CHAPTER 2

Analyzing Technology Trade and Transfer: Conceptual Issues and Policy Choices

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INTRODUCTION

Technology transfer to the Middle East is a complex process that occurs primarily in the commercial marketplace through transactions between suppliers and recipients. In the Middle East, governments and public corporations are the primary recipients. On the supplier side, while governments influence civilian technology trade through various policies and assistance programs, the major participants are private U.S. firms. In Western Europe, Asia, and Soviet bloc nations, the suppliers are often public corporations.

Technology transfer is necessary for the achievement of widely differing goals, and its effects on recipient countries can vary considerably. For example, technology transfers can lead to improvements in agricultural yield (through introduction of irrigation technologies), better quality of life (through provision of medical services), foreign exchange revenues (through the establishment of manufacturing facilities that produce goods for export), or to the potential expansion of regional conflict (through the introduction of enrichment and reprocessing technologies which can be *used* to produce nuclear weapons). When technology transfer works, the recipient develops a greater capability to operate a production process or a service system, and the supplier accrues commercial and sometimes political gains. However, suppliers and recipients rightly worry about the potential negative consequences of technology transfers that fail to achieve anticipated results.

This report evaluates the benefits and costs of technology transfers to the Middle East from the perspective of the U.S. Government. Generally speaking, unless overarching foreign policy interests justify restrictions on technology transfer for military or strategic reasons, the major concern is that technology transfers involve fair exchanges in which U.S. firms and organizations are appropriately compensated, that the transfers be successful in improving the recipient's capability and thereby serve to reinforce mutually beneficial international relations, and that trade frictions with new recipient producers and with other supplier nations be avoided. In practice, however, U.S. policies affecting technology transfer to the Middle East have been distinguished by a tension between political and economic interests. Chapters 13 and 15 identify and assess the competing themes in U.S. policies affecting technology transfer.

Analysis of technology transfer poses some difficult questions: How is commercial technology transfer-l distinguished from trade—and how extensive have technology transfers, in contrast to trade, been to the Middle East during the past decade? What factors affect the ability of recipients to use or "absorb" imported technology? What factors influence flows of technology between suppliers and recipients in the Middle East? What choices do recipients and suppliers face as they engage in technology transfer transactions? This chapter outlines an approach to analyzing these questions. Its primary focus is conceptual; it provides a framework for the analysis of technology trade and transfer in the chapters that follow.

Because of the absence of quantitative indicators which would allow us to measure technology transfer precisely, trade flows can be traced much more easily than the actual ex-

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'Technology transfer can take place illegally through theft of information documents, or products embodying technology. This report, however, focuses on commercial technology transfers.

tent of technology transfer. This chapter explores economic and political factors influencing technology trade, the context in which technology transfer normally occurs. It identifies factors which affect technology transfer directly at the projector firm level, as well as broader effects. A central theme of the chapter is that there are significant constraints on technology transfer, despite the rapid growth and mutually beneficial effects of trade.

Technology transfer to the Middle East raises important foreign, commercial, and development assistance policy issues for the United States. The U.S. Government has a strong interest in the peaceful development of Middle Eastern nations, and Western technology can contribute to this process. This applies not only to the oil-rich countries of the region, but also to other important countries such as Egypt. Transfer of advanced civilian technologies is also important from a strategic perspective, since U.S. policies include restrictions on exports of advanced technologies (e.g., civilian aircraft), in order to achieve foreign policy goals, and technologies with military applications (e.g., some nuclear technologies) in order to reduce the proliferation of nuclear weapons. From a commercial perspective, the United States has an interest in promoting technology trade and in anticipating and avoiding trade frictions arising from the growth of Middle Eastern export industries and from unfair competition between suppliers. Technology transfers are, in turn, affected by and raise critical questions for commercial, assistance, and strategic policies of the United States.

Chapter 2 begins with a discussion of the meaning of technology transfer, which includes consideration of factors directly affecting the process and problems of measurement. Next, the chapter analyzes factors affecting international flows of technology to the Middle East, since technology trade (through various channels such as sales of products and equipment, turnkey plants, technical services, direct investment, licenses and patents) is the means through which technology transfers normally occur in the commercial marketplace. Finally, the chapter deals with the policy choices that recipients and suppliers face, explicitly or implicitly, as they interact in technology transfers.

TECHNOLOGY TRANSFER AND TRADE: MEANING AND MEASUREMENT

RELATIONSHIP BETWEEN TRANSFER AND TRADE IN TECHNOLOGY

Definitions of technology and technology transfer abound. Technology is the knowledge needed to design, create, or implement a production process or the services related to the process. Technology is the specific application of scientific and technical knowledge to the production of goods and services.[2]

As used in this study, technology transfer is a process involving at least two parties, whereby the recipient attains, as a result, an improved capability to design products or to operate a production facility or a service system. Technology transfer involves:

1. technology trade—the provision of technology by a supplier to a recipient through commercial transactions; and
2. technology absorption—the use of that technology by the recipient; e.g., in operating and maintaining a manufacturing facility.

Because technology transfer involves scientific and technical knowledge required for these

[2] See "Technology Transfer: Definition and Measurement," in *Technology and East-West Trade* (Washington, D. C.: U.S. Congress, Office of Technology Assessment, OTA-ISC-1O1, November 1979), pp. 99-105.

specific operations, it differs from the general dissemination of scientific information. Most standardized technologies are rather far removed from science.

For technology transfer to occur, a variety of transactions must take place, often simultaneously. These transactions include the sale of industrial rights, provision of training, technical and management services, designs, plans, and documents, as well as the supply of equipment needed to operate and maintain a complex industrial or service system. Transfer costs incurred by both parties range from trivial to very high. Normally, these transactions take place in the commercial marketplace, but government-supported economic assistance programs and government-to-government technical cooperation programs are also conduits.

A commercial transaction (e.g., the sale of a turnkey plant) indicates only that successful technology transfer might have taken place. The teaching and learning required for technology absorption generally take place over time and imply a two-way interaction. For technology transfer to occur between parties in industrialized and developing countries, it is necessary to bridge a considerable 'technological distance, " and this bridging usually takes place gradually [3]-particularly when the technology transferred results in the addition of completely new production capacity.

Technology transfer occurs through technology trade but should be distinguished from it. If the recipient merely purchases equipment but is unable to use it, technology trade has occurred, but no absorption has taken place; in such a case, only part of the process of technology transfer has been completed. As the recipient more fully absorbs the technology, the capability to operate and maintain it is developed. When technology is fully mastered or absorbed, the recipient is also able to design and produce new products, to adapt the technology. If the recipient depends completely on expatriate workers to operate and maintain the facility, technology absorption is limited. However, even in this case, the production capacity may be an asset to the recipient if revenues accrue from sales of products or services.

Technology transfer normally occurs in the context of a particular enterprise, project, or industrial sector. In order to determine the level of capability that has been developed (the extent of technology absorption), it is therefore necessary to examine the effects of technology transfer in the particular productive enterprise. Although numerous factors—e. g., national development plans, education, labor, investment and trade policies, the political and economic context, and policies of and relations with suppliers—importantly affect and are affected by various transfers, the effects in the productive enterprise or sector receiving the technology are the most important indicators of the extent of transfer.

ASSESSING TECHNOLOGY TRANSFER

Evaluations of the extent of technology transfer are based on judgments about the operational efficiency of the facilities, and the quality and skills of the work force in the particular firm, project, or sector. In addition, the "linkage effects, " or the contribution of the transfer to other economic sectors or to the country's overall science and technology infrastructure, are also often taken into consideration. But policy makers in particular often evaluate the overall "success" (the net costs and benefits) taking a variety of other considerations into account.

Evaluating the Extent of Technology Transfer

Operational Criteria.—From an operational viewpoint, transfer occurs when the transfer and production costs and the quantity and quality of output are acceptable by relevant standards. Particularly for export industries, the relevant standards may be those of the most advanced producers in other parts of the

[3]For a discussion of characteristics of technology transfer between developed and developing nations, see Organization for Economic Cooperation and Development, North/South *7'echnology Transfer* (Paris: Organization for Economic Cooperation and Development, 19811, p. 24.

world. These standards may include costs of production, foreign exchange earnings, and profits of the firms that are the industry leaders. For other types of operations, such as local service systems, the relevant standards may be those of newly industrializing nations. In developing countries, it is often difficult to assess the efficiency of operations: costs may be competitive if labor is cheap, even though efficiency is low by other measures.

In cases of unsuccessful technology transfer, the operation may be abandoned before it goes onstream, or the output of the facility may be of such high cost and low quality that even domestic sales in a protected market are difficult. More specifically, inefficient operations may result from lack of proper maintenance of equipment, owing to improper procedures; inadequate skills and spare parts; and inclement surroundings. Judgments about operational efficiency must be based on knowledge of the technologies and production facilities involved, and comparisons to operations elsewhere.

Quality and Capabilities of the Work Force. –People are essential for technology transfer. Transfer involves technology absorption—learning by the work force of skills needed for effective operation and maintenance of interrelated technical, financial, marketing, and personnel functions of the enterprise. Normally, these capabilities are developed over time when the transfer involves the establishment of a new type of facility in a developing country. In such cases, expatriate workers may be needed at early stages.

The number of indigenous workers alone is an inadequate indicator of technology transfer: local workers may serve in name only to fill an employment requirement. It is more important to determine what positions indigenous people hold, what capability they possess to carry out their jobs, and whether there has been improvement in their capabilities over time. Recipients in developing nations often place special emphasis on technology absorption in their assessments of the extent of technology transfer.

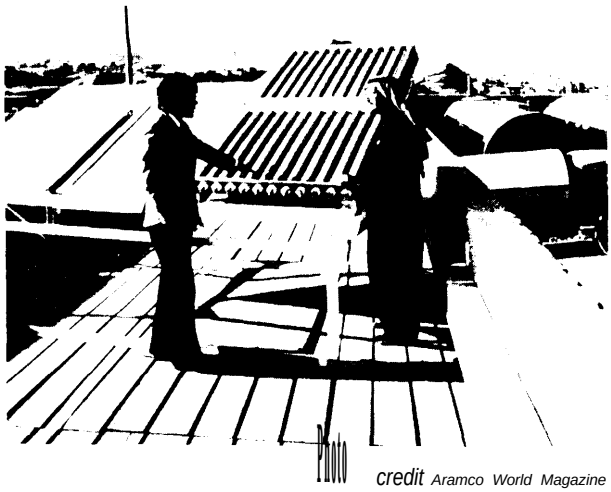
Linkages to Other Sectors.–The extent of technology transfer can also be assessed in terms of the linkages that exist between the technology-receiving firms and other firms and organizations throughout the society. The movement of skilled workers from the original enterprise to other enterprises maybe viewed as a means of diffusing technology transfer to other firms or sectors in the national economy. On the other hand, such movement may result in a loss of capability at the original enterprise. Regional manpower migration in the Middle East is a complex phenomenon, and the benefits and costs may be assessed from the perspectives of the firms, the industrial sectors, and the countries of origin and destination.

Technology transfers can also be evaluated in terms of the contribution they make to the development of a science and technology infrastructure in the recipient country. When research capabilities are expanded, when the numbers of trained scientists and engineers are increased in conjunction with the transfer, the technological capability of the nation may be improved. Development of institutions and centers for research and training is essential for deepening technology transfers in the long term.

Evaluating the Success of Technology Transfer

Evaluations of the overall success (the net costs and benefits) of a transfer depend on the broad policy goals and priorities of suppliers and recipients. Evaluation depends on the priority placed on various political, social, environmental, and economic goals, and on judgments about the past or potential impacts of transfers. As discussed in detail later in this chapter, suppliers and recipients alike weigh a number of factors in deciding whether to engage in technology transfers and in judging their success.

To expand the indigenous work force and to ensure fairness in technology transfer transactions, recipient governments introduce regulations. These may encompass ownership, control, local content, technology and output



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Solar energy research in Saudi Arabia involves researchers from the University of Petroleum and Minerals

pricing, and the ability of the recipient to transfer to third parties. Broadly speaking, the aim is to ensure that transfer will result in a self-sustaining capability for technological development. What is desired over the long term is thus not only a maintenance and production capability}', but also an indigenous technical capability to develop technology and a demonstration that particular projects contribute to achieving this goal.

Recipient governments and firms often select certain types of technologies because of other policy goals-–in order to develop particular economic sectors or because of a preference for labor- or capital-saving technologies. Political considerations may importantly influence choices of technologies and evaluations of success or failure. Planners in developing countries may evaluate technology transfer as problematic if production costs are substantially higher than estimates, if production machinery designed to conserve energy and labor is installed in a labor- and energy-abundant but capital-poor economy, or if equipment designed for large-scale operations is installed in a small factory and operated at high cost. On the other hand, recipients may judge a project successful if they see it as adding to national prestige, regardless of efficiency of operations.

At the supplier firm level, criteria of success may be much narrower than a full operational criterion. When a turnkey plant has paid off the cost, or when the risk has been passed to the government, the supplier is likely to consider the contract a success. This may occur years before the technology-receiving enterprise is fully self-sustaining, and is obviously even more true for equipment sellers whose responsibility normally ends when the goods are shipped.

In certain cases, where continuing supplier relationships are contemplated or where the reputation of the firm is at stake, the technology supplier may apply the full operational criterion. When ownership of the technology-receiving firm is involved, through joint ventures or other arrangements, profitability is an important criterion. In a multinational operation, the contribution to worldwide operations of output of the particular enterprise is also important.

Supplier country governments may or may not take a broader view than that of the firms. Technology transfers are often viewed as foreign exchange earners unless other foreign policy or employment considerations are at stake. When output from the technology-receiving enterprises abroad competes with the supplier country's domestic industries, successful transfer from an operational point of view might be considered unsuccessful from the supplier government's perspective. Similarly, projects supported by economic assistance may be judged successful if recipients are satisfied or, contrastingly, if certain goals of operational efficiency are met.

In other words, evaluations of the success of technology transfers depend on the ranking of these various criteria, 'technology absorption is one basis for evaluating the extent of transfers, but many other criteria can be applied in judging overall success. Evaluations can be based on recognizable effects or impacts which have already occurred, or on expectations about future effects. Generally speaking, when recipients are able to effectively use technologies which fit the requirements

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of a particular production process, they are likely to judge the technologies as appropriate.[4]

MEASURING TECHNOLOGY TRADE

Technology flows internationally through trade in machinery and equipment, investments, technical services, industrial rights, and contracts awarded. Taken together, these flows constitute international technology trade between suppliers and recipients. Such flows are only very imprecise indicators of technology transfer, but they are important in their own right because international transactions are reflected in trade balances between nations. Trade in technology is also important as the major mechanism for commercial technology transfer, and factors affecting trade also influence the technology transfer process, including technology absorption. The third section of this chapter identifies factors influencing general patterns of technology trade; chapter 4 assesses the extent and characteristics of Middle East technology trade during the past decade.

However, as important as international trade in technology is as a discrete topic, it must be distinguished from technology transfer, as used hereto include technology absorption or the development of recipient capability. In order for technology transfer to occur, technology trade (or provision of technology for free through development or other assistance programs) must take place. Technology trade is thus a necessary but not a sufficient condition for full technology transfer, including technology absorption.

Since technology is not measurable in any natural unit, measurements of technology flows (technology trade) are imprecise at best and provide only the roughest approximation of the resulting level of technology absorption. Nevertheless, international flows of technology in machinery and equipment, technical documents, patents and licenses, international contracting for large projects, and investments are the channels for technology transfer. Competition for these sales among various sellers is a characteristic feature of technology trade, and the positions of U.S. firms in the international market are an important concern for the U.S. Government.[5]

Problems with measuring international technology flows are significant and deserve attention. However, despite these difficulties, the various indicators can be judiciously used to assess international flows so long as their limitations are understood. Generally speaking, most of the various indicators include transactions other than those involving technology. In addition, the various indicators, such as equipment and machinery trade and contract awards, overlap.

Machinery and Equipment Imports

Perhaps the most easily accessible single indicator for technology trade is data on imports of machinery and equipment into recipient countries. This trade category includes capital goods, sometimes referred to as “engineering

[4]"Appropriate technology” has been defined variously as capital-savings technology, community technology, environmentally sound and appropriate technology, soft technology, and intermediate technology. For a discussion of appropriate technology and its definitions, see The *World of Appropriate Technology* (Paris: Organization for Economic Cooperation and Development, 1983), pp. 10-11.

[5]The “competitiveness” of U.S. firms is a complex issue. See *International Competitiveness in Electronics* (Washington, D. C.: U.S. Congress, Office of Technology Assessment, OTA-ISC-200, November 1983), for a discussion of competitiveness of U.S. industry that focuses on the domestic determinants. While analysts have measured competitiveness in terms of U.S. share of world exports, there is no agreement on an approach for analyzing U.S. competitiveness in international technology trade. One approach is to look at the competitiveness of “high-technology industries, ” meaning those involving a high level of scientific and engineering skills, those whose R&D effort is high relative to sales, *or* those with a rapid rate of technological development. See, for example, U.S. Department of Commerce, *An Assessment of U.S. Competitiveness in High Technology Industries* (Washington, D. C.: U.S. Government Printing Office, 1983).

Analysis of competitiveness also depends on whether one defines U.S. firms by ownership or location of production, or both. For a discussion, see Sumiye Okubo, *Impact of Technology Transfer on the Competitiveness of U.S. Producers,* paper submitted to the Economic Trade Policy Analysis Subcommittee of the Trade Policy Staff Committee, July 18, 1980, p. 6.

In this report, OTA examines factors affecting sales of technology and equipment, and trends in market shares of supplier firms.

products. "G As a data base for assessing technology trade, this category has several significant virtues: It is probably the most quantitatively complete indicator of technology flows, in that virtually all technology transfers involve imports of equipment recorded in the import accounts. It can be disaggregate to subcategories important for specific types of technology transfers (e.g., telecommunications equipment). Finally, these data reflect actual flows, rather than plans for project development.

However, these data also have significant limitations for analysis of technology flows. Even the finer subcategories group together many types of equipment, making it impossible to clearly distinguish "advanced technology product imports. There is, furthermore, no way to ascertain the number and types of users of the equipment, or the ancillary exports of industrial rights or human capital involved in particular instances of technology transfer. It is thus impossible to determine whether equipment is destined for an entirely new production facility or for an existing facility. Nevertheless, exports of machinery and equipment make up the largest single category of exports to the Middle East.

Technical Services

Balance of payments data also include a category for trade in services. The value of world trade in services for 1980 has been estimated at $350 billion, compared with $1,650 billion for merchandise trade. The United States was the largest exporter of services, with exports valued at $34.9 billion during that year.[7] However, aggregate data on trade in services include a number of elements (e. g., reinsurance, transactions by defense agencies, and passenger transportation) not normally included in civilian technology transfer.[8] Thus, despite the growing importance of service trade for the United States, and the importance of exports of technical services for analysis of technology transfer, there is no aggregate data source adequate for detailed analysis of service trades of particular types, such as technical services.

One recent study by the International Trade Commission carried out a survey of exporting firms in order to build a data base on trade in services.[9] The Office of the United States Trade Representative has also produced a report in support of efforts to promote liberalization of trade in this sector.

Contracts Awarded

Data on major contracts awarded, collected by trade publications, area valuable source of information on technology trade associated with large projects. These data have some advantages. They are organized by specific projects and therefore provide an indication of technology transfer "packages." They provide information about the context of the project; for example, the names of the principal investors and the prime contractor, and the value of the contracts. However, contract data also have glaring deficiencies from the perspective of analyzing technology flows. Since the data are gathered by private sources, such as trade journals, there is no way to be certain how complete the listings are. Even some large projects may escape notice, and many small contracts may be omitted.[10] In addition, the contract data usually do not give much information on the source of the equipment, nor do they identify even large subcontractors.

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[6] Machinery and equipment imports are recorded in Category 7 of the Standard Industrial Trade Classification (SITC), which includes two revisions. The United Nations publishes a Bulletin *of Statistics on World Trade in Engineering Products (New* York: United Nations, 1983), which includes trade in SITC Revision 2, Category 7. Categorizations of high-technology products, of which there are many, all include subcategories of SITC 7.

[7] Office of the United States Trade Representative, *U.S.* National *Study on Trade in Services,* December 1983, p. 111. It is widely believed that official data substantially underestimate the extent of service trade.

[8] For a discussion of service trade, from a national income and product accounts perspective, see Carol S. Carson, "Net Exports of Goods and Services, 1980-82, " *Survey of Current Business,* March 1983.

[9] International Trade Commission, The *Relationship of Exports in Selected U.S. Service industries to U.S. Merchandise* Exports (Washington, D.C.: U.S. Government Printing Office, 1982).

[10] "'Because the principals may wish to avoid public note, some projects may not be reported, or may be reported only in part.

It is thus difficult to measure with confidence the actual shares of various suppliers, since prime contractors from different nations may differ in their reliance on international versus own-country sources. Finally, contract data record commitments to proceed, not actual exchanges. Therefore, the import of goods and services associated with a particular contract recorded in one year may not take place for years to come, and in some cases, contracts may be altered or canceled and payments may be delayed.]'

Foreign Direct Investment

Investments abroad have been an important means of technology transfer worldwide. Since, by far, the greatest volume of transfers measured in royalties and license fees goes from U.S. firms to their subsidiaries abroad, foreign investment data are important as general indicators of potential technology flows. There are, however, significant limitations to the value of these data as a basis for analyzing technology flows. Data on U.S. direct investments are not disaggregated to show types of investments in all Middle East nations. U.S. investments in the region have been limited. The data reflect past technology transfers rather than current transactions.

In addition, these data do not indicate the magnitude of investment by joint venture partners. The reinvested earnings and other equity transaction data, which pertain to the current year, also do not necessarily indicate current technology transfers, both because they may reflect accounting oddities and because they may be invested in assets that have little to do with technology transfer, such as real estate. Data on the assets of affiliates and "new investment" are not complete or very current. Comparison of investment stocks and flows can be highly misleading, since the data on stocks may be more severely distorted by valuation problems.

Investments by Middle Eastern nations in firms in Western nations can also be a source of technology. However, available data indicate that such direct investments in the United States have so far been limited.[12] For example, some recipient firms have expanded their equity participation in Western firms in order to gain access to technology, managerial expertise, or markets. However, even if a foreign firm is purchased completely, it is not necessarily true that all of its technological capability is thereby transferred; some of its staff may depart and the operations of the firm may be changed.

Technology Licensing and Royalty Payments

Technology licensing and royalty payments are commonly used to measure aggregate international flows of technology transfer, but they are of limited usefulness in assessing transfer to developing nations. First, these data are not compiled on a sufficiently disaggregated basis to show receipts for sales in all developing nations, nor do the recipient countries provide accurate reports of payments. Not all relevant transactions are included in the data, since provision of technology in the form of cross-licensing or buy-back agreements is not recorded and those associated with joint ventures are often not systematically covered. Furthermore, these statistics record past as well as present payments for technology trade transactions.[13]

Technology transfer also occurs when supplier firms carry out research and development (R&D) activities in recipient countries. However, only about 7 percent of all R&D expenditures by foreign affiliates of U.S. multinational firms have occurred in developing

[11] Postponement in payments to contractors was reported during 1982-83 in the Middle East, when government revenues were below anticipated levels owing to the fall in demand for oil. See, for example, Michael Field, "Prudent Spending Puts Saudi Spending Back on Target," Financial *Times,* Aug. 18, 1983, p. 3.

[12] According to the Department of Commerce 1980 benchmark survey of direct foreign investment in the United States, total assets of nonbank U.S. affiliates of Middle Eastern foreign direct investors amounted to about $7.3 billion out of a total of $292 billion. See R. David Belli, "Foreign Direct Investment in the United States: Highlights From the 1980 Benchmark Survey," Survey of Current *Business,* vol. 63, No. 10, October 1983, p. 28.

[13] For example, the licensee may pay fees over a period of 5 years, but the major provision of technology may occur during the earlier period.

nations, and only a minuscule portion in the Middle Eastern nations. " U.S. subsidiaries in developing nations are the major source of payments-for royalties and fees made by developing nations: in 1978 their share totaled about 85 percent of all such payments.[15] Thus, among the limited transactions involving payments for industrial property by participants in developing nations, most occur between U.S. firms and their affiliates.

[14] U.S. Department of Commerce, U.S. *Multinational Companies: U.S. Merchandise Trade, Worldwide Sales, and Technology-Related Activities (Washington,* D. C.: U, S. Government Printing Office, 1983), p. 60.

[15] National Science Board, Science *Indicators—1980 (Wash*ington, D. C,: U.S. Government Printing Office, 1981), p. 26.

Technology also flows through noncommercial transactions, such as technical publications and documents, education of foreign students in the United States, government-sponsored technical assistance programs, and cooperation in science and technology. However, there is no authoritative source providing aggregate data on these activities and their contribution to technology transfer, and in many cases they overlap with commercial transactions listed above. A government-sponsored technical assistance project, for example, normally involves payments by the recipient government to U.S. firms and organizations carrying out the programs in-country.

FACTORS AFFECTING TECHNOLOGY TRADE AND TRANSFER

A variety of economic and political factors affect the international flow of technology to the Middle East. The discussion that follows briefly reviews these factors.

FACTORS AFFECTING RECIPIENT DEMAND FOR TECHNOLOGY

A nation's demand for the goods and services of technology trade depends on a complex set of factors. The basic determinants are the rate of economic growth and the nature of the economic structure. In addition, a wide variety of constraining factors limit technology absorption.

The following discussion reviews major elements in recipient country demand for technology, and points to crucial institutions as the key actors in technology selection, bargaining, and utilization in Middle East nations. An important theme is that firms in developing countries, particularly those that compete in world markets, often import technology in the form of "packages." By relying on packaged technology and expatriate labor, Middle Eastern countries faced with constraints to technology transfer (arising from limited technical manpower bases and other factors) can produce products competitive on world markets.

These firms and industries must promote development of indigenous skills in order to increase technology absorption over the long term. Firms producing goods and services for local or captive markets are often required by recipient governments to introduce training and other programs in order to expand the employment and improve the skills of indigenous workers. In firms which export, as well as those producing for local markets, policy makers in crucial institutions make key decisions about the type and volume of technology imports and their utilization.

Basic Economic Determinants

For nations of the Middle East, a major stimulus to technology importation in the last decade has been economic growth based on growing oil revenues. Annual growth in the gross domestic products (GDP) of the nations examined by OTA ranged from a high of 12.1

percent for Iraq, to 10.6 percent for Saudi Arabia, 7.4 percent for Egypt, 7.0 percent for Algeria, and 2.5 percent for both Iran and Kuwait during the 1970-80 period.[16]

While the situation changed in the early 1980's, economic growth in most of these countries during the previous decade was stimulated by the accumulation of surplus oil revenues. During the period 1973-80, four of these six Middle Eastern nations accumulated sizable current account surpluses. Table 1 presents this data.

For all these countries, total imports grew extremely rapidly during the period, ranging from a high of 25 percent for Saudi Arabia to a low of 3 percent for [ran in real terms on an annual basis during the 1973-82 period.[17] Furthermore, government revenues, which grew at rates well over 10 percent per year in these countries, were extremely large in comparison to GDP. In Saudi Arabia, an extreme case, the ratio of government revenues to GDP was almost 63 percent during the 1975-78 period.[18] The basic economic determinants, as well as patterns in technology trade during the past decade, are analyzed more fully in chapter 4.

Generally speaking, economic growth engenders an increasing demand for technology, both in existing enterprises (to expand production) and in new industries and services. Technology imports thus reflect not only the nature of the economic structure, but also planners expectations about the economy, including strategies about production for export or for local markets. Among developing countries, the oil-producing countries of the Middle East were in a unique position to rapidly expand their imports of technologies during the 1970's. However, the six Middle Eastern countries focused on in this report possess widely varying capital, human and natural resources available to support technology transfers, as discussed in chapter 3.

[16] World Bank, *World Development Report, 1982,* pp. 112-113, Data for Iran includes the revolutionary period in 1979 and 1980. Kuwait's comparatively low growth rate reflects falling oil production during the period.

[17] Data provided in table 13, ch. 4.

[18] International Monetary Fund, Oil *Exporters Economic Development in an Interdependent World,* April 1983, p. 45. Data on government revenues do not include Egypt.

Table 1.—Cumulative Current Account Balances, 1973-80: Six Middle Eastern Countries (million U.S. dollars)

	Total
Saudi Arabia	-140,697
Kuwait	68,996
Iraq	41,252
Iran	34,481
Algeria	**-9,700**
Egypt	-10,248

SOURCE International Monetary Fund Oil Exporters *Economic Development* In an *Interdependent World* April 1983, p 21

Constraints on Technology Transfer

Despite the growth in imports of technology, a number of factors constrain the capacity of developing nations to utilize it. With the exception of Israel, most Middle East countries, irrespective of their gross national products, have limited science and technology infrastructures. In such countries, there may be a shortage of technical and managerial skills, owing to inadequate education, training, and research institutions, or to small enrollments in very new institutions. While leaders (including government officials and industrialists) may be extremely well educated, the labor force as a whole is generally inadequately trained in the skills required for operation of complex production facilities. A related problem is that labor markets may fail to provide the incentives (monetary and otherwise) needed to attract and retain properly skilled workers.

In some countries, public infrastructure services, such as electric power, transportation, and communications, are unreliable and thereby inhibit development of new industries and services. Expansion of infrastructure itself requires technology transfers and considerable investment of resources.

Social and cultural values also come into play. Tasks such as replacing spare parts imported from abroad, ordering custom parts to specification from local machine shops, building additions to manufacturing facilities, alter-

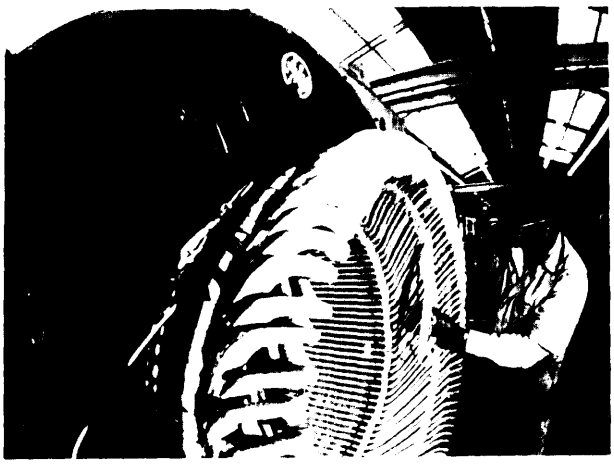

Photo credit: *U. S. Overseas Private Investment Corp*

Mideast Engineering, partially owned by the General Electric Co., provides maintenance and repair services as well as technical training in Saudi Arabia. This IS a project Insured by the U S Overseas Private Investment Corp.

ing materials handling procedures to fit local conditions, or simple troubleshooting adaptations of procedures or technologies needed to get operations going after a breakdown, are difficult enough in a developing country. Where social norms emphasize authority rather than procedures, or where operations and maintenance skills are not valued, it may be extremely difficult to solve these routine operational problems.

Enterprises using imported technology are sometimes inhibited by government regulations. When spare parts sit for months in congested ports and customs areas, when permits required for minor construction are given only after long delays, and when seniority regulations require the retention of incompetent employees, the manager may find it difficult to acquire or properly utilize technologies imported from abroad. Price and economic regulations designed to produce "orderly markets" or to protect consumers may create distortions that hinder operational efficiency.

The major challenges for developing countries that have limited science and technology bases are to operate and maintain properly the technology imported from abroad. These nations usually have isolated successes in technology transfer, but failures are not uncommon. Generally speaking, the number of local manufacturing enterprises is small, and these countries often depend on agriculture or natural resource exports, tourism, or foreign assistance for foreign exchange. In some cases, a significant pool of scientific and technical manpower may be unemployed, causing "brain drain" or labor migration.

Policymakers in these countries seek to promote indigenous technological development so that the country can produce internationally competitive goods and services. Setting their sights on higher levels of economic, technological, and social development, variously defined, their goal *is* to enter the ranks of the newly industrializing countries. This involves installing a reasonably reliable physical infrastructure, promoting the growth of labor markets, and developing a capability in many productive enterprises not only to operate and maintain facilities, but also to adapt technology to changing market demand. For example, local engineers should eventually gain the capability to design new products which can be produced with existing or adapted technology.

Crucial Institutions and "Transfer Packages"

In developing nations, particularly those with limited indigenous technological capability, the crucial institutions involved in technology transfer are normally large, government-owned or strongly government-led organizations. These include government ministries and public enterprises. These institutions–because often they, alone, have the necessary resources–lead the process of technology transfer that results in the establishment of new production facilities.

Initially, these institutions concentrate their efforts on large-scale infrastructure projects—roads, ports, dams, large office buildings and hotels, electric power grids, central communication facilities, and airports-usually built by international contractors hired by government agencies or by multinational corporations. Sometimes the government organization is an

autonomous agency, such as the Suez Canal Authority in Egypt, but often it is a section of a government ministry. The multinational firms may be minerals extraction firms, like ARAMCO in Saudi Arabia, or international food-processing firms.

The primary reason for the predominance of strong institutions is that only they are likely to have the resources (including financial resources, as well as political clout) needed to carry out large-scale importation of advanced technologies into nations with limited indigenous capabilities. These institutions often rely on technology transfer "packages" and expatriate labor in order to maximize the success of firms that produce for competitive, particularly world, markets.

Key features of transfer packages are that substantial process technology is embodied in the hardware (making it comparatively easy to use and maintain) and that considerable technical and managerial assistance is pro-

Photo credit U S *Overseas Private investment* Corp.

Suez Electronics, an affiliate of the International Telephone & Telegraph Corp., provides routine checks, maintenance, repair, and replacement for a broad range of electronic equipment as ships pass through the Suez Canal, The project is insured by the U.S. Overseas Private Investment Corp.

Photo credit Agency for Internaf/onal Development

The Suez Canal is over 100 years old and handles an average of more than 200 ships a day, generating nearly $1 billion annually for Egypt in foreign exchange revenues

vialed in conjunction with the transfer. Such assistance may take the form of high-level management and technical personnel supplied on a continuing basis as part of a joint venture or subsidiary, or technical and management contracts let by an independent enterprise. Alternatively, assistance may consist of a quality-validation team sent by the equipment supplier under an offset or trademark agreement. A major feature of technology transfer packages is that they minimize the amount of technology absorption required and augment indigenous capabilities with technical assistance from abroad.

It would be a mistake, however, to conclude that transfer packages eliminate altogether the need for technology absorption. In fact, a number of factors may stimulate the need to develop indigenous capabilities. It may be necessary, for example, to change products or volumes of production to fit fluctuations in demand. In addition, managers may find it necessary to alter production processes to take advantage of low-cost materials or to take account of shortages in some kinds of inputs. These factors increase the need for adaptation of technology by the enterprise. The firm may rely on new technical assistance contracts, but some local personnel may also be involved in diagnosing the problems, selecting contractors, or (later) adapting technology.

For firms serving international markets, these demands for technology adaptation are likely to be especially strong. After initial market success, firms may find it necessary to expand the scale of production or alter processes. The urgency of such demands maybe particularly great when the firm is competing with world-class manufacturers from other nations. In many cases, the requirements for technology adaptation may be so high that the enterprise has no alternative but to rely extensively on foreign technical and managerial expertise.

In contrast, firms producing goods and services for local or captive markets may find these demands less pressing, at least in the near term. In some instances, the strong institutions primarily involved in technology transfer may not be particularly efficient by international standards. Nevertheless, their existence is more or less guaranteed. Such enterprises may be required by the government to employ all, or great percentages of, local employees, and to introduce training and other programs for improving the skills of indigenous workers. This is not to say that firms producing for local markets are always less efficient than those producing for export; the nature of markets and the orientations of the firms vary.

Indeed, the capabilities of work forces to operate and maintain facilities may be improved substantially over time in firms producing for local markets, though not necessarily to the levels required for some of the firms producing for export. Because such firms are often government enterprises, their dilemma is that expansion of employment (normally promoted in labor-rich nations such as Egypt) may jeopardize operational efficiency.

Even strong institutions importing technology in packages, however, face difficult problems. They may lack the expertise necessary to make good choices of technology and to negotiate good terms. Inadequate labor markets hinder recruitment, or the criteria for selection may be so “political' that even the available skills are underutilized. In infrastructural enterprises, there may be excess demand for the services provided. These enterprises may be overstaffed, and their services may be priced below costs of production. Strong institutions may continue to operate for years in such a fashion, presenting formidable problems for leaders wishing to introduce economic and operational reforms.

Often independent local firms make smaller contributions to manufacturing production than the large government-run enterprises. Be cause the barriers to importation and use of advanced technologies are overwhelming for such firms, private firms need local political support; government policies are often introduced to promote their growth. As the number of such firms grows, and as they compete for shares of local markets, their requirements

for technology adaptation increase. Increasingly concerned with price, quality, and marketing, the independent local firms are in that situation challenged to improve their capabilities, which they sometimes accomplish by establishing joint ventures with foreign firms.

The relationship between public and private sectors in developing nations is often a subtle and interdependent one. Policymakers in developing nations often stress the importance of private sector firms in industrialization. Nevertheless, industry remains largely under government control, and private firms are, in many instances, closely associated with government ministries. The private industries may be heavily concentrated in a few sectors and function to produce for small local markets.[19]

Regardless of whether the recipient firm is private or state-owned, its need for technology adaptation increases with expanded production of goods and services, particularly when firms serve competitive markets-international or domestic. Strong institutions play central roles in technology transfer in developing nations, but they are often unable to operate efficiently, much less to build a capability for self-sustaining technological adapation among their work forces.

FACTORS AFFECTING SUPPLY OF TECHNOLOGY AND COMPETITION AMONG SUPPLIERS

The primary factors affecting supply of goods and services of technology trade are the same economic (including the skill of individual firms in marketing their products and services) and political factors that influence international trade more generally.

Economic Factors Affecting Supply of Technology

Economic theory provides methods for analyzing why some suppliers succeed in selling technology and equipment in developing countries. The traditional theory of what determines the composition of a country's exports and imports, the factor-endowments theory, holds that a country exports goods and services whose production is intensive in the resources it has in abundance. In the United States, human capital, defined as the productive abilities of the work force over and above "raw labor, " is now seen as a factor the United States has in relative abundance. Human capital is developed through education and training. It resides not only in individuals, but also in technology-blueprints, technical manuals, computer programs-and in the know-how embodied in functioning organizations. Empirical research has demonstrated that the United States exports goods and services more intensive in human capital than those we import.[20]

Although many suppliers are theoretically in a position to provide particular types of civilian technologies to buyers in the Middle East, there is a tendency for a small number of specialists to emerge. Comparative advantage and product cycle theories provide partial explanations for this specialization.

Comparative advantage is a theory which can be used to explain why particular countries export some types of goods and services and import others. The basic idea is that firms of a country export the goods and services produced with relative efficiency. (Relatively efficient production involves large amounts of the productive factors that are comparatively abundant and cheap in the country's economy.) Conversely, importers tend to import goods and services that are produced with less relative efficiency. Comparative advantage is normally visible in lower costs and prices for goods and services.

[19] See Charles Issawi, *An Economic History of the Middle East and North Africa (New* York: Columbia University Press, 1982), discussion of Middle East industrialization, pp. 159-169.

[20] See Gary C. Hufbauer, "The Impact of National Characteristics and Technology on the Commodity Composition of Trade in Manufactured Goods, in *The Technology Factor in World Trade,* Raymond Vernon (cd.) (New York: Columbia University Press, 1970). See also Robert E. Baldwin, "Determinants of the Commodity Structure of U.S. Trade, *American Economic Review,* vol. 61, No. 3, March 1971, pp. 126-46. This research helped to unravel the "Leontif Paradox, " which stated that U.S. manufactured goods exports are, contrary to expectation, less capital-intensive than its imports.

One implication of this theory is that, as the comparative advantage of the most competitive firm (e.g., a supplier of technology and equipment to the Middle East) narrows, other factors like government policies may become more important in influencing market competition. In such a situation, the ability of firms to win sales in export markets maybe affected strongly by factors such as supplier government policies, in addition to the production efficiency of the firm itself.

In addition, the theory helps to clarify the fact that U.S. firms compete among themselves for exports. Therefore, a U.S. firm that efficiently manufactures technologically advanced equipment in comparison to counterparts in Western Europe or Japan (as measured in output per man hour, or other indicators of productivity) may nevertheless not export much of this equipment if there are other U.S. firms which are even more efficient producers. At the product level, it is the firms that build up comparative advantage. Because of this, it would be difficult to predict the location of the most competitive firms solely on the basis of country characteristics.

Another way to approach the question of supplier competition is through consideration of the product cycle. Basically, when the embodiment of technology in goods, machinery, people, organizational units, and systems becomes standardized, it becomes transferable to countries that provide appropriate complementary factors at lower cost. This is observable on a product-by-product basis. First, offshore production of some components occurs, followed later by full production overseas of products that were once manufactured in the originating country. This pattern has been noticeable in textiles and consumer electronics, as developing countries have become the major producers, and the industrial nations, the importers. The newly industrializing countries thus gradually gain comparative advantage in certain product lines.[21]

[21] G. K. Helleiner, "The Role of Multinational Corporations in the Less Developed Countries' Trade in Technology, *World Development, vol. 3, No. 4,* April 1975, p. 167.

Both comparative advantage and product cycle theories point to the fact that U.S. firms in many cases no longer hold a strong comparative advantage in exports of machinery and equipment over firms in other industrial countries or even over firms in the newly industrializing countries. In the advanced-technology sectors examined by OTA in this study, there are often many suppliers in Western Europe and Japan producing comparable equipment efficiently. Thus, while one important factor influencing competition in the Middle East market is which firms produce at lowest costs, many other factors in practice come into play and it is often difficult to determine which are operating a particular case.

One way to gauge competition among suppliers is to look at market shares of firms from various nations. A rise or fall in the market shares of U.S. firms should not, however, be simply equated with gains or losses in competitiveness; market shares reflect a variety of other factors. First, some third country markets reflect strong historical or colonial ties to certain suppliers-Japan in Southeast Asia, the United States in Latin America. Second, if demand in the particular market is for more standardized goods and services, the U.S. suppliers would not necessarily be able to supply the demand at the lowest cost. Third, in some sectors such as telecommunications, where standards are particularly important, the initial selection of equipment may help determine which firms will be in the best position to provide follow-on equipment and services.

Finally, the over- or under-valuation of a supplier nation's currency will strongly affect exports, regardless of the productivity and efficiency of particular firms and industries. These effects may be strong in the short run, but over the long term their impact on the overall export competitiveness of nations should diminish.

Corporations compete for sales in a number of ways. Those with unique technological advantages or very efficient manufacturing processes are in a good competitive position, other things being equal. In distant third country

markets such as the Middle East, the ability of supplier firms to market their goods and services may be particularly important. The costs of opening a branch office overseas may be considerable, and a new-to-market firm may be discouraged from selling abroad, particularly in unfamiliar markets. For many U.S. firms, such as those producing telecommunications equipment, the domestic U.S. market has traditionally been so large that many did not see the need to export to distant markets. Corporate strategies, therefore, are often the critical factors influencing the resources that a firm puts into marketing overseas.

In the Middle East, where many recipient countries face constraints in technology absorption, the willingness of supplier firms to put together technology transfer packages, including after-the-sale service and training, may also affect supplier competitiveness. Individual firms, moreover, may develop unique strategies that set them apart from other national firms. The U.S. hospital management firm Whittaker, for example, developed a strategy focusing specifically on the Middle Eastern market. Finally, willingness to participate as joint venture partners may also help firms to win contracts of certain types in some Middle Eastern nations, such as Saudi Arabia, where such partnerships are encouraged in order to expand technology transfers, among other reasons.

Political and Other Factors

Political factors often strongly influence technology trade in developing-country markets. At the most general level, long-term political relations between recipient and supplier nations (including antagonisms as well as alliances) shape the overall context within which technology trade occurs. Close political relations or alliances between supplier and recipient countries set a context conducive to technology transfer, investment, and involvement of supplier country firms. Likewise, recipient governments may attempt to reduce trade with supplier countries whose political perspectives on issues such as the Arab-Israeli conflict differ sharply with their own.

On the recipient side, contract selection for large projects may be highly politicized, and in such cases the preferences of host-country actors in influential positions may be important determining factors of supplier competition. Recipient country regulations (e.g., performance and local employment requirements) may make it easier for certain firms to win contracts.

Supplier governments also attempt to compete by assisting their own firms in a number of ways, including representing business interests abroad, negotiating on behalf of national firms, providing important market information, and enacting industrial policy measures, such as subsidies for their research activities. In addition, supplier governments can assist exporting firms by providing export credits and insurance guarantees that reduce the cost and risk to domestic firms of overseas business activities.

Since the end of World War II, an international trading regime has been established to ensure fairness in competition. The aim has been to eliminate government regulations which provide disproportionate advantages to some firms (usually national firms) over others. As a result, while direct barriers to trade have been reduced, up until recently few specific actions had been taken to affect supplier government subsidies.

The General Agreement on Trade and Tariffs (GATT) subsidies code and the Organization for Economic Cooperation and Development (OECD) arrangement on officially supported export credits are quite new and not fully tested, but their aim is to set ground rules for government subsidies. These agreements are likely to have their major effect through a combination of negotiation and deterrence, because in both cases there is incomplete coverage of countries, specific exclusions, lack of remedies, and weak enforcement. Nevertheless, such agreements do set standards for official subsidies against which deviations can be assessed. No agreements cover international trade in services-including construction, engineering, and management services—

though exploratory discussions have been held.

Only since 1982 have the minimum interest rates established under the OECD arrangement been close enough to commercial rates to make much of a difference. A large loophole remains regarding sales to developing nations: the guidelines established are not valid when soft financing is offered under the guise of official development assistance (ODA).[22] In such cases, called "mixed credit, " official export credits are used in conjunction with concessional financing permitted for development assistance. OECD nations have discussed proposals supported by the United States to establish an agreement on mixed credits, but no agreement has been reached,

To summarize, despite recent efforts to eliminate unfair subsidies, in practice supplier governments determined to support their exporting industries employ a variety of direct and indirect mechanisms.

Perhaps least susceptible to international agreement are the policies which indirectly affect international technology trade included under the general category of domestic industrial policies of supplier nations. Tax benefits, R&D subsidies, and procurement practices favoring domestic firms may be used to support export industries. Government-owned telecommunications firms in some supplier nations are in a particularly good position to receive indirect supports of various types.

All industrial nations have such policies that affect international technology trade; however, it is technically difficult to measure the subsidy element and politically difficult to build a consensus concerning rules of the game. As discussed in chapters 12 and 13, the types of assistance that various Western nations provide to exporting firms reflect differing traditions of government-business relations. In some cases, the large state-owned or strongly government-led firms (particularly telecommunications firms) are the major exporters of equipment and services to the Middle East, heightening the political dimension of large contract awards.

Theoretically, competition among suppliers is determined most importantly by the ability of individual firms to efficiently produce goods and services, as compared to their competitors (including both foreign and other national firms). However, in practice, other factors come into play, particularly in situations where no firm has a clear--cut cost advantage based on the efficiency of its production, and where many firms are in a position to supply roughly equivalent technology. Analysis of competition among suppliers for sales of technology must take this wide range of factors into account.

[22] In order to qualify as official development assistance, the grant element of the loan must be greater than 25 percent of the total. The grant element reflects the financial terms of the transaction: interest rate, maturity, and grace period. It is a measure of the concessionality of the loan. To calculate this benefit, the present value at the market rate and the length of time the funds are available to the borrower are determined. The "grant element" of the loan is the excess of the loan's face value over the sum of these present values, expressed as a percentage of the face value.

TECHNOLOGY TRANSFER: THE POLICY ISSUES

Technology transfer, from the perspective of a policy maker, holds tremendous promise, but also potential problems. The opportunities and the pitfalls are particularly salient when technology flows from developed to developing nations; the stakes are high for recipient governments initiating new and highly visible projects involving the introduction of sophisticated technology imported from abroad. For the supplier, potential losses include grow-

ing resentment about projects that have failed, which may, in extreme cases, jeopardize foreign relations with suppliers.

Technology transfers raise difficult choices for policy makers in recipient and supplier countries because it is impossible to anticipate all the future consequences or even trace the effects of past technology transfers. Because technology transfer normally occurs in the context of economic development projects, it can be viewed as a facet of the development process. Because it is related to other trends such as urbanization, economic growth, improvement in living standards, and political and social change, it is usually difficult to distinguish the discrete effects of technology transfer at the national level.

Because their potential gains and losses differ, recipients and suppliers-whether they be governments, private enterprises, organizations, or individuals-inevitably evaluate the costs and benefits of particular technology transfers in different ways.[23] Recipients and suppliers alike-forced to make choices in a context of inadequate information, experience, and capacity for anticipating results—may seek to maximize political and other goals rather than ensuring the success of technology transfer. Policy choices affecting technology transfer often reflect political compromises, foreign policy aims, and social values. The purpose of this section is to outline briefly the generic choices policy makers face as they seek to affect technology transfer.

RECIPIENT POLICY ISSUES

For developing countries, technology transfer involves learning and applying technologies imported from abroad, commonly from the industrialized nations. The Islamic countries of the Middle East have had historic ties to Europe and were among the last to experience Western colonialism. What distinguishes the region is that the end of the colonial period coincided with the discovery of oil wealth in some of these nations, providing them with unique resources for economic growth and technology transfer.[24] The oil-importing, developing nations of the region have also been affected by these developments through remittances earned abroad by their citizens, Arab economic assistance, and political-military developments in the region. However, the per-capita GNP of most developing nations remains well below that of the major oil-exporting nations.[25] For policymakers in all of these countries, however, the central question is how to use Western technology to speed economic growth and attain social prosperity and, at the same time, preserve their political legitimacy and avoid clashes with traditions.

Selection of Technologies

To recipients, a critical problem is the selection of technologies needed to attain development objectives. Technology transfer will "work" for the recipient only if the recipient knows what to ask for and if the foreign supplier is willing to provide it. Disappointment with foreign firms in technology transfer often results when the recipient does not possess the knowledge or experience needed to define requirements. In such cases, the foreign partner may meet its obligations, but the level and type of transfer may not meet recipients' expectations.

Theoretically, technology selection should fit in with a broad range of policy concerns: economic growth, international trade, and environmental, labor, and social policies. However, because policies are rarely well defined and consistent across these areas, the problems of selection are significant. A group of Kuwaiti policymakers have characterized the problem as follows:

[23] See Joseph S. Szliowicz (cd,), *Technology and International Affairs (New* York: Praeger, 1981). See also Henry N. Nau, *Technology Transfer and U.S. Foreign Policy (New* York: Praeger, 1976), for a discussion of national perspectives on technology transfer.

[24] Dankwart A. Rustow, "Modernization, Oil and the Arab Countries, " *Arab Resources: The Transformation of Society,* I. Ibrahim Ibrahim (cd.) (Washington, D. C.: Centre for Contemporary Arab Studies, 1983).

[25] Egypt's per capita GNP in 1981 was $650, while Kuwait's was $20,900, according to World Bank figures. *World Bank Development Report—1 983* (London: Oxford University Press, 1982), p. 148.

> Developing countries should be selective in the type of technology they choose to meet a prescribed set of objectives and criteria. The choice of technology should be made with a view to enhancing their resource base, to suit their socio-economic setting, and to be consistent with their natural endowments (capital- versus labor-intensive). It should also meet certain environmental constraints, promote self-reliant development, strengthen indigenous research capability, and lessen technological dependence. [26]

Considering their varied resources, it is natural that Middle Eastern countries have chosen different paths to development. The Gulf States, rich in oil and gas and small in population, have made the hydrocarbon sector the focus of development. Saudi Arabia's First Five-Year Plan, for example, outlined a strategy for using oil wealth to purchase advanced technology in order to diversify the economy .[27] The question is how far diversification into steel, aluminum, and petrochemicals should be taken.[28] Some of the new heavy industries in the Gulf, such as steel, are locally marketed, while new petrochemical plants will serve export markets. Technology transfer decisions are interrelated to choices about the type and speed of development, including export and import substitution strategies.

The choices Egypt faces are strikingly different. With limited natural resources and capital, Egypt nevertheless has a wealth of human resources. Egypt's engineering and medical schools date back to the early 19th century. By 1960, the country had twice as many university students as Britain. By 1970, it had twice as many university students among Third World countries as would have been expected, given its industrial infrastructure. " Enjoying a large population and a comparatively high proportion of technically educated people, Egypt's challenge is to use these human resources fully, particularly in industrial development.

Policy makers in different countries may reach different conclusions about what technologies are most "appropriate," even if the national resources are comparable. Considerable attention has been paid to the potential uses of intermediate, small-scale, labor-intensive technologies by developing nations. Technologies have been defined by theorists as "inappropriate' for a number of reasons–such as failure to utilize local materials, to adapt to local markets, or to introduce suitable scale of production.[30] However, in practice policymakers determine the appropriate mix of technologies; and the long-term environmental, social, and other effects are often insufficiently considered.

Public and Private Sectors

Technology transfer also raises questions about the relationship between public and private sectors in developing nations. As discussed earlier, government ministries play central roles in making up development plans, thereby influencing the growth of the private sector. Public corporations, such as the ministries of health and telecommunications, are usually the critical institutions requiring imported technologies. In many instances, government officials plan and implement technology transfer to developing nations.

Successful transfer implies a degree of operational efficiency that is, in some cases, constrained by the presence of a large bureaucratic public sector. Such problems can be traced to high government salary scales, which draw

[26] K. Behbehani, M. Girgis, and M.S. Marzouk, "The Role of Science and Technology in Kuwait 's Development: An overview, ' *The Symposium on Science and Technology For Development in Kuwait*, Behbehani, et al. (eds.) (London: Longman, 1981), p. 2.

[27] Fouad Abdul-Salam Al-Farsy, " King Faisal and the First Five Year Development Plan, *King Faisal and the Modernization of Saudi Arabia*, Willard A. Beling (cd,) (London: Croom Helm, 1980), p. 63.

[28] Abdullah al- Kahlifa of the Bahrain Industry Ministry articulated the question in May 1983, when he asked: "our declared aim is to diversify an oil-based economy. But are we doing the right thing? 1s industrialization real, or is it a gold rush? See " Persian Gulf Industrialization. *New York Times*, May 23. 1983, p.D6.

[29] Clement Henry Moore, *images of Development: Egyptian Engineers in Search of Industry* (Cambridge, Mass.: MIT Press, 1980), p. 4.

[30] "Simon Teitel, "On the Concept of Appropriate Technology' for Less Industrialized Countries," *Technological Forecasting and Social Change*, vol. 11, 1978, pp. 349-369.

qualified technical people from the private sector without using their talents effectively, to the need to reward political allies, and to the lack of experience of government officials with the actual workings of industry. As a general rule, where the public sector completely overshadows the private sector, technology transfer choices may be taken without sufficiently involving those who will use the technologies. As discussed in chapter 11, there is a wide range of variation in the capabilities of government institutions in these countries, but improving efficiency has been a goal in all of them.

All of the Middle Eastern nations studied, including Saudi Arabia as well as war-torn Iraq, have announced plans to promote the growth of private sector firms and organizations in an attempt to liberalize their economies and enhance market operations. In many instances small private firms interact with and are dependent on public sector ministries for special treatment, including protection. Development of private sector firms may promote efficient use of imported technologies over the long term, but significant change in public/private sector roles may involve challenges to vested interests in public sector corporations and agencies.

The Egyptian experience illustrates problems accompanying attempts to introduce changes. Egypt's decision in the early 1970's to promote an "open door" policy for encouraging the growth of the private sector followed years of centralized planning by the public sector. However, despite the open door, the private manufacturing sector has grown slowly. (In ch. 8 the relationship of public and private sector health care enterprises in Egypt is discussed and problems relating to technology transfer are identified,)

Recipient Firms and Foreign Suppliers of Technology

In the Middle East, recipient governments have expanded regulations which help to determine the relationship between recipient firms and foreign suppliers of technology. This is analyzed more fully in chapter 11. For example, some nations encourage foreign investments through special tax policies, including free zones. Egypt's Law 43 is designed to provide incentives for the import of modern capital-intensive technologies. Saudi Arabia has encouraged the formation of joint ventures with foreign firms because these are viewed as a prime avenue for technology transfer. This approach is based on the idea that if a foreign firm is committed over the long term, successful technology transfer is more likely to result than if the firm is interested only in exporting goods. Kuwait, in contrast to Saudi Arabia, has favored a nationalization policy that stresses direct acquisition of foreign firms.

Related to these choices are larger questions about whether to pursue a strategy of technological "self-sufficiency," involving a stress on indigenous technology mastery, or to plan for long-term involvement of foreign suppliers. Laws governing investments, patents, licensing and trademarks, resolution of settlements, and trade affect the type and duration of relationships formed with foreign suppliers.

Similar decisions are made, explicitly and implicitly, concerning the role of foreign governments as suppliers of technology through development assistance and other programs. Participation of the foreign government may be extensive–in planning a technical assistance project, staffing it, and evaluating its success. Recipient countries have sometimes complained that they have insufficient opportunity to set priorities and to participate fully in such development assistance programs. In contrast to lower-income developing countries, Gulf States such as Saudi Arabia and Kuwait receive no development assistance and have become major donors themselves. Such countries may purchase technology directly from private firms abroad or enlist foreign government involvement through technical assistance projects.

In addition, developing countries have attempted to cooperate in addressing questions of relations with technology suppliers, particu-

larly multinational firms. For a decade, developing nations have pressed for the establishment of a code to regulate international technology transfer. Access to science and technology was a primary aim of the New International Economic Order, inaugurated by the U.N. General Assembly in 1974. Developing countries argued that they were unable to bargain effectively with suppliers–that technology was too costly and that the terms of the arrangements were too restrictive. The draft International Code of Conduct on the Transfer of Technology has still not been approved.[31] Although preparation and negotiation of a draft code has continued through the fifth session of the United Nations Conference on an International Code of Conduct on the Transfer of Technology (November 1983), there appears to be little prospect of agreement in the near future.

In addition, a number of multinational conferences sponsored by various U.N. agencies and international organizations have focused on regional technology transfer problems.[32] The U.N. agency UNIDO, for example, is attempting to establish a system for monitoring technology flows in developing nations, through its Technology Exchange System and its Technological Advisory Services.[33] The more narrowly defined efforts of UNIDO and other specialized U.N. agencies have contributed to a greater understanding by developing countries of the problems of technology transfer, particularly the legal issues.

In contrast to the U.N. negotiations that involve a wide spectrum of countries, Middle Eastern nations have also established regional organizations that attempt to improve the capabilities of member states to acquire and bargain for Western technology. Such regional organizations date back to the formation of the League of Arab States in 1945.']4 Many of the more than 400 joint Arab projects actually involve only limited cooperation among member states, and some are virtually inactive.[35]

However, regional organizations such as the Gulf Cooperation Council (GCC) have recently made significant progress in economic cooperation. In December 1982, the GCC countries signed a unified economic agreement that included coordination on tariffs. Other specialized organizations, such as the Gulf Organization for Industrial Consultancy, have worked to improve the ability of member nations to select and use technology. The Islamic Development Bank has established an Islamic Research and Training Institute which aims to improve technology transfer, particularly through increased reliance on local consultants.[36] At present, there is strong interest in technology cooperation among Middle Eastern nations, but defining relations with foreign suppliers ma-y be difficult for organizations with varied membership.

Promotion of Technology Absorption

Another set of choices for recipient countries concerns promotion of technology absorption. Recipient governments have an interest in ensuring that indigenous capabilities are improved—that technology is absorbed or mas-

[31] Dennis Thompson. "l'h'UNCTAD Code of Transfer of Technology," *Journal of World Trade law,* vol. 16, No. 4, July August 1982 (l NCTAD held a general conference June 6-30, 1983, and prior to the meeting, Third World countries called on the conference to improve data on technology transfer, and to explore the possibility of drafting international standards on marketing, promotion, distribution, trade, and technology?' in pharmaceuticals. The United States and other developed nations were criticized for not participating sufficiently' in efforts to speed technology transfer to developing countries. See U.S. *Import Weekly,* May 25, 1983, pp. 301-302. See also Pedro Roffe, " UNCTAD: Transfer of Technology Code, ' *Journal of World Trade Law*, vol. 18, No. 2, March/April 1984, pp. 176-182 for a review of out standing issues of debate.

[32] ECWA (United Nations Economic Commission for Western Asia) has attempted to improve understanding of problems related to technology transfer in various manufacturing sectors of this region developing nations.

[33] UNIDO Secretariat, "Overview of Selected Problems of Technology Transfer to Developing Countries, " UNIDO/LES Joint Meeting on Problems of Licensing Into Developing Countries, Vienna, Austria, June 22, 1982.

[34] See Elias T. Ghantus, *Arab Industrial Integration: A Strategy for Development* (London: Croom Helm, 1982), for a review of the arguments concerning the economic benefits of regional integration,

[35] Yusif A. Sayigh, "A New Framework for Complementarity Among the Arah Economies," *Arab Resources: The Transformation of a Society,* 1. Ibrahim Ibrahim (cd.) (London: Croom Helm, 1983).

"Islamic Development Bank, ' 'The Transfer of Technology and the Role of Development Financing Institutions and the Consulting Engineers," paper, 1983,

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tered. Technology absorption is important for the user firms, and because it can contribute to the national science and technology infrastructure needed for society-wide development.

The desire to use foreign technology effectively, without relying completely on foreigners, leads to difficult choices about manpower. Saudi Arabia's King Faisal, like other Middle Eastern leaders, worried about massive infusions of Western technology:

> It is within our power, for example, to erect an enormous plant-but can we run the plant properly or get the desired results from it? In my opinion, it is far better to equip ourselves with the ability to do things on our own without relying on foreigners or on anyone else.[37]

Particularly in sparsely populated Middle Eastern countries, manpower constraints affect the extent of technology absorption. The Kuwait Ministry of Planning has forecast a shortage of skilled workers .38 Kuwait and other Gulf States have made manpower development a high priority, but reliance on foreign workers will continue for years. There is an ample supply of Egyptian, Palestinian, and Asian workers and during 1983, when oil revenues fell, many of them were sent home. Many countries have used foreign consultants and laborers in the process of industrialization—Japan learned from foreign advisors after the Meiji Restoration, and foreign laborers helped build American railroads and run U.S. industry.

A critical question for Middle Eastern countries is how much to rely on foreign labor, particularly for professional and managerial positions. Related, of course, are issues concerning citizenship rights of foreign workers and the status of women workers. The presence of foreign labor, in itself, may not be a major problem, but related issues of indigenous skill development and efficiency of operations are certainly affected by the foreign labor mix.

These are issues of considerable controversy for Middle Eastern policy makers; rapid "indigenization" programs are costly in the short term, but complete and long-term reliance on foreign workers certainly limits domestic technological development. However, the short-term costs of inefficient production are also great, and in practice, these choices require balancing long- and short-term objectives and setting priorities for manpower development.

Technological development at a national level requires building an institutional infrastructure. This base is needed to incorporate technical, commercial, managerial, financial, and research expertise so that technical know-how will reach the users. Firms in developing countries often have limited abilities to diagnose problems or to select and fully utilize technologies. As a result, operations and maintenance of facilities are often neglected, and equipment is underutilized, or even wasted. A local technical and managerial infrastructure is thus essential for technology transfer.[39]

Foreign Policies

Decisions about civilian technology transfer affect and are affected by foreign policies. Acquisition of advanced civilian technologies can contribute to the political influence and prestige of a developing country, as well as to its economic development. Technology transfers enable developing countries to enhance their bargaining positions through the transformation of their natural resources (e.g., oil) into exports, such as petrochemical products. During the 1970's the power and influence of Middle Eastern countries rose in international politics as a reflection of rising revenues earned by application of oil production and refining technologies. This influence has extended not only to negotiations with industrial oil-consuming nations, but also through Arab

[37] Quoted in Fouad Abdul-Salam Al-Farsy, "King Faisal and the First Five Year Development Plan," *King Faisal and the Modernization of Saudi Arabia,* Willard A. Beling (cd.) (London: Croom Helm, 1980), p. 64.

[38] Behebani, et al., op. cit., p. 10.

[39] Harvey W. WaUender II I, *Technology Transfer and Management in the Developing Countries* (Cambridge: Ballinger Publishing Co., 1979), p. 6.

aid to developing countries worldwide—especially to oil-importing Islamic countries.

Military and strategic considerations are sometimes important for technology transfer choices. Ongoing hostilities such as the Arab-Israeli dispute, the Iran-Iraq War, and inter-Arab rivalries have stimulated demand for military technologies. In recent years, 40 to 50 percent of the world's arms exports have gone to the Middle East. Also, the perception of Israel's technological strength, particularly in the military area, has stimulated expanded demand in Islamic nations for military and dual-use technologies.

However, these countries face difficult choices in balancing military needs against other development priorities, and they must anticipate the possible responses of other countries to their actions. Among the transfer sectors examined in this study, nuclear technology transfers most dramatically illustrate these choices. As explored in chapter 9, demonstration of nuclear weapons capability by any nation in the Middle East would very likely stimulate weapons programs in neighbor countries.

In addition, in transferring both civilian and military technologies, suppliers interact with and perhaps gain some degree of influence over recipients, and this presents important choices for recipient nations.[40] Some recipient countries have attempted to limit their dependence on any one technology supplier by "diversifying" suppliers. Others have responded by building special relationships with key supplier countries. Regardless of which approach is taken, the political and strategic dimensions of technology transfer are key considerations for recipient as well as supplier countries.

[40] One Middle Eastern leader noted the political dimensions of technology transfer:

> Soviet technology is communist. American technology is American, bourgeois and capitalist . . Even when these states export their technology abroad, they are acting *from* political motives, as well as others, including transferring their political and social character to societies in which they are exporting.

Amir I skander, *Saddam Hussein: The Fighter. The Thinker and The Man* (Paris: Hachette Realites, 1980), p. 371.

Impacts of Technology Transfers on Local Social, Political, and Economic Structures

Technology transfer is a process closely associated with a number of factors promoting rapid change in developing nations. While controversy continues concerning the precise meaning of "development,"[41] few would dispute that development is characterized by far-reaching changes. In the process of technology transfer in the Middle East, foreign values and procedures (efficiency, rationality, problem-solving) may conflict with traditional values.[42] Such conflicts may arise in conjunction with the exit of working-age males from the poorer countries or with the influx of foreign workers to the Gulf States.

Similarly, the introduction of modern communications systems into the domain of traditional desert nomads, the growth in numbers of Western-educated Middle Eastern women, and the growing desire of citizens to affect political choices in countries governed by royal families can result from exposure to Western ways. Viewed from the perspective of the governing elites, political instability and social discontent associated with rapid change are serious concerns.

Despite the overriding importance of the impacts of technology transfer for developing countries, it is very difficult to measure effects precisely or to anticipate all results in advance. Chapter 10 assesses the impacts of technology transfers. Political choices normally dictate who benefits from transfers, and often certain groups within society such as the middle or upper classes reap the most immediate rewards from large-scale projects involving importation of advanced technology. (The term "technology transfer," however, is not properly used to encompass all aspects of development.) Nevertheless, policymakers must calculate the combined effects that technology transfer, urbanization, and industrialization may have on domestic society and culture, and

[41] See, for example, Yusif A. Sayigh, *The Determinants of Arab Economic Development* (New York: St. Martin's Press, 1978).

[42] Denis Goulet, *The* Uncertain *Promise* (New York: IDOC North America. 1977), p. 16.

they must attempt to gauge the appropriate pace and scope of these changes.

SUPPLIER POLICY ISSUES

Technology transfers raise important policy issues because supplier governments sponsor programs involving transfer and therefore have an interest in their efficient operation, and because decisions about transfer taken by private firms sometimes run counter to broader national foreign policy goals.

Economic Effects of Technology Trade and Transfer

A central set of issues concerns the economic effects on the supplier nations of technology trade with and transfer to the Middle East. While it is difficult to measure all the economic effects of technology trade and transfer on the United States, aggregate indicators (exports, foreign investment, receipts for patents and licenses, sales of turnkey plants, technical training, and managerial services) of technology trade show that U.S. firms have benefited by sales of technology, equipment, and services in the Middle Eastern market and that these sales have helped offset the balance-of-payment effects of oil imports from the region.

In most cases, technology trade and transfers from the United States to the Middle East have contributed to the growth of manufacturing and service systems that produce goods and services for local consumption. U.S. exports of telecommunications and medical equipment and services, for example, fall into this category. Supplier firms may use their revenues from technology trade to increase their production capacity, begin new marketing endeavors, and expand R&D efforts. Such exports benefit U.S. firms and the American economy more generally, as discussed in chapter 10.

In a few sectors such as petrochemicals, however, technology transfers contribute to the growth of Middle Eastern export industries. The joint venture partners and the firms licensing petrochemical technology and providing contracting services, of course, benefit. In the case of petrochemicals and a few other industries, such as textiles, transfers spur the growth of new Middle Eastern industries that compete with those in the United States and other supplier countries. In view of the worldwide overcapacity in petrochemical production, the establishment of new petrochemical plants in the Middle East will hasten the need for adjustment by U.S. firms.

Some have argued that U.S. firms do not get a fair return on the technology they sell abroad. Multinational firms, they assert, have, by transmitting American technology to foreign competitors, narrowed the technological lead of U.S. firms, eliminated U.S. jobs, and reduced U.S. domestic production. Those who hold this view argue essentially that multinational firms are not able to make wise choices and that the U.S. Government should institute new regulations to limit these activities by multinational corporations.[43]

In addition, some observers note the expansion of recipient government regulations concerning performance requirements, standards, investment, and employment as potential bargaining leverage which developing countries may use to wrest better technology transfer terms." The question which must be posed, however, is whether the Government is in a better position than private firms to define economic interests.

Proponents of technology transfer feel that the commercial gains far outweigh those potential problems. The firms best able to develop technology in the United States are often those most likely to export and invest abroad. Viewed from this perspective, technology transfer is essential for continued technological development and worldwide market success. In the vast majority of cases, U.S. firms

[43] See discussion of this position and others in Edwin Mansfield, et al., *Technology Transfer, Poductivity and Economic Policy (New* York: W. W, Norton, 1982), p. 21.

[44] S. Linn Williams, "Transfer of Technology to Developing Countries," *Federal Bar News and Journal,* vol. 30, No. 5, May 1983, p. 266.

transfer technology to their subsidiaries in developing nations, thereby maintaining a measure of control.

Many conclude that the net effect of U.S. foreign investment has been "good for the U.S. economy. "[45] They also point out that the U.S. trade balance in technology-intensive products (as with services) has shown positive growth in contrast to the overall U.S. trade deficit. Developing countries account for 60 percent of the overall favorable trade balance and 38 percent of U.S. exports in R&D-intensive manufactured products.[46]

In the midst of disagreements about the overall economic effects of technology transfers on the U.S. economy, policy makers are faced with decisions regarding issues such as export financing. Debates over financing highlight controversies about the appropriate role of the Government in promoting technology trade and issues surrounding coordination with other suppliers. All governments provide some financial assistance for exporting firms. The U.S. Export-Import Bank provides such financing, 75 percent of which has been used for exports to advanced developing countries, in order to match financing provided by foreign governments and thereby promote fairness in competition.

As mentioned earlier, OECD nations have established general rules on interest rates for export credits through the OECD Export Credit Arrangement and separate agreements on financing of aircraft and nuclear sales. However, these agreements on official export credits cover only a small portion of total commercial technology trade. The U.S. Government has taken a lead in negotiating reductions of unfair trade barriers, but it is much more difficult to establish clear rules for domestic subsidies such as R&D grants, tax breaks, and other indirect supports often included among domestic industrial policy instruments.

Some argue that the United States must emulate the aggressive subsidy policies of other Western suppliers; others, that such actions would only accelerate movement toward use of these measures elsewhere. The opponents argue that the U.S. taxpayer should not subsidize export industries, even if taxpayers abroad are willing to do so. Chapter 13 analyzes these debates in more detail.

Role of Technology Transfer in Development Assistance

Official development assistance (ODA), or official confessional aid for development purposes, plays a relatively minor role in technology transfer compared to commercial technology trade. However, economic assistance is particularly important for the oil-importing developing nations of the Middle East. The greater part of U.S. economic assistance to the Middle East goes to Israel and to Egypt, which in 1981 received about $1.1 billion, or about 15 percent of all U.S. economic assistance worldwide.[47] The U.S. Government has an interest in ensuring that its economic assistance is effective.

One set of policy issues concerns the extent to which economic assistance should emphasize technology transfer, particularly in the manufacturing sector. During the last decade, Congress has been increasingly concerned that the science and technology component of assistance be raised so that U.S. aid programs emphasize technology rather than resource transfers. While all U.S. Agency for International Development (AID) programs involve a measure of technology transfer, in recent years about one-tenth of the total AID budget for Egypt, for example, was earmarked for science and technology.[48] Proponents of a

[45] National Science Foundation, *The Effects of International Technology Transfers on U.S. Economy,* papers of a colloquium held in Washington. D.C., Nov. 17, 1973, and July 1974, pp. 4, 6 ff.

[46] National Science Board, op. cit., p. 33.

[47] For comparison, in 1981 U.S. military assistance to the Near East and Southeast Asia region amounted to $2.4 billion—almost as much as total U.S. economic assistance to the region ($2.7 billion). Put another way, 59 percent of U.S. military assistance worldwide went to Egypt and Israel in 1981. See U.S. Agency for International Development, U.S. *Overseas* Loans and *Grants,* July 1, 1945 -Sept. 30, 1981.

[48] Third Annual Report Submitted to Congress by the President Pursuant to Section 503(b) of Title V of Public Law 95-426, *Science, Technology and American Diplomacy-1982* (U.S. Congress: Report to Committees on Foreign Affairs and Science and Technology, June 1982), p. 130.

stronger emphasis on technology transfer point to examples abroad. France, for example, in recent years has provided more for technical cooperation and has sent more personnel to work in developing nations according to OECD data.[49]

Nor is there any firm consensus about the extent to which economic assistance should be used to promote U.S. commercial advantage. "Mixed credits, " which combine grant elements with commercial loans, have been denounced by the United States, but in 1984 mixed credits were used by the United States in a few instances. In addition, U.S. development assistance is "tied" aid in the sense that procurement requirements favor U.S. firms.[50] Despite the fact that development assistance and commercial promotion are interrelated, there is no firm agreement about whether this linkage should be promoted or curtailed.

Only a small number of government-supported programs involve technology transfer to middle- and upper-income Middle Eastern countries. Included among this small group are U.S.-Saudi Joint Commission programs, valued at $580 million during the 1975-82 period and directed toward manpower, trade, industrialization, science, and technology. About 80 percent of the funds, which come entirely from the Saudi Government, are transferred to U.S. private sector firms carrying out the programs. Such programs represent a different type of assistance to nations that can well afford it.

Business-Government Relations

Technology transfer issues raise difficult questions about business-government relations, as the discussion of economic effects and development assistance illustrates. The traditional adversarial relationship between government and private business sectors in the United States is reflected in antitrust legislation, and in comparatively stringent regulations on the activities of firms overseas (tax laws and the Foreign Corrupt Practices Act).

As discussed in chapter 13, U.S. export promotion programs have been less extensive than those of some other supplier nations—not only in levels of funding, but also in institutional resources devoted to these activities. This situation contrasts with the leading role that many supplier governments have taken in carrying out "economic diplomacy" missions to developing nations and in their more consistent emphasis on routine commercial representation.

The extent to which public officials organize, facilitate, or inhibit commercial technology transfers is influenced by long-standing traditions. In the United States, perhaps more than in any other Western supplier nation, the distinction between the public and private sectors has been maintained. However, a variety of proposals to expand export programs, including mixed credits, reveal growing support for a more cooperative relationship.

Energy Requirements

Energy requirements have strongly influenced decisions about technology transfers to the Middle East, particularly for Western Europe and Japan. Oil and gas make up 90 percent of the Middle East's exports. In recent years, the dependence of Western Europe and Japan on Middle Eastern oil imports has been considerably greater than that of the United States. For the United States, oil imports from the Organization of Arab Petroleum Exporting Countries (OAPEC) have declined both absolutely and relatively since 1977-79, when they reached a peak of 3 million barrels per day, or roughly 50 percent of total oil imports. In contrast, in 1981 32 percent of French oil imports came from Saudi Arabia and 21 percent from Iraq. In 1983, about 65 percent of Japan's oil still came from the Middle East, Thus, despite the fact that U.S. oil and refined product imports from OAPEC have fallen in recent years, Western Europe and Japan remain dependent on oil imported from these countries for over half of their imports.

[49] *Development Cooperation* (Paris: Organization for Economic Cooperation and Development, 1983), pp. 240-241.

[50] See table II..B.5, "Tying Status of ODA, 1981, " *Development Cooperation* (Paris: Organization for Economic Cooperation and Development, 1982), p 227.

Requirements for Middle Eastern oil have stimulated Western Europe and Japan to participate in development projects in the region. In some instances, firms transferring technology have been provided with oil supplies. Critics charge that when oil is used as a bargaining tool, Western nations and firms may be commercially disadvantaged or, in a more extreme case, that recipient governments may pressure them to change foreign policy positions. Both public and private leaders in Japan and Western Europe tend to view their political and economic interests as convergent in their exchange of technology for energy (see ch. 12). Nevertheless, differing degrees of reliance on energy imports from the Middle East influence technology transfer and political relations among the United States, Japan, and Western Europe, and between them and Middle Eastern countries.

Foreign Policy Goals

Decisions about technology transfer may be closely connected to foreign policy goals. The United States is the only nation that has had a formal system of "foreign policy controls, under the Export Administration Act, which empowered the President to restrict exports of various kinds for political purposes: for example, imposing sanctions on countries that support terrorist activities or violate human rights. These controls have been used to restrict U.S. exports of aircraft and helicopters to countries such as Iraq,[51] Syria, PDR Yemen, and Iran and exports of a broader range of equipment to Libya.

An ongoing and unresolved debate in the United States focuses on different assessments of the costs of such controls, measured in terms of lost markets for American goods and services versus the opportunity to take a political stand on important issues, regardless of the economic sacrifice.

[51] Foreign policy controls affecting Iraq were terminated in 1983. However, debates continued over the question of Iraq's classification. The House of Representatives passed a version of the Export Administration Act, which reclassified Iraq. See "Congress Wrestles *Over* Iraq, *The Washington Report on Middle East Affairs, Dec,* 12, 1983.

Similarly, the United States is the only Western nation with a strong policy of nonsupport for the Arab economic boycott of Israel. The policy requires Government intervention to ensure that U.S. firms are not discriminated against or made parties to a boycott instituted by a foreign nation. As such, anti-boycott policies reveal familiar tensions between political principles and commercial interests.

Some observers say that U.S. anti-boycott policies play a major role in restricting U.S. exports to the Middle East (particularly inhibiting the participation of firms new to the market and those transferring technology over the long term), while others argue that firms find ways to comply with the legal requirements while simultaneously expanding sales. It is extremely difficult to assess the precise impact of these policies on U.S. technology trade and transfer with the region, since many factors affect sales and only rarely can the impact of a particular type of export control be measured.

Nuclear technology transfers represent a very special case. Among Western supplier countries, the United States has the most extensive regulations dealing with exports of nuclear materials and technologies. The United States has enacted special nuclear controls designed to limit shipments of nuclear-related equipment and materials, including dual-use items, in order to reduce the spread of technologies that can be used to develop nuclear weapons. In addition, the United States participates in the International Atomic Energy Agency (IAEA) and supports the Treaty on the Non-Proliferation of Nuclear Weapons.

While there are relatively few nuclear facilities in the Middle East today, and U.S. firms have been less involved than firms from other supplier nations, many Middle Eastern countries will make critical decisions during the next decade about the introduction of nuclear facilities. Chapter 9 assesses the prospects for nuclear weapons proliferation in the Middle East and outlines a limited number of policy options available to the United States.

U.S. civilian technology transfers can be viewed as an important foreign policy asset. The bulk of U.S. civilian technology trade and transfer currently goes to friendly countries such as Israel, Egypt, and Saudi Arabia. To the extent that such transfers result in mutually beneficial relations with recipient countries in the Middle East, they can be viewed as contributing to larger U.S. political interests there. Successful civilian technology transfers help cement political alliances with friends and allies. The U.S. Government thus has an interest in promoting them. This argument can be taken further: if the United States does not pursue active technology transfer policies, Middle Eastern countries may turn to other suppliers, including the Soviet bloc countries.

Policymakers in supplier countries must, however, take note of counter arguments. Critics point to "white elephant projects as symbolic of technology transfers that can lead to damaged relations between suppliers and recipients. Such failures, the critics argue, signify waste of finite economic resources and also pose potential social and political problems in recipient countries. The logical extension of this argument is that since poorly planned technology transfers backfire, and sometimes reduce goodwill for the United States in the region, the U.S. Government should take a more active role in regulating commercial technology transfers.

The question of what roles supplier governments can and should play in promoting or regulating civilian technology transfers to the Middle East is complex. At its center are disagreements about the extent to which transfers have been mutually beneficial, the extent to which governments can influence the volume and type of commercial trade and transfers, and, most particularly, the question of whether governments are capable of identifying the mutually beneficial projects. Despite these uncertainties, it is clear that Middle Eastern nations place a high priority on technology transfer, and other supplier governments have generally viewed such transfers as mutually beneficial.

Cooperation With Other Supplier Countries

A related issue concerns the extent to which cooperation with other supplier countries is possible or desirable. During the 1970's, European and Japanese approaches to the Middle East were sometimes seen by U.S. observers as based on short-term economic considerations. The charge "she stoops for oil" was repeatedly leveled against these nations.[52] On a number of occasions, American policy makers criticized the Japanese for actions such as purchases of Iranian oil in 1979. Beginning with the Washington Conference following the oil shock of 1973-74, tensions among the Western allies over Middle Eastern policy became apparent. Despite calls for coordination of policies, the Western nations during the last decade sometimes diverged in their approaches to Middle Eastern issues, as reflected in various European declarations. Nevertheless, through the International Energy Agency (IEA) the Western nations managed to establish emergency oil-sharing agreements and joint goals on reduction of oil imports.

Before 1973, the European Community began talks with Middle Eastern countries and with Third World countries. The Euro-Arab dialog picked up momentum during the oil crisis as the Europeans signed the Brussels declaration, which called for bilateral cooperation agreements and included a statement of opposition to Israeli occupation of territories held since 1967. The European approach favoring negotiations with oil-producing countries appeared to run counter to U.S. calls for cooperation among suppliers. (As discussed in ch. 12, the Euro-Arab talks have progressed slowly, due in part to Arab desires to include political as well as economic and technology issues in the discussions.)

These multilateral approaches reveal problems in alliance politics. Despite efforts to coordinate Western energy and foreign policies through the IEA and the Euro-Arab dia-

[62] See Dominique Moisi, "Europe and the Middle East, " The *Middle East and the Western Alliance,* Steven L. Spiegel (cd.) (London: George Allen & Unwin, 1982), p. 18.

log, supplier governments have commonly formulated bilateral policies with specific Middle Eastern countries. These bilateral ties continue to be of primary importance for technology trade.

Through the United Nations, the World Bank, and other multinational institutions, supplier countries cooperate in programs involving technology transfer. Technical assistance, however, is generally carried out in bilateral programs that are not coordinated. Given the growing importance of technical assistance to developing nations, some observers have called for improved cooperation among suppliers. Nevertheless, the different perspectives of various OECD nations on development assistance and the strongly commercial flavor of many bilateral programs reduce the prospects for multinational coordination.

For policymakers in supplier countries, decisions about how and when to cooperate with other suppliers are often difficult. At a fundamental level, the supplier countries and their respective firms compete with one another for shares in third country markets. On the other hand, many of the largest industrial projects involve firms from many nations working together. Indeed, the internationalization of U.S. firms (by virtue of their overseas subsidiaries and joint ventures) complicates assessment of national market shares.

POLICY TRADEOFFS

Both recipients and suppliers are forced to balance various economic, social, political, and strategic considerations in formulating policies affecting technology transfers. Supplier, and especially recipient, countries and regional organizations are currently attempting to coordinate such policies.

Over the last decade, a number of proposals have been made for a more coordinated, comprehensive U.S. technology transfer policy, but none of them have been enacted.[53] This reflects, at least in part, the complex policy tradeoffs that transfer decisions raise for policymakers. Should taxpayers subsidize domestic manufacturers through "tied" aid? Are development assistance goals jeopardized by the involvement of profit-maximing firms? Public and private sector interests sometimes diverge in transfer choices. U.S. anti-boycott policies and foreign policy controls illustrate the tradeoffs between promoting commercial gains and upholding political principles. Recipient country governments face equally difficult but different types of tradeoffs which often center around maximizing goals such as indigenous manpower development in the short or long term.

Because most technology transfers occur through commercial channels, specific supplier government policies have limited effects. (The role of the recipient governments is normally stronger, given the prevalence of public sector enterprises in developing nations.) On the other hand, the general context of foreign relations between supplier and recipient countries importantly affects prospects for technology transfer. Conversely, transfers also have implications for those foreign policies. Examples of technology transfers that failed, creating resentment on the part of recipients and perhaps financial dilemmas for suppliers, lead to a cautious approach by both sides.

Policymakers are wary of unanticipated social and political consequences that accompany rapid change. On the other hand, the promise of mutually beneficial transfers is clear. For countries determined to foster economic prosperity, such transfers are a critical element in development planning. For supplier nations, they are a factor in international competition. As recipients and suppliers learn more about how technology transfers can be designed for mutual benefit, the risks for both sides may be somewhat reduced. However, it is inconceivable that they will be eliminated, and this heightens the importance and difficulty of policy choice.

[53] See, for example, Committee on Science and Astronautics, U.S. House of Representatives, hearings, *International Science and Technology Transfer Act of 1974,* May 21, 22, and *23, 1974.*

CONCLUSION

Technology transfer, as the concept is used in this study, refers not only to international trade in technology but also to the process of technology utilization or absorption by the recipient. This chapter has outlined an approach to analysis of technology transfer which includes evaluation of the extent of technology absorption at the firm or sector level, as well as consideration of factors affecting technology trade. While no single indicator can be used to measure technology transfer precisely, technology trade and absorption can be analyzed by considering a number of relevant indicators.

As used in this report, technology transfer involves trade in technology but is not synonymous with it. It involves the development of a capability by the recipient to operate a production facility or service system at a higher level, and this implies a two-way interaction between supplier and recipient. In technology transfer, teaching and learning usually occur over a period of time, particularly when technology is transferred from industrial to developing countries. The extent of transfer is appropriately assessed at the project or sector level because the resulting capability is specific to a particular production or service system.

Technology trade—including international flows of technology in machinery and equipment, patents and licenses, technical documents, technical services and training-is important in its own right, because of its significance in national trade balances. It is also a necessary but net sufficient condition for full technology transfer, including technology absorption. The growth of technology trade indicates the potential for technology transfer, and trade may have beneficial effects even if full transfer does not occur. Factors affecting technology trade include a number of economic trends such as the level and rate of economic development, foreign exchange availability of the recipient, and the comparative advantage of suppliers, product cycles, and exchange rates. In addition, political factors such as industrial, labor, and science and technology policies as well as foreign relations between nations influence technology trade.

Recipients in developing countries often stipulate that considerable technical training and assistance be carried out in association with imports of technology in the form of equipment and machinery. By packaging technology, the supplier may be able to reduce the effect of obstacles to operation and maintenance of facilities, such as shortages of technically trained manpower. Over the long term, however, firms and users in recipient countries must develop their indigenous technological capabilities in order to attain higher levels of technology absorption needed for adaptation of technology.

The effects of technology transfer are most clearly identified in the projects or industrial sectors receiving technology. Improvements in the operational efficiency of the facility and the quality and capabilities of the work force, among other factors, indicate technology absorption. It is much more difficult to assess all the impacts of technology transfer. This is the case because it is difficult to establish the precise contribution of transfer (as distinguished from other aspects of development), to changes in customs or values, or political stability. Nevertheless, because advanced technology transfers often occur in the context of highly visible development projects, their success or failure may be viewed by recipients as symbolic of larger relations between countries.

Because it is often difficult to anticipate future effects of technology transfers or to trace past results, the transfers raise complex issues for policymakers in both recipient and supplier nations. These issues are rarely systematically addressed, and often implicit in policy debates. In many cases, tradeoffs among political, economic, social, and foreign policy goals must be made in formulating policies. Careful examination of past experience with technology transfers may help policymakers to reduce

their risks and enhance their benefits. However, given the problems in assessing transfer discussed in this chapter, uncertainty about effects will inevitably remain a feature of policy choice.

The chapters that follow are designed to assess the process of technology transfer and to identify public policy issues for the United States. As a foundation for this analysis, the Middle East context and technology trade patterns during the past decade are examined. Then the process of transfer in particular sectors is assessed, with special attention given to issues of competition among suppliers and technology absorption by recipients. Policies of various recipient and supplier countries are outlined and compared to U.S. policies. Finally, U.S. policy options are identified with a view toward future prospects for Middle East technology trade.