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Multinational Enterprises and Cross-Border Knowledge Creation

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The model of the multinational enterprise (MNE) has changed dramatically over the last two decades, especially in terms of the role of knowledge creation in the MNE. From the 1960s into the early 1980s, the dominant perspective in International Business viewed the MNE as developing a knowledge-based advantage in its home country and then exploiting it by extending its production system into geographically dispersed markets (see for example Vernon, 1966; Buckley & Casson, 1976; Dunning, 1981; Rugman, 1981). From the mid-1980s on, however, studies of the MNE have increasingly shifted their focus from the questions of why, how, and where a firm ventures beyond its home country borders to the emergent advantages of an established international network of subsidiaries (Bartlett & Ghoshal, 1986; Kogut, 1983; Kogut, 1985a; Nohria & Ghoshal, 1997; Solvell & Zander, 1995). Chief among these advantages is a greater capacity for generating innovations. In other words, the focus of the study of the MNE has shifted from viewing geographic dispersion as a result of knowledge creation to seeing dispersion as a source of knowledge creation.[1]

The shift in focus has reflected both the growing attention to innovation and knowledge creation in theories of strategy and organization in general (Nelson & Winter, 1982 and Nelson's 1995 review article) and changes in MNEs themselves -- that is, it reflects both theoretical and empirical developments. One of the key features of the evolution of the MNE in the last decade has been the growing internationalization of research and development (R&D). As a result of the evolving technological capabilities of long-established subsidiaries and, perhaps even more strikingly, of the large-scale cross-border mergers and acquisitions of the 1980s, many MNEs increasingly found themselves with sizeable R&D centers outside their home country (Hakanson, 1990). A growing body of research on the internationalization of R&D has blossomed under the dual stimuli of managerial concerns with effective management of dispersed technology development units and scholarly interest in the internationalization processes of R&D, the last major function of the MNE to go abroad[2]. As international strategy in the 1980s came to focus heavily on the Triad of the highly-industrialized economies, and as MNEs developed an established network of increasingly capable subsidiaries there, one of the key organizational questions became how MNEs could leverage their existing network for competitive advantage, rather than where and how they expanded their presence.

The advantages of the MNE in knowledge creation rest on one or more of the following characteristics:

(1) Variety in environmental stimuli: Because MNEs are by definition active in more than one national environment, they are exposed to a wider variety of customer, competitor, and technology stimuli to innovation than are domestic firms (see for example Ghoshal, 1987: 431). The MNE here functions as a global scanner, in Ray Vernon's terms (Vernon, 1979: 261), sensing and responding to a diverse array of environmental signals.

(2) Dispersed innovation centers: The established MNE contains centers that generate innovations for local use in a variety of locations. The MNC can identify and select those which have potentially wider applicability and ensure their adoption in other locations. The MNC here is seen as a selection regime, in the terminology of population ecology, selecting for and proliferating certain innovations.

(3) Joint knowledge creation: The dispersed innovation centers can combine their resources and capabilities to create knowledge jointly, in a variety of ways.[3] In this context, the MNC functions as a knowledge-creating network.

The fact that the MNE contains knowledge widely dispersed across its various local subsidiaries does not necessarily mean that it has developed this third capability. The geographic dispersion of R&D provides only the potential for joint knowledge creation; not all MNEs with international R&D centers have developed the organizational capability for realizing that potential.

Nonaka has identified this cross-border synergistic process as "global knowledge creation," and sees it as the key process of globalization (Nonaka, 1990: 82).

This paper explores the patterns and nature of cross-border knowledge creation in the R&D function. We should note that this is a deliberately narrow focus on one aspect of the more general topic of multinational knowledge creation processes. Of the four types of multinational innovation processes identified by Bartlett and Ghoshal (1986; 1989) and elaborated in Nohria & Ghoshal (1997), only one involves "joint cross-border knowledge creation" processes in the R&D function: their "globally-linked" pattern, or what Nohria and Ghoshal call "global-for-global". The other three types -- local-for-local, central-for-local, and locally leveraged (or local-for-global) -- center on single-location knowledge creation rather than cross-border interactive knowledge creation, at least as far as the R&D function is concerned, although they may involve *cross-functional* joint knowledge creation. This paper focuses on the questions of how widespread cross-border knowledge creation is within the R&D function, first within firms with internationally dispersed R&D units and then between firms and external foreign sources of technology, and what organizational and managerial systems support cross-border knowledge creation within companies that have a geographically dispersed R&D function. Finally the paper suggests some concepts for analyzing cross-border knowledge creation processes.

CROSS-BORDER KNOWLEDGE CREATION IN FIRMS WITH INTERNATIONAL R&D UNITS

During the last decade, studies of the internationalization of R&D -- that is, the establishment or acquisition of R&D centers outside a company's home base -- have suggested that cross-border interaction in knowledge creation is increasingly important in MNEs. But in fact most studies map the geographic dispersion of R&D rather than the level of cooperation in technology development across the dispersed units, whether the analyses are based on patenting (e.g. Cantwell, 1989) or on surveys of companies (e.g. Casson, 1991). An R&D center outside a company's home base may indeed be engaged in joint knowledge creation with the parent R&D organization, or even with other dispersed R&D centers in the company. Alternatively, it may be engaged in quite autonomous knowledge creation, either as the sole "center of excellence" for a product or technology within the company, or as what Ronstadt called the Indigenous Technology Unit (ITU), whose mandate is primarily developing products for the local market. There are also a handful of studies of global new product development projects that involve cross-border knowledge creation (e.g. Bartlett & Ghoshal, 1990; Nonaka & Takeuchi, 1995, Ch. 7; Hedlund and Ridderstrale, 1995), but such projects are clearly not typical of their companies' knowledge-creation activities, however strategically important they may be. In other words, although there is a widespread belief that cross-border knowledge creation is important, we have little data to tell us how extensive it is.

A recent research project at MIT provided an opportunity to explore this issue and a number of related topics. In 1994-95, together with Tony Frost (then also of MIT, now at the University of Western Ontario), I conducted a survey of the global management of R&D under the auspices of the Industrial Research Institute based in Washington, D.C., whose member companies account for roughly 80% of the industrial R&D spending in the United States. One-third of the association's member companies agreed to participate: 70 U.S. firms, and 12 foreign-owned firms with R&D centers in the United States (10 European companies and 2 Asian). Of the 70 U.S. firms, 43 had R&D centers outside the United States (we called this kind of company FIRDUs -- that is, firms with international R&D units -- not out of a perverse desire to add yet another acronym to the MNE literature, but to reduce writer and reader fatigue over the constant reiteration of "firms with international R&D units). The other 27 U.S. firms did not have R&D centres outside the U.S., although most were "multinational enterprises" in the classic definition of the term, with sales and production outside their home country; we called this type of firm the HRDU -- firms with home-based R&D units only.

The unit of analysis in this study was not the company, but the technology development unit -- that is, one level below the company/function level that has been the usual focus of organizational studies of the internationalization of R&D and a level above the individual project level that has been the focus of studies of knowledge creation. Obviously the project level is best-suited to the analysis of knowledge creation processes, but the organizational capabilities that sustain the capacity for knowledge creation are best studied at the organizational level. However, in multi-business, multi-national companies, the R&D function has increasingly been segmented into distinct organizational units linked to a specific business area or (in the case of corporate R&D) technology area. Given the resulting intra-company variation, a company-level analysis is too coarse-grained to capture much of the information necessary to understand better the development of the organizational systems that sustain cross-border knowledge creation. Therefore, despite the many problems involved, we elected to direct our study to the R&D unit, or rather, the technology development unit.

Our pilot study revealed that our initial label of "R&D Unit" met some resistance from some of the participating companies, who eschewed the connotation of "blue-sky academic research" that they associated with the use of "research" (as in R&D unit), and preferred the more neutral term "technology development unit". We defined this as a "technical unit engaged in any stage of the technology development process, from fundamental research to design, development, engineering or modification of products, processes, or technologies", but specifically omitting technical units engaged primarily in technical service and support. In other words, we focused on units engaged in technical knowledge creation, both radical and incremental, and in this paper I shall use the terms "R&D unit" and "technology development unit" interchangeably in describing them. The IRI representative from each of the 82 participating companies identified a set of unit heads within the company seen as appropriate targets for the study, and questionnaires were mailed from MIT to these individuals. A total of 318 responded, giving a response rate of 77.4%. The questionnaire was followed by a set of over 40 face-to-face interviews in units in the United States, Europe, and Japan.

Although we found that in many companies technology development units were quite specialized in terms of product or technology, most, even those that were relatively small, covered more than one stage of the R&D value chain (which we operationalized by a question asking about the importance of various types of technology development in the unit's current mandate). Exhibit 1 shows the distribution of units in terms of the four core activities of: developing basic or fundamental technology; developing break-through new products; developing new generations of current products; and process innovations.[4]

EXHIBIT 1 ABOUT HERE

Only 30 of the units (fewer than 10%) had a single mandate (one additional unit identified a fifth activity, "modifying products developed by other units", as its only important mandate in the value chain). Somewhat surprisingly, there was no significant relationship between the size of the unit in terms of the number of technical personnel and the number of mandates it covered. In our interviews and our presentations of the data for the IRI members, it became obvious that this finding reflected the fact that many companies have cut their R&D organization into smaller units that are directly linked with individual businesses and cover the entire R&D value chain for a single business or product family, in order to increase their responsiveness to market pressures.

The 318 responding units were distributed across five categories, depending on ownership, dispersion of R&D, and location, as follows. We had three categories of US-owned units: those in firms without international R&D units (subsequently referred to as HRDUs); the home country (i.e. US-located) units in firms that did have international R&D units (FIRDUs); and units in the US FIRDUs that were located abroad (primarily but not exclusively in Europe). We also had 33 units that were located in the United States but belonged to non-US-owned FIRDUs, and 12 of their home country units. In other words, the map of responding units was as follows:

OWNERSHIP **DISPERSION OF R&D** **LOCATION**

Without International R&D Units (HRDUs)

US OWNED-------| **Located in US**

|__With International R&D Units (FIRDUs) ________| **(Home units)**
|
|__***Located outside US (Foreign subsidiaries)***

NON-US OWNED--With International R&D Units (FIRDUs)____| __**Located in US (Foreign subsidiaries)**
|
|__***Located outside US (Home units)***

Exhibit 2 provides further information on each of these five categories of units.

EXHIBIT 2 ABOUT HERE

The companies covered a range of industries, and reflected to some extent IRI participation: supplier industries were strongly represented, especially the chemical industry. Over one-third of the units (37%) were from the chemical industry; and 23% were from engineering and machinery. Of the remainder, 14% were in drugs and medical equipment, 9% in materials, and 9% in consumer products. Only 2% were in electronics, and 6% were classified as "other". This means that the industries which have been best represented in published case studies of cross-border new product development processes (consumer products and electronics) were much less well represented in our study, in favor of more "mature" industries where one might expect the pressures for cross-border interactions in technology development to be less strong.

Nevertheless, we found cross-border knowledge creation to be extensive. The most direct question could be asked in the FIRDUs (firms with international R&D units). In the version of our questionnaire tailored to such firms, we asked what percentage of their products or technologies involved cooperation with other R&D units in the company but located outside the country in which the respondent was located. Exhibit 3 provides the distribution of the responses.

EXHIBIT 3 ABOUT HERE

These data support the belief that there is widespread cross-border interaction in knowledge creation in firms that have internationally dispersed R&D organizations. As one would expect, in the US-owned companies, foreign units report a higher level of cross-border interaction in technology development than do the home country units. Over 40% of the home units report cooperating with foreign R&D units on less than 25% of their products or technologies. Nearly two-thirds of the foreign units, on the other hand, interact with R&D units outside their country of location for more than half of their product/ technology portfolio. Given that the overwhelming majority of these foreign units are in Europe, and that many have interactions with other European units in their company, this is perhaps not surprising. The foreign-owned R&D centers in the US fall between the home country and foreign units of the US companies: one-third are relatively autonomous (this reflects a broader pattern in the data -- units in this category are very US-focused and less integrated with the rest of their company on a number of dimensions, a pattern which is perhaps not surprising given the size and scope of the US market). We cannot view the very small number of home units of non-US firms as a group that is comparable to the US firms' home units: the number is too small, and the very fact of their participation in a US-based study indicates their very strong international orientation. Of course, we cannot claim that the US home units are "typical", since they were selected by their company representatives as units that might have an interest in participating in a study of global technology management. But the fact that more than half of these units are involved in cross-border interactions with foreign units in the company for over one-quarter of the products or technologies on which they are working indicates extensive cross-border knowledge creation.

The MIT-IRI study provided evidence that cross-border knowledge creation is extensive, both across units within MNEs and between those units and external partners in other regions. But the survey instrument was not well-suited to probing the nature -- as opposed to the extent -- of cross-border knowledge creation processes. For that kind of information, we relied on the interviews, in which we asked for examples of recent cross-border technology development. These examples were not detailed case studies, but very brief descriptions of recent cross-border cooperation, ranging from (for example) a major four-year new product development project involving technology units in the US, Europe, and Japan to an interaction of a few weeks duration in which a local subsidiary in Europe worked with the business unit headquarters' R&D organization in the United States to modify a product and get it appropriately field-tested. In the course of the interviews, it became increasingly clear that while the cross-unit product development project was the dominant form of international knowledge creation, it was by no means the only one. Knowledge creation was occurring outside specifically cross-unit projects -- as for example when someone from one unit flew into another unit to help solve a particular problem, or learn more about a particular set of customer needs.

This was reflected in the responses to a set of questions in the survey about the reasons for sending people abroad to other units in the company. These data are presented in Exhibit 4, which divides the responding units into three categories: low cross-border interaction (those with 25% or less of their products and technologies involving cooperation with other company units outside the country in which they are located); medium cross-border interaction units (25-50%) and high interaction units (more than 50%).

EXHIBIT 4 ABOUT HERE

While project-related travel clearly predominates, especially in the high-interaction units, more general learning -- about technology and markets, and technology transfer -- is also important, and is almost as important in the medium and low interaction units as in the high. And of course, administrative coordination of various kinds is also a major reason for travel -- again particularly in the high-interaction units. But the key point to draw from these data is the range and variety of cross-border knowledge creation activities in MNEs.

The IRI sponsors and participating companies, however, were of course less interested in the extent of cross-border knowledge creation than in how to manage the process more effectively. We used both the questionnaire and the interviews to explore the question of how companies strengthen their cross-border knowledge creation capabilities.

In the 1990s, the concept of organizational capabilities has been increasingly used in the analysis of strategy (see for example Aaker, 1989; Prahalad & Hamel, 1990; and Stalk, Evans &

Shulman, 1992) and of technology management (e.g. Leonard-Barton, 1992). Several terms were used as this perspective evolved -- resources, invisible assets, strategic assets, capabilities, core competences. Gradually, however, the field has converged on the term "capabilities" and on several defining features: capabilities develop over time, involve complex interactions among resources (Amit & Schoemaker, 1993) and across levels (Leonard-Barton, 1992), and are a source of competitive advantage in large part because they are hard to imitate. And one of the reasons they are hard to imitate is that they involve dynamic interactions across levels within the organization: the level of individual skills and capabilities, the routines of the work process, and two organization-level variables: organizational systems (for R&D, human resource management systems, project management systems, and resource allocation systems are particularly crucial), and organizational culture.[5] While a study such as the MIT-IRI study, which focuses on organizational units rather than projects, is not able to illuminate significantly the first two levels of analysis (the individual and the work process routines), it is useful for analyzing the organizational systems level. The following section examines the extent of internal cross-border knowledge creation patterns in the U.S. FIRDUs, and the organizational systems that support them.

CROSS-BORDER KNOWLEDGE CREATION CAPABILITIES IN FIRMS WITH INTERNATIONAL R&D UNITS

The organizational systems used to link units in a geographically dispersed R&D system are key elements of cross-border knowledge creation capabilities. As one of the leading European scholars who has studied the internationalization of R&D, Arnoud de Meyer of INSEAD, has put it, "Learning about different markets, different problem-solving methods, different sources of technological progress, different culture, different competitors, and the rapid diffusion of that learning through the organization is definitely enhanced by creating an international network of R&D laboratories" (De Meyer, 1992: p. 169). Drawing on work by De Meyer (especially De Meyer, 1991) and on input from the sponsoring committee of the IRI, we developed a list of ten mechanisms used to link technology development centers located in different countries into such a network, and asked the survey respondents in the FIRDUs to tell us whether they had used them, and how they rated the effectiveness of those they did use (obviously this question was omitted from the version sent to the HRDUs).

Not surprisingly, virtually everyone uses the standard communications links of frequent long-distance interpersonal communication through phone, fax, and email, and short international visits. But for other mechanisms, such as personnel transfers and some of the resource allocation systems, the percentage of units where they are not used is relatively high -- almost half, in the case of short-term transfers of personnel. Therefore we calculated an "effectiveness ratio", which is the percentage of those units using the particular mechanism that rated it as effective (either 4 or 5 on a 5-point scale). Exhibit 5 presents the percentage of FIRDU units rating the mechanism as "effective" (that is, a 4 or 5 on the 5-point rating scale), the percentage not employing each particular mechanism, and the effectiveness ratio for those that did.

EXHIBIT 5 ABOUT HERE

Not surprisingly, the standard long-distance communications links (phone, fax, and email) were virtually universally employed and received a high effectiveness rating. The major exception in terms of effective ratios was among the foreign subsidiaries in the United States (note: this breakdown is not shown in the Exhibit), who gave the "frequent communication by phone, fax, and email" a startlingly low effectiveness ratio of 51.5%, a low rate that holds for this group regardless of the amount of cross-border interaction on technology development (it is only 54% even for the units for whom 50% or more of their products and technologies involve cooperation with R&D units outside the US). While one might first be tempted to look to a cultural explanation (for instance, that the home country business cultures of these units may be less comfortable with such arm's length communications mechanisms than the US firms), in fact it seems to be related to a pattern revealed in other indicators in the survey and in the interviews: a very strong orientation among these units to the local U.S. market and a high proclivity for autonomy from parental control (which presumably also includes resistance to parental efforts at regular communication). These units were also less enthusiastic about the other virtually ubiquitous linkage mechanism, short visits; the effectiveness ratio among the foreign-owned units in the US was 10% lower than the units in the US FIRDUs, either at home or abroad.

The highest effectiveness ratio went to video conferencing. Our interviews revealed that R&D managers viewed this as a very useful way to reduce travel for meetings, although not to eliminate it (discussed further below). Moving people is still, however, the key mechanism for linking R&D units, and in this function short visits are key to the communications networks, receiving the next highest effectiveness ratio and being used by virtually all the units. The data from another of the survey questions reveals this even more strongly. We asked unit heads to tell us approximately what percentage of their technical personnel had travelled in the past year to technical units in the company outside the country in which they were located. These data are presented in Exhibit 6.

EXHIBIT 6 ABOUT HERE

For roughly 80% of all the FIRDU units in all categories, 10% or more of their technical staff had travelled internationally within the R&D network at least once in the past year; more startlingly, in the US FIRDUs 40% of the home units and 60% of the foreign units reported that a quarter or more of their technical personnel had done so. Not surprisingly, there was a relationship between this travel ratio and the size of the unit, but primarily for the units with very high travel ratios (50% or more): 31% of the units with under 15 technical employees had a travel ratio of over 50%, compared to 20% of the units with 60 or more.

Most of this travel is of course in the form of short visits. But in addition, companies transfer technical people on longer assignments. We distinguished two types of people movement that involve formal transfers of technical personnel: transfers of under six months (called "short-term transfers") and those of more than six months ("long-term transfers"). Based on preliminary discussions, we learned that six months is usually the cut-off point in terms of whether the transfer is viewed as "temporary" and therefore not needing the re-establishment of the person's household in the new location. Long-term transfers had a higher effectiveness ratio, but also a high proportion of units who didn't use them. Short-term transfers were even less common, and more of the units were ambivalent about their effectiveness. Neither type of transfer received as high an effectiveness rating as short visits.

The interviews clarified the different roles of these three types of cross-border people movement. Short visits, obviously, had a clearly targeted mission, and were best used to solve problems (either technical or managerial coordination problems) or to maintain relationships that were supplemented between visits by other forms of communication, such as video conferencing. Short-term transfers were tied to specific projects, and also had a clear target. They were seen as effective for transferring technology, either into or out of the unit. Long-term transfers, on the other hand, are most effective in building individual cross-border capabilities, in terms of a deep understanding of a different business and technical environment and the development of lasting personal networks across units. However, they were seen to have high costs, both literally (in terms of the costs of re-establishing a household in a new country), and in terms of the problems they create for managers. Long-term postings are not usually tied to a specific project, and therefore the "host" unit has to find a role for the incoming person; the "sending" unit usually has to replace him or her, and then find a role for the person upon return. Moreover, the growing number of dual career households in the U.S. was frequently cited in interviews as a factor making technical personnel less flexible in taking long-term transfers abroad.

Short-term transfers do not have these disadvantages, but several managers pointed out in the interviews that people were less likely to return from them with a broad understanding of the local business and technical environment and that they developed less dense and sustained personal ties (since they viewed themselves and were viewed by others as "transients" rather than members, however temporary, of the unit). As several managers pointed out, if a company were systematic about using a mix of short-term transfers and visits, repeated postings and visits to the same international site might well serve as a functional equivalent of long-term transfers in terms of their effect on individual border-crossing capabilities, but few U.S. companies have the Human Resource Management systems in place in their R&D organizations to make such long-term planning possible.

In fact, most companies do not use short and long term transfers as functional equivalents: nearly half the units (46.1%) use both, and over a quarter (28.7%) use neither; 15.9% use short-term but not long-term transfers, and only 9.3% use long-term transfers and not short-term. Of the companies that use both, over half see them as equally effective (57.1% -- but as effective for different purposes, as the preceding discussion indicates); 17.6% see long-term transfers as effective but not short-term, and 9.2% see only the short-term transfers as effective. The remaining unit heads -- a surprising 11.8% of those using both types -- did not view either as particularly effective.

The balance among the different modes of moving people across borders in R&D is especially noteworthy given the fixation of studies of human resource management in the MNE on the expatriate manager (that is, on long-term transfers). In the R&D function, the cross-border movement of technical people is much more extensive for short visits and for transfers (those dubbed "long-term" here as well as the short-term transfers) that are much shorter than the three to five years normal for expatriate managers. For the most part, this cross-border movement of R&D personnel has none of the infrastructure of cross-cultural training and mentoring provided in many companies for "expats". For the knowledge-creating company, improving the effectiveness of the much more numerous short-term transferees and the engineers sent into new cultural and technical environments for short visits -- and often on short notice -- is much more important than further improving the infrastructure for the much less numerous (and in many companies shrinking) number of longer-term expatriates. In our interviews, managers provided some suggestions of how to do this, such as providing designated "local mentors" who have the formal responsibility of helping the visiting engineer or scientist to understand the local environment and improve his or her interactions in it. This is an arena that would benefit from much more extensive and systemic research.

For the resource allocation and decision-making systems, the lowest effectiveness ratio, to our surprise, went to "systems for allocating the costs and benefits of joint activities". In work with several companies prior to this study, we had found that the absence of such a system was often cited as a serious source of problems, and yet, although such systems are in place for 60% of the units in this study, they don't seem to work very well. One inference from these data is that it confirms the view that the geographic dimension of decision-making is a fundamental problem in product-based business-unit structures; another is that companies might be advised not to invest heavily in trying to construct systems for allocating costs and benefits among geographically dispersed units, but to rely instead on strengthening other means of cross-unit coordination.

The low effectiveness ratio given to "frequent meetings of top-ranking managers" was less surprising, given how widely managers in MNEs today complain about the level of travel required for meetings. Although these are widely used, they are not highly valued for effectiveness by half the units. We used two additional resource allocation systems variables that we thought would be closely and inversely related: "different but complementary areas of expertise" and "some overlap of areas of technical expertise". We hoped by this question to discover whether units were using a strategy of differentiation of technical expertise or of redundancy. In fact most units reported using both: only 21 units (8.1%) reported having overlapping areas of expertise but not different but complementary areas, and only 5 (2.0%) reported the reverse. Either we didn't ask the question clearly enough, or the overlap reported confirms the need for some redundancy even with a differentiation strategy, in order to assure absorptive capacity in technology interactions (Cohen & Levinthal, 1990).

Designating a single unit as the worldwide leader for technology development within a business unit or technical area was used by more than three-quarters of the units' companies, but only two-thirds of them found it effective. There were, as one might expect, significant variations by category: units in the home country found the idea more attractive than the foreign subsidiaries, probably because they were more likely to be designated as the leader. The effectiveness ratio among U.S. FIRDUs' home country units was 68.9%, whereas it was 57.1% among the US-owned subsidiaries abroad. It fell to 36.7% among the US-located subsidiaries of non-US MNEs, but their parent company units gave it a 100% effectiveness rating!

It may seem somewhat redundant, but it is also useful to look at these ratings by the units' level of cross-border interaction in technology development. Like Exhibit 4 above, Exhibit 7 divides the responding units into the three groups of low, medium, and high interaction.

EXHIBIT 7 ABOUT HERE

For all ten mechanisms, the percentage of units without experience of the mechanism falls as the cross-border interaction level rises. This is especially noticeable for video conferencing, which is used in virtually all of the high interaction units. For several variables, the effectiveness ratio also rises with the level of cross-border interaction, as we would expect (especially for frequent meetings of top managers). However, there are some interesting departures from this expected pattern. The effectiveness ratio for long-term transfers is very high in the high-interaction units, and significantly higher than for medium-interaction units; however, for short-term transfers the ratio is lower, and it is virtually equivalent to the ratio given by the medium-interaction units, suggesting that the linkages and individual capabilities created by long-term transfers of people are most valuable when interaction levels across units are high. More surprising is the curvilinear relationship for two mechanisms: a system for allocating the costs and benefits of joint activities, which is most valued by the medium-interaction units and least by the low and the high, and designating a single unit as world-wide leader, which exhibits the same pattern. Both suggest that formal allocation systems may be most useful when interactions across borders rise above a certain level, but that as interaction rises to higher levels, they have more difficulty satisfactorily dealing with the complexities.[6] This is a point made by both Gunnar Hedlund and by Bartlett and Ghoshal in their discussions of the "heterarchical", less formalized management systems appropriate for companies with very dense levels of cross-border interdependencies.

An additional organizational system variable about which we enquired in the questionnaire proved to have an interesting, though not unexpected, relationship with cross-border knowledge creation. We asked the respondents to evaluate the importance of a set of factors in how they personally were evaluated and rewarded as R&D unit managers. The responses varied considerably both by the level of cross-border interaction in technology development and by the category of unit (US-owned FIRDUs, home country and foreign, and non-US FIRDU units in the United States). The data for the three factors that exhibited significant differences by interaction levels are presented in Exhibit 8.

EXHIBIT 8 ABOUT HERE

In the US FIRDUs, both home country and foreign units, the unit heads in high interaction units (those in which over 50% of their products or technologies involved cooperation with other company units outside their country of location) were much more likely to assert that cross-unit cooperation was an important factor in how they were rewarded than were low and medium cross-border interaction units. The foreign unit heads were somewhat more likely to believe that cooperation played a role in their evaluation, perhaps because the units with whom they were most likely to be cooperating were the home country units closest to headquarters and therefore likely to have influence in the evaluation process. On the other hand, the non-US-owned unit heads were much less likely to believe that international cooperation was significant in their evaluation and reward, regardless of level of cross-border interaction. These data are from a single point in time, and it is notoriously dangerous to try to infer causality from correlation. But these data do provide some support for the view that behavior that is rewarded is more likely to be observed than behavior which is not. The fact that a number of the other survey indicators show that the non-US-owned units resisted cross-border integration efforts and were strongly locally oriented is unlikely to be independent of their view of how their heads are evaluated.

In summary, then, the MIT-IRI survey revealed that cross-border knowledge creation was extensive, and that the movement of people played a key role, in terms of short visits and short-term transfers, as well as longer-term expatriate assignments of the conventional type. The different modes of moving people have different effects on the development of organizational capabilities and impose different costs on sending and receiving units, and this aspect of cross-border knowledge creation cries out for more detailed research and analysis in the future. The development of management systems to support cross-border knowledge creation seems to be more difficult when interaction levels -- and hence presumably the complexity of interactions -- are high.

Cross-border knowledge creation is not, of course restricted to the dispersed internal network of the MNE. Let us turn now to the exploration of external cross-border knowledge creation links.

CROSS-BORDER KNOWLEDGE CREATING LINKS WITH EXTERNAL ORGANIZATIONS

In the last decade and a half, technology development links with organizations outside the company, both at home and abroad, have become an increasingly important aspect of knowledge creation for many companies. International external technology linkages are an especially important tool for internationalizing the knowledge creation processes of firms that do not themselves have international R&D units.

In the questionnaire, we asked respondents if their units had engaged in joint technology development projects in the past two years with six types of organizations in each of the three major regions: North America, Europe, and Asia. The organizations were: a general category of "Alliances, joint ventures, and consortia"; "competitors" (both these two categories we considered to be "horizontal alliances" involving similar firms); customers; suppliers outside the company (these next two constituted "vertical" linkages); universities and public research institutes; and technical consultants (these last two being different kinds of "expert organizations"). The data we collected on external alliances are less informative than the information we gathered on internal cross-border knowledge creation, since we asked only about whether the unit has engaged in technology development projects with external organizations in other regions, not about the importance or the effectiveness of these activities.

Even so, the results are striking. If we focus particularly on the international links of the two categories of US-owned units located in the United States, the HRDUs and the home units of the US FIRDUs, we find an impressive international reach for both, with surprisingly little overall difference between them. A very high proportion of both had some kind of knowledge creating linkage with organizations in Europe (75% of the HRDUs and 79% of the FIRDUs), and about half had at least one link with an external organization in Asia (47% and 57% respectively). But as these figures indicate, the linkages of both types of units are much denser in Europe than in Asia, and there are some interesting differences between the two types of units, as we can see from that data presented in Exhibit 9.

EXHIBIT 9 ABOUT HERE

One observation from these data may be worth noting. In the 1980s, critics of U.S. antitrust policies asserted that it was easier for U.S. companies to engage in technology development alliances with foreign companies than with other U.S. firms, much to the detriment of U.S. national competitiveness. This was clearly not true by the mid-1990s: both the HRDUs and the FIRDU units were more extensively involved in such linkages at home than abroad, for all six types of cooperative links, including those with competitors.

The comparison of the patterns of external technology cooperation in Asia with that in Europe provides some food for thought. The HRDUs are less active in Asia than in Europe on all six linkages. The FIRDUs are as active in horizontal links in Asia as they are in Europe, but they are less likely to maintain vertical links (with customers and suppliers) in Asia. And both are much less likely to maintain "expert linkages" -- that is, with universities and government labs or with technical consultants -- in Asia than in Europe.

This last pattern suggests one explanation for the lower level of cooperative links in Asia:

continuing scepticism about the degree to which technology development in Asia is original, valuable, and distinctive. One interviewee, when asked about his unit's lack of technology links in Asia, replied that all the Asians' technology came from the U.S. in the first place, that he felt that his unit was more likely to lose technology than to gain it by such technical links in Asia, and that there really wasn't as much of interest there as he found in Europe. Other interviews suggested other explanations. One is that a regional approach whereby a center or an alliance in one country in the region provides wider geographic access -- a strategy increasingly common in Europe -- is less viable in Asia, where the national technology systems are less interactive than they are in Europe. Moreover, Asia is less well-established operating terrain for US firms than is Europe, and many units have not had the time to develop the knowledge of potential partners and the cross-border capabilities in Asia to engage as effectively in extended alliances there. And for US firms, Japan, which is the undisputed technology leader in Asia, poses more formidable problems of language and access to centers of expertise than do most European countries.

The salience of the familiarity and access factors may be gauged by looking at the difference in the Asian linkages of home country units in US FIRDUs whose companies have technology development units in Asia and those whose companies do not (Exhibit 10).

EXHIBIT 10 ABOUT HERE

The cooperative linkages of the firms with technology development units in the region are comparable to those in Europe (virtually all of the companies in the US FIRDU group do have technology development centers in Europe, and so a similar comparison in that region is not possible) -- with the exception of the expert organization linkages, which remain significantly lower in Asia. But these data suggest that having a unit in the region can provide a "bridge", in terms of both information and support for developing a cooperative relationship, which is lacking for the HRDUs and the units in firms without such a center.

We can also compare the local cooperative knowledge creation links of FIRDU subsidiaries in order to assess how "embedded" they are in local technology systems. These links are not, of course, themselves cross-border links, but they extend the technology reach of the local technology development subsidiaries of the MNE and thereby provide extended resources for intra-company knowledge creation processes. They also, as the previous exhibit suggested, can provide a cross-national "bridge" for their parent organizations into the local technology system.

EXHIBIT 11 ABOUT HERE

As Exhibit 11 shows, these units are deeply embedded in their local technology systems, and in very similar fashion. Even the Asian units (although their number is very small and we cannot make statistical significance tests with so small a sample) have developed local external knowledge creation partnerships to an extent virtually indistinguishable from their counterparts in Europe and comparable foreign-owned units in the U.S. Although we have no control group for the US FIRDU subsidiaries, we can compare the non-US-FIRDU subsidiaries located in the US with the HRDUs and the US FIRDU home units. When we do, we find there is no statistically significant difference in terms of technology development linkages with local organizations, at least on this admittedly coarse-grained measure.

One further issue that these data allow us to explore is whether the kind of external knowledge creation links that companies create abroad is similar to the kind they develop at home. We must remind ourselves that we are working with a very coarse-grained measure here -- simply having or not having a technology development cooperative link with a certain category of external organization. But the data are suggestive (Exhibit 12).

EXHIBIT 12 ABOUT HERE

Exhibit 12 divides the US-owned, US-located units -- the HRDUs and the US FIRDU home country units -- into eight categories for the three most common external partnerships, the "alliances, JVs, and consortia"; customers; and universities. The eight categories are: those which have no links, domestic or international, with that type of external organization; those which have only domestic (i.e. U.S.) partners; three categories of those which have US and international partners (U.S. + European; "Triad" -- that is, U.S., European, and Asian; and U.S. and Asian);

and three categories in which the unit has international but not domestic partners (European partners only, Asian only, and European and Asian). The most immediately obvious observation is how few units have links with international but not domestic partners. The number is largest for the "alliances" type of partner: 8 HRDU units and 22 FIRDUs (15% of the total in both cases). For customers and universities, none of the HRDUs and only a very small fraction of the FIRDUs have international but not domestic partners (5% and 3% respectively). The figures are very similar for the other three types of partners, which are not presented here only for reasons of space. Moreover, it is striking how few of the units, in either HRDU or FIRDUs, have links at home and in Asia but not in Europe. The pattern seems to one of incremental internationalization in external technology cooperation, comparable to the incremental pattern found in the process of expanding operations internationally in production (see for example the classic piece Johanson & Vahlne, 1977). In external networking across borders, R&D units, like the companies in developing their international capabilities in general, build their border-crossing capabilities over time.

The issue of border-crossing capabilities raises a final issue about external knowledge creation linkages: do R&D units use them as a substitute for internal international knowledge creation links? Clearly for HRDUs, they can serve as a functional equivalent to or substitute for their own R&D units abroad. But in FIRDUs, are the units that are less engaged in international joint knowledge creation internally more likely to engage in external linkages as a substitute? The data in fact indicate the opposite: that the units with low levels of intra-company joint knowledge creation are also less active in external linkages. For the 149 US-owned FIRDU home units, the correlation between the 5-category raw data for cross-border internal technology cooperation and the 12-category variable for the total number of types of external technology partnerships outside the US (six each in Europe and Asia) is .379 (significant at a level of $p<.001$). Exhibit 13 provides these same data in a reduced and more visually interpretable format.

EXHIBIT 13 ABOUT HERE

This strongly suggests that a common core of border-crossing capabilities, particularly in terms of moving people and knowledge across borders, undergirds both internal and external international knowledge creating networks, and that units develop and use that core in both contexts.

CROSS-BORDER KNOWLEDGE CREATION PROCESSES IN R&D

Let us now move beyond the data gathered from the MIT-IRI study to look somewhat more conceptually at the processes of joint cross-border knowledge creation in the R&D function in MNEs.

In one of the few explicit discussions of the basic principles of cross-border knowledge creation to be found in the literature on MNEs, Ikujiro Nonaka has defined *global knowledge creation* as "global synergy of the local tacit knowledge and the global articulate knowledge" (1990: 86). Clearly a core element of global knowledge creation is, as Nonaka makes clear, bringing together knowledge that is geographically dispersed. But as he also indicates, "local" and "global" can have two very distinct dimensions. One is the location of the knowledge (where it is); the other concerns its nature (the kind of knowledge it is). In terms of location, "local" usually means situated in a single subsidiary outside the central R&D organization, whereas "global" means that it is located centrally (by "central" one usually means in the home country, where most firms still have most of their innovative activity concentrated, particularly R&D, but in the transnational or "network" model of the MNC it can mean widely shared in the network). The location of knowledge can be most usefully be described in geographically specific terms.

The nature of "local" and "global" knowledge is a more complex issue. Nonaka sees local knowledge as tacit, and global knowledge as explicit. While we found that this was often the case in the various examples of international knowledge creation we collected, it was not always so. Sometimes locally situated knowledge was highly explicit: for example, knowledge of the projected future needs of local customers, or local national standards. And much of the centrally located knowledge is tacit. A more consistent distinction in terms of the nature of knowledge seemed to be between knowledge that was location-specific (that is, applicable to and in a specific, circumscribed local context) and knowledge that was, for want of a better term, generic (that is, applicable in and to all similar contexts). Location-specific knowledge can indeed be tacit, but it can also be explicit: for example, national regulations governing electrical transmission standards, the kind of building materials that function best in the British housing industry, or the preferences of French manufacturers in terms of the functionality of production equipment. Generic knowledge can vary by context, but only when the contexts themselves can be described in general rather than idiosyncratic terms: for example, the boiling point of water varies by altitude, but "altitude" is itself a generic descriptor of context ("X feet above sea-level", as opposed to "at the top of Mount Rainier"). In technology terms, generic knowledge that varies by context can include such examples as the technologies needed for motors operating in extremely polluted or humid environments, the kind of operating system needed to support complete non-alphabetical scripts in software programming, or the miniaturization technologies needed for products in markets that prefer small-scale, space-saving attributes. There is a dynamic interaction between generic and location-specific knowledge akin to that between tacit and explicit knowledge: often generic knowledge is expanded by the need to incorporate or explain location-specific knowledge (for example, the development of technologies needed for motors operating in extremely polluted environments can be derived by examining carefully the motors that work best in Mexican factories). And location-specific knowledge is expanded by applying generic knowledge to particular contexts.

Nonaka's definition does, however, alert us to a very important point: like tacit knowledge, location-specific knowledge is difficult to move across borders and to share across locations, largely because an understanding of the local context is often necessary to give it validity. This difficulty is compounded by the fact that in most contexts generic knowledge is seen as being "higher-order" knowledge than location-specific knowledge. This can be a source of some tension in cross-border, as in cross-functional, interactions. And although ideally the distinction between location-specific and generic is objective, in practice it is not uncommon for location-specific knowledge to be seen as generic by its holders, especially in the MNC's home country. In particular, engineers and scientists in R&D units often see technology-related knowledge -- especially their own knowledge -- as generic, and market-related knowledge as location-specific. This causes problems when the technical knowledge is in fact location-specific (i.e. it applies in the product or process context in which the engineers are located but not another location, where surrounding conditions may vary considerably) -- a fact that most technical people are very reluctant to recognize.

One example concerns a product which is usually seen as among the most internationally standardized in the world: the color television set. When Japanese companies first began trying to sell their sets to Western distributors, they were astonished to hear complaints about the quality of the color, which they regarded as superior to that of many Western manufacturers. Considerable investigation showed that whereas most Japanese viewers watched television under overhead fluorescent lighting, most Americans watched it in rooms lit by standard bulbs, and most Europeans watched television in dark rooms. Color quality varied considerably depending on the lighting conditions under which the set was watched. The "generic" knowledge about color quality held by the Japanese R&D organizations turned out to have a larger element of location-specific knowledge than they had realized. Note that this was a technical problem -- the maintenance of colour quality under a wide variety of lighting conditions. Considerable further technology development on generic technologies for improving and increasing the range of color quality was necessary to develop a product whose color could be adjusted to fit the requirements of various markets.[7]

This last example exemplifies the classic mode of joint cross-border knowledge-creation in R&D, indicated by Nonaka's definition of global knowledge creation as the synergy between local tacit and global explicit knowledge: *combining generic knowledge located in the central R&D organization with location-specific knowledge in various subsidiaries to produce locally-tailored* *products.* In this mode, the key role of the local R&D unit in a dispersed network is to be the repository of location-specific knowledge, in explicit rather than tacit form as much as possible, to facilitate the combining process, which can take place primarily at the center, in the local subsidiaries, or, increasingly, in a "virtual co-location" setting (where there are dense communications links across two or more locations), with varying degrees of central and local participation. As the example of the color television set indicated, often the location-specific knowledge demands further development of generic knowledge to produce appropriate products or processes. In HRDUs, combining dispersed location-specific and central generic knowledge is not, as a rule, cross-border knowledge creation within the R&D function, since the location-specific knowledge is usually supplied by local marketing people (especially those in technical sales and support) or local manufacturing personnel; the cross-border aspects of the knowledge-creation process are therefore cross-functional. There are cases, however, where R&D personnel are dispatched to other locations to absorb location-specific knowledge and bring it back to the center for the knowledge combining process. A well-documented example is provided by the development of the Nissan Primera described in Nonaka & Takeuchi (1995).

A second pattern of joint cross-border knowledge creation is that of *combining generic knowledge from several locations.* Two of the reasons given for the increased internationalization of R&D over the last decade assume that the target of geographic expansion is generic technical knowledge, rather than local adaptation capabilities: the increased dispersion of centers of scientific excellence around the world, and the shortage of scientists and engineers in the home country, which can be addressed by hiring technical personnel in other countries (Westney, 1991; Granstrand, Hakanson & Sjolander, 1992; Howells, 1995). Where the dispersed generic knowledge is complementary, joint knowledge creation has potentially high pay-offs. A well-documented case of this is the development of liquid detergent in Proctor and Gamble, where technical centers in Europe, North America, and Japan contributed the complementary generic knowledge that they had developed in order to respond to the particular needs of their local markets

(Bartlett & Ghoshal, 1990). In their introduction to their edited volume on the internationalization of R&D, Granstrand, Hakanson, and Sjolander pointed out that "Creating and maintaining technological competitive advantage increasingly require access to a wider range of scientific and technological skills and knowledge than is available in the home market" and that consequently we increasingly see foreign R&D units that are "charged with the creation and renewal of core technological capabilities" (Granstrand, Hakanson & Sjolander, 1992: p. 9). This involves not only combining dispersed generic knowledge in the context of specific projects to develop new products or product platforms, but also another mode of combining geographically dispersed generic knowledge: the creation of ongoing "competence communities" to link geographically dispersed specialists of various types in an ongoing learning community to sustain and develop generic knowledge in key technologies.

Yet another -- and much less studied -- mode of joint cross-border knowledge creation involves sharing location specific knowledge. One of the oft-cited advantages of the MNC is its internal variety -- to review the earlier quotation from Arnoud de Meyer "learning about different markets, different problem-solving methods, different sources of technological progress, different culture, different competitors...."(De Meyer, 1992: 169). Much of this knowledge is location-specific, but this does not mean it is not relevant for other locations. There are two kinds of joint knowledge creation based on dispersed location-specific knowledge. One is *using location-specific knowledge as a base for developing generic knowledge*, through abstraction and hypothesis formation and testing (for example, why does a certain material work better in the high-humidity, high-pollution environment of a certain tropical metropolitan market?). A second mode is *moving directly from location-specific knowledge to location-specific knowledge through analogy* (certain kinds of customers prefer X features in the product in France -- what kinds of customers in the US might be like them; this kind of motor works best in Mexico City-- what environments in the US are like Mexico City?).

In summary, then, we can identify at least four distinct cross-border knowledge creation processes:

(1) Combining centrally-located generic knowledge with locally dispersed location-specific knowledge to add value to products and improve processes (the "classic" mode);

(2) Combining generic knowledge from two or more locations (the "transnational" mode);

(3) Joint cross-border interactions using location-specific knowledge as a base for generating generic knowledge for transfer to other locations;

(4) Using analogy to apply location-specific knowledge from one location to another.

The first process can occur in a number of venues, from the major cross-border-project to relatively short "technology transfer" interactions. The second usually revolves around large-scale cross-border joint projects. We know much less about the third and fourth modes, because they have been less studied, but our interview-based examples suggest that they are more likely to occur as a by-product of the interaction of people across borders in various ways, rather than in specific projects.

Although adding yet another category to the typology of knowledge may seem to be unnecessary elaboration, the distinction between generic and location-specific knowledge can help to address some key issues in international knowledge creation. For example, we saw earlier that different kinds of travel seem to be effective in different contexts. Given the assumption that location-specific knowledge is more difficult to share across borders than generic knowledge, and that tacit location-specific knowledge is the most difficult to share, then we can suggest that fitting travel patterns to the kind of knowledge sharing is one way to make better use of cross-border travel of technical personnel (see Exhibit 14).

EXHIBIT 14 ABOUT HERE

Information technology links and short visits may well be adequate for sharing explicit generic knowledge across borders, whereas sharing tacit generic knowledge might benefit from short-term transfers. Sharing explicit location-specific knowledge may be accomplished through a combination of visits and short-term transfers, whereas sharing tacit location-specific knowledge may be the venue where long-term transfers are most effective. It should be possible to test these relationships empirically.

Finally, one of the most difficult questions facing MNEs today is how geographically dispersed their R&D ought to be. No company can afford to match the dispersal of R&D to the dispersion of markets or even of production; most companies have, and will continue to have a smaller proportion of R&D abroad than of either production or sales. One answer has been the extent to which the technology-related knowledge needed to compete effectively is geographically dispersed and locally embedded. Indeed, it is now a commonplace to say that much useful knowledge is locally embedded, with the implication that one must have a physical presence there (usually in the form of an R&D unit) to gain access to that information. But "locally embedded" can have several meanings:

(a) a high proportion of tacit knowledge;

(b) a high proportion of location-specific knowledge;

(c) knowledge dispersed among several local organizations;

(d) any combination of the above.

How one goes about gaining access to such knowledge will be greatly affected by which of these aspects is applicable.

The key factor is indeed the level of dispersion of relevant technological knowledge. But given the relative ease with which explicit generic knowledge can be transferred across borders, it is useful to make some finer distinctions. The geographic dispersion of tacit generic knowledge is a more important motivator for the internationalization of R&D than that of explicit generic knowledge. An even more important criterion is the level of value added by location-specific knowledge to the products and processes of the business. The higher that level is, and the greater the proportion of tacit location-specific knowledge within that level, the greater the potential advantages of the geographic dispersion of knowledge creation capabilities.

To summarize the main argument of this paper, cross-border knowledge creation is extensive in MNEs and in all likelihood will increase in importance over the coming years. Studying new product development projects probably remains the most promising locus for research aimed at understanding the processes of international knowledge creation. But this should not be the only level of analysis. Research on the development of cross-border capabilities at both the organizational systems level and at the level of the border-crossing individuals -- moving across borders on short visits and short-term transfers as well as long-term expatriate assignments -- is an essential complement to project-level research, and has relevance for cross-border learning well beyond the R&D function.

REFERENCES

Aaker, D. A. (1989). Managing assets and skills: the key to a sustainable competitive advantage. California Management Review, 31(2), 91-106.

Amit, R., & Schoemaker, P. J. H. (1993). Strategic assets and organizational rent. Strategic Management Journal, 14(1), 33-46.

Bartlett, C. A. (1986). Building and Managing the Transnational: The New Organizational Challenge. In M. E. Porter (Ed.), Competition in Global Industries, (pp. 367-404). Boston, MA: Harvard Business School Press.

Bartlett, C. A., & Ghoshal, S. (1986). Tap your subsidiaries for global reach. Harvard Business Review, 64(4), 87-94.

Bartlett, C. A., & Ghoshal, S. (1989). Managing Across Borders: The Transnational Solution. Boston, MA: Harvard Business School Press.

Bartlett, C. A., & Ghoshal, S. (1990). Managing innovation in the transnational corporation. In C. A. Bartlett, Y. Doz, & G. Hedlund (Eds.), Managing the Global Firm, . London: Routledge.

Buckley, P. J., & Casson, M. C. (1976). The future of the Multinational Enterprise. London: Macmillan.

Cantwell, J. A. (1989). Technological Innovation and Multinational Corporations. Oxford: Basil Blackwell.

Casson, M. (Ed.). (1991). Global Research Strategy and International Competitiveness. Oxford: Basil Blackwell.

Cohen, W., & Levinthal, D. (1990). Absorptive Capacity: A New Perspective on Learning and Innovation. Administrative Science Quarterly, 35(1), 128-152.

De Meyer, A. (1991). Tech Talk: How managers are stimulating global R&D communication. Sloan Management Review, (Spring), 49-58.

De Meyer, A. (1992). "The Management of International R&D Operations". In O. Granstrand, L. Hakason, & S. Sjolander (Eds.), Technology Management and International Business: The Internationalization of R&D, (pp. 163-179). Chichester, UK: John Wiley & Sons.

Dunning, J. (1981). International Production and the Multinational Enterprise. London: Allen and Unwin.

Gast, A., & Lessard, D. (1996). Managing Multi-point Learning in the Multinational Firm (Working paper): MIT Sloan School of Management.

Ghoshal, S. (1987). Global Strategy: An Organizing Framework. Strategic Management Journal, 8(5), 425-440.

Granstrand, O., Hakanson, L., & Sjolander, S. (1992). Technology Management and International Business. Chichester, UK: John Wiley and Sons Ltd.

Hakanson, L. (1990). International decentralization of R&D - the organizational challenges. In Y. D. C. A. Bartlett, and Gunnar Hedlune (Ed.), Managing the Global Firm, (pp. 256-278). London: Routledge.

Hedlund, G. (1986). The Hypermodern MNE: A Heterarchy? Human Resource Management, 25, 9-35.

Hedlund, G. and Ridderstrahle, J. (1995). "International Development Projects: Key to Competitiveness, Impossible, or Mismanaged?" International Studies of Management and Organisation 25-1/2: 158-184.

Howells, J. R. (1995). Going Global: The use of IT Networks in Research and Development. Research Policy, 24(2), 169-184.

Johanson, J., & Vahlne, J.-E. (1977). The Internationalization Process of the Firm -- A Model of Knowledge Development and Increasing Foreign Market Commitments. Journal of International Business Studies, 8(1), 23-32.

Kogut, B. (1983). Foreign Direct Investment as a Sequential Process. In C. P. Kindleberger & D. B. Audretsch (Eds.), The Multinational Corporation in the 1980s, (pp. 38-56).

Cambridge, Mass: MIT Press.

Kogut, B. (1985a). Designing Global Strategies: Comparative and Competitive Value Added Chains. Sloan Management Review, Summer, 15-28.

Leonard-Barton, D. (1992). Core capabilities and core rigidites: a paradox in managing new product development. Strategic Management Journal, 13(Summer Special Issue), 111-125.

Nelson, R., & Winter, S. (1982). An Evolutionary Theory of Economic Change. Cambridge, Mass: Harvard University Press.

Nelson, R. (1995). Evolutionary Theorizing about Economic Change. In N. J. Smelser and R. Swedberg (Eds.), The Handbook of Economic Sociology. Princeton: Princeton University Press.

Nohria, N., & Ghoshal, S. (1997). The Differentiated Network: Organizing Multinational Corporations for Vaue Creation. San Francisco: Jossey-Bass Inc.

Nonaka, I. (1990). Managng globalization as a self-renewing process: experiences of Japanese MNEs. In C. A. Bartlett, Y. Doz, & G. Hedlund (Eds.), Managing the Global Firm. London: Routledge.

Nonaka, I., & Takeuchi, H. (1995). The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation. New York: Oxford University Press.

Prahalad, C. K., & Hamel, G. (1990). The core competence of the corporation. HBR, 68(3), 79-91.

Rugman, A. M. (1981). Inside the Multinationals: The economics of internal markets. London: Croom Helm.

Solvell, O., & Zander, I. (1995). Preface (The Dynamic Multinational Firm). International Studies of Management and Organization, 25(1/2), 3-16.

Stalk, G., Evans, P., & Shulman, L. E. (1992). Competing on Capabilities: The New Rules of Competition. Harvard Business Review, 70(2), 57-69.

Vernon, R. (1966). International Investment and International Trade in the Product Cycle.

Quarterly Journal of Economics, 190-207.

Vernon, R. (1979). The Product Cycle Hypothesis in a New International Environment. Oxford Bulletin of Economics and Statistics, 41, 255-267.

Westney, D. E. (1991). Organizational Change and the Internationalization of R&D. In T. Kochan & M. Useem (Eds.), Transforming Organizations, . New York: Oxford University Press.

ENDNOTES

1. Defining "innovation" and "knowledge creation" is a notoriously difficult task. In this paper, as at this conference, the term "knowledge creation" is used instead of "innovation", although the meaning of the two is very close (knowledge creation referring more to the process, and "innovation" being used to refer either to the process or the outcome). Knowledge creation or innovation is here considered in the context of the particular firm in which the specific knowledge -- usually a product or a process (material or organizational) -- is developed, regardless of whether that knowledge is "created" in the sense of never having existed anywhere before.

2.The lead on this kind of research was taken by European scholars, and much of the European research on the topic is represented in Granstrand et al (1992).

3. Andreas Gast and Don Lessard in a recent working paper (1996) have pointed out that capabilities in dispersed locations can be complementary or similar; joint knowledge creation in the first case enhances the scope of the MNC, and in the second enhances scale.

4. There are obviously great differences across industries and companies in how these different categories of technology development are defined; in this study, given the range of industries and companies covered, we left it up to the responding individuals to decide on their unit's portfolio of activities, without providing more detailed definitions.

5. This three-level (individual, work process, organization) typology builds on and modifies somewhat Dorothy Leonard-Barton's very useful (1992) model.

6. It is worth noting that this pattern holds across the categories for the "worldwide leader"

mechanism: for the US FIRDU home units, the effectiveness ratios across the levels of interaction from low to high are 51.4 %, 81.8%, and 71.9%.

7. I am indebted for this illustration to Mr. Takeyoshi Ohgai, formerly an executive of Matsushita and now enrolled in the doctoral program at Kobe University's Institute of Management Research.

EXHIBIT 1: VERTICAL TECHNOLOGY SCOPE

This table presents the ways in which mandates are clustered -- the shaded "boxes" are the mandates undertaken by units in that category.

Basic research	Break-through products	Next generation products	Process Innovations	103	33.8%
Basic research	Break-through products	Next generation products	Process Innovations	26	8.6%
Basic research	Break-through products	Next generation products	Process Innovations	44	14.5%
Basic research	Break-through products	Next generation products	Process Innovations	16	5.3%
Basic research	Break-through products	Next generation products	Process Innovations	12	3.9%
Basic research	Break-through products	Next generation products	Process Innovations	9	3.0%
Basic research	Break-through products	Next generation products	Process Innovations	18	5.9%
Basic research	Break-through products	Next generation products	Process Innovations	32	10.5%
Basic research	Break-through products	Next generation products	Process Innovations	8	2.6%
Basic research	Break-through products	Next generation products	Process Innovations	5	1.6%
Basic research	Break-through products	Next generation products	Process Innovations	1	.3%
Basic research	Break-through products	Next generation products	Process Innovations	3	1.0%
Basic research	Break-through products	Next generation products	Process Innovations	4	1.3%
Basic research	Break-through products	Next generation products	Process Innovations	8	2.6%
Basic research	Break-through products	Next generation products	Process Innovations	15	4.9%
TOTAL				304	99.80%

EXHIBIT 2: CATEGORIES OF RESPONDING UNITS: HRDUs AND FIRDUs
NUMBER, AVERAGE SIZE, AVERAGE AGE

TYPE OF UNIT	Number of responding units		Average size (# of technical employees)	Average Age (yrs since est.)
US Firms - Home-based Technology Development Units only (HRDUs)	53	16.7%	106.3	27.6
US Firms with International Technology Development Units (FIRDUs) -- Home units	149	46.8%	213.4	31.3
US Firms with International Technology Development Units (FIRDUs) -- Foreign units	71	22.3%	52.1	16.4
Non-US Firms with International Technology Development Units (FIRDUs) -- US-based units	33	10.4%	125.0	13.8
Non-US Firms with International Technology Development Units (FIRDUs) -- Home units	12	3.8%	121.2	11.1
TOTAL	318	100.0%	146.5	24.8

EXHIBIT 3: LEVEL OF CROSS-BORDER KNOWLEDGE CREATION IN FIRDUs, BY CATEGORY

Question (only on questionnaires for firms with international technology development units): Approximately what percentage of the products and technologies your unit works on involve some form of collaboration with the company's technical units outside the country in which you are located?

PERCENT OF PRODUCTS/TECHNOLOGIES INVOLVING CROSS-BORDER COOPERATION	US FIRDUs- Home units	US FIRDUs- Foreign units	Non-US FIRDUs- US units	Non-US FIRDUs- Home units
None	3.4%	0	0	0
Less than 25%	43.8%	13.2%	33.5%	25.0%
25-50%	26.0%	22.1%	27.3%	33.3%
50-75%	26.7%	64.7%	39.4%	41.7%
TOTAL (Number of units)	99.9% (146)	100% (68)	100.2% (33)	100% (12)

EXHIBIT 4: REASONS FOR INTERNATIONAL TRAVEL OF TECHNICAL PERSONNEL IN FIRDUS, BY LEVEL OF CROSS-BORDER INTERACTION

Q: For your technical unit, how important are each of the following reasons for sending personnel outside the country in which you are located? Responses on 1-5 scale where 5 = very important. Following table presents the percentage of each type of unit rating the reason 4 or 5.

	High Cross-border interaction units (n= 101)	Medium Cross-border interaction units (n= 66)	Low cross-border interaction units (n = 92)
Work on a joint project with another unit.	90.1%	74.2%	64.4%
Follow a project from R&D to manufacturing	86.1%	81.8%	63.0%
Transfer technology (including "knowhow") from your unit to another unit.	80.2%	72.2%	55.4%
Transfer technology to your unit from another unit	64.4%	56.1%	41.3%
Learn about another unit's products or technologies	65.3%	74.2%	55.4%
Learn about customer or market requirements	60.4%	65.3%	54.3%
Use specialized or expensive equipment	31.7%	39.4%	18.5%
Coordinate plans about future products/technologies	93.1%	72.7%	53.3%
Review goals, budgets, or recent performance	50.5%	50.0%	22.8%
Evaluate the progress of a project	64.4%	62.1%	41.3%
Fill a position that could not be filled locally	27.7%	25.8%	10.9%
Technical training or career development	60.4%	66.7%	32.6%
Management training or career development	43.6%	48.5%	22.8%

EXHIBIT 5: MECHANISMS IN FIRDUS FOR LINKING TECHNOLOGY DEVELOPMENT UNITS IN DIFFERENT COUNTRIES

Linking Mechanism	% rating "effective"	% "not tried"	Effectiveness ratio*
INFORMATION TECHNOLOGY			
Frequent communication by phone, fax, e-mail	73.1%	1.5%	74.2%
Video conference	76.9%	15.9%	91.4%
HUMAN RESOURCE MANAGEMENT SYSTEMS: TRAVEL			
Short visits (<3 weeks) by technical personnel	80.2%	2.7%	82.4%
Short-term transfers (1-6 mths) of technical personnel	38.6%	44.4%	69.4%
Long-term transfers (>6 mths) of technical personnel	48.1%	37.7%	77.2%
RESOURCE ALLOCATION AND DECISION-MAKING			
System for allocating costs & benefits of joint activities	13.6%	38.1%	22.0%
Frequent meetings of top-ranking managers	46.7%	7.7%	50.6%
Different but complementary areas of expertise	40.2%	11.6%	45.4%
Some overlap of areas of technical expertise	41.4%	5.0%	43.5%
Designating a single unit as worldwide leader within a business or technology	48.1%	23.1%	62.5%

*"Effectiveness ratio" calculated by taking the % of those who used the mechanism who rated it as effective.

EXHIBIT 6: PROPORTION OF TECHNICAL PEOPLE TRAVELLING ACROSS BORDERS, BY CATEGORY

Question: During the past year, approximately what percentage of your unit's personnel took at least 1 trip:
(a) (for FIRDUs) to another technical unit in the company outside the country in which you are located?
(b) (for HRDUs) outside the country in which you are located?
0% 5% 10% 25% 50% 75% 100%

PERCENT OF TECHNICAL PERSONNEL TRAVELLING INTERNATIONALLY	US FIRDUs- Home units	US FIRDUs- Foreign units	Non-US FIRDUs- US units	Non-US FIRDUs- Home units
None	3.5%	12.5%	3.0%	0
5%	18.9%	15.6%	15.2%	18.2%
10%	37.1%	10.9%	30.3%	9.1%
25%	26.6%	21.9%	30.3%	45.5%
50% or more	14.0%	39.1%	21.2%	27.3%
TOTAL (Number of units)	100.1% (143)	100% (64)	100% (33)	100.1% (12)

Chi-square: differences significant at p=.000 level

EXHIBIT 7: USAGE AND EVALUATION OF CROSS-BORDER MECHANISMS LINKING DISPERSED UNITS IN FIRDUS, BY LEVEL OF CROSS-BORDER INTERACTION

Q: Consider you unit's interactions with the company's technical units outside [the country of location]. In the last two years, how effective was each of the following factors in contributing to a good working relationship with them? Response categories: 0 = "Have not tried"; then a 5-point scale where 1 = "not at all effective" and 5 = "Very effective".

TYPE OF CROSS-BORDER LINKING MECHANISM	Low Cross-Border Interation Units (<25%) *[n = 92]*		Medium Cross-Border Interation Units (25-50%) *[n = 66]*		High Cross-Border Interation Units (>50%) *[n = 101]*	
	"Not tried"	Effective-ness ratio	"Not tried"	Effective-ness ratio	"Not tried"	Effective-ness ratio
Frequent communication by phone, fax, email	4.4%	60.9%	0	75.7%	0	85.15%
Video conference	29.7	84.4	12.1	93.1	5.9	95.8
Short visits	6.6	72.9	0	84.6	1.0	90.0
Short-term transfers (1-6 mths)	57.8	57.9	43.9	73.0	34.0	71.9
Long-term transfers (>6 mths)	50.0	73.3	34.8	67.4	29.6	84.1
Frequent meetings of top mgrs	17.8	37.8	3.1	46.0	2.0	63.3
System for allocating costs & benefits of jt. activities	44.3	14.3	49.2	37.5	26.0	21.6
Different but complementary areas of expertise	16.9	18.9	7.7	56.7	10.1	58.4
Some overlap of areas of technical expertise	4.4	60.9	0	75.7	0	85.1
Designating a single unit as worldwide leader within a business or technology	42.2	53.8	12.1	72.4	14.3	58.3

EXHIBIT 8: BASIS FOR EVALUATING AND ASSESSING THE PERFORMANCE OF UNIT MANAGERS

Q: Please indicate how important each of the following factors is in determining how you personally are rewarded (i.e. compensated, promoted, or otherwise recognized):
Responses on a 1-5 scale where 1 = "Not at all important" and 5 = "Very important".

	US FIRDUs - Home country units (n = 145)			US FIRDUs - Foreign units (n = 67)			Non-US-FIRDUs - Units in United States (n = 33)		
LEVEL OF CROSS-BORDER INTERACTION	LOW	MEDIUM	HIGH	LOW	MEDIUM	HIGH	LOW	MEDIUM	HIGH
Units' degree of Cooperation with other units in the company	27.5%	23.7%	52.6%	22.2%	20.0%	62.8%	9.1%	22.2%	23.1%
Business unit/division performance in the market in which the unit is located	75.4	63.2	46.2	66.7	40.0	32.6	54.4	62.5	69.2
Business unit/division performance world-wide	50.7	65.8	71.8	41.4	33.3	53.5	18.2	44.4	46.2

EXHIBIT 9: CROSS-BORDER TECHNICAL COOPERATION WITH OUTSIDE ORGANIZATIONS IN EUROPE AND ASIA BY HOME COUNTRY UNITS IN US FIRMS - HRDUS AND FIRDUS

Q: During the past two years, has your unit participated in product, process, or technology development activities with any of the following organizations?

TYPE OF CROSS-BORDER JOINT TECHNOLOGY DEVELOPMENT PARTNER	US		EUROPE		ASIA	
	HRDU	FIRDU	HRDU	FIRDU	HRDU	FIRDU
HORIZONTAL COOPERATIVE LINKS						
Alliance, JV, or consortium	60.4%	57.4%	49.1%	39.9%	26.4%	39.9%
Competitor	35.8%	25.7%	22.6%	12.8%	9.4%	13.5%
VERTICAL COOPERATIVE LINKS						
Customer	77.4%	78.4%	39.6%	52.7%	22.6%	33.8%
Supplier (not owned by company)	64.2%	75.0%	22.6%	45.9%	15.1%	18.2%
COOPERATIVE LINKS WITH "EXPERT ORGANIZATIONS"						
University or public research institute	86.8%	73.0%	28.3%	41.2%	7.5%	8.1%
Technical consultant or contractor	83.0%	81.1%	35.8%	35.8%	7.5%	14.2%

EXHIBIT 10: RELATIONSHIP BETWEEN JOINT TECHNOLOGY DEVELOPMENT NETWORKS IN ASIA AND R&D CENTRE IN THE REGION

TYPE OF PARTNER	With Centre (N=123)	Without Centre (N=26)
Alliance, JV, or consortium*	44.7%	15.4%
Competitor**	16.3%	0
Customer*	39.0%	7.7%
Supplier (not owned by company)**	21.1%	3.8%
University or public research institute	8.9%	3.8%
Technical consultant or contractor	16.3%	3.8%

*Chi-square test significance level <.01

**Chi-square test significance level <.05

EXHIBIT 11: LOCAL EXTERNAL TECHNOLOGY DEVELOPMENT LINKAGES, FIRDU SUBSIDIARIES

TYPE OF EXTERNAL PARTNER	Non-US-Owned FIRDUs - R&D units in US - US links (n = 33)	US FIRDU units in Europe - % with European links (n=55)	US FIRDU units in Asia - % with Asian links (n=8)
Alliance, JV, or consortium	48.5%	43.3%	75.0%
Competitor	27.3%	28.3%	62.5%
Customer	87.9%	56.7%	75.0%
Supplier (not owned by company)	72.7%	61.7%	62.5%
University or public research institute	81.8%	65.0%	62.5%
Technical consultant or contractor	63.3%	58.3%	62.5%

EXHIBIT 12: ALLIANCES AT HOME AND ABROAD: HRDUS AND U.S. FIRDU HOME UNITS

Location of Joint Knowledge Creation Links with External Organizations	Alliances, JVs, Consortia		Customers		Universities	
	HRDUs	FIRDUs	HRDUs	FIRDUs	HRDUs	FIRDUs
No external JKC Links	24.5%	26.8%	22.6%	16.7%	13.2%	23.5%
US links only	22.6	17.4	37.7	28.2	54.7	33.6
US + Europe	18.9	12.1	17.0	18.1	24.5	31.5
US + Europe+ Asia (Triad)	18.9	22.1	22.6	30.2	3.8	6.7
US + Asia	0	6.0	0	2.0	3.8	1.3
Europe only	7.5	4.0	0	3.4	0	3.4
Asia only	3.8	9.4	0	0	0	0
Europe + Asia, no US	3.8	2.0	0	1.3	0	0
	100% *(n=53)*	99.8% *(n=149)*	99.9% *(n=53)*	99.9% *(n=149)*	100% *(n=53)*	100% *(n=149)*

EXHIBIT 13: RELATIONSHIP BETWEEN EXTERNAL AND INTERNAL INTERACTIONS IN KNOWLEDGE CREATION, HOME COUNTRY UNITS OF U.S. FIRDUS

External Technology Partnerships outside the U.S. - number of types	Low internal cross-border interaction (25% or less of technology)	Medium internal cross-border interaction (25% or less of technology)	High internal cross-border interaction (25% or less of technology)
0-1	46.4%	23.7%	12.8%
2-5	40.6	52.6	41.0
6 or more	13.0	23.7	46.2
	100% (n = 69)	100% (n = 38)	100% (n = 39)

EXHIBIT 14: THE NATURE OF KNOWLEDGE AND THE TYPE OF CROSS-BORDER INTERACTION FOR EFFECTIVE JOINT KNOWLEDGE CREATION

	EXPLICIT KNOWLEDGE	TACIT KNOWLEDGE
GENERIC KNOWLEDGE	*Information Technology Links* *Short visits*	*Short-term transfers*
LOCATION-SPECIFIC KNOWLEDGE	*Short visits* *Short-term transfers*	*Long-term transfers*