Linking International Technology Transfer with Strategy and Management: A Literature Commentary

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Sloan School WP# 3371-92/BPS

January 10, 1992

ABSTRACT

This article represents an attempt to link literature from diverse but fundamentally related areas: research on international technology transfer as well as on technology strategy and management. It argues that these literatures need to be linked because, essentially, these literatures are concerned with problems inherent to managing technology development that must succeed at the level of the firm -- not the level of the nation state or government facilities. The first section discusses how researchers respond to several questions that frequently appear in recent writings on international technology transfer regarding (1) the sequence of activities that constitute the transfer process, (2) the relationship between assimilating foreign technology and developing indigenous capabilities, (3) organizational options available to transfer technology, (4) external factors that affect the development of technological capabilities, and (5) policies that governments can adopt to promote technology transfer. The second section reviews what ideas or findings from writings on technology strategy and technology management appear to add a useful perspective to these questions.

INTRODUCTION[1]

This article represents an attempt to link literature from diverse but fundamentally related areas: research (primarily a sampling of articles published recently) on international technology transfer as well as on technology strategy and management (see Appendix). Writers on these subjects all deal with problems of technology development at different levels, ranging from the individual engineer or manager to the nation-state. But, since researchers on these topics adopt the different perspectives of various academic disciplines, the literatures and observations can too easily be viewed as separate and aimed at different audiences.

For example, research on international technology transfer frequently treats issues involving national-government policies and problems faced at local organizations in developing countries related to the importation of product or process technology from advanced nations, often through multinational corporations or licensing agreements. The researchers come from domains as different as political science, economics, public policy, management, and sociology. Many writers tend to see transfers as a relatively predictable process whereby recipient organizations acquire, assimilate, and then improve foreign technology, aided by government policies to attract investment or protect local industries. There is concern with how organizations manage the process of technology learning, designing, and making products, although the literature usually does not specifically focus on managerial issues or details.

In contrast, research on technology strategy and management specializes in understanding how organizations as well as individuals or groups within organizations

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[1] This study has been funded by the Leaders for Manufacturing Program at the Massachusetts Institute of Technology. The authors would also like to thank Max Morris for his suggestions in the formative stages of this project.

can best create new products and processes for competing in particular industries. The context usually consists of companies in developed countries, with common topics such as how to evaluate strategic investments in R&D or manufacturing; how to coordinate functions or transfers of technologies such as from research into manufacturing; how to manage professionals in R&D projects; how to make choices such as when to cultivate in-house expertise as opposed to relying on external licensing, suppliers, or strategic alliances for technical capabilities; how to use new technologies such as computers more effectively; and many others.

Whether or not the context is developed or developing nations, the assumption of this article is that writers on international technology transfer and writers on technology strategy and management exhibit many common concerns. To bring these literatures together, the first section discusses how researchers respond to several questions that frequently appear in recent writings on international technology transfer regarding (1) the sequence of activities that constitute the transfer process, (2) the relationship between assimilating foreign technology and developing indigenous capabilities, (3) organizational options available to transfer technology, (4) external factors that affect the development of technological capabilities, and (5) policies that governments can adopt to promote technology transfer. The second section reviews what ideas or findings from writings on technology strategy and technology management appear to add a useful perspective to these questions.

1. KEY QUESTIONS IN INTERNATIONAL TECHNOLOGY TRANSFER

1.1 What is the sequence of activities that constitute the process of international technology transfer?

Several researchers that we examined (for example, Perlmutter and Sagafi-Nejad, 1981; Contractor and Sagafi-Nejad, 1981; Simon, 1982 and 1991; Stobaugh and Wells, 1984; Agmon and von Glinow, 1991) recognize international technology transfer as a complex process that needs time to evolve, i.e. that this is not a "one-act" phenomenon. Writers differ from one another with regard to the content and sequence of related activities that constitute the transfer process. Some (Zakariya, 1982; Pugel, 1982; Vickery, 1986) focus almost exclusively on the acquisition of foreign technology. Most emphasize that, while obtaining access to technology is a necessary step toward a successful international transfer, this access in itself, or the passive possession of technology in some form, does not guarantee that a country or company will effectively use the acquired technology (Contractor and Sagafi-Nejad, 1981; Mansfield, 1982; Simon, 1982 and 1991; Stobaugh and Wells, 1984; Westphal, Kim and Dahlman, 1985; Ozawa, 1985; Mytelka, 1985; Agmon and von Glinow, 1991). As a result of this conviction, many writers have tried to break down the process of technology transfer into a sequence of interrelated stages in order to study the relationship between the acquisition process for foreign technology and the development of an indigenous technological capability, although researchers have not usually probed very deeply into this process.

For example, various writers have identified three major stages in the process of international technology transfer: acquisition, adaptation, and improvement. In addition, recipients are, it is assumed, normally obliged to devote substantial technological resources in order to acquire, adapt, and eventually improve upon the

original technology (Rosenberg and Frischtak, 1985). Baranson and Roak (1985) in particular have singled out three crucial kinds of resources that organizations need to assimilate technology from abroad: operational, duplicative, and innovative. They have further suggested that none of these come automatically, and that recipients have to exert increasing amounts of effort and allocate greater amounts of better quality resources as international technology transfer advances. This interpretation underlines the link between the quality and quantity of technological resources, laid out by countries and companies to assimilate foreign technology, and the effectiveness of international technology transfer. A related issue is the importance of building up indigenous technological capabilities not only for facilitating the acquisition of foreign technology, but also for the subsequent integration of the acquired technology into the production systems of the recipients (Molero, 1983; Lynn, 1985; Westphal, Kim and Dahlman, 1985).

In a similar vein of analysis, some writers have tried to find out how managers should make decisions regarding the type of technology to be acquired. Some claim that managerial choices should mostly be influenced by considerations related to efficiency -- such as relative cost factors, quality control procedures, material waste minimization, response time to fluctuations in demand, or the desire to minimize training and labor relations problems (Wells, 1975; Yeoman, 1984). Others (Simon, 1982, 1991; Pavitt, 1985; Agmon and von Glinow, 1991) contend that the selection of the technology to be acquired should be influenced by the in-house R&D capacity of the recipients. Thus, writers disagree to what extent international technology transfer needs to take into account what organizations would like to do versus what they appear able to do prior to the transfer process.

1.2 What is the relationship between assimilating foreign technology and cultivating indigenous capabilities within the technology recipients?

Much of the recent literature on international technology transfer deals with the process through which recipients -- countries and companies -- assimilate technology that has been developed abroad. Several writers have gone beyond this, emphasizing that building an indigenous technological base is both a vital prerequisite and a valuable consequence of the international technology transfer process, and that, in order to deploy new technology effectively in an economic or operational sense, recipients need to cultivate an in-house as well as indigenous technological capability (Mansfield, 1982; Westphal, Kim and Dahlman, 1985; Ozawa, 1985; Mytelka, 1985; Simon, 1991; Agmon and von Glinow, 1991).

With regard to cultivating in-house skills, an important distinction in the literature separates "design transfers" from "capacity transfers" (Mansfield, 1982; Stobaugh and Wells, 1984; Davidson and McFetridge, 1984; Simon, 1991; Agmon and von Glinow, 1991). Design transfers generally involve the movement of designs, blueprints, and the know-how to manufacture previously designed products or equipment. The major objective of recipients is to acquire the basic information, data, and guidelines needed to create a desired capability. Capacity transfers, on the other hand, include provision of the know-how not only to manufacture existing products, but also to innovate and adapt existing products and processes, and ultimately design new products and processes. Despite making this distinction, however, international researchers tend not to elaborate on how firms can best develop innovative in-house capabilities as opposed to acquiring and assimilating technological capabilities.

1.3 What organizational modes or options exist for international technology transfer and when are these most effective?

Various authors have noted that international transfers of technology take place through a number of formal and informal organizational modes involving governments, academic institutes, companies, and individuals. These also range from direct contact with foreign sources to indirect contact (Aggarwal, 1991; Kim, 1991; Simon 1991). For example, in a recent article, Simon (1991) singled out five basic organizational modes: (1) the international technology market, which is made up of independent buyers and sellers; (2) intra-firm transfer, where organizations (as in a multinational corporation) do not resort to the market but transfer technology through either an internal venture or a wholly-owned subsidiary; (3) government-directed agreements or exchanges, where the counterparts can either be public or private actors; (4) education, training, and conferences, where the dissemination of information is made public for common consumption by either a general or specialized audience; and (5) pirating or reverse-engineering, where organizations obtain access to technology without resorting to the market but at the expense of the property rights of the owners of the technology. Except for some rather abstract or anecdotal suggestions, however, the technology transfer literature does not elaborate or offer much in the way of empirical research on when different options might be more frequent or useful.

One exception is the issue of the mode of transfer and the size of the technology-supplying firm. A British study has shown a negative correlation between the size of the supplying firm and the incidence of pure contractual forms (Science Policy Research Unit, 1972). Other research has also found that large companies appear more willing to expand their business operations (mostly manufacturing) in foreign countries and, hence, to transfer technology internally but across national borders. They usually do this to improve operational efficiency by taking advantage

of differences in location-specific factors, such as variations in the quality or availability of labor, capital, or raw materials and other natural resources, as well as differential characteristics of individual markets, such as elasticity of local demand or the intensity of local competition (Yeoman, 1984).

Another issue on this theme brought up in the literature but not explored in much detail is the relationship between technological complexity and organizational modes of international technology transfer. For example, a strong positive correlation has been found between the complexity of the technology to be acquired and the level of equity ownership. The level of equity ownership also appears to be in direct proportion to the intensity of contacts among the involved parties (which can even be departments of the same company). Moreover, the intensity of contacts among the individual constituencies seems to be a crucial factor for augmenting the technological capabilities of the recipient firms. Hence, the conclusion follows that there is a higher probability for a successful transfer of complex technologies if the partners in the transaction employ organizational modes based on a high level of equity ownership (Mytelka, 1978).

1.4 How do external factors affect the development of technological capabilities on the part of technology transfer recipients?

Regardless of the specific organizational mode or level of equity, various researchers have emphasized that external factors such as the "technology package" -- the bundle of information, rights, and services that accompanies a technology transfer -- greatly affect the success of international transfer agreements. This is because the composition of the package will help determine to what extent the technology contributes to the recipient firms's technological capabilities (Contractor and Sagafi-Nejad, 1981; Driscoll and Wallender, 1981).

How broad a technology package needs to be depends on the capabilities of the recipient firm. In general, researchers have argued that it is counter-productive for recipient organizations to try to transfer technology without securing the active support of the technology suppliers for whatever assistance they are likely to need. For this reason, recipients should try to obtain not only technical documentation and patent rights, but also detailed technical information, direct engineering support, and training assistance (Business International, 1972; Lasserre, 1982; Simon, 1982 and 1991; Stobaugh and Wells, 1984; Agmon and von Glinow, 1991). Along with the composition of the technology package, the actual commitment of the suppliers and the duration of the business arrangements also appear to be key determinants of the effectiveness of international technology transfer (Mason, 1980).

Another set of issues discussed in the strategy and international competition literature is the extent to which a combination of circumstances may lead to greater capabilities among firms in particular industries or regions within particular countries. These circumstances include (1) local factor conditions (such as availability of skilled labor, infrastructure, or capital), (2) demand conditions (size and character of local demand for particular goods and services), (3) supporting industries (presence of competitive suppliers or related industries), and (4) firm strategy, structure, and rivalry (pattern and intensity of domestic competition) (Porter, 1990). While Porter does not directly address the concerns of potential technology recipients, his discussion clearly outlines elements that affect their abilities to acquire and assimilate new technology.

Elenkov (1991), following Duncan (1972), has argued further that the specific characteristics and evolution of the major components of the "task environment" (customers, suppliers, competitors, and socio-political as well as technological factors) all have a significant impact on organizational patterns, including the ability

to take advantage of international technology transfers. It also appears that the relative importance of different task-environment components varies as the overall institutional system evolves. For instance, in "distorted" institutional systems characterized by undemocratic social and political institutions as well as a lack of consistency between prevailing cultural norms and behavioral requirements of the dominant economic institutions (such as in the former Soviet Union or Eastern European countries), the socio-political component of the task environment has proved to be of primary importance as far as the institutional influence on technological capabilities of organizations is concerned. When some of the basic institutional distortions disappear, however, other components of the task environment, such as customers, suppliers, or competitors, may gradually increase in relative importance. When this occurs, then, the effect of international technology transfer on technological capabilities of local recipients is conditioned by micro-institutional factors (which are still external to the firm). At the same time, because organizational expectations, measures of success, working ethics, and learning abilities vary across different institutional systems, it is relatively more difficult to manage technology transfer projects that involve organizational entities located in more than one country, as opposed to taking place within a single socio-cultural system (Elenkov, 1992).

1.5 What kind of policies should host-country governments adopt to promote or control transfers of foreign technology?

A large literature that cuts across various disciplinary fields discusses how governments can play a role in fostering the acquisition of foreign technology, the integration of this technology into the technological systems of recipient organizations, and the promotion of indigenous innovative capabilities at national,

regional, industry, and company levels. This literature is too large to cover in depth here because it extends to both developing and developed nations as well as to issues of technology transfer and the promotion of innovation (literature reviews and anthologies include Pavitt and Walker, 1976; Contractor and Sagafi-Nejad, 1981; Sagafi-Nejad et al. 1981; Rosenberg and Frischtak 1985; Reddy and Zhao, 1990; Agmon and Glinow, 1991). Nonetheless, a few examples illustrate some of the main issues.

One debate centers around whether governments should promote open or closed markets with regard to technology imports. For instance, some writers argue that relaxing technology transfer regulations can help recipient countries benefit more from foreign technology than imposing tight regulations on technology imports, such as by raising the effectiveness and speed of technology assimilation (Reddy and Zhao, 1990). Others believe that strict regulations are necessary for recipient countries so that governments can direct international technology transfers toward areas that can contribute most to building up an indigenous science and technology base (Mundkowski, 1979; Zahlan, 1980).

Another debate focuses on whether governments should be directly involved in international technology transfer or take only an indirect part in this complex activity. Most scholars recognize that technology is an important determinant of economic growth and that international technology transfer may alter the nature of an economy and the parameters that describe it by changing the possibilities of production and choice in this economy (Mesthene, 1970; Coombs, Saviotti, and Walsh, 1987). As a result, various studies argue for active and direct government participation in international technology transfer through the selective promotion of wholly, or at least partly, state-owned national technology champions, as well as through central negotiation of technology transfer agreements, improvement of

education, and stimulation of private investments in research (Mytelka, 1978; Vaitsos, 1979; Ariga, 1981; Janiszewski, 1981; Aharoni, 1991; Chiang, 1992).

Another view is that, with the rapid worldwide diffusion of information in recent years, the importance of government bureaucracies as economic agents may be starting to decrease (Aggarwal, 1991). On the one hand, there has been a marked rise in the acceptance of market mechanisms and individual initiative as important determinants of economic growth, with socialism and state control of economic enterprises on the decline globally since the mid-1980s (Ozawa, 1986). In general, bureaucratic systems have not proved to be very good at responding to rapidly changing markets or selecting technologies for industrial development. More specifically, however, since independent economic units appear to be more suited to adapting to rapid environmental changes. Consequently, many scholars have concluded that the type of economic system best able to keep an economy growing is the free enterprise system with minimal government interference, and that any more than minimal governmental participation in international technology transfer has been regarded as a counter-productive "external" force (Woodman, 1977; Tuchman, 1978; Aggarwal, 1991).

The strongest opponents to direct government interference in transferring technology across national borders have argued that an appropriate role for government is to use tax and investment banking systems to ensure a continuing supply of venture capital and the ability to retain the rewards from taking the risks inherent in new technology-based ventures. Several scholars also contend that governments should encourage international technology transfer via direct foreign investment, often managed by expatriates and carried out through the international extension of multinational companies (Mason, 1978; Findlay, 1978), and tie technology transfer efforts to building indigenous capabilities (UNIDO, 1977; Aharoni, 1991).

The level of economic and technological development of the country is often considered the main determinant of what alternatives government should choose to promote or regulate international technology transfer. Thus, there clearly is agreement that governments can and should do much in this arena, although researchers disagree on the specific role, direction, and magnitude of policy instruments by which recipient governments can most effectively promote technology transfer.

2. LINKAGES WITH TECHNOLOGY STRATEGY AND MANAGEMENT

2.1 What is the sequence of activities that constitute the process of international technology transfer?

Technology strategy and management scholars have discussed the cultivation of technological capabilities as a logical sequence, though not necessarily a continuous or linear process, that can be sub-divided into a series of functionally separate but interacting and interdependent stages (Rothwell and Robertson, 1973; Ford, 1984, 1988; Cusumano, 1985, 1986; Davis, 1986; Cohen and Zysman, 1987). In general, these stages consist of identification and evaluation of technological options or related R&D activities, acquisition of selected technologies, integration of new technologies into current operations, and implementation of these technologies in specific products and processes (Hayes and Wheelwright, 1984; Cohen and Zysman, 1987; NRC, 1987; Clarke, Ford, and Saren, 1989). In addition, writers have assumed that the time needed for technology development can be reduced by improving the links among R&D, design, engineering, manufacturing, and marketing, since greater coordination of these functions and parallel efforts can cut the lag between the initial conception of a new product or process idea and its commercial application (Davis, 1986; NRC,

1987; Carlsson, 1991).

It follows that the assertion that international technology transfer can be broken down into three distinct stages, i.e. acquisition, adaptation and improvement, appears to be oversimplified or too abstract to be very useful to managers. Moreover, some technology strategy and management writers have convincingly argued that, while various technologies are acquired, adapted and improved, these stages take place at different points of the technology development process, and not necessarily in such a continuous fashion (Morone, 1989; Clarke, Ford, and Saren, 1989).

2.2 What is the relationship between assimilating foreign technology and cultivating indigenous capabilities within the technology recipients?

It is clear that a unifying theme in technology strategy and management literature, as in international technology transfer, is how organizations can cultivate, utilize, and improve their technological capabilities (Freeman, 1982; Burgelman, 1983; Horwitch, 1983; Pappas, 1984; Ford, 1984, 1988; Ford and Ryan, 1981; Davis, 1986; Maidique and Hayes, 1988; Maidique and Patch, 1988; Clarke, Ford, and Saren, 1989; Morone, 1989; Cooper, 1989; Josty, 1990). Perhaps more than writers on international technology transfer, however, management researchers tend to view the cultivation of technological capabilities not in an abstract manner nor as a phenomenon at the nation-state level, but as a process occurring along multiple dimensions aimed at improving the ability of firms to operate specific functions and compete in specific markets and industries.

The dimensions along which technology development occurs include the firm- and intra-firm levels. These embrace interactions among individuals and groups within the firm, and include activities such as research or manufacturing, as well as extend across independent units such as a product division. In addition, development

occurs within networks of firms, consisting of producers, suppliers, and customers, and perhaps rival producers, universities, and government facilities (Friar and Horwitch, 1986; von Hippel, 1988). When individuals or organizations in this network are located in different countries, then the process of developing technology takes place across international borders and can be thought of as falling into the realm of international technology transfer.

One specific suggestion from the strategy and management literature is that an effective technology transfer requires continuous and intensive contact between functional and technically specialized groups within the firm (Pavitt, 1985 and 1986; Davis, 1986; Kimberly, 1986). Another point is that the effective cultivation of technological capabilities depends heavily on continuous and intensive contact between individuals, as reflected in communication patterns within research, development, and technical service departments (Allen, 1977; Allen, Tushman, and Lee, 1979; Katz and Allen, 1985). Without these organizational and individual contacts, there are no "anchors" within the firm to receive, utilize, and develop new skills. Other strategy and management researchers have emphasized that, to be useful to an organization, transfers of new technology need to have concrete short-term as well as long-term applications that affect operations, such as extending the capacity of existing manufacturing plants, breaking bottlenecks in production or engineering processes, adjusting to new input sources or materials, altering the firm's product mix, or introducing specific improvements in product designs (Rogers, 1983; Davis, 1986; Clarke, Ford, and Saren, 1989).

2.3 What organizational modes or options exist for international technology transfer and when are these most effective?

One of the most critical yet least explored issues in the international technology

transfer literature is when are different organizational options for transferring technology more or less appropriate? On this general theme of organizational options and frameworks for predicting when one form is better than another, a large number of writers on technology strategy and management have much to offer (Roberts, 1980, 1988; Meyer and Roberts, 1986; Roberts and Berry, 1985; Cusumano, 1985, 1986; Teece, 1987; Teece, Pisano, and Russo, 1987; Pisano and Teece, 1988; Ford, 1988; Clarke, Ford, and Saren, 1989).

For example, Roberts and Berry (1985) have identified several organizational modes that may be appropriate (under certain conditions) for transferring technology across national borders: internal development, acquisition, licensing, internal ventures, joint ventures and alliances, venture capital and internal nurturing, and educational acquisitions. Moreover, they argue that business development takes place not only through technology development and technology transfers, but also through entry into new markets and product diversification. They also assume that the success of business development efforts depends on the degree of familiarity of organizations with the new markets, products, and technologies. Accordingly, it follows that companies should choose internal development or acquisitions when business development takes place through related market or product diversification. Conversely, companies should use venture nurturing or educational acquisitions when entering unfamiliar markets or dealing with unfamiliar products. These recommendations appear equally valid for firms attempting to acquire new skills or develop new businesses within a single country or internationally.

Another topic touched upon but not developed well in the international technology transfer literature is the strategic distinctions between technology transfers that are "direct" (such as through outright licensing or purchases of technology) versus "indirect" (such as through visits abroad or studying advanced

products or equipment). This distinction is particularly important because of the potential managerial implications each option has with regard to the ability of managers to be creative as they attempt to cultivate in-house capabilities for research, product development and engineering, as well as manufacturing process improvement.

Cusumano (1985, 1986), for example, has shown that the key innovations in production and quality management introduced by Japanese manufacturers after World War II came as creative responses to local market and internal conditions during a more general process of technology transfer and improvement. In particular, Toyota, the originator of the "just-in-time" production system, relied far less on direct borrowing of manufacturing concepts, equipment, and assistance from American firms, and at least partly as a result, had sufficient flexibility and vision to change fundamental concepts of mass production that were common in the United States and Europe, as well as at other Japanese producers before they began to imitate Toyota's practices.

In addition, technology strategy and management scholars have convincingly argued that the relationship between the size of the technology-supplying firm and organizational modes of international technology transfer can be better explained by exclusively strategic considerations. Large firms have been found to have both the resources (various critical complementary assets) and the time to explore the implications of technological discontinuities for their business and to link them to the core firm competencies through internal development without exposing certain valuable firm-specific assets to the threat of misappropriation by competitors (Teece, 1987; Pavitt, 1990).

Furthermore, technology strategy and management literature has stressed that there is a positive correlation between industry maturity and the incidence of pure contractual arrangements, such as licensing, off-setting agreements, and production-sharing contracts, used by companies to guide their international

technology transfers (Science Policy Research Unit, 1972; Teece, 1987; Pisano and Teece, 1988). In other words, the relationship between technological complexity and organizational modes of international technology transfer (which has been examined in the literature on transferring technology across national borders) can be re-evaluated using the findings of technology strategy and management scholars regarding the impact of industry or technology dynamics on organizational patterns.

Generally, researchers assume that the emphasis of technology development within companies shifts from product innovations to process improvements as the given industry or technology becomes more standardized around a dominant product design (Utterback and Abernathy, 1975; Abernathy and Utterback, 1988). Consequently, at the later stages of industry evolution, companies need to use international contractual arrangements in order to acquire foreign technology more efficiently, since these firms can hardly lose their competitive advantages (based on cumulative process improvements) to prospective strategic allies, who may also be important competitors. At the earliest stages of industry evolution, however, companies would appear to be better off with policies emphasizing internalization, that is, building up internal technological capabilities to produce goods or deliver services in a fashion appropriate to meet the challenges of competition, because the threat of misappropriation of valuable technology-based assets by outside imitators is more real.

2.4 How do external factors affect the development of technological capabilities on the part of technology transfer recipients?

Technology strategy and management scholars have also studied the external aspects of technology development and the impact of external factors on the outcomes of international technology transfer process (Baranson, 1970, 1978; Horwitch and

Pralahad, 1981; Kim and Utterback, 1983; Katz, 1985; Van de Ven, 1986; Rogers and Valente, 1991, Horwitch, 1992). The prevailing conclusion seems to be that the effect of international technology transfer on the recipient's technological capability is conditioned not only by the composition of the technology package and the technical aspects of the respective business agreements, but also by other institutional factors.

For example, Katz (1985) studied how the structure and functioning of socio-economic institutions, such as currently active economic agents, the resource endowments they control, and the public policies by which they are affected over time, may influence the process of effective foreign technology assimilation and utilization. Horwitch and Pralahad (1981) examined the complex mechanisms through which external stakeholder networks, consisting of government agencies, public interest groups, suppliers, and customers, may affect the success of innovation activities of what they call "multi-organization enterprises." Rogers and Valente (1991) analyzed how the operation of a "technopolis" can improve the effectiveness of technology transfer, defining this as a geographically concentrated technological complex characterized by collaborative research and development activities between private industry, a research university or institute, and government agencies, as well as by the presence of venture capital and entrepreneurial spin-off firms. Research on entrepreneurship confirms the importance of regional concentrations of good research universities and venture capital, as in the case of high-technology spinoffs formed by faculty and graduates from the Massachusetts Institute of Technology (Roberts 1991). Researchers on public policy and urban planning concerned with technology development (Sabel et al., 1987; Storper and Harrison, 1991; Saxenian, 1991) have also found that firms develop and transfer technology much more successfully when firms form partnerships with suppliers, research institutes, and industry associations concentrated in particular regions.

2.5 What kind of policies should host-country governments adopt to promote or control transfers of foreign technology?

As already argued in this article, any process of learning and developing technology that involves individuals, organizations, and knowledge from more than one country is a form of international technology transfer. It follows that government policies need to establish some degree of balance and coordination among objectives such as relaxing technology transfer regulations enough to stimulate the acquisition of technologies available abroad, integrating newly acquired technologies into the technological systems of the recipients, and regulating multinational firms enough to support the cultivation of indigenous technological skills. These require complementary, although at times potentially conflicting, policies. Researchers on various aspects of technology policy and management have frequently addressed these questions. Again, the literature is too large and diffuse to summarize fully, although a sampling of integrative articles, including several by researchers who do not generally write about international management or developing countries, illustrate the ideas that this body of scholarship can contribute.

For example, Long (1979), in a general paper on sociological aspects of technology transfer, suggests eight ways that governments in less-developed countries can both promote and regulate the acquisition and usage of foreign technology. He begins with recommendations to control the activities of multinational corporations (MNCs) and then to "unpack" or enforce the dissemination of their technology. He goes on to recommend the improvement of public and private institutions as well as linkages between such institutions in developing countries and those in developed countries; improvement of technology marketing; incentives and regulations aimed at boosting technology from currently or potentially productive sectors; development of regional integration schemes; and improved selection of

foreign technology in terms of local product and factor market requirements. These appear to be fundamentally sound recommendations that are frequently found as well in international management literature, as discussed earlier.

But perhaps most important as a complement to the literature on international technology transfer are discussions that describe in detail the areas where government attempts to stimulate innovation -- whether this relies on technology transfers from abroad or the cultivation of indigenous capabilities -- have been effective as well as ineffective (Rogers and Valente, 1991). Much of the debate has also been stimulated by the case of Japan, which has frequently been used to argue in favor of extensive direct government involvement. The consensus of Japanese specialists familiar with particular industries is that protecting and indirectly promoting local firms in their developmental stages through restrictions on imports or foreign direct investment, as well as by measures such as tax incentives and pressure on foreign firms to provide access to critical patents, have been far more effective in Japan than direct attempts to organize companies or collaborative research efforts (Patrick, 1986; Cusumano, 1985, 1986, 1991). A wide variety of other research strongly agrees that governments, in Japan or elsewhere, are best at playing a mostly indirect role in technology transfer and development.

For example, Pavitt and Walker (1976), in an extensive review of empirical research done as of the mid-1970s, concluded that innovation is such a complex and unpredictable business, especially given the enormous variety across different industries and customer markets, that governments should do no more than support general education and long-term basic research, such as through government institutes and universities that are closely linked to industry. Nelson and Langlois (1983), after analyzing several historical case studies of U.S. government support of R&D, with some comparisons with European nations, came to similar conclusions and

added specific policy recommendations. They found only three areas of successful government involvement: (1) support for R&D in which government agencies have strong and direct procurement interests, as in technologies applicable to the military sector (whether or not there are civilian spinoffs); (2) decentralized support of "generic" research that falls in between "basic" (usually done at universities) and "applied" (usually done at firms); and (3) decentralized support for R&D aimed at specific "clientele" that might not otherwise do the needed research, such as farmers. On the other hand, Nelson and Langlois observed that government attempts to pick technologies (such as supersonic transport aircraft) in the hopes these would become commercial winners have proved to be a dismal failure.

From the point of view of hopeful recipients who also need to cultivate domestic capabilities to acquire, assimilate, and even improve upon imported technologies, in developing or developed countries, these lessons appear equally applicable and have broad support in other studies. For example, another group of scholars involved in a comparative international study found that effective technology transfers need to have a commercial foundation in particular firms, since the package of information, rights and services commonly included in international technology transfers is essentially of a proprietary nature. They also recommend that recipient governments concentrate on creating a receptive industrial environment and controlling the availability and distribution of critical local resources (Allen, Utterback, Sirbu, Ashford, and Hollomon, 1978).

CONCLUSIONS

As a result of having done this exercise, it appears to us that writings on technology strategy and management provide a useful complement to the writings on

international technology transfer, in the context of developing or developed countries, for a simple reason. Ultimately, this is because these literatures are concerned with problems inherent to managing technology development. The literature review suggested several specific points.

First, researchers, policy-makers, and managers should not view the assimilation of foreign technology and cultivation of indigenous technological capabilities as separate processes or objectives; they need to be a single, integrated long-term goal. If they are not, firms are likely to continue being derivative in technology as well as dependent on external sources that may always be limited in availability or sophistication.

Second, firms that acquire technology do not automatically experience phases of adaptation and improvement; this requires a deliberate strategy and conscious management attention. International technology transfer scholars and policy makers, as well as managers, thus need to address more adequately the specific managerial practices and resources necessary to ensure that this sequence of adaptation and improvement does indeed follow the importation of foreign technology. Clearly, recipient organizations should lay out not only resources that will exclusively support technical functions like engineering and manufacturing, but also resources that will create capabilities for R&D as well as manufacturing improvement.

Third, while international technology transfer takes place on a global or cross-border level, technology assimilation and improvement takes place within specific functions and within groups of technical specialists or networks of people and organizations. These actors need to be primarily from firms, including main producers and their suppliers, and occasionally may include useful contributors from rival firms, universities, government laboratories, or industry associations, especially if these actors are concentrated in specific geographical regions.

Researchers, policy makers, and managers thus need to consider how to accommodate the needs of different functions as well as how to stimulate the formation of a useful local network of critical actors. The effectiveness of the transfer process on a recipient's technological capability also appears to be conditioned by the composition of the technology package and the technical aspects of the respective business agreements, as well as by the local environment or infrastructure characteristics.

Fourth, the international literature is particularly weak in discussing when and why particular modes of transfer may be more or less effective than alternatives. For example, the relationship between the size of a technology-supplying firm and organizational modes of transferring technology across national borders can be better explained with more attention to firm-level strategic considerations, as discussed in the strategy and management literatures. The relationship between technological complexity and organizational modes of international technology transfer might also be re-evaluated using insights from the management literature that deal with the impact of industry or technology dynamics on organizational patterns.

Finally, these literatures should be linked because technology transfer needs to succeed at the level of the firm (or comparable organizations). Many international researchers recognize but do not focus on what may well be the most important long-term issue in technology transfer: how an organization, once personnel have acquired some knowledge or skills from abroad (such as a new product design or manufacturing process know-how), can utilize this knowledge to create an independent capability to design and manufacture products as well as evolve along with a technology and customer needs. Ultimately, therefore, international technology transfer requires a strategic and managerial perspective because an effective transfer process demands, at the most fundamental level, a coherent set of management policies, organizational initiatives, and organizational capabilities.

APPENDIX

To select literature to review for this article, we began with readings used in ten courses taught at the M.I.T. Sloan School of Management that related to the areas under study: International Technology Transfer; Technology Strategy; Economics for Technology Strategy; Management of Research, Development, and Engineering; R&D Process, Communication, and Technology Transfer; Managerial Psychology; International Business Management; Management of Technological Innovation; Japanese Technology Management; and Strategic Management. We then examined articles not listed in these syllabi in major journals, including Research Policy, R&D Management, Academy of Management Review, Journal of International Business Studies, and many others listed in the reference section. We were especially interested in finding review articles that provided some perspective on the key research and problems of the field. In addition, we reviewed articles in several collections of articles dealing with the areas of inquiry, as well as several major books that frequently appeared in the citations or syllabi. Our list is by no means comprehensive, although we believe that we have covered major writings and issues discussed in the literatures under study.

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