INNOVATION IN MULTINATIONAL CORPORATIONS: CONTROL AND COMMUNICATION PATTERNS IN INTERNATIONAL R&D OPERATIONS

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This paper addresses issues of global innovation in multinational corporations by examining the patterns of communication and control in international R&D operations. Using a sample of 110 international R&D units from 15 multinational corporations, we identify three types of R&D unit role (local adaptor, international adaptor, international creator). We show that: (1) each type of R&D unit is managed primarily through a different mode of control; (2) local and international adaptors both focus their communication on their internal corporate network; and (3) international creators have strong internally and externally oriented networks of relationships. The implications for the management of global innovation are discussed. © 1998 John Wiley & Sons, Ltd.

INTRODUCTION

A challenge facing many large multinational corporations (MNCs) today is how to effectively make use of their far-flung research and development operations. Research has suggested that large MNCs undertake between 5 percent and 25 percent of their R&D outside their home country (Cheng and Bolon, 1993; Håkanson and Nobel, 1993). International R&D units may have originally been established to undertake adaptation work or because of host country demands, but increasingly the evidence suggests that they are becoming active contributors to the MNC's global innovation effort (Ghoshal, 1986; Pearce, 1989), and even members of the core development group in 'global innovation projects' (Hedlund and Ridderstråle, 1995). As this trend continues, the ques-

tion of how best to manage the relations between R&D operations around the world becomes ever more critical. In the words of De Meyer, 'One of the most important productivity problems in R&D is stimulating communication among researchers ... it becomes more difficult when laboratories are located far from each other' (1991: 49).

The importance of effectively managing international R&D units is underlined by the centrality of R&D to the *raison d'etre* of the MNC. Theory postulates that a necessary condition for international production is the existence of an ownership-specific advantage (Dunning, 1980). An ownership-specific advantage can take many forms, but in many cases it is embodied in the proprietary technologies of the MNC. And it is the R&D function which is responsible for the maintenance and upgrading of the MNC's proprietary technologies.

The approach taken in this paper is to use recent advances in thinking on MNC management, in general, to inform the specific case of international R&D management. The MNC

management literature has shown, first, that foreign subsidiaries develop over time and take on increasingly specialized roles (Bartlett and Ghoshal, 1986; Birkinshaw and Hood, 1996; Jarillo and Martinez, 1990). Specialized roles can best be managed, it is argued, by tailoring control and coordination mechanisms to the specific situation of each subsidiary (Ghoshal, 1986). The second key insight from the MNC management literature is that traditional assumptions of head office superordination and hierarchical control break down as subsidiaries take on these increasingly specialized roles. Alternative models, such as the Transnational (Bartlett and Ghoshal, 1989) and the Heterarchy (Hedlund, 1986), are needed to understand the emergent organizational forms.

Much the same arguments can be made for the specific case of the R&D function. There is considerable evidence of a differentiation of roles across international R&D units (Cordell, 1973; Håkanson and Nobel, 1993; Pearce, 1989; Ronstadt, 1977), and some discussion of the need to manage different units in different ways (De Meyer and Mizushima, 1989; Håkanson and Nobel, 1993). The implication is that it should be possible to narrow the issue identified at the outset into a more specific question, namely 'How do control modes and communication systems vary across international R&D unit roles?' Of course, certain systems may be uniformly used across the whole sample, but if we accept that distinct types can be identified, the appropriate starting point from theory (notably Ghoshal, 1986) is an expectation that modes of control and communication also vary.

The paper is organized as follows. In the first section we briefly review the literature on international R&D, focusing on typologies of R&D units and communication and control systems. This discussion leads into the derivation of research propositions relating various control modes to the three types of R&D unit, and some open questions regarding the variation in communication systems across the three types. The second section describes the methodology, notably the selection of a sample, the selection of measures, and the validation of the typology. The third section describes the findings, and presents a discussion of the major issues that arise from the study, both in terms of international R&D management and in terms of broader issues.

LITERATURE REVIEW AND THEORETICAL BACKGROUND

There is a small but significant literature dealing specifically with the management of R&D in MNCs. As noted in a recent review by Cheng and Bolon (1993), this literature has focused predominantly on the extent of multinational involvement in R&D and the factors affecting it, while paying relatively little attention to the organizational and managerial aspects of the phenomenon. As this paper is concerned exclusively with organizational and managerial issues, no review of the broader literature will be attempted. Suffice it to say that: (1) MNCs, particularly those in Europe and the United States, are increasingly performing their R&D outside the home country (De Meyer and Mizushima, 1989; Håkanson and Zander, 1986; National Science Foundation, 1990); and (2) the motivations for internationalizing R&D are many and varied, but typically include access to scientific talent, access to ideas in multiple markets, responsiveness to local needs, responsiveness to host governments, and international division of labor (Behrman and Fischer, 1980; Håkanson and Nobel, 1993; Ronstadt, 1977; Taggart, 1991; Terpstra, 1977).

The managerial and organizational aspects of international R&D have been addressed only in a handful of studies. These studies have utilized relatively small samples and followed predominantly case study methodologies. Their findings are therefore rich in detail, but with questionable generalizability. The aim of this review is to examine the findings from prior studies in some detail, focusing on the two dominant themes: (1) the roles of international R&D units; and (2) the communication and control systems used in international R&D. It is, perhaps, self-evident that these two themes are interrelated, in that the role of a given R&D unit is determined in part by the contextual mechanisms used to coordinate and control its activities (Ghoshal, 1986). What is surprising is that previous research has always focused on one theme or the other. Our objective in this study is to explicitly bring the two together.

Table 1. Typologies of R&D unit roles

	Local adaptor	International adaptor	Global creator	
Ronstadt (1977)	Technology transfer unit	Indigenous technology unit	Global technology unit	Corporate technology unit
Pearce (1989)	Support laboratory	Locally integrated laboratory	Internationally interdependent laboratory	
Håkanson and Nobel (1993)	Technical support unit	Adaptive R&D unit	Generic R&D unit	Research unit
Kuemmerle (1996)	Home base exploiting unit		Home base augmenting unit	
Ghoshal (1986)	Implementer subsidiary	Contributor subsidiary	Innovator subsidiary	

NB: (1) Pearce (1989) also acknowledges the work of Cordell (1973) as a major contributor to his typology; (2) Ghoshal's typology refers to the subsidiary as a whole, and not just the R&D unit.

Typologies of R&D units

Four studies have developed comprehensive typologies of foreign R&D units, and several others have added useful or related insights (see Table 1). The preference has been to type R&D units primarily according to the nature of their activity, i.e., whether they are responsible for adapating technology, developing new products, undertaking pure research, etc. Other characteristics that have been used to discriminate between types are the geographic scope of the unit, linkages to other entities in the corporation, and mode of formation. While the samples were very different in each case, there is a surprising consistency in the proposed types. What follows is a discussion of the three major types. To ensure consistency with our method of operationalization we have called these the local adaptor, the international adaptor, and the international creator respectively.[1]

Local adaptor

This is the equivalent of Pearce's *support unit* which 'helps the local producing unit to assimilate and effectively utilize the existing mainstream technology of the MNC' (Pearce, 1991: 14). It is similar to Ronstadt's (1977) *technology transfer unit* and Håkanson and Nobel's (1993) *techni-*

cal support unit. Local adaptors are always local in scope, and with a rather limited development mandate. The essence of their role, as implied by Ronstadt, is to ease the transfer of technology from the parent company to the subsidiary manufacturing location. As such, the local adaptor is entirely consistent with the product life cycle model (Vernon, 1966), whereby innovations arise in the home country and are 'rolled out' in succession to foreign markets.

As noted in the Introduction, however, assumptions of home market hegemony are no longer as appropriate as they were 30 years ago. Foreign subsidiaries are often at the forefront of technological innovation, and are increasingly international in scope. Whereas Ronstadt's study (in 1977) suggested that the vast majority of international R&D units were local adaptors, the reality now is that a relatively small number are (Håkanson and Nobel, 1993; Pearce, 1989). The reason for this shift is that subsidiary manufacturing operations have mostly shifted from domestic to international focus, and their associated R&D units have likewise migrated from pure support to greater value-added activities such as adaptation and product development (Ronstadt, 1977). Local adaptors still exist, but they are becoming rare.

International adaptor

This is the equivalent of Pearce's *locally integrated laboratory* which 'provides backup for a local producing unit, but aspires to a more fundamentally creative role than a support labora-

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[1] This typology suggests that there could potentially be a 'local creator' with a mandate for research but local scope. However, prior research suggests that this is an unlikely combination.

tory, seeking to endow its subsidiary with some kind of product autonomy' (Pearce, 1991: 14). Other counterparts are Ronstadt's (1997: 9) *indigenous technology unit*, which has responsibility for developing 'new and improved products expressly for foreign markets' and Håkanson and Nobel's (1993) *adaptive R&D unit*. Kuemmerle (1996: 45) proposes the *home base exploiting* unit which appears to cover both the local adaptor and international adaptors in our typology.

This unit's role is substantially broader in scope than that of the support laboratory, and it is somewhat more creative as well. As noted by Pearce, locally integrated laboratories were traditionally attached to locally focused manufacturing operations, whose responsibility was exclusively towards the domestic market. With the globalization of manufacturing, many operations now have regional or global mandates, so development responsibilities are likewise international in scope (Håkanson and Nobel, 1993).

Ronstadt showed that indigenous technology units typically arise out of support laboratories as they take on additional development responsibilities. The theoretical foundation, again, was the product life cycle, in that the foreign subsidiary was expected to graduate from technology transfer to modification or enhancement according to the needs of the local market (Vernon, 1966). More recently, Pearce envisioned a broader role directed towards 'product autonomy,' with the implication being that locally integrated laboratories could potentially offer technological enhancements to other entities within the MNC. Theoretically speaking, this represents a departure from the assumptions of the product life cycle model towards some of the newer models of MNC organization in which subsidiaries have contributing or leading roles in product innovation (Bartlett and Ghoshal, 1989; Hedlund, 1986). The suggestion is that locally integrated laboratories are probably in a transitional state from that observed by Ronstadt to that implied by Pearce.

International creator

This is the equivalent of Pearce's internationally interdependent laboratories, which 'provide inputs into a centrally defined and coordinated R&D program, with no necessary connection with host country producing operations' (1991: 15). The distinguishing characteristics *vis-a-vis* inter-national adaptors are: (a) research and development, rather than improvement and adaptation responsibilities; and (b) linkages primarily to corporate and divisional R&D, not local manufacturing. Kuemmerle's (1996) counterpart is the *home base augmenting* unit. Ronstadt (1977) proposed *global* and *corporate technology units*, the former oriented more towards product development and the latter towards long-term research. Håkanson and Nobel (1993) identified *generic R&D* and *research* units, the latter being very close to Ronstadt's corporate technology unit, but the former being something of a hybrid.

The theoretical foundation for internationally interdependent laboratories is consistent with new models of the MNC such as the Heterarchy and the Transnational. These units are typically global leaders in their area of expertise, often located specifically to tap into a particular market or body of expertise (Bartlett and Ghoshal, 1986; Porter, 1990). They would be expected to have multiple linkages to other R&D units and to entities in the local market. They might also expect to have links with various business units, depending on the precise mix of research and development work.

One important question is raised by the discussion of different types of R&D units: Is there any substantive difference between an 'international' unit and a 'home' unit? Both the latter two types could just as meaningfully apply to an R&D unit in the home country as one in a foreign country. They are also the types that are apparently becoming more common, while the local creator, which was the only type that had no counterpart in the home country, is becoming rarer. This issue will be left as an open question for the moment. Our approach in this research was to poll both foreign and domestic R&D labs, so that the hypotheses could be tested for both an international sample *and* a comprehensive (international plus domestic) sample of R&D labs.

To summarize this section, three types of R&D units can be discerned from the literature with reasonably clear characteristics and theoretical foundations. There are certainly blurred boundaries in a few cases, notably with the hybrid types identified in Håkanson and Nobel, but the state of knowledge is sufficient that the existence of a meaningful typology can be put forward as a foundation for further analysis. Below, we out-

line the control modes we would expect to be associated with each type. And in the research methodology section we explain how the three-fold typology was operationalized and empirically validated.

Control modes and communication systems

The second major research focus within the organizational and managerial dimensions of international R&D has concerned itself with various aspects of control and communication. Control is defined here to mean the 'regulation of activities within an organization so that they are in accord with the expectations established in policies and targets (Child, 1973: 117). Communication simply refers to the exchange of information through various media, including face-to-face contact, telephone, letter, and electronic mail. In essence, control is concerned with the way a given unit relates to head office, while communication involves the totality of relationships between both internal and external entities.[2]

An issue that formed the basis of Behrman and Fischer's (1980) research, and was subsequently discussed by Håkanson and Zander (1986) and De Meyer and Mizushima (1989), is the level of autonomy given to an international R&D lab. This is probably the most important aspect of control, in that it indicates the extent to which head office managers actively influence decisions made in the R&D unit.[3] More recently, Asakawa (1996) explored some of the asymmetries in perception of autonomy between the R&D unit and the head office.

The issue of communication between R&D labs was explored in most detail by De Meyer (1991), and to a limited degree by Håkanson and Zander (1986) and Håkanson and Nobel (1993). The basic premise of De Meyer (1991) was that communication is central to effective R&D, and

that it is made harder by geographical and cultural dispersion. A variety of mechanisms, he argued, must therefore be used to circumvent the problems, including socialization of managers, formalization of systems, use of boundary-spanning individuals, a network organization, central office processing, and electronic systems. His empirical evidence suggested that most companies were experimenting with several, if not most, of these systems. Håkanson and Zander (1986), likewise, concluded that 'systems and procedures must be developed to facilitate world-wide coordination and information exchange' (1986: 143), including informal networks, lateral communication between subsidiaries, product councils, and long-range corporate research funding. They proposed the term 'integrated network' to refer to the complex array of relationships they observed in their case studies.

Control modes

Control refers to the variety of mechanisms used by corporate management to regulate the activities of the organization's disparate parts. Three different modes of control will be considered here: Centralization, in which decision-making power is retained at the headquarters; Formalization, in which decision-making is routinized through rules and procedures; and Socialization, whereby organization members develop common expectations and shared values that promote like-minded decision-making. These modes are well established in the organization theory literature (e.g., Etzioni, 1961; Ouchi, 1981; Pugh *et al.*, 1968; Vancil, 1979), and they have been used to model parent–subsidiary relationships in MNCs (Cray, 1984; Gates and Egelhoff, 1986; Ghoshal and Nohria, 1989; Hedlund, 1980). A key point is that the three modes are complementary *and* competing approaches to control. Any given parent–subsidiary relationship is liable to exhibit elements of centralization, formalization, and socialization at the same time, but to the extent that the roles of subsidiaries are differentiated to cater to the heterogeneity of the MNC's environment the relative emphasis of the three processes is expected to vary from one parent–subsidiary relationship to the next.

Which control modes would one expect to see in the three types of international R&D unit? *Local adaptors* undertake activities that are rela-

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[2] A third term, coordination, is also frequently used in association with these terms. Coordination is 'an enabling process to bring about the appropriate linkages between tasks' (Cray, 1984: 86). It includes aspects of control and communication, but cannot be readily disentangled from either, so our preference in this paper is not to use it.
[3] Behrman and Fischer (1980)/Fischer and Behrman (1979) observed two levels of autonomy: participative centralization and supervised freedom. The supervised freedom approach was more common in nonscience-based industries. It resulted in somewhat more innovation, but it 'invited problems of omission and redundancy' (Fischer and Behrman, 1979: 34).

tively less critical to the MNC than those under-taken by other R&D units. Their mandate is essentially to adapt the existing products and processes to local demands. Using the logic of information processing theory (Galbraith, 1973; Lawrence and Lorsch, 1967; Thompson, 1967), we would expect that the preferred mode of control in this situation is formalization. As stated by Galbraith (1973; 10), 'the simplest method of coordinating subtasks is to specify the necessary behaviors in the form of rules or programs.' More sophisticated modes of control could also be used but they are not necessary, given the lack of interdependence between the local adaptor's tasks and those of other units around the world. For reasons of cost efficiency, therefore, formalization is likely to be the preferred approach (Ghoshal and Nohria, 1989: 328), with centralization as the second most favored approach to control.

> *Proposition 1: Local adaptors will exhibit moderate levels of centralization, high levels of formalization, and low levels of socialization.*

International adaptors, by contrast, have con-siderably greater strategic importance and signifi-cantly more resources than local adaptors, and they demand increased degrees of freedom to be effective. Using an information-processing per-spective, we would therefore expect to see greater use of centralization and socialization because they are modes of control that cope more effec-tively with high levels of information flow (Egelhoff, 1991: Galbraith, 1973). Of these two, centralization is likely to be the preferred mode, because the relationship between international adaptors and head office is one of pooled or sequential interdependence rather than reciprocal interdependence (Thompson, 1967). Socialization is also far more costly than centralization, so it would be avoided if possible.

> *Proposition 2: International adaptors will exhibit high levels of centralization, low levels of formalization, and moderate levels of socialization.*

Finally, *international creators* are both heavily endowed with resources and strongly interlinked with one another (Pearce, 1989; Ronstadt, 1977). Using an information-processing perspective, we would expect that the high levels of reciprocal interdependence between units creates the need for sophisticated control mechanisms such as socialization (Galbraith, 1973; Thompson, 1967). Centralization and formalization can also be used in such a setting, but socialization is important as a way of enhancing the organization's infor-mation-processing capacity and for building an underlying set of norms and values that can guide decision-making under conditions of uncertainty (Etzioni, 1961; Hedlund, 1986). Expressed rather differently, international creators can also be seen as one of the principal characteristics of the network model of the MNC, in that they are large, influential centers located away from head-quarters. In such a model, it is neither desirable nor practical to control international creators through hierarchical means, so social control is used instead (Hedlund, 1986; Prahalad and Doz, 1981). Thus:

> *Proposition 3: International creators will exhibit moderate levels of centralization, low levels of formalization and high levels of socialization.*

Communication systems

Communication is the exchange of information through various media including face-to-face vis-its, letters, phone calls, and electronic mail. Com-munication serves a multitude of functions in the management of the MNC (including control) but the information intensity of R&D work makes an understanding of patterns of communication cen-tral to the effective management of corporate R&D (De Meyer, 1991). Building on the conceptualization of the MNC as an interorgani-zational network (Ghoshal and Bartlett, 1991), four different types of coordination mechanisms can be identified for international R&D units. *First*, there are vertical lines of communication with entities in the head office. These are overlain on, and often part of, the MNC's control mech-anisms, but they are conceptually separate in that it is possible to have vertical communication without control and, indeed, control without com-munication (e.g., through formalization). *Second*, there are lateral lines of communication with other international R&D units. These are partic-ularly important when there are task inter-dependencies, for example in international inno-vation projects (Hedlund and Ridderstråle, 1995;

Ronstadt, 1977), but they are also useful for promoting the flow of new ideas between units. *Third*, there are lateral lines of communication to other functions, notably manufacturing and marketing, within the same subsidiary (Pearce, 1989). Again, these are most necessary where there are interdependencies, but there is potential for synergistic interaction as well. *Fourth*, and somewhat differently, there are lines of communication to external entities such as customers, suppliers, and local universities, that comprise the environment in which the MNC is embedded. These lines of communication facilitate the adoption of new ideas by the MNC and responsiveness to local contingencies.

How would we expect communication patterns to vary across the three types of R&D unit? The existing literature has very little to say on this issue. As noted earlier, typology-based studies have tended to focus on the nature of the activities undertaken by the unit types, whereas studies of R&D communication patterns have either looked at communication within units (Allen, 1977) or talked about communication in general (De Meyer, 1991). The approach taken here, then, is not to build tenuous arguments but to let the data speak for itself. Of course we could put forward some of our expectations—such as local adaptors communicating more with local customers, or global creators having more interaction with universities—but our preference is simply to specify a series of research questions, and then to interpret the findings *post hoc*.

Research Questions 1 to 4: How, if at all, does (1) the level of vertical communication with head office functions, (2) the level of lateral communication with other R&D sites, (3) the level of lateral communication with manufacturing and marketing sites, and (4) the level of external communication with customers, suppliers and universities vary across the three types of R&D units?

METHODOLOGY AND MEASURES

The propositions were tested using data from a questionnaire mailed to all the R&D unit managers in 15 large Swedish MNCs. The questionnaire represented the final stage of an extensive research project, whose broad objectives were to understand the scope of international R&D in Swedish MNCs, the organizational systems that are used to control it, and the critical managerial issues being faced.

Exploratory study

The exploratory study was conducted by a group of four researchers. In-depth interviews were conducted in 50 R&D units across five large Swedish MNCs. The selection of sites was made using the criterion of maximum variety (Cook and Campbell, 1979), so that a mix of organizing models (centralized vs. decentralized), industries, and expected R&D unit roles were all sampled. Interviews were thus conducted across a wide spectrum of conditions in a total of eight different countries (including Sweden). Present at these interviews were two or three researchers and between one and three senior managers (the R&D manager, and sometimes the general manager and/or the manufacturing manager). Interviews were structured using a protocol of key topics, but managers were encouraged to elaborate on issues that had not been identified in advance. Notes were taken by both researchers, and subsequently brought together for discussion.

The output from the exploratory study was a very clear picture, in qualitative terms, of the major issues in the management of international R&D. This study has been written up elsewhere (Håkanson and Nobel, 1992). One key finding was a recognition of the importance of effective communication in international R&D management. This finding allowed us to probe further on the relevant facets of communication, which proved valuable when it came to designing a questionnaire instrument (see below). We also determined that the R&D unit manager was the key respondent, in that no one else, at head office or in the subsidiary unit, was knowledgeable about both the activities of the R&D unit *and* its relationships with other entities.

Questionnaire development and sample selection

The questionnaire was put together to build on the qualitative findings of the exploratory study and to investigate in more detail some of the communication patterns that appeared to be central to international R&D management. We wrote

an initial draft of the questionnaire using a combination of scales taken from prior studies and original questions based on issues uncovered in the exploratory study. We then assembled a reference group consisting of three corporate R&D managers from major Swedish MNCs, representatives of the royal academy of engineering and the Swedish agency for technical development (NUTEK), and several academics with expertise in this area. The group met twice to discuss the face validity of the questions and any modifications or enhancements that they felt were appropriate. This process resulted in several substantive changes to the questionnaire.

The sampling frame for the questionnaire survey was the population of R&D laboratories in the 20 largest Swedish MNCs. These MNCs account for approximately 75 percent of all industrial R&D undertaken in Sweden (Håkanson and Nobel, 1993). Of these 20 MNCs, 15 agreed to participate in the study. Discussions with corporate R&D management led to the identification of 210 R&D units. The R&D manager in charge of each unit was mailed a copy of the questionnaire with a cover letter indicating the support of the parent company. Follow-up telephone calls and a second mailing to nonresponders yielded a total of 110 usable responses, of which 34 were Swedish units and 76 foreign. A test of nonresponse bias using parent company and host country as dependent variables revealed no significant differences. The breakdown of responding units by company and host country is presented in Table 2.

A separate questionnaire was mailed to a sample of divisional and corporate R&D managers. This questionnaire was primarily for general information, but it included a few questions that were identical to those answered by R&D unit managers. We were able to use these common questions to assess reliability, which was acceptable.[4]

Operationalization of constructs

Constructs were operationalized using a combination of existing measures and measures that were appropriate to the specifics of the R&D function. The reference groups were very useful in this regard, in that they were able to refine the wording of questions to ensure that they were appropriate to the R&D setting. The remainder

of this section outlines the measures used and the steps taken (where appropriate) to ensure reliability.

R&D unit typology

Several factors make the generation of a meaningful typology difficult. First, it is known that roles change over time, so the boundaries between units are often blurred (Pearce, 1989; Ronstadt, 1977). Second, a single site can easily have more than one role—a local adaptor laboratory, for example, may coexist with an international adaptor laboratory—but the questionnaire will always be answered by a single manager. And finally, the boundaries between types are not that clearly defined in the literature. The typologies of Pearce, Ronstadt, and Håkanson and Nobel were described above, and they include a number of different factors (e.g., geographic scope, proximity to manufacturing, type of activity), so it is not obvious which are the critical delimiters of the three types.

We elected to use a very simple heuristic to identify the three types.[5] Local adaptors were those with 50 percent or greater of their work devoted exclusively to the local market. Of the remainder, we looked at the nature of the work, divided up into (i) basic research, (ii) development, (iii) product/process improvement, and (iv) product/process adaptation. Where more than 50 percent of the total fell into the first two categories we called them international creators; where more than 50 percent fell into the latter two categories we called them international adaptors. This resulted in 28 local adaptors,[6] 40

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[4] Both corporate R&D management and the foreign units were asked to assess on a 7-point scale the extent to which the foreign units achieved cost, time, and quality outcomes. For the 22 units where both corporate and R&D unit responses were obtained, the answers were the same or one different 71 percent of the time. Interestingly, R&D units over- *and* under-represented their achievements in comparison to HQ.

[5] We chose not to use self-typing measures, despite their ease of use. There is always a high risk of inflated assessments of roles for reasons of social desirability. In the case of this study we felt that the risk was particularly high because it is known that most support laboratories over time move (or attempt to move) to international adaptor status.

[6] Note that six of the 28 local adaptors devoted 50 percent or more of their time to R&D work, so strictly they should have been called local creators. A quick analysis of the data using all four types showed no significant differences between these six and the other 22 local adaptors, so they have been lumped together.

Table 2. Breakdown of responding units by company and country

	S	US	D	GB	B	NT	I	Other Europe	Other Asia, America	Total
Aga		1	1							2
Alfa Laval	6	4	1	2	1	1	1		1	17
Atlas Copco	1		1		4					6
Ericsson	8	1	1	2		1	1	4	4	22
Esab		1		1		1				3
ABB	9	2	5					5	2	23
Nobel				1						1
Kabi	2	1								3
Saab Scania	1	1				1			3	6
Sandvik				1						1
SKF	1		1			1	1			4
Stora			1							1
Tetra Pak	2		2	1			1	1	2	9
Trelleborg	2	1			1					4
Volvo	2	3		2					1	8
Total	34	15	13	10	6	5	4	10	13	110

Key: S = Sweden, US = United States, D = Germany, GB = Great Britain, B = Belgium, NT = Netherlands, I = Italy. Other Europe = Norway, Denmark, Finland, Ireland, Switzerland, France, Spain. Other America, Asia = Canada, Mexico, Brazil, Argentina, Singapore, Japan, Australia, India.

international adaptors and 41 international creators.

To validate the typology a number of additional tests were undertaken. First, we conducted *t*-tests to establish whether the type of work undertaken in local adaptors was significantly different from the other two types. This confirmed that basic research ($p = 0.019$) and development ($p = 0.09$) were significantly lower and adaptation($p = 0.008$) significantly higher in the local adaptors. Second, we examined the levels of process (rather than product) improvement and existence of co-located manufacturing to establish whether there were any significant differences between international adaptors and international creators. Using *t*-tests, both variables were significantly higher for the international adaptors than the international creators ($= 0.018$, $p = 0.001$), again confirming the validity of the typology.

Centralization

Hedlund's (1981) measure of subsidiary unit autonomy was used as the basis for this scale, but the wording was altered where necessary to make it specific to R&D units. Following a factor analysis, two subscales were identified, namely strategic issue centralization (4 items,

alpha = 0.84) and operational issue centralization (7 items, alpha = 0.92). See the Appendix for the wording of individual items.

Formalization

Two measures were used: (a) the existence of standardized reports to various other units within the MNC; and (b) the use of technical standards for drawing, testing, etc. for that R&D unit. Neither of these measures was established in the literature, but from pilot study interviews and the reference group meetings it became apparent that these were the mechanisms used by parent management to formalize the activities of the R&D units. These items were measured with yes/no answers for several types of reports and standards. Absolute values are reported.

Socialization

Items were selected from prior studies (notably Ghoshal, 1986) and on the basis of strong face validity with the reference group. We identified four measures all of which tap into different facets of the construct: (a) visits by R&D unit members to other R&D units; (b) visits by other R&D unit managers to this unit; (c) staff

involved in corporate training programs; and (d) staff involved in long-term job rotation programs.

Communications systems

Respondents were asked to assess their frequency of personal face-to-face contacts and their frequency of other types (letter, phone, digital) of contacts for a series of different units both inside and outside the firm. Our intention was to identify the entire set of entities with which the focal R&D unit communicated. The units identified were as follows: vertical communication—R&D, marketing, and manufacturing units in Sweden;[7] lateral communication—other R&D units in the local market, R&D units in other countries, marketing units in the local market and other countries, manufacturing units in the local market and other countries; external communication—with universities, customers, and suppliers in the local, Swedish, and international domains. The data are reported individually to ensure that the subtle differences between communication patterns are brought out.

RESULTS AND DISCUSSION

We performed a series of ANOVAs on the data, using the typology as the independent variable (three levels) and the various measures of control and communication as the dependent variables.[8] Tables 3–5 list the results of the analysis. The results are described and discussed below.

Control modes

The data showed, as expected, that all three control mechanisms were exhibited in all three

R&D unit types but that the relative emphasis on the different modes varied significantly. Local adaptors were managed, as predicted, with significantly higher levels of formalization than the other two types. Interestingly, they also exhibited the lowest level of centralization. International adaptors were managed predominantly through centralization, with moderate levels of formalization. Perhaps surprisingly they also exhibited lower levels of socialization than the local adaptors—in terms of number of personnel rotated, for example. This difference was not significant though. Finally, international creators were controlled, as predicted, through relatively high levels of socialization, low formalization, and moderate levels of centralization. While the difference in emphasis in control modes across the three types was fairly modest, it is in keeping with our expectations and provides confirmation of the arguments presented in the theory section of the paper.

Communication systems

Table 4 reports the raw data from the communication analysis, where the absolute values are the average number of meetings or contacts per year held by R&D unit management with the entity in question. Where significant differences between units were obtained, the relevant *F*-score and *p*-value are listed. These data allow us to sketch some interesting patterns of variation across the three types.[9]

Local adaptors are, as would be predicted, firmly embedded in their local context. Their five most frequent relationships, in order, are with local manufacturing, local marketing, other local R&D, local customers and local suppliers. Communication with the parent company is very limited, confirming the preference for formalization over centralization as a control mode, and communication with marketing and manufacturing units outside the local country is extremely low. Local adaptors have essentially no links with universities, even local ones, which again is not

[7] Note that in cases where the R&D unit was in Sweden, responses to questions about the local market and the Swedish market were the same. In the analysis, questions that specifically mention Sweden were only answered by the foreign R&D units.

[8] We tested that the assumptions of ANOVA (i.e., multivariate normality and equal variance) were satisfied using the Kolmogorov–Smirnov test and Bartlett's test of sphericity. The Kolmogorov–Smirnov test indicated that the assumption of normality was only marginally satisfied in some of the measures. We therefore tried running the statistical analysis using the nonparametric Kruskal–Wallis test, but the results were no different so we retained the ANOVA analysis.

[9] We were aware that differences in communication levels between Swedish and non-Swedish R&D units could potentially impact this analysis. Consequently we performed *t*-tests on all communication variables. Only two gave significant findings: communication with 'other local manufacturing', and communication with 'local universities,' both of which were higher for Swedish R&D units.

Table 3. Control mechanisms by R&D unit type

	Mean, number respondents	Local adaptor	International adaptor	International creator	F-score, probability
Centralization					
Strategic issue centralization (reversed)	3.42 100 resps.	**3.88**	3.10	3.40	3.78 ($p = 0.026$)
Operational issue centralization (reversed)	4.09 94 resps.	4.46	3.89	4.03	2.13 ($p = 0.125$)
Formalization					
Formalization of reporting to: corporate R&D	0.39 94 resps.	0.48	0.30	0.41	0.953 ($p = 0.39$)
. . . to manufacturing	0.24 94 resps.	0.24	0.33	0.18	1.08 ($p = 0.34$)
. . . to marketing	0.27 94 resps.	**0.36**	**0.40**	0.10	4.95 ($p = 0.009$)
. . . to corp. mgmt	0.34 94 resps.	**0.56**	0.30	0.23	4.05 ($p = 0.021$)
Formalization of standards for drawing	0.47 110 resps.	0.46	0.38	0.58	1.8 ($p = 0.17$)
. . . for testing	0.42 110 resps.	0.54	0.45	0.29	2.24 ($p = 0.12$)
. . . for measuring	0.35 110 resps.	**0.54**	0.30	0.30	2.65 ($p = 0.08$)
Socialization					
Visits to other units	3.96 97 resps.	3.78	3.82	4.20	1.35 ($p = 0.26$)
Visits from other units	3.91 97 resps.	3.78	3.65	4.23	2.49 ($p = 0.08$)
Personnel trained	20.4 107 resps.	23.2	9.33	30.0	1.63 ($p = 0.20$)
Personnel rotated	2.7 109 resps.	2.9	1.2	**4.0**	2.40 ($p = 0.09$)

Centralization measures: 1 = decided by HQ; 5 = decided by subsidiary alone. Formalization measures: 0 = no; 1 = yes. Socialization measures: Visits, 1 = never; 5 = more than 10 times; Personnel trained = actual number of individuals; Pesonnel rotated = actual number of individuals. Significant differences are indicated in bold and underline (where bold is the significantly higher number and underline significantly lower).

surprising but is evidence that their role is limited to applied tasks such as process improvement and product adaptation. Communication with *other local R&D units*[10] is, however, quite frequent (face to face, 74 times per year), so clearly there is some exchange of ideas that goes beyond the immediate location of the local adaptor.

International adaptors have a significantly more international profile of communication than local adaptors, but their relationships are predominantly with other corporate entities and *not* with external parties. In particular, international adap-

tors have significantly more communication with 'other local manufacturing' units and manufacturing in other countries than local adaptors. By contrast, communication with other R&D units and with marketing units in other countries is very limited. These data suggest that international adaptors have a rather specific role, namely to act as the adaptation/improvement center for a network of integrated manufacturing sites. Consistent with previous research, international adaptors can thus be seen as 'evolved' local adaptors, whose role expanded as the role of the associated manufacturing operation became increasingly international. In terms of vertical communication, international adaptors were not significantly different from local adaptors. The higher level of

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[10] For example, Alfa Laval has four R&D units in the United States that report high levels of communication between one another.

Table 4.   Communication by R&D unit type

	Mean, number respondents	Local adaptor	International adaptor	International creator	Significant differences
Vertical communication					
R&D units in Sweden	Face: 34	Face: 28	Face: 25	Face: 54	None
	Other: 172	Other: 164	Other: 149	Other: 208	None
Mfg. units in Sweden	Face: 12	Face: 5	Face: 7	Face: 25	None
	Other: 37	Other: 12	Other: 69	Other: 32	None
Mktg. units in Sweden	Face: 12	Face: 18	Face: 5	Face: 12	None
	Other: 22	Other: 4	Other: 29	Other: 36	None
Lateral communication					
Other R&D units	Face: 74	Face: 89	Face: <u>30</u>	Face: **102**	$F = 2.43$, $p =0.09$
locally	Other: 113	Other: 102	Other: 89	Other: 139	None
R&D in other countries	Face: 34	Face: 28	Face: 25	Face: 54	None
	Other: 71	Other: 37	Other: 66	Other: 100	None
The local mfg. unit	Face: 214	Face: 228	Face: 187	Face: 236	None
	Other: 277	Other: 274	Other: 284	Other: 272	None
Other local mfg. units	Face: 34	Face: 26	Face: 52	Face: 27	None
	Other: 56	Other: <u>34</u>	Other: **114**	Other: 30	$F = 3.3$, $p = 0.045$
Mfg. in other countries	Face: 12	Face: <u>5</u>	Face: 10	Face: 21	None
	Other: 38	Other: <u>10</u>	Other: **63**	Other: 30	$F = 2.51$, $p = 0.09$
Local mktg.	Face: 135	Face: <u>150</u>	Face: 118	Face: 140	None
	Other: 182	Other: 234	Other: 153	Other: 164	None
Mktg. in other	Face: 9	Face: 4	Face: 7	Face: 15	None
countries	Other: 31	Other: 6	Other: 49	Other: 33	None
External communication					
Local universities	Face: 9	Face: <u>4</u>	Face: <u>7</u>	Face: **15**	$F = 6.6$, $p = 0.002$
	Other: 16	Other: <u>10</u>	Other: <u>11</u>	Other: 27	None
Swedish universities	Face: 1	Face: 0	Face: 0	Face: 3	None
	Other: 1	Other: 0	Other: 1	Other: 3	None
Foreign universities	Face: 3	Face: <u>0</u>	Face: <u>1</u>	Face: **6**	$F = 4.8$, $p = 0.01$
	Other: 3	Other: <u>1</u>	Other: <u>3</u>	Other: 4	None
Local customers	Face: 29	Face: **60**	Face: <u>22</u>	Face: <u>11</u>	$F = 4.1$, $p = 0.02$,
	Other: 42	Other: **87**	Other: <u>32</u>	Other: <u>14</u>	$F = 6.3$, $p = 0.002$
Swedish customers	Face: 2	Face: <u>0</u>	Face: <u>1</u>	Face: **4**	$F = 6.8$, $p = 0.002$
	Other: 2	Other: <u>0</u>	Other: <u>1</u>	Other: **3**	$F = 5.6$, $p = 0.006$
Foreign customers	Face: 8	Face: <u>3</u>	Face: 7	Face: **12**	$F = 4.3$, $p = 0.017$
	Other: 20	Other: <u>10</u>	Other: 26	Other: 21	None
Local suppliers	Face: 43	Face: 53	Face: 37	Face: 44	None
	Other: 75	Other: 83	Other: 75	Other: 70	None
Swedish suppliers	Face: 3	Face: 3	Face: 1	Face: 3	None
	Other: 17	Other: 22	Other: 22	Other: 7	None
Foreign suppliers	Face: 13	Face: <u>5</u>	Face: 8	Face: **26**	$F = 2.7$, $p = 0.07$
	Other: 37	Other: <u>21</u>	Other: 44	Other: 41	None

Numbers refer to average number of communication incidents per year, face to face and through other media (letter, phone, datalink, etc.) Significant differences are indicated in bold and underline (where bold is the significantly higher number and underline significantly lower). Note that to avoid interpretation problems, the questions that refer to Swedish units were only answered by those units located outside Sweden ($n = 76$).

centralization observed in the previous section is obviously not reflected in the communication patterns with head office.

International creators were distinct primarily in terms of the level of communication with external entities. They had significantly more communication with local universities, foreign universities, Swedish customers, foreign customers, and foreign suppliers, than the other two types, and significantly *less* communication with

local customers than the local adaptors. International creators also had more communication with virtually all other entities as well, in comparison to the other types. Contrary to expectation, international creators even had strong communication with local manufacturing and marketing units. The suggestion is not that international creators communicate with external entities *at the expense* of internal relations, but rather that their external network is built *on top of* an internal network of relationships. Local customers, in fact, are the only group with which international creators have lower levels of communication (*vis-a-vis* the other types).

What do these patterns of communication tell us about the theory of the MNC? Clearly, international creators are consistent with the Heterarchical/Transnational models of the MNC, in that they have strong lateral links with one another and strong relationships with external entities. It is worth pointing out, however, that they do still retain their vertical relationships back to divisional or corporate head office. This has implications for the information-processing perspective on MNC organization: it suggests that rather than reducing the need for information processing, MNCs have instead opted to increase their capacity to process information (Galbraith, 1973: 15), through the creation of lateral relations and investment in vertical information systems. Local and international adaptors, on the other hand, are very much consistent with traditional hierarchical concepts such as the division of labor, and communication through vertical channels. Boundary-spanning activities are restricted to customer and supplier relationships, again reinforcing the emphasis on 'division' (into clearly defined sectors) rather than 'multiplication' (Hedlund, 1994).

Additional analysis: Firm-level variations in control and communication

While our main concern in this paper was with the differences between types of R&D units, we were also able to shed some light on certain company-specific effects. In particular, we got a large number of responses from Alfa Laval (17), Ericsson (21) and ABB (23), so we conducted a series of ANOVAs using these three companies as the independent variable categories. Table 5 reports all significant findings, i.e., cases where

control or communication levels varied significantly across companies.

The most obvious insight from Table 5 is that Ericsson's R&D units engage in an extraordinary amount of control (all types!) and communication. From our interviews, it is apparent that Ericsson's approach is to build a high level of interdependence between units. Most units are global creators (12 of 21), or more specifically development centers working on telecommunications software. Socialization is necessary to build the linkages between units, but at the same time there have to be clearly defined standards to ensure compatibility. What is perhaps surprising is the relatively high level of centralization in Ericsson—this might look like overkill, but the reality is that Ericsson has always opted to retain a high level of central influence. To a greater extent than most other Swedish MNCs, Ericsson continues to place Swedes at the head of its foreign subsidiaries.

Alfa Laval, by contrast, has adopted a very decentralized approach to R&D management. Communication levels (in all directions) were lower than in Ericsson. Socialization was used to a very low level.[11] And decision-making was the least centralized of the three companies. From our interviews, it seems that the vast majority of Alfa Laval's R&D units are locally focused and oriented toward applied development, rather than basic research.

Finally, ABB lies somewhere between these two extremes. Visits between units are frequent, but personnel rotation and training on an international basis are low. Formalization of standards is low. Communication with Swedish manufacturing units and local customers is very high, but other forms of communication are relatively low. Again, building on our interviews, it is clear that ABB's R&D units are much more independent of one another than in Ericsson. This is partially a function of the multiple industries in which ABB competes, but it is also related to ABB's philosophy of being a 'multi-local' company rather than 'global' or 'Transnational.'

The above comments are meant to provide

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[11] However, we should point out that during our interviews it was apparent that Alfa Laval as a whole uses socialization mechanisms such as personnel transfer to a very large extent. Presumably the R&D organization is somewhat different to the rest of the organization on this dimension.

Table 5.   Company-specific analysis: Alfa Laval, Ericsson, and ABB

	Alfa Laval (17 units)	Ericsson (23 units)	ABB (22 units)
Centralization			
. . . of strategic issues (reversed)	**4.13**	<u>3.24</u>	3.63
Formalization			
. . . of standards for drawing	0.35	**0.68**	<u>0.35</u>
. . . of standards for testing	0.41	**0.59**	<u>0.22</u>
. . . of standards for measuring	0.29	**0.45**	<u>0.09</u>
Socializations			
Visits to other units	<u>2.73</u>	**4.45**	**4.05**
Visits from other units	<u>2.60</u>	**4.41**	**4.06**
Personnel trained	<u>0.88</u>	**49.90**	<u>15.8</u>
Personnel rotated	<u>0.59</u>	**7.18**	<u>1.65</u>
Face-to-face communication with R&D units in Sweden			
R&D units in Sweden	<u>4</u>	**108**	<u>36</u>
Manufacturing units in Sweden	<u>1</u>	<u>4</u>	**30**
Marketing units in Sweden	<u>9</u>	**70**	<u>3</u>
R&D in other countries	<u>4</u>	**108**	36
Marketing in other countries	<u>5</u>	**37**	<u>5</u>
Local universities	<u>4</u>	**12**	<u>5</u>
Local customers	<u>11</u>	22	**43**
Local suppliers	<u>8</u>	**55**	20
Number of local adaptors	4	5	7
Number of international adaptors	9	4	9
Number of international creators	4	12	7

Table only includes those measures with significant differences. Significant differences are indicated in bold (higher) and underlined (lower) font.

some tangible examples of the different approaches used to manage international R&D units. Taken in conjunction with the earlier findings this analysis suggests a very complex system, such that the control and communication patterns in a single unit are a function of its assigned role, the management approach of the MNC, and probably a number of other factors as well (e.g., industry, host country, and technology). While our primary focus was on R&D unit roles, there is clearly scope for additional research that focuses on some of the other contingency variables.

CONCLUSIONS

This study provided insight into the management of international R&D units on a number of different levels. At the simplest level, the data provided a more detailed description of the communication patterns and control systems in international R&D units than any previous study. For example, the fact that 82 of the 110 units claimed to be international in scope is an interesting finding. From prior research (Håkanson and Nobel, 1993) we know that the volume of R&D work undertaken outside the home country for Swedish multinationals is no more than 25 percent. These data indicated, in addition, that foreign R&D units do not typically work on a local-for-local basis but that they are predominantly international in orientation. The communication data provided a detailed qualitative impression of the nature of the relationships between the three types of units and various entities in the corporate and external network.

Returning to the broader theoretical issues, the data presented here provided strong support that R&D unit roles are differentiated, both in terms of the nature of their activities and the types of control mechanisms used. This is consistent with

Ghoshal's (1986) thesis which was conducted at the subsidiary level. It is not appropriate to suggest normative implications at this stage, but there is at least the suggestion in these data that the management of international R&D can be facilitated by the definition of an appropriate 'structural context' to guide the activities of R&D unit managers. A specific issue which is related to this point is the rather selective use of socialization, e.g., in terms of the transfer and training of personnel. This study showed that only the international creator units made extensive use of socialization as a control mechanism. Moreover, the company analysis at the end showed that these levels were driven to a large degree by the Ericsson cases. Given the normative preference among many writers in multinational management (e.g., Bartlett and Ghoshal, 1989) to advocate greater socialization, it is interesting to observe just how little it appears to be used in this sample.

From a more managerial perspective, it would appear that the local adaptor units are the most problematic to manage. These units apeared to be rather disconnected from the central R&D activities of the corporation, and they expressed (in the interviews) some dissatisfaction in areas of product development and know-how exchange. Given that most international adaptors have evolved out of local adaptors, it is important to recognize the potential strategic value of local adaptors. Certainly there would appear to be good reasons to *not* solicit their involvement in projects beyond their scope, but at the same time it is important for headquarters to retain some openness to their ideas. The importance of subsidiary units for tapping into new ideas has, of course, been extensively discussed in the international management literature (Bartlett and Ghoshal, 1986; Birkinshaw, 1995).

A separate issue that is raised by this study is the absence of evidence for the 'virtual laboratory' in which multiple units in different locations collaborate on common projects. The exploratory interviews in particular suggested, instead, that the most international R&D units are given discrete responsibilities that seek to minimize the level of technological interdependency between units. This may in part be an issue of timing, in that the last round of data was collected in 1991, and it is only in the last 5 years that international collaboration between R&D units around the world has been in vogue. However, it may also be that international collaboration has been attempted and subsequently rejected. The recent work of Ridderstråle (1996), for example, showed that four international innovation projects in ABB and Electrolux were long and expensive, typically fraught with difficulties, and often much less international in practice than they were in theory. It may be necessary to conclude, therefore, that global R&D collaboration is—in theory at any rate—a desirable goal but one which in practical terms may not be achieved in the near future. This study showed that there is a lot of communication going on, horizontally, vertically, and with outside parties. De Meyer (1991) arrived at a similar conclusion. But none of this represents true global collaboration, in which R&D units are working simultaneously on the same development projects.

This study had a number of limitations, the most constraining of which was its dependence on Swedish-based multinationals. Thus, while we can be confident that these results are reflective of the population of Swedish-owned R&D units, we cannot generalize to the broader population of foreign-owned R&D units. It would seem likely, from our knowledge of other companies, that Swedish multinationals have a greater number of R&D units abroad than normal, but there is no reason to suspect that the basic typology, or the observed relationships, would vary significantly in a replication study. Indeed, the typology as used here is entirely consistent with that developed by Ronstadt (1977) and Pearce (1989) in rather different settings. The other limitation of this study was its rather exploratory nature. Detailed measurement of communication patterns across R&D units had not been attempted before, so we opted to provide large amounts of raw data rather than clearly labeled constructs. Now we have a sense of how communication patterns vary across R&D unit types, and how such patterns relate to theory, it should be possible to move to a more deductive approach in subsequent research.

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REFERENCES

Allen, T. J. (1977). *Managing the Flow of Technology: Technology Transfer and the Dissemination of Technological Information within the R&D Organization.* MIT Press, Cambridge, MA.

Asakawa, K. (1996). 'The multinational tension in R&D internationalization: Strategic linkage mechanisms of distant contextual knowledge in Japanese multinational companies', unpublished PhD Thesis, INSEAD, Fontainebleau, France.

Bartlett, C. A. and S. Ghoshal (1986). 'Tap your subsidiaries for global reach', *Harvard Business Review*, **64**(6) pp. 87–94.

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

Behrman, J. N. and W. A. Fischer (1980). *Overseas R&D Activities of Transnational Companies.* Oelgeschlager, Gunn & Hain, Cambridge, MA.

Birkinshaw, J. M. (1995). 'Entrepreneurship in multinational corporations: The initiative process in foreign subsidiaries', unpublished doctoral dissertation, University of Western Ontario.

Birkinshaw, J. M. and N. Hood (1996). 'Multinational subsidiary development: Capability evolution and charter change in foreign-owned subsidiary companies', Institute of International Business Research Paper, 96/02.

Chandler, A. D. (1962). *Strategy and Structure: Chapters in the History of the Industrial Enterprise.* MIT Press, Cambridge, MA.

Cheng, J. L. C. and D. S. Bolon (1993). 'The management of multinational R&D: A neglected topic in international business research', *Journal of International Business Studies*, **1**, pp. 1–18.

Child, J. (June 1973). 'Predicting and understanding organization structure', *Administrative Science Quarterly*, **17**, pp. 168–185.

Cook, T. D. and D. T. Campbell (1979). *Quasi Experimentation: Design and Analysis for Field Settings.* Houghton Mifflin, Boston, MA.

Cordell, A. J. (1973). 'Innovation, the multinational corporation: Some policy implications for national science policy', *Long Range Planning*, **6**(3), pp. 22–29.

Cray, D. (1984). 'Control and coordination in multinational corporations', *Journal of International Business Studies*, **15**, Fall, pp. 85–98.

De Meyer, A. (1991). 'Tech talk: How managers are stimulating global R&D communication', *Sloan Management Review*, **33**, Spring, pp. 49–58.

De Mayer, A. and A. Mizushima (1989). 'Global R&D management', *R&D Management*, **19**, pp. 135–146.

Dunning, J. (1980). 'Towards an eclectic theory of international production: Some empirical tests', *Journal of International Business Studies*, **11**, pp. 9–29.

Egelhoff, W. G. (1991). 'Information processing theory and the multinational enterprise', *Journal of International Business Studies* **22**(3), pp. 341–368.

Etzioni, A. (1961). *A Comparative Analysis of Complex Organizations.* Free Press, New York.

Fischer, W. A. and J. N. Behrman (1979). 'The coordination of foreign R&D activities by transnational corporations', *Journal of International Business Studies*, **19**(3), p. 34.

Galbraith, J. R. (1973). *Designing Complex Organizations.* Addison-Wesley, Reading, MA.

Gates, S. R. and W. G. Egelhoff (1986). 'Centralization in headquarters–subsidiary relationships', *Journal of International Business Studies*, **17**(2), pp. 71–92.

Ghoshal, S. (1986). The innovative multinational: A differentiated network of organizational roles and management processes', unpublished doctoral dissertation, Harvard Business School.

Ghoshal, S. and C. A. Bartlett (1991). 'The multinational corporation as an interorganizational network', *Academy of Management Review*, **15**(4), pp. 603–625.

Ghoshal, S. and N. Nohria (1989). 'Internal differentiation within multinational corporations', *Strategic Management Journal*, **10**(4), pp. 323–337.

Håkanson, L. and R. Nobel (1992). 'International R&D networks - exploiting dispersed capabilities'. Proceedings from the European International Business Association Annual Conference, Reading, U.K.

Håkanson, L. and R. Nobel (1993). 'Determinants of foreign R&D in Swedish multinationals', *Research Policy*, **22**(5–6), pp. 397–411.

Håkanson, L. and U. Zander (1986). *Managing International Research and Development.* Sveriges Mekanforbund, Stockholm.

Hedlund, G. (1980). 'The role of foreign subsidiaries in strategic decision-making in Swedish multinational corporations', *Strategic Management Journal*, **1**(1), pp. 23–36.

Hedlund, G. (1981). 'Autonomy of subsidiaries and formalization of headquarters–subsidiary relationships in Swedish MNCs'. In L. Otterbeck (ed.), *The Management of Headquarters–Subsidiary Relations in Multinational Corporations.* Gower Publishing, Aldershot, Hampshire, UK, pp. 25–76.

Hedlund, G. (1986). 'The hypermodern MNC—A heterarchy?', *Human Resource Management*, **25**(1), pp. 9–35.

Hedlund, G. (1993). 'Assumptions of hierarchy and heterarchy: An application to the multinational corporation'. In S. Ghoshal and D. E. Westney (eds.), *Organization Theory and the Multinational Corporation.* Macmillan, London, pp. 211–236.

Hedlund, G. (1994). 'A model of knowledge management and the N-form corporation', *Strategic Management Journal*, Summer Special Issue, **15**, pp. 73–90.

Hedlund, G. and J. Ridderstråle (1995). 'International development projects: Key to competitiveness, impossible, or mismanaged?', *International Studies of Management and Organization*, **25**(1–2), pp. 121–157.

Jarillo, J.-C. and J. L. Martinez (1990). 'Different roles for subsidiaries: The case of multinational corporations in Spain', *Strategic Management Journal*, **11**(7), pp. 501–512.

Kuemmerle, W. (1996). 'Home base and foreign direct investment in research and development: An investigation into the international allocation of research activity by multinational enterprises', unpublished doctoral thesis, Harvard University.

Lawrence, P. and J. Lorsch (1967). *Organization and Environment: Managing Differentiation and Integration*. Harvard University, Boston, MA.

National Science Foundation (1990). 'Research and development in industry', NSF 90-319, Washington, DC.

Ouchi, W. G. (1981). *Theory Z: How American Business Can Meet the Japanese Challenge*. Avon Books, New York.

Pearce, R. D. (1989). *The Internationalization of Research and Development by Multinational Enterprises*. St. Martin's Press, New York.

Pearce, R. D. (1991). 'The globalization of R&D by TNCs', *CTC Reporter*, **31**, Spring, pp. 13–16.

Porter, M. E. (1986). *Competition in Global Industries*. Harvard Business School Press, Boston, MA.

Porter, M. E. (1990). *The Competitive Advantage of Nations*. Free Press, New York.

Prahalad, C. K. and Y. L. Doz (1981). 'An approach to strategic control in MNCs', *Sloan Management Review*, **23**, Summer, pp. 5–13.

Pugh, D., D. J. Hickson, C. R. Hinings and C. Turner (1968). 'Dimensions of organization structure', *Administrative Science Quarterly*, **13**, pp. 67–105.

Ridderstråle, J. (1996). 'Global innovation: Managing international innovation projects at ABB and Electrolux', doctoral dissertation, Institute of International Business, Stockholm School of Economics.

Ronstadt, R. C. (1977). *Research and Development abroad by U.S. Multinationals*. Praeger, New York.

Taggart, J. H. (1991) 'Determinants of the foreign R&D locational decision in the pharmaceutical industry', *R&D Management*, **21**(3), pp. 229–240.

Terpstra, V. (1977). 'International product policy: The role of foreign R&D', *Columbia Journal of World Business*, **12**, Winter, pp. 24–32.

Thompson, J. D. (1967). *Organizations in Action*. McGraw Hill, New York.

Vancil, R. F. (1979). *Decentralization: Managerial Ambiguity by Design*. Dow Jones Irwin, Homewood, IL.

Vernon, R. (May, 1966). 'International investment and international trade in the product cycle', *Quarterly Journal of Economics*, **81**, pp. 190–207.

Williamson, O. E. (1975). *Markets and Hierarchies: Analysis and Antitrust Implications*. Free Press, New York.

APPENDIX: QUESTIONNAIRE ITEMS

Centralization

Respondents were asked to indicate who makes decisions (where 1 = decided by HQ or division, and 5 = decided independently by subsidiary) for the following: The overall direction of the R&D unit's effort; Which new R&D projects to pursue; Documentation standards and norms; The R&D budget; Hiring and firing of the R&D unit's management; Cooperation with other R&D units in the company; Cooperation with other manufacturing units in the company; Cooperation with external firms or organizations; Training programs for R&D personnel; Salary level for R&D employees; Transfer of R&D personnel between units. The first four items together comprise 'strategic issue centralization,' the latter seven comprise 'operational issue centralization.'

Formalization

Two questions were used. (1) Please tick those items for which your company has common technical standards for R&D work: Drawing standards; testing standards; measuring standards. (2) To which of the following units do you submit the standardized reports: Corporate R&D; manufacturing; marketing; corporate management? All answers were either one or zero.

Socialization

Four questions were used. (1) In 1991, approximately on how many occasions did you or other personnel from your R&D unit visit other R&D units in your company (1 = never, 5 = more than ten times)? (2) In 1991, approximately on how many occasions did your unit receive visitors from other R&D units in your company (1–5 as above)? (3) How many of your R&D personnel took part in your company's program for rotation of R&D personnel in 1991? (4) How many of your R&D personnel took part in your company's training program for R&D personnel in 1991?

Communication

Respondents were asked to estimate the frequency of (a) personal face-to-face contacts and (b) other types of contacts, in terms of the average number of contacts per year (split into seven categories from daily through to never). These data were requested for 10 entities within the corporation and nine external to the corporation, as follows.

Communication with units in your own division or business area. R&D units in Sweden; Manufac-

turing units in Sweden; Marketing units in Sweden; Other R&D units in the local market; R&D units in other countries; The local manufacturing unit, if relevant; Other manufacturing units in the local market; Manufacturing units in other countries; The local marketing unit, if relevant; Other marketing units in the local market; Marketing units in other countries.

Communication with external units. Local universities and research institutions; Swedish universities and research institutions; Foreign universities and research institutions; Customers in the local market; Customers in the Swedish market; Customers in other countries; Suppliers in the local market; Suppliers in Sweden; Suppliers in other countries.