
CHAPTER 10

**Patterns in Technology Transfer:
Impacts and Experiences**

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Patterns in Technology Transfer: Impacts and Experiences

INTRODUCTION

Transfers of advanced civilian technologies can have significant effects, positive and negative, on both recipients and suppliers. Because technology transfer is a complex process, assessment of impacts requires consideration of the interrelationship between technology transfers and major social, economic, and political changes. As discussed in chapter 2, evaluations of 'success' inevitably depend on rankings of the political, economic, and social criteria used in evaluation. Assessment of the impacts, or the effects of complex processes such as technology transfer, is necessarily inexact and tentative. Analyzing experiences with civilian technology transfers to the Middle East during the past decade is nevertheless essential because it provides insights useful to U.S. policy makers as they develop policies affecting technology transfers in the years ahead.

The purpose of this chapter is to compare and contrast findings concerning impacts across sectors and countries. The major questions include the following: Have technology transfers of certain types been particularly conducive to technology absorption? Have the experiences of various recipient and supplier nations differed significantly? Have the effects of these civilian technology transfers been generally favorable or adverse for suppliers and recipients? The impacts discussed here include those related to technology absorption by recipients, as well as other economic, political, and social effects important to suppliers and recipients.

The effects of technology transfer are more readily assessed at the firm or sector level than at the national level. This is because these ef-

fects depend on the content of the technology transfer, and because the changes in capability that result are most apparent in the recipient firm—its efficiency of operations and the skills of its personnel. This chapter compares and contrasts impacts of technology transfers in commercial aircraft support systems, telecommunications systems, medical services, petrochemical production facilities, and nuclear power production. The extent of technology absorption across these sectors varies considerably. While technology absorption has been limited in all sectors, it has been more extensive in sectors where goods and services are being provided for local markets. Even in sectors such as petrochemical production where technology absorption has been limited, however, recipients benefit from technology transfers that help to build world-class export industries.

The chapter also examines broader issues relating to the larger (nonsectoral) implications of technology transfer. The analysis underscores the point that it is extremely difficult to predict these larger effects. In light of OTA's findings, it also addresses controversies concerning the broader national implications for technology transfers.

Some observers have suggested that technology transfers to developing nations necessarily challenge the status quo because they involve the introduction of foreign personnel, values, and equipment into traditional cultures. In their view, technology transfers are fundamentally destabilizing. Others see technology transfers as contributing to economic growth, which brings benefits to and improvements in the recipient society. A major theme

in the discussion that follows is that the effects of technology transfer are conditional upon a number of factors, such as the pace of change, the distribution of benefits, and the wisdom of political leaders. Technology transfers, in conjunction with other social, political, and economic developments do have important effects, but it is not possible to identify the discrete contribution of all technology transfers on societywide change.

The civilian technology transfers examined by OTA have in most cases contributed to

growth of Middle Eastern economies and the expansion of export revenues for Western nations. At the same time, OTA identifies problems associated with some technology transfers (e. g., potential nuclear weapons proliferation, anticipated export competition with Middle Eastern petrochemical manufacturers, and the symbolic use of technology transfer by various political groups) which are legitimate concerns for policy makers.

IMPACTS OF TECHNOLOGY TRANSFER IN THE SECTORS EXAMINED BY OTA

Chapters 5 through 9 examined the process of technology transfer in a number of civilian production facilities and service systems in the Middle East. The primary focus of that analysis was technology transfers occurring during the last decade of rapid economic growth. The sections that follow analyze and compare the effects to date. Technology transfers in these sectors are still underway, and in some cases, just beginning. Therefore, potential impacts are also mentioned where it seems appropriate. The major emphasis, however, is on analysis of impacts already apparent.

COMMERCIAL AIRCRAFT SUPPORT SYSTEMS

The primary effects of technology transfers in the commercial aircraft support systems sector have been economic. Sales of large commercial aircraft are significant in terms of the large dollar-volume of aircraft sales and in follow-on sales of auxiliary equipment, including testing and maintenance equipment, avionics packages, and spare parts. Requirements for technical services (including ground support) have made this sector an important revenue earner for the supplier firms, including not only the aircraft manufacturers and airport

construction firms, but also airport management firms. For the recipient countries, these airlines are in many cases not great revenue earners, but they have added to the expansion of transport infrastructure.

The most significant problem, from the perspective of the suppliers, has been that competition among them has led to the expansion of government-supported export credits. These official credits represent a cost to the supplier governments and to taxpayers. In some cases, attractive financing has played an important role in competition for sales. The Organization for Economic Cooperation and Development nations have reached a special agreement covering export credits for aircraft sales. Nevertheless, continuing competition for sales of aircraft and support services among U.S. and West European firms indicates the need to strengthen agreements among suppliers about international trading rules.

The political or military effects of technology transfers in this sector are less clear-cut than the economic effects. Supplier governments have in some cases attempted to assist their exporting firms through high-level economic diplomacy, and the involvement of U.S.

firms in sales and servicing of aircraft in Saudi Arabia was preceded by discussions involving President Roosevelt. However, foreign policy controls affecting sales of U.S. aircraft have earned the United States a reputation as an unreliable supplier and have acted to reduce U.S. sales in the region. To many developing nations, commercial airlines stand as symbols of national prestige. In response to foreign policy controls, Middle Eastern countries have in some cases attempted to diversify suppliers. Because commercial aircraft exports have been subject to foreign policy controls, the political factors have strongly influenced trade in this sector.

Runways, fuel storage facilities, and radar capability contribute in a general sense to strategic defense capabilities. However, military equipment is much more specialized and complex than commercial airline support equipment, and civil aircraft maintenance experience is not directly applicable to military aircraft. Nevertheless, export controls have been used to restrict aircraft sales by those concerned about the spread of terrorist activities, who see these controls as necessary regardless of the consequences for commercial trade.

Among the sectors examined by OTA, technology absorption has been comparatively extensive in this sector. Indigenous personnel in the Middle East are increasingly performing the tasks needed to support and operate these airlines. For example, over one-half the pilots of Saudia (the Saudi Arabian airline) are currently nationals, in contrast to much lower representation of indigenous personnel in many other sectors (e.g., medical services). Indigenous personnel also hold key managerial positions in these airlines. However, particularly in Kuwait and Saudi Arabia, nonnationals, generally from other Middle Eastern countries, are performing maintenance and servicing functions. Therefore, despite comparatively high levels of technology absorption, some aircraft operations will probably not become fully staffed by nationals for many years.

There are a number of possible explanations for this pattern of fairly extensive technology absorption. First and foremost is the considerable length of experience. In a sense, commercial airline support systems represent a model for technology absorption in other sectors because many Middle Eastern countries have had commercial airlines for as long as a generation and the process of building indigenous capability has developed gradually over that comparatively long period. Secondly, the technologies involved are straightforward and well established, and procedures for training and operations are fairly standardized. Requirements of airline safety and maintenance have provided clear operational standards. Finally, Middle Eastern airlines serve local markets primarily and, while they have not all been profitable, they are viewed as important symbols of national prestige.

TELECOMMUNICATIONS SYSTEMS

The economic impacts of technology transfers in the telecommunications sector have also been particularly prominent. Telecommunications systems can be viewed as infrastructure in the sense that they provide the services needed for growth in other sectors. Of the Middle Eastern countries examined in OTA's research, Kuwait and Saudi Arabia have the most effective telecommunications systems. Kuwait's importance as a regional financial center depends, at least in part, on this system. In contrast to the aircraft support sector, local production of telecommunications equipment (including cables, crossbar switching, and television) has begun in some Middle Eastern nations and contributes to their ability to absorb the technology and to expand employment. The effects in job creation have been more notable in Egypt and Algeria, where more conventional technologies have been introduced, than in Kuwait, where state-of-the-art, capital-intensive technologies are preferred. Regional economic cooperation,

through Arabsat, is particularly noticeable in this sector.

For the supplier firms, exports of telecommunications equipment and services have been important sources of export revenues. While large firms and consortia have been central as prime contractors, many small firms have also been involved as subcontractors and suppliers of equipment. The specific requirements of Middle Eastern countries have stimulated suppliers to modify and adapt equipment. As is the case in the aircraft support sector, official government export subsidies, including mixed credits, have been used extensively. As the disparity among the major suppliers in technological capabilities has narrowed, West European and Japanese suppliers have aggressively marketed their most advanced technologies in order to win contracts.

Political and social effects of telecommunications technology transfers include the linking of rural and urban areas and expansion of communications with other nations. In some cases, such as Egypt, the poor functioning of telephone systems has tarnished the reputation of supplier nations providing assistance in some projects. In Iran, the telecommunications system was used by revolutionaries to consolidate their power. Like civil aviation, telecommunication systems contribute to a country's strategic infrastructure, but the more sophisticated the military establishment, the more limited the overlap and substitutability of civilian and military communication systems. Certain applications of these technologies have important social effects. Radio and TV, for example, have been instrumental in the health education efforts of several Middle Eastern countries.

Technology absorption in telecommunications has been comparatively extensive, particularly in Egypt and Algeria, and in Iran before the revolution. Recipient governments have increasingly extended requirements for training by supplier firms, and supplier firms have established specialized technical training programs. However, in nations such as Egypt, where unemployment is high, the PTT

(ARENTO, in this case) has expanded the number of employees beyond requirements demanded by the technologies, with a resulting decrease in efficiency of operations. Furthermore, due to the extensive requirements for lower skilled technicians in this sector, the Gulf States have faced problems attracting and keeping indigenous workers in these positions and in developing suitable curricula. Thus, the Gulf States have relied heavily on foreign Middle Eastern nationals to fill these positions.

Telecommunications, like aircraft support systems, function primarily to meet local requirements, and this provides a partial explanation for the development of recipient capability to operate and maintain the systems. Telecommunications systems serve captive markets. State-owned PTTs have introduced training and employment requirements in order to develop local capabilities. Local production, limited though it is, also certainly assists recipient firms in mastering standards and technology requirements. Regional cooperation in Arabsat also contributes to telecommunications planning capabilities in these countries.

MEDICAL SERVICES

To a greater extent than is true for the other sectors examined in OTA's study, the impacts of technology transfer in the medical services sector have been socioeconomic. During the last decade, the quality and longevity of the life of the average Middle Eastern citizen has improved because of better and more extensive medical services. These services have certainly contributed to the expansion of the productive work force. On the other hand, the urban middle and upper classes have benefited disproportionately from technology transfers in this sector, a trend that Middle Eastern planners are now attempting to rectify. Medical services employ large numbers of workers, and the personal contact required between medical personnel and patients accentuates the social and cultural effects on the society.

For suppliers, technology transfers in this sector have been priority concerns for development assistance. The U.S. Agency for International Development's programs involving preventive and rural health care have been generally well received in Egypt and have contributed to good political relations. Requirements for after-the-sale service and maintenance of medical equipment have stimulated private firms, particularly those in Europe, to provide specialized technical services. Personnel requirements at both professional and lower technical levels in the Gulf States have stimulated a large influx of foreign workers—from Western developed, Asian developing, and other Middle Eastern nations, such as Egypt and Jordan. Foreign medical workers there have been rewarded with high salaries, but they have also been obliged to accept restrictions on their behavior and political participation.

In medical services, technology absorption has been most varied, reflecting the wide range of channels for provision of services—ranging from small rural health clinics to large-scale, state-of-the-art curative hospitals. In the Gulf States, where large hospital complexes have been very recently established, technology absorption remains quite limited and reliance on foreign medical personnel will continue into the next century. In Saudi Arabia, for example, Saudi nationals make up only about 5 to 8 percent of the doctors and 10 to 15 percent of the nursing staff. Of all the countries included in OTA's study, Egypt has the greatest indigenous capability to operate and maintain medical facilities, but administration and infrastructure remain problem areas.

It is difficult to generalize about technology absorption in medical services across these countries, because they have developed strikingly different strategies for public health care. In the future, prospects for more extensive technology absorption appear good, because of growing experience and because of the pressing need for these services. Decisions made by government planners to promote curative or preventive health care will strongly

determine the nature and extent of medical services technology transfers in the years ahead.

PETROCHEMICAL PRODUCTION

Like telecommunications and commercial aircraft support systems, the impacts of technology transfers in the petrochemical sector have been primarily economic. For recipient countries, the principal effect is in the potential that petrochemical production offers for providing substantial export revenues and for diversifying domestic economies now heavily centered on the oil sector. These effects will be particularly evident in Saudi Arabia, the nation with the most extensive petrochemical projects underway, but may also be significant for Algeria and possibly Kuwait. In addition, petrochemical production will allow these countries to use their natural resources better: in Saudi Arabia, for example, expansion of petrochemical production will provide an opportunity for better use of natural gas, which was previously often simply flared.

For the supplier countries, the economic effects have been twofold, albeit, somewhat less positive. As illustrated by the experience of the Japanese firm Mitsui in Iran, the export of petrochemical plants and technology has been associated with investment risk. While investment risk is common to all the sectors, the large scale of the petrochemical projects may leave foreign firms more exposed. In addition, the growth of a Middle Eastern petrochemical industry will affect domestic production by supplier country firms, requiring some restructuring. This is particularly evident, in Japan, where declines in anticipated market share and the perceived inability to compete against low-cost feedstock countries have already contributed to plant closure and industrial restructuring. Only in this sector have Middle Eastern firms extensively used equity investments in Western firms as a means to acquire technology.

The political and social effects of technology transfers in the petrochemical sector, on the other hand, have been comparatively limited. As a capital-intensive and export-oriented industry, employment effects are minimal, and the production of petrochemicals in the Middle East is expected to have only limited effects on local consumption patterns. Joint ventures such as the Saudi and Kuwaiti project in Bahrain promise prospects for greater regional cooperation in this sector. Disputes have arisen between supplier and recipient governments over petrochemical projects, and concerns have grown among West European producers over future import penetration by petrochemicals produced in the Middle East. These political disputes between recipient and supplier governments concerning petrochemical production in the Middle East have, however, been exceptions rather than the norm.

Compared to the other sectors discussed above, the extent of technology transfer in the petrochemical sector has been limited. Expatriate workers predominate in both production operations and management. As illustrated by efforts in Egypt, however, technology absorption may be extended through improvements in managerial capabilities and the establishment of manufacturing firms using petrochemical products to produce consumer and industrial goods.

COMMERCIAL NUCLEAR POWER

Of all the technology transfer sectors examined by OTA, commercial nuclear power is today the least developed in the Middle East. Nevertheless, there have been significant political, military, and economic effects. Even for oil-rich nations with considerable financial resources, planning for nuclear power development requires political commitment. Iran's ambitious peaceful nuclear power development program under the Shah, for example, became the object of criticism by revolutionary leaders who saw the program as grandiose Westernization, as well as by technocrats who questioned the scope of the program and the tech-

nical choices made. In Egypt as well, controversy over powerplant siting led to the revision of plans after opposition grew to the proposed Alexandria locale. Even more serious have been the dilemmas faced by nations intent on acquiring sensitive nuclear technologies. Iraq's program raised concerns among neighboring countries that ultimately led to a preemptive military strike by Israel.

Suppliers of nuclear technologies to these countries have been able to influence the nuclear programs of recipients. Nuclear cooperation agreements, like the U.S.-Egyptian accord, have provided incentives for recipient nations to accept full-scope safeguards and to provide assurances that intentions are peaceful. Suppliers have also influenced recipient programs through denial of certain types of technologies and through insistence that requests be modified to include technologies less susceptible to use in nuclear weapons programs. French proposals to use low-enriched uranium fuel for Iraq's research reactor are a case in point. Suppliers have been forced to expend considerable resources in attempting to build consensus among themselves on export policies, but the benefits in slowing weapons proliferation have been significant. Because OTA's analysis indicates that the likelihood of nuclear weapons proliferation in the Middle East will increase in the years ahead, the long-term risk of proliferation is certainly a liability that all supplier nations share.

Economic effects have also been noticeable. In the future, commercial nuclear power may provide low-cost electricity in countries such as Egypt, but to date, planning and preparation have been costly. Egypt will be able to develop nuclear power only with subsidized financing. Supplier firms involved in Iran's program have gained export revenues, but they also faced difficulties as construction was terminated by the new revolutionary government. In the future, supplier firms could be stimulated to develop small reactors to meet Middle Eastern requirements, but so far, firms have generally not considered such efforts to be cost effective. Some nations supplying nuclear technology have received oil from recip-

ient countries, but there is little evidence that oil for technology deals have provided supplier countries with assured oil supplies in times of crisis. Indeed, France in 1983 was pressed to purchase Iraqi oil as the only conceivable means Iraq had to repay its debts. While in the future nuclear power may contribute to electricity generation in some Middle Eastern countries, the major economic effects to date have been felt by countries such as Iran and Egypt where purchases of and negotiations for nuclear power reactors have been carried to comparatively advanced stages.

Technology absorption has been quite limited in the nuclear sector, but a science and technology infrastructure is the foundation for future absorption of advanced technologies. Egypt has the largest nuclear research establishment, but the number of scientists and engineers working at the national nuclear research center (about 2,000) simply do not compare with the 18,000 in India's nuclear establishment, for example. Egypt has decided to import turnkey reactors. The major explanations for the limited technology absorption in this sector certainly lie in the complexity of the technology and in the reluctance of suppliers to provide sensitive facilities. On the other hand, in the years ahead, Egypt in particular may be able to improve gradually the capabilities of its scientists, engineers, and, most importantly, technicians, and may eventually operate and maintain power reactors independently. In the future, as Middle Eastern countries build their technical capabilities and as new suppliers perhaps more willing to sell sensitive technologies enter the market, military and political problems associated with nuclear weapons proliferation can be expected to grow.

COMPARISON OF SECTORAL IMPACTS

OTA's examination of the technology transfer process in all of these sectors indicates that technology absorption has been limited to the capability to operate and maintain technologies and equipment imported from abroad. In

no case have recipients developed the capability to design or significantly adapt these technologies themselves. To be sure, adaptation of technologies has taken place, as exemplified by special features of the airport in Jeddah, Saudi Arabia (designed to accommodate the special requirements of the Muslim pilgrimage), the modification of telecommunications equipment for use in desert climates (heat- and dust-resistant modules), and the preparation of special training manuals for medical and technical personnel. In these cases, foreign consultants have generally carried out the modifications to meet requirements identified by recipient country nationals. This assessment of the extent of technology absorption, it should be stressed, applies only to the advanced civilian technology sectors examined in this study. In other sectors and in particular countries, the extent of technology absorption may be much greater. Egypt, for example, has had an Engineering and Industrial Design Center for a decade, and technology adaptation may have been carried out in certain sectors such as textile production and agriculture. (See fig. 1.)

In addition to the effects associated with technology absorption in the five sectors examined by OTA, there has also been considerable variation in associated economic, political, and social effects. While economic effects are apparent in all cases, social impacts were identified as particularly salient for medical services technology transfers, and political effects for nuclear technology transfers. In these sectors and during the time period examined by OTA, recipients have been more directly affected than suppliers. For policy makers in the Middle East, technology transfers in these sectors are central to national development plans. With the exception of technology transfers that raise issues of subsidies, export controls, and weapons nonproliferation, technology transfers have been more directly relevant to supplier firms than to supplier governments.

There are a number of possible explanations for the variations observed in technology absorption. Table 96 lists major areas of impact,

Table 90.—Major Areas of Impact of Technology Transfers in Sectors Examined by OTA

	Potential contribution to foreign exchange	Value of imported goods and technical services (\$1982) to Middle East	Local production of equipment	Job creation in Middle East	Now serving local markets	Technology adaptation required	Level of indigenous capability developed	Regional cooperation Middle East	Dual-use or military application
1. Commercial aircraft support systems	X	xx	X	XX	XXX		XXX	XXX	X
2. Telecommunications		xxx	XX	XXX	XXX	XX	XX	XXX	XX
3. Medical services		xx	X	XXX	XXX	X	XX	X	
4. Petrochemical production	xxx	xx		X	X		X	XX	
5. Nuclear power							X		XXX

KEY XXX large impact, XX moderate impact, X small impact
SOURCE Office of Technology Assessment

including technology absorption as well as other types of economic, political, and other effects. Indigenous capabilities to use imported technologies have been most extensively developed in those sectors, commercial aircraft support systems and telecommunications systems, where there has been longer term experience with imported technologies and where the systems are currently serving local markets. In such cases, the industries and services are not forced to compete head-on with foreign firms, and recipient governments have the leeway to introduce local employment and training requirements.

In contrast, technology absorption in petrochemical production in the Middle East may be comparatively limited for some time, owing to the complexities of the technologies and to requirements ensuing from anticipated direct competition with petrochemical manufacturers abroad. In order to produce quality petrochemical products efficiently on world-class scales, Middle Eastern industries rely heavily on packaged technology imported from abroad and on the ongoing participation of expatriates. Packaged technology, in the form of turnkey nuclear powerplants, may also allow Middle Eastern nations to meet international operational and safety standards so important in that industry. Extensive technology absorption by recipients is only one indication of the effects of technology transfer; in sectors such

as petrochemical production, recipients will reap foreign exchange revenues from transfers even though absorption is limited.

Because medical services technology transfers are so varied, involving both large-scale, capital-intensive hospital projects and small-scale, rural health clinics, it is particularly difficult to generalize about the extent of technology absorption in that sector. The prospects for development of indigenous capabilities in medical services appear good since these services are provided to meet local requirements, are comparatively labor-intensive (and therefore offer prospects for expanded technology absorption in countries like Egypt where labor is comparatively abundant), and have been given high priority by leaders in Middle Eastern countries.

Impacts of technology transfer vary widely across these sectors, but the most noticeable effects have been in expanding the productive capacities of countries in the Middle East. Improvements in medical and telecommunications services contribute indirectly but significantly, while expansion of petrochemical production directly contributes to manufacturing and export growth. By relying on technology importation in the form of packages that include long-term involvement of foreign workers, the firms importing technology can ensure

proper functioning of facilities, even if indigenous capabilities are developed only gradually.

VARIATIONS IN NATIONAL EXPERIENCE

For both recipient and supplier countries, major issues have been associated with the importation of advanced technologies during the past decade. There has been considerable variation in the experiences of the supplier and recipient countries, and in the importance of political, economic, and social questions.

From the perspective of Middle Eastern leaders in these countries, the overall effects are undoubtedly viewed in a positive light. The fact that governments in all of these countries place high priority on technology transfer and are attempting to improve their capabilities to select and use foreign technologies indicates that their general assessment is favorable. Planners in the Middle East see technology transfer as essential for economic development, improvements in the technical expertise of the indigenous populations, greater social and economic welfare, an improved position in international markets, and as important in regional integration. They see technology transfer as generally raising national prestige, both regionally and internationally. For Middle Eastern countries it has brought expanded revenues from exports and remittances earned by workers working in the Gulf States.

On the other hand, however, Middle Eastern leaders do not disregard the potential negative impacts that technology transfer can bring in its wake: dependence on foreign suppliers of technology, an influx of foreign workers that may influence the social and political fabric of the recipient country, the creation of new social schisms among indigenous groups, disaffection among those groups that do not benefit from technology transfer, or the potential for embarrassment when technology transfers fail to achieve intended results. Saudi Arabia, Kuwait, and Iraq have found it necessary to import many foreign workers to carry out their development strategies, but at

the same time these countries have attempted to limit the participation of expatriates in politics and society in an attempt to preserve national values and traditions, and in order to limit political disaffection. With the growth of Islamic fundamentalism, projects involving technology transfer have in some cases become targets of criticism by those who fear that Western influences are inimical to Islamic traditions. Although technology transfer, for the most part, is thus viewed in a positive light, the challenge for Middle Eastern planners is to minimize the associated real and potential negative impacts. Given these potential problems, it is not surprising that Middle Eastern policymakers increasingly emphasize technology transfers that contribute to the development of a local capability, rather than imports of high-technology equipment per se.

For many recipient nations, the political dimensions of technology trade have become increasingly important in the past decade. Hoping to exchange oil for technology and foreign expertise, some recipient countries have at times included promises of oil supplies in negotiations over technology imports carried on with foreign firms and countries. All of the recipient nations have come to emphasize the goal of diversifying suppliers, to greater or lesser degrees, for political and economic reasons, as discussed more fully below.

On the supplier side, the most noticeable dimension of technology trade in the sectors examined by OTA has been commercial, and the most direct effects of these technology transfers have been on firms rather than on governments. However, these commercial efforts are more significant for nations such as Japan, Italy, and France—whose worldwide trade is much more strongly directed to the Middle East—than for the United States. In a period of worldwide recession, the Middle East represented a fast-growing market for these supplier nations. Negative effects, in terms of investment losses due to revolution in Iran or repayment problems in Iraq, have been considerable for a few firms. For Western supplier governments as well as newly industrializing countries and many Soviet bloc countries, the



Photo credit: Embassy of Kuwait

The Nasser Sabah Al-Nasser Al-Sabah Mosque in Kuwait City

major economic effects have been growing export revenues. Suppliers have been stimulated to adapt technologies to requirements of Middle Eastern countries, and revenues from sales of equipment and technical services in the region have contributed to the ability of supplier firms to continue to innovate and develop technology. Much of this research and development takes place outside the region, but there are exceptions such as solar energy development in Saudi Arabia.

The newly industrializing countries such as South Korea and India have been primarily involved in exports of construction services, including lower skilled laborers and, in the latter case particularly, technical personnel. In general, these nations have not provided advanced technologies, but they have been involved in staffing and infrastructure building

for large-scale projects. The major impacts on these supplier nations have been in the form of contracts and remittances earned by workers temporarily in the Gulf States. However, during the recent period of falling oil prices, many workers have been dismissed as the Gulf States cut back on new infrastructure projects.

For many West European nations and for Japan, technology trade with the Middle East has provided markets for industries faced with recession at home. In some cases, firms from supplier nations have, however, suffered investment losses associated with political and economic changes in host countries. With respect to the West European nations, technology trade has contributed at least in part to continuing but uneven efforts to establish multilateral policies toward the region. Competi-

tion among suppliers has stimulated some governments to intervene with export subsidies and supports for domestic firms. With the exception of the United Kingdom, most of these major Western suppliers of advanced technology continue to import large proportions of oil from the Middle East.

For the United States, the effects of technology trade have been similar to those affecting Western Europe and Japan. However, both exports to and imports from the region have been slightly less important in total U.S. trade than is the case for Japan, France, or Italy. Nevertheless, exports of technology to the Middle East have increased export revenues in a period when trade frictions between the United States and other nations have increased. As the postwar leader of the Western alliance, the United States has developed policies that emphasize political interests more than do those of most other Western suppliers. In part because of this emphasis, problems associated with the political dimensions of technology trade (including charges that advanced technology transfers may be destabilizing for the Islamic nations, or that they undermine relations with Israel) have been the subject of controversy. Technology trade and transfers have certainly helped to reinforce good political relations with countries such as Egypt and Saudi Arabia. On the other hand, foreign policy controls may well discourage or inhibit relations with other countries whose political relations with the United States are more ambiguous. Finally, the overwhelming preference of Islamic Middle Eastern countries for Western technology indicates that technology trade is an asset for the United States and other Western countries in countering Soviet influence.

Technology transfers have thus had important political effects. Through their policies governing nuclear transfers, suppliers have been able to influence the development of nuclear programs in these nations. While there has been some criticism of certain development projects, civilian technology transfers have reinforced good relations between the United States and the major recipient nations, such as Egypt and Saudi Arabia. On the other hand, because the United States alone has used foreign policy controls to limit exports of certain types for political purposes, these have undoubtedly reduced sales of certain types by U.S. firms and led some Middle Eastern governments to favor non-U. S. suppliers.

For the Soviet bloc nations, commercial technology trade with the Middle East has been quite limited in comparison to that of the Western nations. Nevertheless, exports to the Middle East make up a large share of these nations' exports to less developing countries worldwide. Egypt in particular changed policies and consciously reduced the involvement of Soviet advisors some years ago, an action that signified a setback for the Soviet Union. Political concerns remain paramount for the Soviet Union in its interactions with the region, but economic factors are increasingly important. For the East European nations, commercial exports, though limited to specialized niches, have been and remain at the center of their economic interactions with the region. The interest of Middle Eastern countries in diversifying suppliers may provide limited entrees for Soviet bloc exports in the years ahead.

BROADER IMPLICATIONS OF TECHNOLOGY TRANSFER

The previous discussion focused primarily on the past effects of technology trade and transfer. However, a decade is a relatively brief period and many projects are still under

development. The long-term contribution of the technology transfers studied by OTA will probably not be clear for another 10 years, and in some cases even longer.

Nor have all effects on the lives of individuals and groups within these nations been identified. OTA's research was designed to focus primarily on the effects significant for the supplier and recipient governments and firms involved. In order to understand the effects on individuals and groups better, it would be necessary to ask their opinions and to observe the actual operation of the facilities. For example, such research might clarify whether male patients are troubled by the presence of female nurses in hospitals, whether foreign laborers resent restrictions placed on them by recipient governments, or whether certain ethnic or regional groups complain about unequal distribution of the benefits accruing from technology transfers.

Perhaps even more complex are questions concerning the indirect effects of these technology transfers. The technology transfers studied by OTA have generally occurred in a larger context of rapid change in the recipient countries. It is often impossible to identify the discrete effects of technology transfer, that is, to separate those effects from others associated more closely with social phenomena such as urbanization or expanded communication and political participation. Together with these other changes, the implications of technology transfer can be substantial.

Experts disagree about the causes of nationwide transformations, such as political revolutions and value change. Isolating the unique contribution of technology transfer to such developments is simply not possible. The decisions made by policy makers about what types of technologies to import, how rapidly to promote change, who should be involved, and who benefits are key to understanding the broader implications of technology transfer. If the term "technology transfer" is used vaguely to refer to all social changes, however, it loses its meaning. The content, determined by policy-makers, is thus the key to evaluation of effects.

Policymakers nevertheless make decisions about technology transfer in the midst of uncertainty about its effects. While OTA's re-

search cannot conclusively resolve the continuing debates about the broader effects of technology transfer, such disputes can be tentatively evaluated in light of this research. Controversies concerning the broader effects of technology transfer are evaluated in this section, with special reference to Iran. Iran is the one nation in this study that has recently experienced fundamental political changes. The anti-Western character of the revolutionary government has been viewed by some as a reaction against rapid Westernization under the Shah, one aspect of which was technology transfer.

TECHNOLOGY TRANSFER AND POLITICAL INSTABILITY

Some have argued that technology transfers are inherently "destabilizing," meaning that they embody foreign (usually Western) norms and values that come into conflict with traditions. In some cases, the argument goes, these conflicts erupt into opposition to the ruling regime, and sometimes lead to its downfall. Another approach to these issues is to see ruling elites as challenged to spread the benefits of technology transfer and to adapt it to local requirements and traditions in order to preserve their own political legitimacy. The first approach, it should be noted, equates technology transfer with all foreign influences and assumes an irreconcilable conflict between foreign and traditional values. The second places emphasis on the choices of leaders who determine the substance of technology transfer, and assumes that foreign and traditional values can be integrated or reconciled.

The second approach is useful for understanding the course of events in Iran. Under the Shah the problems of unequal distribution of benefits of technology transfer gradually became glaring, but these problems were the direct result of decisions taken by the ruling elite. The recipients of advanced technology in Iran were fiercely loyal to the Shah. The political elite were rewarded for their allegiance with technical assistance, feasibility studies, market surveys, and loans. In addi-

tion, technology transfers were selected to meet the growing consumer desires of the emerging middle class. A case in point were the modern private medical service centers established in Teheran as joint ventures between U.S. and Iranian firms, which were out of the reach of the average citizen. Since modern industry and the communications media served the Westernized upper-middle class, the resentment and frustration of other classes grew. The government promoted “growth poles” (called industrial estates), and the population of the cities swelled, accentuating the gap between the urban and rural areas. Technology transfers could have been promoted to achieve other purposes, such as enriching the countryside, but that was not done. The choices of political elites, rather than technology transfers per se, helped create the conditions that led to revolt.

Nor is it likely that the course of history would have been different if the United States had adopted an arms-length attitude. The Shah could have turned to any number of alternative suppliers in Western Europe and Japan to fulfill his technology requirements. If the Western nations had been unwilling, Soviet bloc nations would have been available as suppliers. The conclusion that must be drawn is that even if foresighted U.S. leaders had anticipated Iran's problems and instituted policies designed to reduce or modify technology flows, it is unlikely that such policies alone could have changed the political outcome.

Certainly large projects have, on occasion, become the objects of political criticism. In Iran, the revolutionary leadership criticized the ambitious nuclear program of the Shah as evidence of his craving for Western high technology. In other instances, large projects such as new airports in Saudi Arabia are viewed by many local citizens with pride, as symbols of national accomplishment. Because large projects involving technology transfer are highly visible in developing countries, they can be easily identified as objects of either criticism or pride. Choices made by leaders in recipient countries, and the ability of leaders to ensure

that many groups in society benefit, shape political events rather than technology transfers per se.

THE TERMS OF TECHNOLOGY TRANSFER

Many observers have argued that technology transfers are fundamentally unfair. In their view, the supplier firms and governments have disproportionate power to dictate the terms of the transfers, with the result that the recipients pay too much, or receive technology that is out of date, or that suppliers are unwilling to provide the knowledge necessary for the recipients to absorb the technology fully. Underlying such criticisms are suspicions about the monopolistic character of multinational corporations, a theme that has reverberated in the debates over the proposed New International Economic Order. On the other hand, supplier firms point to their extensive training efforts, the investment risks associated with doing business in developing nations, and the inability of recipients to select and utilize technologies. The basic assumption of those who hold this view is that profit-maximizing firms are willing to sell technology, equipment, and services, but the recipient



Photo credit: Overseas Private Investment Corp.

Training programs carried out by the Xerox Corp. involving more than 200 local technicians are designed to improve communications and business support services in Egypt

must know what to ask for and be willing to pay a fair price.

Many Iranian entrepreneurs objected to restrictive clauses and practices that prevented the full diffusion or utilization of imported technology. These complaints included claims that foreign partners would not provide adequate training and that unnecessary hurdles were placed in their way when they tried to use local components. Many Iranians saw themselves as increasingly capable of handling more complex tasks than they were assigned in production facilities. Some pointed to cases of influence-peddling by foreign firms.

On the other hand, expatriate supervisors and managers sometimes found recipients unable to handle certain tasks. In fact, there were cases of both successful and unsuccessful cooperation between U.S. and Iranian firms. In retrospect, the ability of both partners to understand and respect each other and the emphasis on training and technical assistance were distinguishing factors of those instances viewed positively by both sides. The role of Westinghouse in the military-owned Iran Electronics Industries Corp. has been cited by some as such a case. When both supplier and recipient firm partners prepared workers to understand and appreciate the values and norms of the other, the partnership was more often viewed as a success. In prerevolutionary Iran, however, there were many cases of very costly projects which failed to achieve desired results. Anxious to introduce advanced technologies quickly and lacking the expertise necessary to make good choices or monitor progress, Iranian leaders sometimes accepted terms set by foreign firms which would not have been acceptable elsewhere. The foreign firms and the Iranian political elite in those cases benefited directly, while other groups in Iran grew more resentful.

All of these Middle Eastern countries have set restrictions on foreign direct investment, as outlined in chapter 11. Some countries, such as Iran under the Shah and Saudi Arabia today, encourage foreign investment more than others, but all maintain some restrictions. Such restrictions are designed to limit "de-

pendence" on foreign capital. In Iran before the revolution, the percentage of foreign equity declined, but it is unclear that this came as a result of government policies. Throughout the region, the level of foreign investment remains quite limited. However, OTA's research does not indicate that low levels of equity participation by foreign firms necessarily ensure that reliance on expatriate expertise will be limited or that projects will achieve desired results. The extent of technology absorption, the economic benefits of the partnership, and the perspectives of both sides concerning "success" do not relate consistently to the level of foreign equity participation in the technology transfer sectors examined by OTA. In some cases, such as petrochemicals, continuing involvement by the foreign supplier is essential for the proper functioning of the production facilities. As discussed in chapter 11, Middle Eastern countries have developed different policies governing foreign investment; their assessments of potential gains and losses are in no sense uniform.

Regulations introduced by recipient (and to some extent supplier) governments attempt to ensure "fairness" in commercial technology transfers. Controversies continue, however, concerning the terms of technology transfers, indicating the serious concerns of developing nations. Recipients are improving their capabilities to select, bargain for, and utilize imported technologies. As this capability is improved, and as supplier firms have more experience in these markets, both sides may become more adept in striking terms which ensure that the projects are viewed as mutually beneficial over the long term. Competition among suppliers from many firms and nations for sales of advanced civilian technologies serves to limit the ability of any one actor to dictate terms of technology transfers.

"APPROPRIATE TECHNOLOGY" TRANSFER

The term "appropriate technology" means different things to different people. It has been used to refer to capital-saving technology, small-scale technology, and technologies

needed for rural development. The underlying assumption of those who advocate the introduction of appropriate technologies has been that it is possible to identify technology transfers that are especially needed for the long-term well-being of developing countries. Some would also argue that particular types of technologies are “inappropriate” for developing countries. This last statement, in particular, has been disputed by leaders in many developing countries, who resent what they see as an attempt by those in developed countries to deny them state-of-the-art technologies required to compete directly with developed country firms.

OTA's approach has not been to assume that certain types of technologies are “appropriate,” but rather to examine the process of technology transfer in a number of sectors and to observe results. The emphasis has been on assessing the extent of technology absorption and on understanding the perspectives of the supplier or recipient governments and firms concerning these technology transfers. Policy-makers in the Middle East must make critical judgments about what kinds of technologies “fit” with their long-term economic development strategies. Such judgments require anticipating what the economy and society will be like some years hence and also require political leadership in building a consensus on how to get there.

Technology transfers such as those involving petrochemical production facilities that appear well-suited to Saudi Arabia would not be popular in other countries, where there is a larger indigenous labor force and smaller oil and gas reserves. As mentioned earlier, Kuwait has chosen capital-intensive, state-of-the-art telecommunications equipment, while Egypt has relied more on conventional telecommunications equipment that is more labor-intensive. Similarly, these nations have developed different health care strategies, with correspondingly different choices of technologies. Certain types of technology transfer (those introduced in systems operating to produce goods and services for local markets) were found to be particularly conducive to building



Photo credit: Aramco World Magazine

Merchants in Asir Province, Saudi Arabia



Photo credit: Aramco World Magazine

Modern supermarket in Saudi Arabia

recipient capabilities. Others such as telecommunications systems create linkages to other sectors, thereby causing “multiplier effects” in the economy. Of the technology transfer sectors examined by OTA, those in telecommunications and medical services had perhaps the most extensive effects on other domestic industries and on general living standards. In contrast, the critical effects of nuclear technology transfers have been political and military,

What is appropriate in one country may be seen as inappropriate in another. Judgments about the appropriateness of the technologies depend on the fundamental goals and values

of policymakers and citizens in these nations. Foreign suppliers are properly cautious when there is clear disagreement among various groups in recipient nations concerning certain types of technologies. Unfortunately, such disagreements often arise only after a project has been undertaken.

THE QUESTION OF "DEPENDENCE" ON FOREIGN WORKERS

Some argue that the presence of foreign workers in a developing nation is undesirable because it signifies ongoing dependence on foreigners and may lead to political and social unrest at home. Others argue that foreign workers make an important economic contribution and that their presence is generally beneficial to the host nation. OTA's research suggests that both types of impacts have been concerns in the Middle East. Expatriate workers in the Middle East must be present for technology transfer to occur, and the key questions are how long they stay and what they teach local workers in the process. Since no nation can be completely self-sufficient, the challenge is to utilize foreign workers effectively, based on a realistic understanding of both the problems that can arise and the potential contribution they can make. The question of foreign workers is part of a larger issue of dependence on foreign suppliers faced by developing nations.

Middle Eastern countries, particularly the labor-short Gulf States such as Saudi Arabia and Kuwait, have attempted to promote policies that utilize foreign workers while reducing potential political problems. Their concerns have been with potential political instability and with the prospect that foreign workers might attempt to influence host country policies, domestic and foreign. In Kuwait, for example, incidents of violence, both within and outside of the workplace, have been reported involving Palestinian workers, Indians, and others denied the rights and benefits afforded Kuwaiti citizens. On the other hand, developing nations appreciate the indispensable contribution of foreign manpower and exper-

tise to economic growth. As discussed in chapter 11, these recipient nations have developed manpower policies to address both goals simultaneously, including the use of enclaves, to deal with the problems associated with employing foreign workers.

Foreign labor is also an important issue for supplier countries. In Egypt, for example, the supply of manpower to other Middle Eastern countries has been associated with both positive and negative effects: the migration of Egyptian skilled workers to other parts of the Arab world has brought with it significant revenue in the form of workers' remittances, but it has also proved to be the root cause of a "brain drain" in certain sectors. These issues are equally if not more salient for the labor suppliers outside the Middle East. The migration of Pakistani workers, for example, brought remittances amounting to approximately 50 percent of Pakistan's foreign exchange earnings in recent years, but it also caused social dislocations at home when men left their families behind. Because of the large number of Asian workers in the Middle East, the Asian countries that supply labor to the Middle East could be affected socially and economically by a sudden and sweeping dismissal of workers.

THE VULNERABILITY OF SUPPLIERS OF TECHNOLOGY TO RECIPIENT LEVERAGE

Some observers worry that suppliers of technology can become susceptible to undue leverage, economic and political, by the recipients. Underlying this perspective is the recognition that technology transfer involves long-term relationships between individuals and firms in both countries and the assumption that when supplier involvement is great, the result can be vulnerability to the whims of the recipient governments. In particular, some supporters of Israel fear that involvement by U.S. and Western firms in Islamic nations might result in those supplier nations succumbing to po-



Photo credit Aramco World Magazine

Udhailiyah, located near the center of the giant Ghawar oil field, is the newest of Aramco's four permanent family communities

litical pressures counter to the interests of Israel. Others argue that technology transfer is primarily a commercial exchange and that the political leverage accruing to recipient governments is minimal or manageable. Some would take this argument further to suggest that the supplier actually gains considerable influence over the recipient in the process.

Debates over recipient leverage represent the obverse of questions concerning recipient dependence on suppliers. The major focus of concern has been with the issue of oil leverage, or the idea that Western governments in particular can be forced to take political stands contrary to their interests because of their dependence on Middle Eastern oil. Both Japan and a number of West European nations re-

main heavily dependent on oil imported from the Middle East and will remain so for years to come. Particularly during the period immediately following the oil crisis of 1973, West European and Japanese leaders moved to build bilateral alliances quickly with oil-producing nations, offering assistance in large development projects (including technology transfer) in conjunction with assurances of oil supplies. U.S. policy makers viewed these bilateral initiatives with concern because they seemed to some to diminish the ability of the Western nations to coordinate their policies through the International Energy Agency. In addition, the West Europeans and the Japanese took political positions independent of the United States and in some cases were more strongly supportive of Arab nations and the

rights of Palestinians, increasing the concern about oil leverage. There is no question that oil is a major factor in the strategic and foreign policies of supplier nations, and technology transfers certainly occur within this context.

On the other hand, it does not appear that the nations that most aggressively attempted to build bilateral relations have been particularly successful in securing oil supplies in periods of crisis. While a multilateral embargo of oil by Arab nations would undoubtedly have considerable effect on consumer nations if it were prolonged, the threat of oil leverage by a single oil-producing nation is limited by the availability of alternative suppliers. In the near term, the recent leveling of demand for oil in the West has diminished the feasibility of oil leverage. In addition, Western nations have gradually put in place a number of policies—including emergency oil-sharing schemes, stockpiles, and energy conservation—which strengthen their capabilities to respond to sudden changes in the oil market. To be sure, oil is an important element in the relationship between France and Iraq, for example, and in the growing ties between Japan and Iran. OTA's research indicates that the joint venture partners in the Saudi Arabian petrochemical projects were attracted by guarantees of oil supplies in addition to favorable returns on investment. However, there is no evidence that the oil-producing nations have (through the use of oil leverage alone) successfully forced supplier governments to take positions which they themselves view as counter to their own interests. Indeed, some cases, such as the cancellation of British Foreign Minister Pyre's trip to the Middle East in 1983 discussed in chapter 12, suggest that some suppliers are unwilling to subordinate their political principles to economic interests.

It is beyond the scope of this study to analyze the broader issues of Middle Eastern politics and diplomacy. However, OTA's research on the foreign policy context of supplier nation policies indicates that Western nations have established widely varying political relations with Middle Eastern countries. Chapter 12 analyzes the tendency of Western Europe

and Japan to bring economics more to the fore in their policies than is the case in the United States. In some instances, these nations have developed policy perspectives that diverge from those of the United States. Some West European spokesmen, for example, question the appropriateness of an allied Middle Eastern policy and call instead for harmonization of policies. In their view, the alliance is strengthened when various Western nations develop relations with different Middle Eastern nations, rather than prohibiting trade with certain nations. Oil is certainly a consideration in these foreign policy perspectives of the technology-supplying nations, but it would be incorrect to conclude that Japanese and West European policies are determined solely by oil concerns.

Nor would it be correct to assume that suppliers gain no influence over recipients through technology transfers. While there is no evidence indicating that supplier nations have effectively forced recipients to modify their foreign policy positions simply by threatening to withhold or by offering to supply civilian technology, there have been cases where suppliers have successfully negotiated terms for transfers that maximize broader foreign policy interests. Suppliers have noticeably affected the type and extent of nuclear technology transfers. For example, by offering nuclear cooperation, the United States has persuaded Egypt to agree to very stringent safeguards on nuclear transfers. In contrast to nuclear export controls, however, there is little evidence that foreign policy controls have been implemented in the sectors examined by OTA so as to significantly reduce their access to advanced civilian technologies or change the political positions of the recipients.

This discussion does not resolve the issue of supplier vulnerability, but it does serve to caution against simply equating commercial relations with political positions. Evidence of both suppliers and recipients exerting influence is most apparent in the specific technology transfer contracts shaping the terms of transfer. Because the interests of supplier firms and their governments sometimes di-

verge, it is not necessarily the case that the commercial strategies of the firms will be strongly supported by governments. Technology transfer relationships require long-term interactions between suppliers and recipients,

but sometimes the result is resentment and disagreement, while at other times mutual understanding leads to shared views and perspectives.

CONCLUSION

The impacts of technology transfers in the sectors examined by OTA have been widely varied across nations and technology sectors. It is difficult to identify and assess all the impacts of past technology transfers, and the task of anticipating future effects of proposed technology transfers is even more demanding. The implications for public policy are that it would be beyond the capacities of a supplier government to evaluate all proposed civilian technology transfers to ensure that all projects attain intended goals and that those are consistent with the national interest. Nevertheless, choices are currently made by many actors—supplier and recipient firms, in particular, and governments.

The long-term significance and promise of technology transfer is as a process that can stimulate continuing and self-sustaining economic growth in recipient nations, and one which can further the economic and techno-

logical progress of the suppliers as well. Whether these goals are achieved depends to a great extent on the wisdom of political leaders, particularly those in the recipient countries. The technology transfers examined by OTA have in most cases contributed importantly to the process of economic growth and technological development.

Another aspect of long-term significance is the influence of politics on technology transfer, seen in recipient attempts to diversify suppliers and in increased efforts by suppliers to use technology as a lever to reach political goals. Both supplier and recipient partners necessarily consider not only the risks of technology transfer, but also the promise of mutually beneficial exchange. The next chapters analyze efforts by both recipient and supplier governments to introduce policies which attempt to ensure that technology transfers achieve desired results,