work could have been saved by subcontracting to other local firms producing components.

- (65) "Inadequate personal interaction and inadequate supply of printed technical economic material" were judged by C.E.I.AL's executives as "great obstacle" to efficient use of their human potential.
- (66) Lack of flexibility in investment planning and long administrative procedure of the Algerian system were judged by C.E.R.I.AL and C.E.I.AL executives as a "serious handicap" to the innovation process.
- (67) Even machinery and equipment were initially expected to be supplied by local firms. However the latter could not deliver them in the time agreed upon and foreign suppliers were awarded the contract.

CONCLUSION AND POLICY IMPLICATIONS

We set out to examine the impact of the policies of industrialization through imports of technology and of 'packaging', on local technological development in the LDCs, in the light of Algeria's experience. In the first chapter we argued that those who put forward arguments in the 1950's and 1960's for industrialization in LDC's paid little attention to the fact that the technologies needed to carry out these policies have to be imported. This is a rather important oversight for the following two reasons. First, because the international income distribution effects that result from transferring technologies are likely, at least in the short-run, to reduce the surpluses available for re-investment and so curtail the ability of the industrial sector to be self-generating. Empirical evidence on Algeria's experience in the 1970's revealed that technology payments were extremely high both in absolute and relative terms, and has considerable adverse effects on the country's balance of payments. Second, if technologies are transferred in such a way that learning does not take place, the economy will forego some of the important 'external economies' which are used to justify the policy of industrialization in the first place.

It was also argued that the straight forward application of concepts of comparative advantage to the transfer of technology and to the dependence on foreign sources of technologies in LDCs

is simplistic and inadequate for at least two reasons. The first is that it does not take into account doing-based learning in the technological field. This means that if market forces are left alone to determine the extent to which foreign skills, as opposed to local ones, are used in the investment process, there will be less accumulation of experience than is socially desirable. This argument holds even if the technology in question is widely available - so there is an inherent tendency to a sub-optimality which has nothing to do with the 'monopolization' of technology. This particularly occurs in packaged technology transfers where all, or most of the elements of technical knowledge and equipment needed to carry out an investment project are provided by the supplier of technology. Failure to use local suppliers of goods and services in such packaged deals precludes the possibility of local accumulation of human capital through both explicit training of local personnel and experience based learning. The economy as a whole therefore is deprived of experience and skills that are directly relevant to the industry's subsequent development. Second, on top of this inherent characteristic of the market for skills there is the question of a technology 'monopoly' which tends strongly to reinforce the way the market works - thus making it even more difficult for locals to get involved in the learning-by-doing process.

Both of these reasons, in addition to the direct costs of technology imports, are arguments for direct state intervention in the technology field. Indeed many LDCs have increasingly

resorted to interventionist efforts to restructure the demand for, and supply of technology in their respective economies. However, the empirical evidence available so far suggests that most of these policies have been misconceived, have lacked consistency and political commitment and have been poorly implemented. For example, many LDCs have chosen to protect locally manufactured consumer goods rather than protect capital goods and encourage the technological learning process. They have also tended to concentrate their efforts on establishing publicly supported R & D institutions, rather than encouraging technological efforts at the firm or enterprise level.

Underlying the creation of many of these R & D institutions was the naive belief that technological change is a linear process which starts with R & D and proceeds by stages automatically to commercial application. However, subsequent evidence has shown that this initial faith in the efficacy of these institutions was misplaced, and they almost invariably had virtually no links with, or impact upon the production system.

The second chapter dealt with the implicit technology policies inherent in the basic-industry strategy followed by Algeria in the 1970's and examined in great detail the effects of its inherent contradictions as well as shortcomings in its application in Algeria, on economic growth and local technological development. It was argued that the implementation of the basic-industry strategy requires heavy investment in basic and capital goods industries using advanced technologies that are

unlikely to be mastered by the developing country in its initial stage of development. Thus it seems inevitable that such industries will have to be started and maintained for some time, under foreign patents and at least partially foreign skills. This is only part of the learning process, a necessary but not sufficient step towards mastery of the technology. It was also argued that proponents of this strategy tend to overlook the strategy's inherent contradictions between medium-term heavy reliance on foreign technology and skills and the long term objective of technological autonomy, and technological progress in the supplying countries - progress which may render imported technologies obsolete, even before they are fully mastered by the locals. Another likely danger is that local managers may become complacent within their protected structures and therefore lose, or never develop the ability to respond to changes in conditions outside their protected structures.

Algeria's experience reveals that these contradictions inherent in the strategy coupled with the numerous and considerable systemic shortcomings and policy miscalculations, have tended to curtail the ability of state enterprises to make effective use of imported technologies, and to inhibit local technological development. Examples of the former are central control over investments and imports, a significant role in planning production and distribution and administrative regulation of factor and product prices. Examples of the latter are, first and foremost, the planners' approval of numerous mammoth investment

programmes whose simultaneous implementation was much beyond the ability of the economy to efficiently carry them out. In turn this led to a heavy reliance on foreign skills, long delays in project execution, cost overruns and capacity underutilization. Second, investment was highly concentrated in a limited number of industrialized branches at the expense of the socio-economic infrastructure and agriculture. This led to serious bottlenecks and deterioration of the neglected sectors, as well as to shortages.

Even after the early 1980's reorganization, the centre has retained a dominant direct role in planning investment and imports, a significant role in planning production and distribution and full control over factor and product prices. The system as it operates at present cannot foster the interests of enterprises in the long-run profitability and stimulate innovative activities. Although the principle of self-financing and self-accounting was the cornerstone of this re-organization, state enterprises have been unable to gain control over their surplus funds and to give efficient workers significant bonuses as central organs continued to control investment and factor prices as well as imports. A transitional solution to this dilemma is to split investment projects into two categories: those written into the National Economic Plan, which the banks and the Treasury will be obliged to finance, and those where particular state enterprises will have to convince the banks that what they wish to do is economically viable. Once implemented,

this division may eliminate many wasteful or oversize projects and stimulate innovative activities. This is not an easy task in a country which has inherited archaic practices of old French state banking style which often prefers to observe the minutiae of complicated rules rather than to take bold initiative. Consequently, for such a policy to succeed such practices will have to be removed and the senior staff of all Algerian banks will need to be strengthened and many more managers trained in the skills of project assessment.

The third chapter dealt with the various technological capacities and the efforts required on the part of recipients to assimilate an imported technology. Certain misconceptions concerning the nature of industrial technology and how it is derived were dispelled so as to deal realistically with the problems related to local technological development in and technology transfers to LDCs. The main argument was that technology cannot be packaged like any other commodity for immediate use and shipped from one country to another. Technology is derived from a continuum of activities encompassing research, development and engineering which in turn is intimately linked to on-going production and marketing activities. Consequently successful acquisition and assimilation of an imported technology depends largely on the quantity and quality of technological effort made by its recipient. Generally firms in LDCs have been found to undertake substantial technological efforts in order to make effective use of imported technologies. Empirical evidence showed that some of

the firms studied appeared to have followed explicit technological strategies aimed at specific objectives. Others seemed merely to have reacted defensively to changes in their circumstances, or to obvious needs to adapt imported technologies.

In the fourth and fifth chapters we set out to examine the significance of learning on technological development and production performance in the cement and flour milling industries in Algeria. The idea of learning-by-doing has been widely used in the literature to capture conceptually the knowledge and skills that are generated by performing tasks over a period of time. As treated in most economic analysis, learning-by-doing arises passively, takes place automatically with the passage of time and acquired as a free by-product from carrying out usual tasks and results in regular improvements in performance. The implication of this model is that increased learning requires increased doing, and hence various forms of protection for doing are seen as appropriate means for enhancing learning - the benefits of which will offset the inevitable costs of protection.

The validity of this concept was examined by looking at the local content in and the lead-times of project execution as well as the production performance and technical change in the cement and flour milling industries, over the last fifteen years. The results of our empirical findings suggest, first, that learning does not take place automatically but depends on the quantity and

quality of efforts allocated to generate, screen and exploit that experience (and skills). In other words, there is no inevitable causal link between increased doing on the one hand, and learning and production and technical improvement on the other. The policy implication of this finding is that protectionist measures may be necessary but not sufficient by themselves to enhance learning and stimulate local technological development. While protectionist measures may be necessary for some time, it is also necessary for national technology policies to go beyond negative restrictive measures to create necessary conditions to enhance learning and stimulate technical changes, otherwise such protective measures may be counter-productive as local managers may become complacent within their protected structures and lose, or never develop, the ability to augment local technological capacities. Second, learning from experience (and skills acquired) depends, at any level above that of the individual task, on the existence of a feedback system for generating, interpreting and diffusing that experience and skills. Without such a system, the ongoing performance of tasks will, for practical reasons, generate little or no useful experience. Third, firms' behaviour towards selection and assimilation of imported technologies, under very similar macro-economic conditions, differs substantially. Thus although both industries are state owned, and managed according to a common set of regulations, there has been a considerable variation in the way selection and assimilation of imported technologies has taken place, and this in turn has considerable effects on the results

achieved in terms of production performance and local technological development in each industry. However, macro-economic conditions have also a major impact upon the actual contribution of imported technologies to economic growth and local technological development. Fourth, packaging of technology imports, often results in precluding potential local suppliers of goods and services and consequently tends to inhibit the process of learning on the part of the locals. In addition, turnkey contracts often deliver a plant together with instructions for operating it under the conditions assumed in its design, but fail to provide the recipient with an understanding of the full details of how the plant operates or of how it operates as it does. This hampers the recipient's ability to improve plant operating productivity or to adapt to changes which may occur over time. These outcomes can be avoided by having the technology unbundled and the recipient's personnel actively involved in every phase of project execution, so as to create the necessary conditions for participation of potential local suppliers and acquisition of 'know-how' and 'know-why' related to the imported technology. This in turn could stimulate the process of learning that is directly relevant to the industry's subsequent development.

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following operations:

operations	None	- 10%	10- 25%	25- 50%	50- 75%	75-
Basic engineering						
Detailed engineering						
Production equipment						
Construction and installation						
Training						
Start-up operations						
Total cost of the plant						

(6) Would you give an estimate of the time taken from the signing of the contract to the startup: _____ months.

(7) What were the contractual dates for (month/year):

(a) signature of the contract:...../19..

(b) construction start-up:/19..

(c) project completion:/19..

(8) Were these contractual dates observed?

_____ yes

_____ no, longer, by how much? _____ months

_____ no, shorter, by how much? _____ months

If no, please give reasons.

(9) Is the Algerian team which was involved in commissioning the plant still together?

___ yes

___ no, if no, please explain what happened to the team?

(10) What was the role of this team in project execution?

(a) ___ mainly technical (b) ___ mainly administrative

(c) ___ both technical and administrative

(11) Does the plant have an engineering department?

_____ yes

_____ no, if no, is there an engineering department at:

a) ___ The enterprise level b) ___ the Ministry level

(12) What are the activities of the engineering department?

(a) _____ improvement in process control

(b) _____ improvement in process

(c) _____ improvement in product design

(d) _____ new product development

(e) _____ adaptation of the product/process to local conditions

(16) What managerial and technical skills does your personnel possess at present?

- (a)_____ to assemble similar plants
- (b)_____ to operate efficiently the plant
- (c)_____ to maintain efficiently the plant
- (d)_____ to train local employees
- (e)_____ to modify the imported technology
- (f)_____ to carry out equipment design
- (g)_____ to carry out process design
- (h)_____ to carry out product design
- (i)_____ others (please specify)

II Capacity Utilization

(1) is the plant at present operating at its full capacity?

_____ yes _____ no

If no, please give reasons for this

(2) What was the time taken to achieve full capacity?

..... months

(3) Was this time compatible with that specified by the contractor?

_____ yes

_____ no, longer, by how much? months

_____ no, shorter, by how much? months

If no, please explain why?

(4) Is the level of manning similar to that specified by the contractor?

_____ yes

_____ no, greater, by how many?

_____ no, less, by how many?

If no, please give reasons for this?

(5) Is labour productivity (in volume) at present equal to that specified in the contract?

_____ yes, _____ no, higher, _____ no, less.

If no, please explain why?

(6) Who carries out at present quality control at the plant?

(a) _____ Algerians only, if Algerians only, how long did it take for Algerians to replace foreigners?

(b) _____ Algerians and expatriates

(c) _____ Expatriates only

III Maintenance

(1) Who used to carry out maintenance during the first year of the plant operation?

(a) _____ Algerians only: _____ those employed at the plant
_____ others, please specify

(b) _____ expatriates only: _____ those employed at the plant
_____ other, specify

(c) _____ Algerians and expatriates, please explain

(2) Who carries out maintenance at present?

a) _____ Algerians only _____ those employed at
the plant
_____ others, specify

b) _____ expatriates only _____ those employed at
the plant
_____ others, specify

c) _____ Algerians and expatriates; please explain

(3) How long did it take for Algerians to replace expatriates
with respect to maintenance?

IV. Replacement of Wornout Engineering Components and Parts

(1) Would you please give an estimate (in value) of the
proportion of imported components and parts required to
replace wornout ones last year?.....%

(2) Has there been an increase in the proportion of locally
supplied components and parts since the plant was completed?
_____ yes, by how much per year?%
_____ no.

(3) Would you please specify whether locally supplied components
and parts is produced by:

_____ other national firms, if so who carries out
design work?
_____ the plant itself
_____ others, specify

- (4) What do you think of the quality of locally produced components and parts, compared with those previously imported?
(a) _____ similar (b) _____ higher (c) _____ lower

V Adaptation and Development of Imported Technology

- (1) Do you know of any local modifications in the process/product that has been introduced on the process you use or products you manufacture?
_____ yes, if yes, please describe them
_____ no

- (2) Would you explain how these modifications were achieved
(a) in cooperation with:
_____ Algerian research institutions
_____ Algerian engineering firms
_____ Algerian producers of capital goods
_____ the users of the product(s)
_____ foreign firms, explain
(b) at the plant level without outside help

incorporated into your plant?

If yes, please give some examples

(9) Do you know if there are Algerian firms that are capable of carrying out:

(a) _____ all tasks involved in projected execution in your branch? please give examples.

(b) _____ some tasks, please explain which? and give some examples.

(10) Do you know of any Algerian R & D institution that is working in your field of activity?

_____ yes _____ no

If yes, please specify relationship between your plant and the institution.

Appendix to the questionnaire: please give data for the following:

	Year 1	2	3	4	5	6	7	8	9	10	1982	1983	1984
Total employment of which expatriates													
1. Top Management: 1.1 - Algerians 1.2 - expatriates													
2. Technical Middle Management 2.2 - Expatriates 1.3 - Algerians													
3. Non-Technical Middle Management 3.1 - Expatriates 3.2 - Algerians													
4. Skilled workers 4.1 - Expatriates 4.2 - Algerians													

Appendix continued:

	Year 1	2	3	4	5	6	7	8	9	10	1982	1983	1984
5. Semi-skilled workers 5.1 Expatriates 5.2 Algerians													
6. Unskilled workers													
Rate of labour turnover among Algerians													
Rate of capacity utilization													
Number of days lost due to technical problems													
Number of days lost due to shortage of inputs													
Local content in consumption of components and parts													