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THE GLOBALIZATION OF TECHNOLOGY AND THE INTERNATIONALIZATION OF R&D

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In the latter half of the 1980s, Japanese avowals of their growing commitment to basic research and the increasing Japanese spending on research and development have thrown into sharp relief one of the major transformations of the final two decades of the twentieth century: the globalization of technology. As Ray Vernon has pointed out, "The propensity of technology to cross national boundaries has been growing rapidly, mainly as a result of the improvement in communication and transport."[1] But the globalization of technology involves more than the growing permeability of national technology systems, with technology quickly moving from the most advanced to the less advanced nations. It increasingly extends to the growing interdependence of the science and technology systems of the highly industrialized countries. At the level of the firm, it entails not only the need for carefully constructed strategies for transferring technology to subsidiaries and affiliated firms abroad, but also increasing pressures to participate in the technology systems of countries outside the home country.

The globalization of technology is being driven by four kinds of factors: those directly concerned with science and technology; market factors; government-related and regulatory factors; and competitive factors. The latter two operate primarily at the level of the firm; the first two affect the growing interdependence of national systems directly as well as through the border-spanning activities of firms. Those activities can take three forms: international technology scanning and acquisition; strategic alliances with foreign partners; and setting up R&D facilities abroad.

Japanese firms have been notably successful at using the first two strategies to increase the international reach of their corporate R&D organization (Rosenberg and Schonmueller, 1988; Mansfield, 1988; Hamel et al, 1989; Perrino & Tipping, 1989). They are now beginning to expand into the third (Herbert, 1988), and as they do they face problems in developing the control structures, human resource management systems, and communications for these facilities analogous to those they have encountered in managing Western professionals and managers that have emerged in manufacturing and financial institutions (Pucik et al, 1990). European and U.S. multinationals, in contrast, have greater experience in setting up R&D facilities abroad: many U.S. firms have established or acquired technology development facilities in Europe, while large European firms have built or acquired technology centres in North America (Perrino & Tipping, 1989). However, both American and European firms have been much slower to use any of the three modes to penetrate the national technology systems of Asia, particularly Japan, and they are currently faced with the problems of deciding on appropriate technology strategies for Asia and of building the organizational capacity to realize that strategy.

This paper surveys the major drivers of the globalization of technology and the organizational issues involved in the three modes of extending the firm's technology reach beyond its home country, with a particular focus on the Western firms' penetration of the Japanese technology system.

THE GLOBALIZATION OF TECHNOLOGY[2]

SCIENCE AND TECHNOLOGY FACTORS

(1) Growing Science and Technology Parity Across Societies: In science, the resources of the highly industrialized nations of North America, Western Europe, and Japan (using such indicators as papers published in refereed science journals and peer evaluation[3]) have grown increasingly equal over the last decades, and the increase in the science capabilities of Japan has been particularly striking. In technology (as measured by the number of engineers graduated and the technical competence of the labour force), the gap between the long-dominant countries of North America and Western Europe and the later developing societies, particularly those in Asia, has been narrowing dramatically. And within the highly industrialized societies, Japan has moved from being a follower to being a leader in several technology areas, including robotics, electronic imaging, and

(2) Complementarity of National Strengths in Science and Technology: While the overall capacities of national systems are becoming increasingly equal, the various national systems are often seen to differ somewhat in their sectors of

greatest strength (Perrino & Tipping, 1989: 14). This is becoming increasingly important as new industrial products and businesses are emerging from the intersection of different technologies (for example, chemicals and electronics, or mechanical engineering and electronics). The centers of excellence in these different technologies may well be located in different countries (for example, European and American strength in chemicals and complex systems, Japanese in electronics). The result is mutual learning across societies, growing interdependence, and increasing internationalization of the technology strategies of large firms.

(3) Shortages of Scientific and Technical Labour: The multinational enterprises of countries with relatively small populations (such as Canada and Sweden) have already been driven to locate at least some of their product development offshore in response to shortages of technical labour in their home country (Hakanson & Zander, 1986). Increasingly, as the need for specialized labour grows and as the populations of the highly developed countries age, major development projects (both public and private) will look beyond the borders of a single country for the required technical expertise.

MARKET FACTORS

(4) Growing Geographic Dispersion of Lead Users: Recent research on innovation has stressed the importance in many industries of close interactions with lead users in generating product innovations (Von Hippel, 1988). But increasingly, firms have been finding that their lead users are not always found in their home markets. As technical interaction with foreign or multinational customers becomes increasingly important, the flow of technical information across borders increases, and firms are increasingly drawn into internationalizing their technical organization (for instance, the growing number of Japanese auto components makers who are putting R&D centres in the United States, in order to interact more intensively with the Japanese auto transplants and the U.S. auto firms).

(5) Customization of Products for National Markets: In the mid-1980s, the "globalization" of markets was widely portrayed as leading to "global products" -

- standardized products that were virtually identical in all national markets. However, more recent work both in the popular and the more academic business literature has re-emphasized the importance of customizating products to foreign markets, either as a prerequisite of entering the market at all (e.g. kanji word processing for selling personal computers in Japan), or as a means to cultivate the higher-return niches in each national market. Such customization requires either a dense flow of market and technical information across borders or the internationalization of the firm's product development organization.

STATE/REGULATORY FACTORS

(6) Standards Setting: In industries involving telecommunications and computers and in industries where R&D costs are extremely high (such as pharmaceuticals), the importance of global standards (or at least compatibility across national standards) is increasing. This has intensified state-to-state negotiations over standards setting, and firms are increasingly eager to participate in national standards setting activities outside their home countries. Eastman Kodak, for example, now participates in eight Japanese standards setting committees as a consequence of its establishment of its R&D centre in Japan.

(7) Research Funding: As expenditures for R&D rise in certain industries, companies are increasingly attracted to opportunities for obtaining government R&D subsidies or tax incentives outside their home countries. And there are several reasons why governments might be eager to provide such access: to raise the level of technology in certain key industries, as part of a general set of policies for attracting foreign direct investment, or to ease technology-related frictions with other states (as is the case for Japan today). The Japanese government is proposing, for example, to locate some of the research centres for its project on Intelligent Manufacturing Systems in the United States and Europe, in order to encourage participation by foreign companies.

(8) Access to State-Controlled Markets or State-Regulated Markets: In industries where the government is a major purchaser or where it controls market access (including India and Brazil), some form of technology interdependence is often either a condition of market entry or a significant competitive advantage in

gaining market share.

COMPETITIVE FACTORS

(9) Geographic Dispersion of Key Competitors: As firms have increasingly found that foreign companies are among their major competitors, they have felt a growing need to understand and monitor the technology strategies, capabilities, and environments of those firms. In addition, current fashions in competitive strategy have been reinforcing the market factors outlined above, especially the belief that "global competition" requires a firm to have a significant market presence in the home market of major competitors (Porter, 1984 and 1986; Doz and Prahalad, 1987).

(10) Image-building: Increasingly multinational firms, particularly Japanese firms, find that even in "global" industries it is important to be seen to have a full range of value-adding activities located within major national markets, including research and product development. And, foreign firms trying to establish themselves in certain markets (particularly Japan) find that having highly visible technical capabilities on the ground is important in demonstrating to prospective customers and employees their commitment to the market.

These ten factors are the main drivers of the globalization of technology. They are far from uniform across industries, and even within the industries where they seem most prominent, the perception of their importance is far from uniform across companies. But increasingly, the long-term strategy of technology-based firms must take into account at least some of these factors in the growing interdependence of national technology systems.

B. STRATEGIC RESPONSES OF FIRMS

Companies have three basic strategies for responding to the globalization of technology by tapping into the science and technology systems of other countries:

(1) Increased resources for global technology scanning and acquisition;

(2) Cooperation with foreign firms, through joint ventures, strategic alliances, etc;

(3) Internationalizing the R&D function by setting up R&D facilities abroad. The strategies are not mutually exclusive, and indeed many companies eventually pursue all three simultaneously. A strategic alliance with a foreign company can provide a useful window for identifying and licensing technology not only from that company but from others in its home country with which it is associated. A U.S. company that maintains an R&D centre in Japan can often involve its employees there in its technology alliances with Japanese companies and thereby improve its ability to draw technology out of the alliance (Pucik, 1988).

Each strategy, however, requires the development of the following organizational subsystems: a control system for allocating resources, defining (and redefining) the mandate, and assessing effectiveness; a human resource management system for recruiting people into the subsystem (technology scanning, the strategic alliance, or the offshore R&D facility), developing their capabilities, and evaluating and rewarding them; and a system of information networks, both internal (within the technology development functions and across functions) and external (with key sources of scientific and technical information).

<u>(1) Increased Resources for Global Technology Scanning</u>

Of the three basic strategies, scanning -- identifying useful technologies on a global scale and bringing them into the headquarters research organization -- has the advantages of preserving economies of scale in R&D, providing the greatest control of the firm's own technology, and putting the lowest demands on financial and managerial resources.

The main task of global technology scanning, especially in the absence of either of the other two strategies (cooperation and internationalization of R&D), is to identify external technologies whose acquisition could contribute to the speedy development and production of products that meet the needs of customers, and acuire them or aid in their acquisition. It can also assess the technology strength and strategies of key competitors and help "benchmark" the firm's research organization (i.e. measure the relative efficiency and effectiveness of its use of resources in the R&D function).

A company can focus its efforts on increasing the amount of time its technical people in R&D and in other functions pay to science and technology developments outside the home country, on the grounds that those working directly with the technology can best understand and assess the importance of external technology developments. This means encouraging (and paying for) participation in international conferences, international travel, technical presentations by foreign researchers, and acquiring and disseminating foreign scientific and technical reports.

A company can also respond by increasing the number of specialized technology scanning positions (a) within the research organization; (b) in overseas marketing or manufacturing subsidiaries; (c) in specialized overseas technical offices whose primary role is technology scanning.

Expenditures directly on the technical community itself may be most cost-effective in the long run, and necessary in order to overcome the parochialism of the headquarters research organization; however, they are often most vulnerable to cost-cutting efforts by top management or even by the research organization itself, who are prone to regard foreign travel for researchers as a boondoggle. Yet expenditures on specialized foreign technology scanning, while easier to justify on a budget line, may be wasted because, without complementary expenditures on broadening the international awareness within the research organization, the technological information generated may not be believed or used.

This dilemma illustrates one of the reasons why companies often move to the second and third strategies. There are at two additional reasons, the first company-specific and the second system-specific: (a) a strong NIH (Not-Invented-Here) syndrome in the headquarters R&D organization, which leads researchers to undervalue externally derived technology, and (b) low permeability of key national science and technology systems ("permeability" in this context means accessibility to foreign researchers and companies).

Japanese firms are widely seen as having impressive success in identifying and acquiring technology abroad and bringing it back to their home-country research centres to develop products that appeal to customers throughout the world. This success is usually ascribed in part to their researchers' receptivity to outside technology and a commitment to incremental improvements of technology, whether internally or externally derived. And in part it is portrayed as a consequence of the relative openness of Western -- particularly U.S. -- science and technology systems. Japanese firms are able to take advantage of this openness, it is said, because of their ability to use highly qualified technical employees with strong personal networks into the research organization as technology scanners; they serve in relatively short-term overseas assignments as part of their normal career ladders. Japanese companies have also been willing and able to invest in equipping these people with the language skills and experience to fill such assignments effectively (many, for example, have been sent at company expense to U.S. or European graduate schools in science or engineering).

U.S. firms, in contrast, are seen as handicapped in building effective technology scanning systems. The long dominance of U.S. technology in many industries has led to a strong NIH syndrome in many companies, reinforced by an image of other nations (Japan in particular) as builders on U.S. science and technology rather than potential contributors to it. Although the proportion of foreign-born students in U.S. graduate schools has been steadily increasing, relatively few American scientists and technologists pursued graduate work abroad, and few firms hire researchers without U.S. degrees into their headquarters R&D organizations. Few U.S.-born researchers have learned any language but English. Therefore, in U.S. corporate research organizations, the lingistic skills and the familiarity with foreign science and technology systems are both relatively low. Moreover, the lower level of control exercised by the company over its researchers' careers makes it more difficult for companies to persuade people who are highly qualified technically to serve in scanning roles (which traditionally have low prestige and low prospects for future advances in the company), either at home or abroad.

The obvious solution -- to hire technically qualified locals to act as scanners overseas -- runs into barriers from the relatively low credibility such "outsiders" can develop in the home research organization; often the information they gather, however potentially useful, is ignored. And even when circumstances force home country researchers to turn to overseas scanners for help, the expectations of the depth of information they can acquire and the range of technologies they can cover are often unrealistically high, and the individual scanners quickly "lose credibility" under a barrage of unmeetable demands.

Scanning, even at its best, can cope with only a subset of the factors behind the globalization of technology. While it can help to acquire foreign technology and monitor the technology of foreign competitors, it is less able to contribute to developing close relationships with lead users overseas, and even a well-staffed scanning office does not enable a firm to participate in overseas standards setting. Moreover, a visible scanning presence may be a liability in terms of corporate image.

The scanning strategy is therefore increasingly seen as inadequate on its own, even for Japanese firms. However, both of the other two strategies entail technology scanning, and indeed provide a better base for such activity than a stand-alone scanning office.

(2) Cooperation with foreign firms

Extending the firm's technology reach by cooperating with another firm embedded in the science and technology system of another country has become an increasingly popular strategy for dealing with the globalization of technology. Until about a decade ago, international cooperative strategies such as joint ventures and OEM agreements were primarily driven by the desire of one partner for access to a foreign market. Over the last decade, however, market access has been eclipsed by technology as a reason for international cooperation, and both partners are motivated by such technological considerations as gaining access to complementary technology, tapping into the science and technology system of another society, technological help in developing products appropriate for the local market, and so on. Long-standing modes of cross-border cooperative strategies -- such as cross-licencing and joint ventures -- have been supplemented by newer forms of "strategic technology alliances." These are non-equity partnerships between firms focused on specific activities such as joint product development, joint marketing agreements that include technical service and support, and OEM agreements where both partners contribute technology (one in product development, one in process technology).[4] The newer "strategic technology alliances" have greater flexibility than the older forms, and can be adjusted more quickly to meet the inevitable changes in the business environments of the partners (Contractor and Lorange, 1988).

Growing numbers of managers and management analysts agree that no one firm, however large, can adequately cover all relevant technologies in all countries solely with its own resources, and that technology partnerships and alliances are an inescapable feature of the era of technology globalization (Ohmae, 1986, 1989; Horwitch, forthcoming). While cooperative strategies have been increasingly popular over the last decade, however, they have not been without their critics. In the international joint ventures of the 1960s and early 1970s, where one partner was a multinational firm and one was a local firm through whom the MNC was seeking local market access, both partners benefitted from the alliance, in different ways. In growing numbers of technology alliances today, however, both partners are likely to be multinationals and both are oriented to markets beyond their home countries (Contractor and Lorange, 1988). They are potential, if not actual, competitors. Some American and European critics have asserted that in such alliances one partner will usually gain at the expense of the other. In the words of a recent Harvard Business Review article,

"A strategic alliance can strengthen both companies against outsiders even as it weakens one partner vis-a-vis the other. In particular, alliances between Asian companies and Western rivals seem to work against the Western partner." (Hamel et al, 1989: 133).

The concern over the balance of benefits in strategic alliances between Western and Japanese partners is growing, as many of the most visible technology alliances are between Western firms whose global dominance is eroding even as the Japanese companies are expanding. Japanese firms are seen to benefit more from strategic technology alliances for two major reasons. First, Japanese firms are portrayed as having a longer-term strategy in which cooperative strategies are merely a temporary mechanism for expanding the technology scope of the firm. Second, Japanese firms are seen to be better at learning from the cooperation than their Western partners, in part because of the higher number of technical people with the linguistic and organizational knowledge to understand and learn from the partner firm, and in part because of a greater willingness to learn. As Hamel, Doz, and Prahalad themselves state, "Western companies won't realize the full benefits of competitive collaboration until they overcome the arrogance born of decades of dominance" (1989: 138).

Although there is little systematic evidence for this imbalance, the anecdotal information is overwhelmingly weighted toward the image of the Japanese firm as benefitting disproportionately from strategic alliances. The fact that Japanese firms are seen as excelling in two of the strategies for coping with technological globalization -- global scanning and cooperative technology alliances -- may be one important reason for the fact that increasing numbers of Western firms are turning to the third strategic option: the internationalization of R&D.

(3) Internationalization of R&D

To internationalize the firm's technical organization by locating R&D facilities outside the home country is the most expensive and demanding of the three strategic options. But it also provides a base for responding to virtually all the factors behind globalization -- market, competitive, and regulatory factors as well as those concerned directly with science and technology, as indicated in Exhibit 1, which summarizes, in very general fashion, the relative response capacity of the three strategic options.

EXHIBIT 1 ABOUT HERE

As a result, increasing numbers of multinationals are moving to establish R&D facilities offshore. Japan has been the major target of the recent efforts by Western corporations (Westney and Sakakibara, 1985), as the accompanying list of foreign companies establishing R&D centers (Exhibit 2) shows. Firms in chemicals and pharmaceuticals -- industries where U.S. and European multinationals are in a strong competitive position vis-a-vis their

Japanese counterparts -- have been most active in setting up R&D centres in Japan, followed by firms in the seminconductor industry. These facilities have primarily local or regional strategic mandates, but some have a global mandate in certain new technology areas.

EXHIBIT 2 ABOUT HERE

A dispersed R&D system can be built either through setting up new facilities outside the home country or through the acquisition of firms with established facilities overseas (De Meyer and Mizushima, 1989). There have been two types of internationalization of R&D through acquisition. One can be called "targeted acquisition," where a major motivation of the acquisition is the technical capacity and organization of the acquired firm. The other can be called "inadvertent acquisition," where overseas R&D facilities are part of an acquisition motivated by other considerations. "Inadvertent acquisition" often leads to the erosion of the technical capacity of the acquired firm. For example, when Matsushita acquired the U.S. television business of Motorola in the 1970s, it deservedly received much praise for its achievements in improving the manufacturing capabilities of the Motorola plants. Less attention was paid to the fact that Motorola's product design and engineering organization, which had a high reputation, quickly deteriorated. From the outside, it is often difficult to tell whether the erosion of technical capacity that occurs in such cases is the result of deliberate strategic decisions (because the acquiring firm sees the acquired technical capacity as redundant and therefore unnecessary) or the consequence of neglect.

One of the first issues in managing overseas R&D facilities is their strategic mandate. The first major academic study of the internationalization of R&D was carried out in the 1970s by Robert Ronstadt. At that time, he observed four kinds of overseas research facilities in the U.S. multinationals he studied:

1. Technology Transfer Units (TTUs): to facilitate the transfer of the parent's technology to the subsidiary, and to provide local technical services;

2. Indigenous Technology Units (ITUs): to develop new products for the local market, drawing on local technology;

3. Global Technology Units (GTUs): to develop new products and processes for world markets;

4. Corporate Technology Units (CTUs): to generate basic technology for use by the corporate parent.[5]

It has become clear since Ronstadt's work that the strategic mandate of a facility is potentially more complex than his four categories suggest. Instead, the research mandate involves some combination of three variables: geographic scope, vertical technology scope, and horizontal technology scope.[6]

Geographic Scope refers to the target market for the research. There are three categories: the local market, the regional market, or the world market.

Vertical Technology Scope refers to the value adding activities within R&D. The following categories are the most commonly used: (1) facilitating the transfer of technologies from the parent; (2) modifying products to suit the local market; (3) new product development; (4) basic research. In some industries, of course, the R&D value-adding activities are somewhat different: in pharmaceuticals, for example, the distinction between basic research and new product development is extremely difficult to apply, but testing is an important activity. In other industries, research on process technology is a key element of the value adding activities.

Horizontal Technology Scope refers to the range of technologies covered by the facility. This can be a subset of the technologies covered by the home country R&D organization; the entire range of those technologies; or a distinctive set of technologies whose choice is shaped by local technology strengths.

These variables provide a useful way of thinking about change over time in the strategic mandate. The categories within the first two variables form a continuum from less to more complex and demanding tasks. Previous studies from the 1970s (Ronstadt, 1977; Behrman and Fischer, 1980) have indicated that in cases where the mandate changed from less to more complex (e.g. from local to regional or to global, and from technology transfer to product development), the main initiative for the change came from the local facility. It was motivated by a desire to use more fully its growing capabilities and to stretch them even further. In cases where the mandate changed from more to less complex (most commonly, from basic to product development or product modification), the initiative came from the headquarters management, and was largely in response to a deteriorating competitive position in the market. One of the unanswered questions for the new wave of internationalization of R&D in the 1980s is whether the parent company will take on a more active role in building up the capacity of its overseas research organization and in raising the complexity of its research mandate, or whether the older pattern of the major initiatives coming from the local facility will persist.

Identifying the different dimensions of the strategic mandate is useful because in the complex research environment of today's multi-business multinational corporations, it is difficult to classify the emerging overseas R&D facilities into any one category. A single overseas facility may easily be entrusted with the following research mandates:

- in one business, where the facility has focused on developing expertise on a subset of the parent's technologies in that business, work is focused on modifying some major products to make them more suitable for the local market;
- in another business, where the facility covers virtually the same span of technology as the parent organization, work is focused on developing new products for the regional market;
- in still another business, where the facility has cultivated expertise in an area where the local science and technology system has a distinctive strength, the task is basic research aimed at the development of a new world-wide business.

Of course, when an overseas R&D facility is first established, its immediate operating mandate will, of necessity, be fairly narrowly defined. But its development over time will be profoundly influenced by the vision of the strategic mandate of the facility five to ten years down the road, a mandate which is usually diversified and complex. Building the organization to make that vision a reality is a major management challenge.

C. DEVELOPING A FOREIGN R&D FACILITY: MANAGEMENT CHALLENGES

R&D can be defined as a boundary-spanning and an information value adding function. That is, its task is to bring science and technology from the external environment across the boundaries of the firm, to add value to that information through its own accumulated knowledge and knowhow, and to pass the physical embodiment of that value added information (product prototypes, specifications, etc.) to the production organization. The keys to its activities are therefore:

(a) the knowledge base of its technical people;

(b) its expertise in managing the information value adding processes (i.e. the research management system);

(c) its external knowledge networks (those that link the firm to the external science and technology system and help to identify and acquire scientific and technical information);

(d) its internal knowledge networks (with other functions within the corporation), through which it passes the value-added information that it has produced (product prototypes, specifications, etc.) to the production organization and through which it gathers information and knowhow that improve its value adding activities.[7]

Even within one's own country, developing these elements in a new R&D facility and adjusting them as business conditions change are major management challenges. Abroad, the challenges are infinitely greater.

The first step is of course the articulation of the strategic mandate of the facility, and this usually involves the following steps:

(1) the framing, in very general terms, of the research mandate of the facility by top corporate management and headquarters R&D management, usually as part of the process by which the decision to establish such a facility is taken;

(2) the development of a more circumscribed initial research mandate by top SBU management, headquarters R&D management, and the newly appointed local R&D top management;

(3) the identification of a set of specific projects embodying the initial research mandate by headquarters and local R&D management and the managers of the business entities providing the research budget.

The selection of the initial project portfolio has two dimensions. The first is the output: that is, reasonable targets enabling the facility to generate visible value added for the business or businesses of the company. The second is the developmental agenda: the projects lay the foundation for developing the knowledge base, the internal and external networks, and the research management systems of the facility in ways that will enhance (or hinder) its capacity for achieving its longer-term strategic agenda.

Both the output and the developmental considerations are strongly influenced by a third set of considerations: those usually covered by the term, "internal politics." Any decisions about the allocation of R&D resources that involve reallocation, or even new lines of expenditure, have significant implications for existing organizational subunits and individual careers. While research managers may agree in principle with the need for developing an R&D presence overseas, they may be much less enthusiastic about seeing R&D resources go into supporting projects in the new facility rather than in their own organization. The strategic mandate and the project agenda which meet the least resistance within the multinational corporation's home country organization involve either new activities, such as basic research in a new field where the foreign country's science and technology system has a clear comparative advantage, or activities to which the existing research organization has committed a low level of resources, such as product modification or product development for a particular local market. These may not, however, always be the areas in which the corporation itself could reap the greatest long-term returns.

The early project agenda, however, has a critical influence on the subsequent development of the facility. It defines what initial knowledge base is necessary and therefore what kinds of people will be hired. It also helps to define the kinds of external linkages needed. For example, a mandate in basic research will require close linkages with local basic research centres, usually universities and major research institutions such as government laboratories. A mandate in local product enhancement will require closer linkages to the customer base. The initial project agenda shapes the direction in which the knowledge and skills of the facility's personnel develop, and begins to institutionalize external and internal linkages.

Therefore a significant mismatch between the long-term strategic mandate and the initial project agenda can lead to serious problems. For example, if the long-term mandate is advanced product development but the initial project agenda is exclusively focused on modification of existing products, able and ambitious researchers may well be discouraged and either leave or feel resentful and frustrated that their skills are not being used and developed. If an exclusive focus on the output agenda or on a project agenda that avoids taking resources from the existing R&D organization creates a mismatch with the general long-term strategic mandate, the facility may have difficulties attracting and keeping able people and enhancing the knowledge base and networks on which to realize its long-term strategy. However, if the focus is too strongly on the developmental aspects of the project agenda, the facility's credibility with line management may suffer.

The development of the research management system poses distinctive problems. Because R&D has been the last function of the multinational corporation to be geographically dispersed, we are only beginning to confront one of the key organizational and managerial issues involved in internationalizing R&D: how much to introduce the research management systems and external and internal linkage patterns from the home country and how much to follow patterns dominant in the local environment. Traditional views in the field of international management tended to assume that localization -- adopting the organizational patterns and managerial styles dominant in the local environment -- is always the best strategy. Even more recent writers, such as Kenichi Ohmae, have asserted that effective international management depends on building a cadre of local managers who manage in accordance with local patterns (Ohmae, 1989b). However, such advice is largely based on the experience of marketing, which is the function where the interactions with the local environment are most dense and sustained. It is less useful in the following cases:

(a) where organizational structures and processes are key elements of the firm's competitive advantage (for example, in manufacturing in the Japanese auto industry);

(b) where the interactions between the local organization and the rest of the multinational firm are dense and sustained (social science research indicates that interactions are easier between similarly structured organizations.[8]

The external and internal knowledge networks of the R&D organization are therefore important not only for their role in transmitting knowledge, but also because they are channels for information about organizational models and themselves exert "pulls" on the organization toward certain institutionalized patterns.

Factor (a) is a firm-level variable: firms differ significantly in the extent to which they regard their research management systems or their modes of internal and external linkage as key elements of their competitive advantage. But there are some important commonalities across multinational firms on the second factor, linkages between the local organization and the rest of the multinational. Recent shifts in the predominant patterns of organization within multinationals -- from geographic organizations to global product divisions -- have weakened the autonomy of local country subsidiaries and increased the level of interaction across borders. This has increased the costs of maintaining organizational structures and processes in the various subsidiaries that are incompatible, and increased the pressures within the MNC for greater similarity across subsidiaries. It has also increased the pressures within the R&D organization as a whole to focus on output considerations, sometimes at the expense of developmental considerations.

Whether the R&D facility follows local or headquarters patterns or whether it develops "hybrid" patterns of its own are matters both of conscious management decision and of the unanticipated consequences of environmental pressures. One of the most important forces pulling the facility towards local patterns is the implicit organizational model or models held by the local mid-career research managers who are recruited to staff the facility (or in the case of acquisition, are already employed). Their experience in other organizations has given them models of how organizations should be structured. In some cases, these are based on the organization in which they have had their most extended working experience; in some cases, their past experience provides a negative model -- a strong view of what should be avoided.

When a multinational corporation is recruiting managers for foreign R&D facilities, the process is often focused on the individual's technical abilities and accomplishments, and perhaps his or her networks into universities and professional societies. It less often explores in detail the individual's views of what constitutes a good research management system, how the knowledge base of an R&D facility is best fostered, and the appropriate modes of external and internal linkages (for example, in handing off technology to the production organization). Yet these will have a profound impact on how the emerging facility is organized, and major incompatibility with the patterns currently prevailing within the MNC's research organization may cause serious problems, either for the individual or (if the person is in a top-level management position) for the facility itself. One of the key challenges in the initial research agenda of the R&D facility is to foster the building of the networks of communication between these upper and mid-level R&D managers and the home country R&D organization.

The major strategy for countering the inevitably strong local organizational pulls is the two-way exchange of researchers. Sending local researchers on assignment to the headquarters research organization enhances their technical abilities and provides them with a grounding in the research systems of the parent organization. Sending home country researchers to the local facility increases the number of people in the home country organization who are aware of and sympathetic to the developmental as well as the output considerations in building the R&D agenda, and provides greater incentives to bring local research management systems into alignment with those of the parent organization.

However, building career ladders that create and reinforce the networks among the R&D facilities world-wide may well demand a kind of personnel development structure (including the provision of language training) that the headquarters R&D organization has never previously had to generate. Long-term career planning is necessary to build a cadre of home country researchers with experience abroad at critical stages of their careers (not just as senior-level administrators) and a cadre of local R&D managers with extensive experience in the headquarters R&D organization. Both are crucial for the success of the internationalization of R&D. However, especially for many U.S. firms, the kind of long-term, individual-specific planning necessary may require some major rethinking of their human resource development strategies.

Because the level of accumulated wisdom about managing the internationalization of R&D is still relatively low, many MNCs are adopting an emergent strategy: establishing facilities and watching to see what patterns seem to work and what structures and processes cause serious problems. Monitoring and analysis of these processes by managers and by management researchers will add a relatively new subfield to the body of "research on research" -- research on the management of the internationalization of R&D.

EXHIBIT 1: COMPARISON OF EFFECTIVENESS OF THREE MODES OF STRATEGIC RESPONSE

	STRATEGIC RESPONSE		
	TECHNOLOGY SCANNING	CROSS-BORDER COOPERATIVE STRATEGIES	INTERNATION-ALIZATION OF R&D
DRIVERS OF GLOBALIZATION			
Access to Science and Technology	X	X	X
Participation in Standards-setting	-	X	X
Access to public research funding	-	X	X
Technical linkages with lead users	-	-	X
Localization of Products	-	X	X
Technology Monitoring of Competitors	X	X	X
Corporate Image	-	-	X

EXHIBIT 2:
U.S. AND EUROPEAN CORPORATIONS WITH R&D FACILITIES IN JAPAN (recent cases)

INDUSTRY	COMPANY	DATE OF ESTABLISHMENT
Pharmaceuticals	Hoffman-LaRoche	1972
	Merck	1981
	Pfizer	1985
	Bayer	1985
	Travenol	1985
	Upjohn	1988
	Glaxo	1989
	Sandoz	1990
Chemicals		
	Dow Chemical	1982
	Monsanto	1984 (agricultural chem.)
	Monsanto	1986 (silicon wafers)
	L'Air Liquide	1986
	Dupont	1986
	Hoechst	1986
	Henkel	1987
	Celanese	1987
	ICI	1987
	Ciba-Geigy	1990
Semiconductors	Intel	1983
	Applied Materials	1984
	LSI Logic	1986
	Texas Instruments	1989
Computers	Digital Equipment	1982
	IBM	1990 (software)
Other	Eastman Kodak	1988
	Honeywell	1987
	Pioneer Seeds	1987
	TetraPak International	1987

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1. Raymond Vernon, "Coping with Technological Change: U.S. Problems and Prospects" pp. 160-190 in Bruce R. Guile and Harvey Brooks, eds, Technology and Global Industry: Companies and Nations in the World Economy (National Academy of Engineering Series on Technology and Social Priorities - National Academy Press, 1987).

2. The following list of factors is based on interviews with technology managers in nine U.S. firms with technology development activities in Japan (five of whom also have R&D activities in Europe) and three Japanese firms with technology development activities in North America.

3. See for example the National Science Foundation's International Science and Technology Data Update: 1988 (NSF Special Report 89-307), and such analyses of the NSF data over time as Sarah Slaughter and James Utterback, "U.S. Research and Development: An International Comparative Analysis" in Business in the Contemporary World (Winter 1990): 27-35.

4. See the discussions in the various contributions to the volume edited by Farok Contractor and Peter Lorange, Cooperative Strategies in International Business (Lexington, Mass: Lexington Books, 1987).

5. Robert C. Ronstadt, "R&D Abroad by U.S. Multinationals" in Robert Stobaugh and Louis T. Wells Jr., eds., Technology Crossing Borders: The Choice, Transfer, and Management of International Technology Flows (Boston: Harvard Business School Press, 1984): 244.

6. This typology owes much to the three-variable typology of MNC subsidiaries developed by R. White and T. Poynter (1984), which includes geographic scope, value-added scope, and product scope, categories which are analogous to the geographic scope, vertical technology scope, and horizontal technology scope used in this paper.

7. For more detail on internal and external networks and their effect on organizational structure, see Westney 1989.

8. This is one of the pillars of the recent developments in institutionalization theory in organizational sociology. See for example, Paul DiMaggio and Walter W. Powell (1983) and Lynne Zucker, ed. (1987).