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**SYNERGISTIC INNOVATIONS IN
INTERNATIONALLY DISPERSED R&D LABS**

By

Aditha N. S. Persaud

B. Soc. Sc. (Econ.); M.A. (Banking and Finance); M.M.S

**A Thesis submitted to
Faculty of Graduate Studies and Research
In partial fulfillment of
the requirements of the degree of
Doctor of Philosophy
School of Business
Carleton University
Ottawa, Ontario**

December, 1999

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**SYNERGISTIC INNOVATIONS IN
INTERNATIONALLY DISPERSED R&D LABS**

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I would like to make it clear that I take full responsibility for all errors and omissions of this study.

Ajax Persaud

Abstract

This study examined the extent to which networking among internationally dispersed research and development (R&D) laboratories (labs) of multinational corporations (MNCs) enhanced their capacity to create synergistic innovations. Networking was expressed as the set of formal and informal relationships among the labs. These relationships were studied in the context of four structural elements characterizing internationally dispersed R&D labs. These are autonomy, formalization, socialization, and communication among the labs. Communication among the labs was analyzed at two levels, namely, communication between HQ and subsidiary labs and communication among subsidiary labs. Synergistic innovative capacity was initially operationalized as a unidimensional construct comprising twelve items which reflect the innovativeness of a firm. A sample of 79 R&D labs owned by North American, European and Japanese MNCs provided data for this study by means of a survey questionnaire. Results from a variety of quantitative techniques including multivariate regression, factor analysis, and Partial Least Squares (PLS) analysis suggest that the structural variables explained approximately 40 percent of the variations in synergistic innovative capacity. It was also found that synergistic innovative capacity consists of four distinct dimensions and that the structural elements had different impacts on the four dimensions of synergistic innovative capacity.

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CHAPTER 1

INTRODUCTION

Throughout the 1960s and 1970s, the majority of multinational corporations (MNCs) performed most of their research and development (R&D) activities in their home country (De Meyer and Mizushima, 1989; Dunning, 1992; Håkanson, 1992; Pearce and Singh, 1992; Patel and Pavitt, 1992). During this period, the overseas subsidiary laboratories' (labs) primary role was to modify the products of the parent MNC to suit local market conditions (Ronstadt, 1977; Hewitt, 1980; Pearce and Singh, 1992). Basically, the MNC's headquarter (HQ) was viewed as the provider of innovations that were subsequently exploited overseas through the MNC's overseas subsidiaries (Vernon, 1966).

For decades, the philosophy of concentrating the most sensitive R&D activities at the HQ and assigning primarily adaptive R&D activities to subsidiary labs has served MNCs well (Hedlund, 1986; Bartlett and Ghoshal, 1989; Dunning, 1992). Several researchers, however, observed that rapid technological development especially in information and communications technologies, intense international competition and substantial market changes in the early 1980s have eroded the effectiveness of this approach (Hedlund, 1986; Bartlett and Ghoshal, 1989; Prahalad and Doz, 1987; Grandstand *et al.*, 1992; Nohria and Ghoshal, 1997). Based on anecdotal case study evidence from a few

companies, these authors contended that MNCs, which relied on the traditional unidirectional HQ to subsidiary innovation process, would be unable to generate innovations at the speed and scale necessary to sustain competitive advantage.

Multinational corporations were thus looking for new ways to foster innovations and to maximize their innovative capacity. In this process, many leading MNCs seem to have discovered a tremendous amount of capabilities throughout their worldwide units that were previously untapped (Prahalad and Doz, 1987; Bartlett and Ghoshal, 1989; Granstrand *et al.*, 1992; Nohria and Ghoshal, 1997). A major challenge which managers faced, is to design their organizations in ways that would enable them to simultaneously tap into these capabilities, promote worldwide learning within the MNC and foster innovativeness in their organizations. David Withwam, the Chief Executive Officer of Whirlpool Corporation, described this challenge as, “being able to leverage your capabilities around the world so that the company as a whole is greater than the sum of its parts” (Maruca, 1994, p. 134). Essentially, companies were looking for ways to organize their global activities to create synergies among the various parts of the multinational system.

Recognizing the strategic importance of the R&D function towards the long-run survival and competitive advantage of the firm, many MNCs began experimenting with a variety of approaches aimed at forging closer links among their worldwide R&D labs.

Researchers investigating organizational development in MNCs have reported a trend towards decentralization of key functions and activities (Hedlund, 1986; Bartlett and Ghoshal, 1986; Prahalad and Doz, 1987). These authors argued that the former hierarchical structure which emphasizes the division of the MNC into a HQ and several foreign subsidiaries is being replaced by more ambiguous and flexible forms of operations. Foreign subsidiaries are now regarded as strategic contributors having global or regional responsibility for a particular product or function, thereby playing a bigger role in corporate decision making. Essentially, the new organizational arrangements are designed to substantially reduce the degree of hierarchy, which in turn is expected to enhance interactions among subsidiaries. Hedlund and Rolander (1990) believed that the new trend towards greater decentralization and networking among subsidiaries has the potential of turning the entire MNC into an arena of entrepreneurs because the emphasis is on innovation and knowledge generation by subsidiaries rather than exclusively by HQ. Thus, the assumption underlying the trend towards greater decentralization of R&D activities and closer collaboration among worldwide R&D units seems to be that greater synergies in innovative activities will be realized.

The trend towards greater decentralization and closer collaboration has different names. However, it appears that researchers are converging around the general description of the *Network Organization* (Westney, 1993). In a network of R&D labs, the labs are basically equal partners with close interactions, sharing equally in the risks and rewards of the

network. It has been argued that the success of such decentralized structure crucially depends on effective inter-unit coordination and communication as integrative devices (Lawrence and Lorsch, 1967; Bartlett and Ghoshal, 1986; Hedlund, 1986). For such effective cross-border coordination and communication to take place among R&D labs, the labs must be given the autonomy to establish formal and informal networks with other labs within the MNC group (Buckley and Brooke, 1992; Brockhoff and Schmaul, 1996; Medcof, 1997; Malnight, 1996; Chiesa, 1996). The assumption seems to be that only when managers, project leaders, and R&D professionals of internationally dispersed R&D labs are able to establish strong personal networks among themselves will the MNC be able to exploit its worldwide capabilities.

Previous research on the internationalization of R&D has focussed on the determinants of internationalization (Granstand *et al.* 1992; Dunning, 1992; Pearce, 1989; De Meyer, 1993; Odagiri, 1996), the establishment processes of R&D activities in foreign countries (Hakanson, 1992; De Meyer and Mizushima, 1989; Kuemmerle, 1997; Reddy, 1994), the activities performed by overseas R&D labs (Casson, 1992; Hewitt, 1980; Ronstadt, 1977; Pearce, 1989; Reddy, 1994), and the organizational structures of international R&D labs (Buckley and Brooke, 1992; Brockhoff and Schmaul, 1996; Medcof, 1997; Malnight, 1996; Chiesa, 1996).

It is observed that a disproportionately large number of studies in the early stages of the

internationalization of R&D focused on the reasons for internationalization and the location decisions for R&D labs. Research on the organizational structures of international R&D labs and its attendant management challenges is a more recent development. Research which examines the impact of the internationalization of R&D on the innovativeness of MNCs is virtually non-existent (Brockhoff and Schmaul, 1996; Chiesa, 1996). Thus, it seems that the research focus on the internationalization of R&D has followed an evolutionary path beginning with the reasons for internationalization, to the extent and patterns of internationalization, to the management challenges following internationalization, to the impact of internationalization of R&D on the MNC.

Despite the rhetoric regarding the internationalization of R&D and networking among internationally dispersed R&D labs, and the increasing trend among MNCs to internationalize R&D, there is no systematic evidence which shows that the internationalization of R&D has enhanced the synergistic innovative capacity of MNCs. The lack of systematic evidence makes it very difficult to draw conclusions concerning the effectiveness of international R&D labs in exploiting worldwide technical and managerial resources for rapid technological innovations and sustainable competitive advantage. The current study will shed light on this very critical issue.

The current study is a first attempt to analyze the extent to which the formal and informal collaborative relationships between the HQ lab and subsidiary labs and among

internationally dispersed subsidiary labs enhance the synergistic innovative capacity of the MNC. In this study, synergistic innovative capacity refers to the incremental improvements in the labs innovative capacities attributed to the interdependence among the labs. Synergistic innovative capacity is measured by the extent to which the capabilities of R&D labs have changed, using thirteen performance dimensions¹.

It is argued here that the ability of subsidiary R&D labs to establish formal and informal networking relationships among themselves is influenced by the following factors²:

1. *Autonomy* of subsidiary labs in decision making, that is, the degree to which a subsidiary lab has control over the strategic decisions affecting its direction and operations (Nohria and Ghoshal, 1997; Mintzberg, 1979; Brooke, 1984; Medcof, 1997; Brockhoff and Schmaul, 1996; Chiesa, 1996). *Influence* which is closely related to autonomy refers to the degree to which a subsidiary lab may affect the strategic decision outcomes of the HQ regarding its own lab or other labs within the MNC group (Nohria and Ghoshal, 1997; Mintzberg, 1979; Brooke, 1984);
2. *Formalization* of decision making based on systematic rules and procedures (Hedlund, 1986; Nohria and Ghoshal, 1997; Mintzberg, 1979; Brooke, 1984);

¹ Detailed descriptions of the measures are provided in Chapter 3. The actual measures are listed in question 12 of the questionnaire sent to subsidiary labs.

² Discussion of the rationale for selecting the four factors is presented in Chapter 3.

3. *Shared Corporate Goals, Values and Culture* as a basis for decision making, that is, the degree to which decision making in subsidiary labs are influenced by common goals and shared values between subsidiary labs and the HQ (Nohria and Ghoshal, 1997; Birkinshaw and Morrison, 1995; Mintzberg, 1979); and
4. *Communication* between the HQ and subsidiary labs as well as inter-subsidiary labs communication patterns (Nohria and Ghoshal, 1997; Medcof, 1997; Stock *et al.*, 1996; Chiesa, 1996).

A model of the relationship between these four elements and the synergistic innovative capacity of R&D labs is proposed. Factors that may *moderate* the impact of networking on synergistic innovative capacity are also identified and discussed. These factors include the level of trust among R&D managers and staff, cultural diversity, the resource levels of the labs, and the uncertainty of the environment in which the labs operate.

This study is based on a sample of Canadian, American, European and Japanese high technology manufacturing MNCs operating principally in the electrical and electronics, chemical and pharmaceutical, and automotive industries³. Firms within these industrial sectors are selected because the evidence on the extent and pattern of internationalization of R&D indicates that these sectors are the most internationalized (OECD, 1998).

³ Software firms (e.g., Microsoft) are not included in this study.

Similarly, the bulk of R&D internationalization activities (close to 90 percent) are located in the triad regions of North America, Europe and Japan. The unit of analysis is the R&D lab.

Data was collected from the most senior R&D personnel at the labs (Vice Presidents, Managing Directors, and Directors) by means of a questionnaire. In addition, follow-up telephone interviews were conducted with several respondents. The qualitative data from these interviews provided context for the interpretation of the quantitative data obtained from the questionnaires.

This study contributes to ongoing academic research, discussions and debates on the internationalization of R&D in several unique ways. First, this study provides a conceptual framework of the relationship between networking among internationally dispersed R&D labs and the creation of synergistic innovative capacity of MNCs. Conceptual models of the relationship between the structural characteristics of internationally dispersed R&D labs and the labs' innovative performance are lacking (Medcof, 1998; Brockhoff and Schmaul, 1996; Chiesa, 1996).

Second, this study is the first to investigate empirically the relationship between networking among internationally dispersed labs and the innovativeness of the labs using data from a cross-section of R&D intensive firms.

Third, the concept and measurement of *synergistic innovative capacity* proposed in this study are new and have not been used elsewhere to study the impact of internationalization of R&D. Several individual measures of innovative performance have been used in previous studies but no measure of synergistic innovative capacity was found in the literature.

Finally, a number of previous studies which investigated the organizational structures of international R&D labs have reported that managers still face serious challenges in finding practical organizing frameworks that enable them to exploit their worldwide capabilities for maximum competitive advantage. As noted by several researchers, competitive advantage can only be sustained by continually innovating quickly with a series of winning products (Burgelman *et al.* 1996; Tushman and Anderson, 1997) or as Peters (1990) puts it, “get innovative or get dead.” From a practical standpoint, the findings of the study will provide a benchmark of current practices regarding the organizational structure and management practices of internationally dispersed R&D labs. An understanding of current practices and their efficacy could help managers develop appropriate R&D organizations which will enhance their managerial and operational efficiency and avoid duplication and waste.

The remainder of this thesis is organized into twelve chapters. Chapter two presents a review of the literature. Chapter three describes the theoretical framework on which the

study is based. Chapter four discusses the data collection and analysis methodology. Chapters five through nine present the findings based on various quantitative and qualitative analyses. Chapter ten discusses the implications of the findings. Chapter eleven highlights the benefits and limitations of the study. This is followed with the conclusion in Chapter twelve.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Although the trend towards the internationalization of R&D by MNCs can be traced back to the 1970s, it was only around the mid-eighties that a larger number of MNCs began decentralizing their corporate R&D function overseas (Granstand *et al.* 1992). Since then, a substantial amount of research has been published on issues such as the reasons for internationalization of R&D (Granstand *et al.* 1992; Dunning, 1992; Pearce, 1989; De Meyer, 1993; Odagiri, 1996), the establishment processes of R&D activities in foreign countries (Hakanson, 1992; De Meyer and Mizushima, 1989; Kuemmerle, 1997; Reddy, 1994; 1996; Reddy and Sigurdson, 1996), the types of activities performed by foreign R&D labs (Casson, 1992; Hewitt, 1980; Ronstadt, 1977; Pearce, 1989; Reddy, 1994, 1996; Reddy and Sigurdson, 1996), and the organizational structures of international R&D labs (Buckley and Brooke, 1992; Brockhoff and Schmaul, 1996; Medcof, 1997; Malnight, 1996; Chiesa, 1996).

The literature review is organized around three broad themes, namely, the reasons for internationalization of R&D, the pattern of the internationalization of R&D, and the organization of internationally dispersed R&D labs.

2.2 Reasons for Internationalization of R&D

The internationalization of R&D is viewed as a process of distributing R&D labs in different countries around the world (OECD, 1998). MNCs may establish an R&D presence in a foreign country either by deliberately establishing an R&D lab, by acquiring the R&D facility of another company, or by using an existing production or marketing facility as an R&D lab (Casson and Singh, 1992). Acquisition is the most common means used to establish overseas R&D labs (OECD, 1998).

Table 2.1 provides a comprehensive list of factors influencing the centralization or decentralization of R&D activities.

Table 2.1

Factors Favoring the Centralization and Decentralization of R&D

Factors Favoring the Centralization of R&D
<ul style="list-style-type: none">• Existence of economies of scale within the parent company (synergies between production, manufacturing, marketing, finance and R&D departments both within and with outside customers and sub-contractors) that cannot easily be reproduced abroad.• Need for maximum protection of R&D findings. Fear of “loss” of results to foreign competitors.• Insufficient critical mass in R&D laboratories located abroad.• Creation of ‘greenfield’ affiliates abroad with increased technological dependency on the parent company.• Costly technology transfers.• Horizontal acquisitions abroad and the need to reduce the cost of coordinating and controlling R&D.• Difficulties in hiring highly skilled personnel in certain specialized areas.• Skills of scientific personnel at home are greater than in host countries.• Lack of training facilities to teach researchers foreign languages (notably English).

- Problems experienced by the parent company in organizing and controlling R&D at the world level.

Factors Favoring the Decentralization of R&D

- High level of production by affiliates abroad and continuous need to adapt products to the requirements of local markets.
- Shortage at home of highly skilled scientific personnel.
- Proximity to highly renowned foreign universities and laboratories, and attractive local infrastructure.
- Duration of investment abroad, particularly in sectors widely exposed to international competition.
- High R&D intensity, both in the home country and host country, in the sector in which the affiliate is operating.
- Large parent companies with large affiliates located in a large number of countries (highly internationalized).
- Need to follow competitors in establishing research centers into local markets abroad (imitation).
- Capacity of the firm to manage complex systems in a decentralized structure at all levels between the parent company, affiliates and other firms belonging to the same group or network.
- Acquisition of foreign firms conducting complementary R&D activities. These activities are sometimes more important than those of the parent company.
- Establishment of shared laboratories with foreign firms (joint ventures).
- Increased product differentiation and greater competition over quality.
- Very high cost of domestic research (need to reduce or share costs).
- Ready access to capital in the host country.
- Costs to technological diffusion, calling for proximity to production abroad.
- Local regulations and technological policies in support of innovation and human resources development.
- Adequate protection of intellectual property in host country.
- Financial or fiscal incentives offered by the host country.

Source: OECD Report, Internationalization of R&D, 1998.

Although this list of factors is illuminating, such a laundry list does not provide a strong enough conceptual framework for understanding the internationalization of R&D.

Recognizing this deficiency in conceptual understanding, several researchers have advanced various frameworks. Some of the frameworks are discussed in the remainder of this section.

Perhaps, one of the most frequently used arguments is that the internationalization of R&D follows the globalization of industrial production or manufacturing activities (Hymer, 1972; Knickerbocker, 1973; Lall, 1979). According to this view, MNCs which seek to extend their control over a foreign market will establish R&D labs in these markets to support product differentiation through product innovation and development. Basically, the role of these labs is to extend the life of the MNCs' technology through minor product adaptations to suit local market conditions so that the MNC could maintain control over the market. One limitation of this approach is that it fails to provide adequate explanations for cases where a MNC has established a lab or has acquired a lab in a market where it has no production facilities. For example, in analyzing the pattern of industrial R&D of Swedish MNCs, it is observed that a number of Swedish companies have R&D facilities in the United States although they have no production facilities in the USA. Similarly, this argument breaks down when R&D intensities (R&D/Manufacturing Turnover) are substantially greater than 1 as is the case for several countries shown in Table 2.2.

Table 2.2
R&D Intensities in the United States by Country in 1994

Country	R&D Intensity
Switzerland	3.22
Canada	1.66
Germany	1.66
France	1.30
United Kingdom	1.03
Netherlands	0.82
Japan	0.46

Source: OECD, Internationalization of R&D, 1998.

A second approach argues that the internationalization of R&D has more to do with tapping into the scientific and technical capabilities of foreign countries than with supporting local production (Dunning, 1988; Pearce and Singh, 1992; Håkanson and Noble, 1993). Thus, companies will establish or acquire R&D facilities in areas where there is a high concentration of very talented professionals. This approach may explain why MNCs have foreign R&D labs in areas where there are no production facilities as well as the growth of high-tech clusters such as Silicone Valley, Boston Route 128 and numerous others around the world.

Another approach uses the “product life cycle” model to explain how demand and supply

factors drive the internationalization of R&D (Dunning, 1992; Håkanson, 1992; Håkanson and Noble, 1993; Pearce and Singh, 1992)⁴. This framework combines the various phases of the product life cycle with the stages of its innovation in domestic and foreign markets (Vernon, 1966). The argument is that in the initial stages of an innovation, there is a need for close coordination of scientific, engineering, marketing and financial activities, and because of the high risks involved in R&D activities, they should be kept under close surveillance in physical proximity to the parent company. Once the technology is developed and production is transferred abroad, the associated levels of R&D will be high enough not to require the input of additional R&D resources from overseas (Vernon, 1977; Cantwell, 1992).

Although this framework provides explanation of the dominant role the HQ still plays in R&D activities, it fails to account for the increasing number of overseas R&D labs which engage in upstream R&D (basic research or new product development rather than just product adaptations). Mowery and Rosenberg (1979) argued that the internationalization of production and the increasing sophistication of foreign market demand make it necessary for MNCs to develop a larger number of innovations overseas. Behrman and Fischer (1980) argue that MNCs whose activities are primarily focussed on the domestic

⁴ *Demand factors* include locating technical support labs in large manufacturing subsidiaries in significant markets; regulations by host countries' governments to set up local adaptive R&D; market proximity; integration with local production; and local ambitions among overseas labs. *Supply factors* include access to scientific and technological skills and knowledge; strategic intra-firm co-operation or acquisition; tapping into foreign scientific infrastructure; cost differentials; availability of R&D inputs; and subsidies by national governments to encourage foreign companies to establish R&D in their countries.

market, tend to establish overseas R&D labs that perform adaptive R&D. In contrast, MNCs oriented more towards world markets tend to set up labs that perform the full range of R&D activities, ranging from product adaptations, to applied research, to even basic research.

Yet another perspective was advanced by De Meyer (1992, 1993a), who argued that the underlying explanation can be summarized through the concept of learning. In this view, the contribution of international R&D to the technological strategy of the firm lies in the improvement of the company's learning about the long-term evolution of markets, technologies, competitors and suppliers. Linking learning to technological strategy requires an extremely well organized diffusion of knowledge throughout the firm. This diffusion can be stimulated by seeing the R&D organization as a 'network of labs' which are connected with each other inside as well as outside the company (De Meyer, 1993b).

A number of international management researchers argue that MNCs internationalize their R&D for strategic reasons rather than for purely cost considerations (Pearce and Singh, 1992; Patel and Pavitt, 1992; Hedlund, 1986; Bartlett and Ghoshal, 1989; Prahalad and Doz, 1987; Porter, 1990; White and Poynter, 1990; Nohria and Ghoshal, 1997). According to this view, intense international competition has made it increasingly difficult for MNCs to sustain competitive advantage by centralizing R&D at the HQ because this strategy cannot adequately generate innovations at the speed necessary to

remain competitive. To survive, MNCs must create distributed innovations by being able to exploit the technical, managerial and marketing competencies of its subsidiaries to create products, processes and administrative practices that can be used locally and globally. Instead of relying exclusively on the HQ for innovations, MNCs must maximize their “combinative capacity” – the ability to generate innovative combinations based on knowledge and capabilities throughout the multinational system (Kogut and Zander, 1992). In this regard, the internationalization of R&D is regarded as an essential first step. This latter view seems to have gained widespread acceptance among management researchers.

Finally, Reddy (1994, 1996) contended that the internationalization process has passed through four waves and the major driving forces are different at each wave. The major driving force at the first wave (which lasted up to the 1960s) is the desire of MNCs to enter into local markets abroad. Building market share overseas and national government policies are the main driving forces for the second wave (1970s). The need for world-wide learning and new technology inputs characterize the third wave (1980s); and, access to scarce R&D personnel and increasing R&D costs are the major driving forces of the fourth wave (1990s).

2.3 Extent and Pattern of International R&D

2.3.1 Data on Internationalization of R&D

While there are no disputes among researchers that the trend towards the internationalization of R&D is increasing, there seems to be disagreement over its scale and significance. Two reasons may account for much of the disagreement.

The first reason relates to the data on which conclusions are made regarding the extent of R&D internationalization. The data on which much of the literature is based were obtained from one of three principal sources:

1. National data provided by statistical agencies of individual countries such as Statistics Canada, National Science Foundation, US Department of Commerce, and Fortune 500.
2. Cross-country data provided by international institutions such as the OECD.
3. Data collected by individual researchers through surveys and case studies.

As expected under these circumstances, the data on which the research is based are fragmented, incomplete and not directly comparable because the methodologies underlying their collection vary significantly from source to source. In an attempt to address this deficiency, the OECD has released its first ever Activities of Foreign Affiliates (AFA) database which currently tracks 18 variables including R&D

expenditures and R&D personnel (OECD, 1998). It is also worth noting that the United States is the only OECD country that has legislation requiring companies to disclose their overseas R&D activities. Thus, the US data sources represent the most complete and reliable source of information on the internationalization of R&D.

The second factor contributing to disagreements over the scale and significance of international R&D relates to the indicators used. Generally, there are at least eight different indicators used in the discussion, although some are more common because the data is more readily available and widely used. These indicators are as follows:

1. R&D expenditures overseas
2. R&D employees overseas
3. R&D intensity⁵ overseas
4. Volume of scientific publications produced jointly by researchers from different countries
5. Number of international strategic alliances
6. Number of patents filed in a foreign country
7. Number of research labs overseas
8. Role of overseas labs in terms of research orientation (e.g., basic research, applied research, and product adaptations).

⁵ Overseas R&D intensity is measured in two ways: (1) R&D expenditure overseas/sales, and (2) R&D expenditure overseas/manufacturing turnover.

A discussion of the merits and limitations of each of these measures is considered outside the scope of the current study. Suffice to say, however, that data on some of the indicators is very difficult to obtain and even when they are obtained, the reliability is often doubtful.

2.3.2 Evidence of Internationalization of R&D

Several key trends on the extent and pattern of internationalization are reported by the OECD (1998). Some of the more notable, general and specific country trends are summarized below:

- Overseas R&D expenditures among the 15 OECD countries averaged about 12 percent of the total R&D expenditures of the OECD countries in 1994.
- In most countries, the R&D of foreign affiliates is concentrated in a few industrial sectors: electrical; electronics; computers; pharmaceutical; chemical; and automotive industries.
- A significant proportion of R&D internationalization comes from the acquisition of foreign R&D labs. For example, when a Canadian company buys the R&D lab of a UK company.
- In the **United States** more than 105,000 R&D jobs and approximately 10 percent of the total industrial R&D of the US were related to the research activities of foreign companies in the US.
- **Japan's** overseas R&D expenditure in 1993 reached 2.1 percent compared to

less than 0.5 percent at the beginning of the decade.

- R&D expenditures by foreign companies in **Germany** were 16 percent of the country's total industrial R&D and the number R&D jobs related to foreign companies was about 15 percent.
- R&D expenditures by foreign affiliates in **France** were 16 percent of the country's total industrial R&D.
- R&D spending by foreign affiliates in the **UK** reached 37 percent in 1995, the highest among all OECD countries.
- In **Canada**, about 40 percent of the country's R&D spending are attributed to foreign firms, mainly U.S. firms. About 80 percent of pharmaceutical and automobile R&D is done by foreign affiliates while about 70 percent of the R&D in aerospace and the computer industry is under foreign control. In terms of manufacturing R&D intensities, Canadian firms have a higher level than foreign affiliates in Canada.
- In 1995, the R&D expenditures of **Swedish** MNCs abroad and foreign affiliates in Sweden were approximately 20 percent respectively.

Dunning (1992, 1994) showed that there is some convergence of innovatory capacity at the country-level since the 1970s. For example, in 1970, the former USSR, Canada and USA accounted for 65.4 percent of the world's R&D expenditure and 57.4 percent of the scientists and engineers. Moreover, 75 percent of all US patents were granted to North

American firms. However, by the early 1980s, these proportions had fallen to 47.7 percent, 54.6 percent and 57 percent respectively. The most noticeable convergence occurred among the five leading industrial countries (i.e., US, France, Germany, UK and Japan).

The innovatory capacity of developing countries has also increased markedly over the same period. For example, developing countries' contribution to world R&D expenditures increased from 2.5 percent to 6.2 percent between 1970 and 1987; their share of world patenting doubled during the same period, and R&D scientists and engineers increased from 8.5 percent to 11.2 percent by 1984 (Dunning, 1992, 1994). In spite of this convergence, the author concludes that the relative importance of foreign R&D activities varies greatly between countries and industries, and foreign R&D tends to follow the pattern of international sales and production. That is, MNCs tend to set up R&D labs where they have large production facilities and significant markets because overseas R&D labs tend to perform more adaptive work.

In spite of the trend towards greater geographical dispersion, Dunning (1992, 1994) and Patel and Pavitt (1992) argued that the world's R&D and technological activities are far from globalized in two senses. First, in most of the countries at the world's technological frontier, foreign R&D and technological activities are still insignificant. For example, in 1982, only 12 percent of the R&D expenditures of 792 of the world's leading MNCs were

undertaken outside their home country. Second, large firms' technological performance strongly depends on the performance of their home country, rather than independent of it.

Pearce and Singh (1992) observed that only a very small number of R&D facilities deliberately set up abroad are more than twenty years old. Internationalized R&D was found to be established in UK corporations and other European companies with below average tendency among U.S. and Japanese MNCs. At the industry level, a global perspective of R&D is most clearly established in pharmaceuticals and least established in aerospace and metal manufacture and products.

According to Cantwell (1992), wherever the world's largest MNCs have dispersed their activities, they have generally been attracted to the main centers of innovation for their industries. For example, between 1978-1986, most foreign firms in the pharmaceutical industry were located in the U.K. because it was among the world's leaders in pharmaceutical R&D. Similarly, in Japan most foreign firms were keen to invest in the electrical equipment, motor vehicles, and professional and scientific instruments industries. Furthermore, although many leading MNCs (IBM, ICI and Sony) established R&D labs in North America, Western Europe and Japan, their R&D labs tend to cluster within specific regions in the triad such as California's Silicone Valley.

Casson and Singh (1992) observed a shift in the focus of R&D at the parent R&D labs

among US, European and Japanese MNCs. Many U.S. and European MNCs are moving towards more applied research and less basic/original research, while the Japanese MNCs are moving towards more basic/original research and away from applied research. They suggested that this tendency is consistent with the view that Western firms invest in Japan in order to get access to Japanese corporate know-how, whilst the Japanese try to get access to Western institutions of basic/original research.

Odagiri and Yasuda (1996) in their study of Japanese firms' R&D practices, observed that the motive for overseas R&D differs between the R&D in developed countries, such as the USA and Europe, and that of developing countries, such as those in Asia. Japanese firms appear to conduct R&D in the US and Europe, to gain access to the leading scientific and technological knowledge or to recruit high-quality researchers. In Asia, the firms appear to set up R&D labs to support local manufacturing.

In terms of the types of activities undertaken by foreign R&D labs, the evidence indicates that, with some exceptions, they still supply support services or perform product and process adaptations. For example, Granstrand and Sjölander (1990, 1992) indicate that adaptive research is the dominant motivation for US MNCs to undertake foreign R&D. Casson and Singh (1992) found that 57 percent of a sample of 218 Japanese MNCs in 1990 indicated that support services are the main objective of their foreign labs. Except for a few sectors, notably mining, food processing and pharmaceuticals, and in a few

developing countries (e.g., Brazil, India and South Korea), it is the only R&D carried out.

Casson and Singh (1992) and Pearce and Singh (1991, 1992) observed that overseas R&D plays an increasingly distinctive role in many leading MNCs in at least two ways. First, development work replaces adaptation, so that R&D labs work with marketing and engineering units to develop distinct product variants using the MNCs technology. Second, some overseas R&D labs provide market-support services for a range of markets. Limited support was found for the view that overseas R&D labs play a role in basic/original research programs. Further, where overseas facilities performed basic/original research, there was a strong propensity for this to be integrated into internationally networked programs. For instance, Bell Northern Research and Northern Telecom overseas R&D labs perform a variety of tasks ranging from technology scanning to product adaptations to new product development.

Finally, within the international network of MNCs, technological activity is becoming broader. First, there is increasing external and cross-border acquisition of technology among MNCs through acquisitions, licensing, contract R&D, international joint ventures, and technology scanning. The internationalization of R&D has improved the efficiency of sourcing of new technologies because R&D activities are established geographically near the source of these technologies. Second, there is a trend, in varying degrees, for R&D to become more diversified, especially in labs located in the US and UK, and to a

lesser extent, Japan and Sweden. The tendency towards technology diversification tends to increase the pressure for external technology acquisition which could lead to further technology specialization of countries (Granstrand and Sjölander, 1992).

2.4 Management of International R&D

The literature on the organization and management of international R&D focused on two interdependent issues. The first issue pertains to developing an understanding of the structural relationships between the HQ lab and overseas labs, and among overseas labs themselves. The second issue pertains to developing an understanding of the role overseas labs play within the broad range of R&D activities undertaken by the MNC group.

Based primarily on empirical research, researchers have, over the years, developed an array of taxonomies to describe international R&D labs in terms of their structural relationships and the activities they perform. Tables 2.3 and 2.4 below provide a summary of the taxonomies as presented in Medcof (1998). Medcof's (1998) schema is based on conceptual arguments which have not been tested empirically as yet.

In Table 2.3, Medcof (1998) classified research labs into four groups based on the type of R&D activities they perform and whether these activities are carried out at the local or international level. Using these classifications, Medcof (1998) mapped the taxonomies from previous studies on to his schema in order to arrive at a framework that will allow

for comparisons among previous studies.

A similar approach has been adopted in Table 2.4 with respect to the organizational structures of overseas R&D labs. In Table 2.4, overseas research labs are classified as belonging to either a network, cluster or hub structure depending on the level of autonomy and influence they enjoy in decision making, the strategic significance of the R&D tasks they perform, and the nature of communications among the labs. Generally, networks labs have the greatest autonomy, undertake work of higher strategic significance and have more frequent and dense communications with a larger number of labs. Labs that are subjected to greater control by the HQ, have very little interactions with other labs, and perform work of lower strategic significance are referred to as 'hub' structure labs.

A cursory examination of Tables 2.3 and 2.4 suggests that there are serious contradictions resulting from the proliferation of taxonomies. For example, in Table 2.4, the definitions of the *network structure* advanced by Medcof's (1998), Malnight (1996) and Buckley and Brooke (1992) appear to be inconsistent with that advanced by Brockhoff and Schmaul (1996). Similarly, how can Chiesa's (1996) global specialized lab be consistent with Brockhoff and Schmaul's definition of the network structure?

In Table 2.3, how can Ronstadt (1977 and 1978) Technology Transfer Unit fit with three

of Medcof's taxonomies (Local Development Units, Local Marketing Support Units, and Local Manufacturing Support Units)? According to Medcof (1998), one of the reasons for the apparent contradictions in this body of research is that while excellent field research has been conducted, there is a lack of conceptual models to guide empirical investigations. Nohria and Ghoshal (1997) called for new conceptual and analytical frameworks of MNCs which capture and explain the new organizational realities of MNCs as well as the rapidly changing and complex environment under which they operate.

Table 2.3**Correspondences among Technology Unit Types**

<u>Units Involving Local Collaboration</u>				
	Local Research Units	Local Development Units	Local Marketing Support Units	Local Manufacturing Support Units
Medcof (1998)				
Cordell (1973)	--	--	Support Lab	--
Ronstadt (1977, 1978)	Corporate Technology Unit	Transfer Technology Unit	Transfer Technology Unit	--
Behrman & Fischer (1980)	--	Host Market Company	Host Market Company	Home & Host Market Companies
Hewitt (1980)	--	Product Adaptive R&D	Product Adaptive R&D	--
Hood & Young (1982)	--	Locally Integrated Lab	Support & Locally Integrated Labs	Support & Locally Integrated Labs
Pearce & Singh (1982)	--	Locally Integrated Lab	Support Lab	Support Lab
Hakanson & Nobel (1993)	--	--	--	--
Cheng (1994)	--	Indigenous Labs, Local Markets	--	Technology Transfer Lab
Nicholson (1994)	--	--	Technical Service	--

Units Involving International Collaboration

	International Research Units	International Development Units	International Marketing Support Units	International Manufacturing Support Units
Medcof (1998)				
Cordell (1973)	International Interdependent Lab	--	--	Support Lab
Ronstadt (1977, 1978)	Corporate Technology Unit	Global & Indigenous Technology Units	--	--
Behrman & Fischer (1980)	World Market Company	--	--	--
Hewitt (1980)	--	Local & Global Origin R&D	--	Process Adaptive R&D
Hood & Young (1982)	International Interdependent Lab	--	--	--
Pearce & Singh (1992)	International Interdependent Lab	Locally Integrated Lab	--	--
Hakanson & Nobel (1993)	Monitor Research	Monitor Research/ Market Proximity/ Production Support	Market Proximity	Production Support
Cheng (1994)	International Interdependent Lab	Indigenous Lab Multiple Markets/ International Interdependent Lab/ Global Technology Center	--	--
Nicholson (1994)	Regional Technical Center	Regional Product Development Center	--	--

Source: Medcof (unpublished, 1998)

Table 2.4**Taxonomies of Organizational Structures****Correspondences among Classifications of Organizational Structures**

Medcof (1998)	Network	Cluster	Hub
Brockhoff & Schmaul (1996)	Competence model	Network model	Hub model
Chiesa (1996a)	Integrated global Integration based	Isolated specialized (dev.) Support specialized Isolated specialized (res.)	Specialized contributor Support specialized Integrated local
Chiesa (1996b)	Global integrated	Global specialized	Global central
Malnight (1996)	Network-based	Decentralized	--
Buckley & Brooke (1992)	Network model	Competitive model	Hub model
Bartlett & Ghoshal (1990)	Globally linked	Local-for-local	Global-for-local
Bartlett (1986)	Integrated	Decentralized	Centralized
Franko (1978)	Global structure	Mother/Daughter	International division
Perlmutter (1969)	Geocentric	Polycentric	Ethnocentric

The classifications for Franko (1978) and Perlmutter (1969) are based upon Hakanson (1990).

Adapted from Medcof (1998).

Despite these apparent contradictions, the existing research has advanced our understanding of the approaches used by MNCs to coordinate, control and integrate their internationally dispersed R&D activities. First, it has been reported that the strategic significance of the tasks undertaken by the overseas R&D labs vary from purely adaptive work to tasks of high strategic significance such as basic research (Casson and Pearce 1992; Birkinshaw and Morrison, 1995; Brockhoff and Schmaul, 1996; Chiesa, 1996; Nohria and Ghoshal, 1997). Similarly, it was observed that the level of autonomy and

patterns of communication and coordination by overseas R&D labs are not uniform across all labs. That is, while some labs are given greater freedom to decide their research directions and have dense interactions with other labs, others are still closely controlled from the HQ.

An important question here is what factors determine the extent of autonomy and strategic significance of the R&D tasks assigned to overseas labs? The underlying reasons are not yet well understood. However, Bartlett and Ghoshal (1989) and Nohria and Ghoshal (1997) suggested that the labs' administrative heritage, resource levels, and the complexity of the environment in which they operate are possible explanations. The differentiated network model of MNCs advanced by Nohria and Ghoshal (1997) is an attempt to illustrate both conceptually and empirically how these factors may help explain the observed variations.

In an attempt to develop a deeper understanding of how MNCs organize their international R&D, researchers have focussed on the structural elements characterizing the complex relationships among worldwide R&D labs. Three interdependent issues dominate this body of research. One issue concerns the level of autonomy granted to overseas subsidiary labs to make strategic decisions and how autonomous labs relate to the rest of the labs within the MNC group. The second issue concerns the coordination structure used to integrate and control globally distributed R&D labs. The third issue relates to the communication

patterns among the labs. The research on each of these issues is discussed below.

2.4.1 Autonomy of R&D Labs

Generally, in HQ-subsidary relationships, control is a central issue. Child (1973) defines control as regulating the activities within an organization so that they are in accord with the expectations established in policies, plans and targets. In the traditional hierarchical model, control is primarily 'bureaucratic' and managers are monitored to prevent opportunistic behavior (Birkinshaw, 1994). The network model proposes a system of primarily 'normative' or cultural controls, whereby managers are imbued with the values and goals of the MNC and thus, act in accordance with them (Hedlund, 1986; White and Poynter, 1990).

Bureaucratic control is still necessary, but is of secondary importance.

De Meyer and Mizushima (1989) identified three factors that determine the amount of local autonomy given to overseas R&D labs. These are as follows:

1. A company orientation towards centralization, that is, companies that were highly centralized tended to centralize their international R&D as well.
2. Time pressure. The greater the time pressure to complete an R&D project, the greater the tendency towards centralization.
3. Size of the R&D lab. The smaller the overseas R&D lab, the stronger the corporate control exercised over them.

Bartlett and Ghoshal (1989) observed that the level of autonomy of overseas labs vary with the innovation tasks performed. R&D labs that only created innovations had the greatest autonomy while those that created, adopted, and diffused innovations had intermediate amounts of autonomy. Their data did not support the view that autonomy facilitates creation and diffusion of innovations, or that it impedes adoption.

Behrman and Fischer (1980) identified four management styles in relation to foreign R&D: absolute centralization; participative centralization; supervised freedom; and total freedom. However, participative centralization and supervised freedom were the two most commonly used management styles. Firms with a **home-market** orientation (emphasize the home market) appeared to be more centralized than firms with a **host-market** or global market orientation (emphasize the foreign or world market). Among firms with a host-market orientation, those in high-tech industries such as electronics, pharmaceuticals and chemicals, tended to use participative centralization.

Casson and Singh (1992) characterized the relationship between the HQ R&D facility and overseas R&D labs that performed basic/original research as 'supervised freedom'. De Meyer and Mizushima (1989) found that among the companies they studied, managerial decision making was closer to participative centralization than to supervised freedom.

According to Voisey (1992), some Japanese firms have been internationalizing their R&D

by adopting a more localized strategy which he described as 'supplier R&D' instead of indigenous offshore development by a division, or acquisition of offshore capabilities followed by mandated integration within the MNC network. The 'supplier R&D' establishment process is one of acquisition of an offshore capability followed by non-assimilation within the MNC in a formal sense. In other words, the local MNC-owned organization retains nearly all of its pre-existing management systems and internal consistency, but nevertheless develops a strong and effective relationship with the Japanese parent.

Kuemmerle (1997) suggested that managers who are responsible for internationalizing R&D should follow a two-stage strategy. First, a local (offshore) R&D lab that is as closely integrated into the local environment as possible should be established -- acquisition of a local high-tech company is one way of achieving this. The second stage is one of non-formal integration. This means giving primacy to the local R&D subsidiary in order to interact with and respond to the various isomorphic pressures of its environment without interference. Instead, the HQ role becomes more of a facilitator, by providing every reasonable opportunity for the offshore R&D center to gradually develop ties at multiple levels throughout the MNC.

2.4.2 Coordination and Integration of R&D Labs

One outcome of establishing internationally dispersed R&D labs is that coordination becomes much more difficult due to geographic, time and cultural differences. Advances in information and communications technologies have helped to mitigate some of the coordination difficulties. Nonetheless, significantly more time and resources are needed to achieve effective coordination, compared to the traditional approach where R&D is centralized.

Nohria and Ghoshal (1997) reported that MNCs use a combination of formalization and socialization mechanisms to coordinate and control the activities of their decentralized subsidiaries⁶. Many researchers argue that coordination and control of internationally dispersed R&D labs is achieved more effectively through socialization or normative cultural control rather than by rules and edicts (Baliga and Jaeger, 1984; Nohria and Ghoshal, 1997; Marschan, 1996; Neff, 1995; Gwynne, 1995; Krogh, 1995; Ouchi, 1980; Kanter, 1988). According to Coleman (1990), socialization is important for building trust and shared values; for learning the organization's code of conduct; and for monitoring in order to ensure compliance with the norms. Both trust and shared values reduce coordination costs within organizations (Ring and Van de Ven, 1992).

⁶ Formalization refers to coordination and control through the use of systematic rules, procedures and policies. Socialization refers to coordination and control through the creation of common goals and shared values (Nohria and Ghoshal, 1997).

Nohria and Ghoshal (1997) argued that socialization allows the multinational to leverage its worldwide pool of resources much more effectively than through the formal structure. Hence, as the need to tap into the innovative potential of its overseas R&D labs increases, the multinational must devote more resources into building its social capital -- the individual's network of contacts.

Mechanisms which have been used to encourage socialization include corporate training programs, joint planning involving personnel from HQ and overseas labs, internally sponsored conferences for R&D staff, job rotation, exchange visits, using expatriate managers to head overseas R&D labs, mentorship programs, social and recreational events, language and cultural sensitivity training, and open communications throughout the organization (Neff, 1995; Gwynne, 1995; Medcof, 1998, Brockhoff and Schmaul, 1996, Kuemmerle, 1997).

2.4.3 Communication among R&D Labs

Within internationally dispersed R&D labs, communication must be managed both between the HQ and overseas labs and among the overseas labs. The importance of internal communications for innovation is well established in both the theoretical and empirical literature on innovations (Tushman and Anderson, 1997). In the traditional hierarchical organization, communication is achieved through the formal structure, while in the networked organization, lateral and personal communications replace the formal

structure and function as integrative devices connecting various parts of the organization.

Stock *et al.*, (1996) examined the communication patterns between HQ and subsidiaries of European and Japanese biotechnology MNCs in the US with respect to processing technical information. They observed that processing technical R&D information in an international setting substantially increases the complexity and difficulty of such processing. However, the effectiveness of such processing greatly influences innovative performance. Stock *et al.*, (1996) reported that HQ-subsidiary communication of technical R&D information differs significantly between European and Japanese MNCs. Differences were observed at the organizational, technological and cultural levels.

Nohria and Ghoshal (1997) observed a connection between HQ-subsidiaries communication patterns and innovations within the context of their four structural types (i.e., local-for-local, local-for-global, center-for-global and global-for-global). Local-for-local types are characterized by high-density communication within subsidiaries. Local-for-global have high-density communication both within and among subsidiaries. Center-for-global structures are characterized by high-density communication between HQ and subsidiaries. Global-for-global types have high-density communication within subsidiaries, among subsidiaries, and between HQ and subsidiaries. In addition, interpersonal networking has substantial positive effects on R&D managers' communication, both with the HQ and with other subsidiaries.

Bartlett and Ghoshal (1989) reported that subsidiaries that had higher levels of inter-lab communications were also more effective in the creation of innovations. Strong inter-subsidary communication is facilitated through organizational directives from corporate HQ and the use of advanced communication technologies. Hakanson and Zander (1988) noted that extensive inter-subsidary communication, particularly lateral information flows among subsidiaries, is a primary contributing factor to achieving international coordination among foreign subsidiaries.

De Meyer and Mizushima (1989) found two patterns of communication in the context of international R&D in large MNCs. In the first one, the HQ lab collects technical information and disseminates it to overseas R&D labs. In the other, which they describe as a network organization, the labs are interconnected and information flows through the network. De Meyer (1992) found that although most MNCs are using electronic communications media, most managers still prefer personal contacts and the traditional 'handshake' to build mutual trust and confidence. It appears that the handshake is an important pre-condition for the effective use of electronic communication systems.

Finally, Marschan (1996) examined the impact of less-hierarchical structures or networks on horizontal and personal communications within a single multinational, KONE elevators. The author found that the adoption of a less-hierarchical structure has many different consequences on communication patterns at different organizational levels. For

instance, top management communication patterns improved, but middle management and those at the operating level experienced barriers in their information exchange with other labs. Communications at the top management level became less formal, while at the middle and operating levels the perception was that communication had become more formal.

2.5 Conclusion

The studies reviewed here have certainly improved our understanding of the critical issues involved in managing international R&D globally. However, a number of issues require much more rigorous and extensive research in order to draw firm conclusions regarding the way MNCs organize and manage their world-wide R&D labs. For instance, although case study evidence suggests that the internationalization of R&D has resulted in improved performance, there is hardly any systematic study confirming this trend. Indeed, the impact of the internationalization of R&D on the ability of MNCs to innovate has yet to be explored. Even though the studies done by Bartlett and Ghoshal (1990) and Nohria and Ghoshal (1997) are two exceptions, they include all types of organizational innovations (administrative, product and process) and focus on a wide range of multinational subsidiaries, rather than just R&D operations. The extent to which their findings apply to the performance of overseas R&D labs in the advanced high-technology sectors needs to be validated.

Granstrand *et al.*, (1992) contended that the shift in paradigm from the traditional hierarchy to the network model has created the need for new theories of multinational R&D in order to reach normative conclusions regarding the structure and management processes required to co-ordinate and control decentralized R&D labs. Medcof (1998) noted that excellent field research has been conducted but there is an obvious lack of theory-based research.

In addition, the literature review indicates that network-based MNCs have been associated with expanding horizontal linkages among labs through an array of mechanisms such as greater autonomy for overseas labs and greater involvement of overseas labs in higher value-added research. However, the evidence available suggests that to date the majority of overseas labs, particularly those in developing countries still perform adaptive R&D (i.e. product modification to suit local market conditions). This trend suggests that there is a lot to be learned in terms of enhancing the role of HQ, while simultaneously promoting efficiency and allocating more value-added R&D to the overseas labs.

CHAPTER 3

THEORETICAL FRAMEWORK

3.1 Background

The preceding literature review indicates that the trend towards the internationalization of R&D has been increasing since the mid-1980s. Several management researchers contend that MNCs have realized that the traditional approach of centralizing R&D in the home country is no longer a viable option for maintaining strategic advantage (Hedlund, 1986; Bartlett and Ghoshal, 1989; Prahalad and Doz, 1987; Grandstand *et al.*, 1992; Nohria and Ghoshal, 1997). A popular view among managers of MNCs and some academicians is that only those corporations that can leverage their worldwide capabilities to create synergies will survive in the fiercely competitive international arena. The phenomenal increase in the rate of intra-firm and inter-firm collaborations among research laboratories of the world's leading MNCs is probably one indication of how serious and widespread this view is. The increasing research focus on finding ways to effectively organize and manage globally distributed R&D labs in order to achieve the synergies expected from collaborations underline the difficulties involved in managing R&D within the new boundary conditions.

In spite of the push for greater collaborative R&D among research labs, a key question still remains unanswered: Does greater collaborative R&D enhances the innovative

capabilities of research labs? Reports in the popular press suggest that greater collaboration has a positive impact on the creativity of companies. However, there are few systematic, large-scale empirical studies supporting this claim. This is precisely the issue which the present study addresses.

3.2 Research Question

The central focus of this study is the extent to which collaboration in the form of greater networking among internationally dispersed R&D labs of MNCs enhances the synergistic innovative capacity of the MNC. Specifically, the study addresses the following question:

To what extent does networking among the R&D labs of a MNC group enhances the synergistic innovative capacity of MNCs?

In this study, networking refers to the set of formal and informal relationships existing between the HQ and the subsidiary R&D labs and among subsidiary labs. These relationships range from information sharing to joint R&D projects involving frequent contacts either by electronic means or in-person by R&D managers and scientists and engineers from the various labs.

Since the landmark study of the Aston Group (1967), centralization and formalization have become central constructs in the analysis of internal relations in complex

organizations (Pugh, Hickson, Hinings and Turner, 1968; Pugh, Hickson and Hinings, 1969). Similarly, since the studies of Edstrom and Galbraith (1973) and Ouchi (1980), normative integration or socialization has been treated as another primary structural element in the analysis of multi-unit organizations. Studies by Lawrence and Lorsch (1967), Burns and Stalker (1961), Aiken and Hage (1971), Rogers (1995) and Burt (1982) emphasize the importance of effective communications across units for the creation of innovations. Thus, it can be plausibly asserted that *centralization, formalization, socialization and communication*⁷, analyzed individually and together, constitute a fairly comprehensive characterization of the nature of the internal relationships between and among units in complex multi-unit organizations such as MNCs.

In the context of internationally dispersed R&D labs, *centralization* refers to a situation where strategic decision-making at the subsidiary labs is controlled by the MNC HQ. For the purpose of this study, centralization is operationalized by its obverse, subsidiary labs *autonomy*, as suggested by De Bodinat (1975) in order to be consistent with previous studies in this research domain.

Formalization is operationalized by the extent to which decision-making at subsidiary

⁷ These constructs are defined and discussed in greater detail in the following section. At this point it is noted that the three constructs are not entirely independent. The study by the Aston Group reported correlation of -.02 between formalization and centralization (Pugh *et al.*, 1967). Aiken and Hage (1968) reported correlation of .28 and Nohria and Ghoshal (1997) reported correlation of -.18. Nohria and Ghoshal (1997) reported correlation of -.22 between socialization and centralization and .42 between socialization and formalization.

labs is controlled through systematic rules and procedures established by the HQ.

Socialization or normative integration emphasizes the creation of common and shared understandings of goals, values, and practices to influence both how subsidiary labs perceive their interests and how they act. Socialization is operationalized as the extent to which the labs share the *corporate goals, values and culture*.

Communications among internationally dispersed R&D labs is analyzed at two levels: 1) communications between the HQ and the subsidiary labs; and 2) communications among the subsidiary labs. It is operationalized as the frequency of communication, both electronic and in-person, between top managers, project managers and R&D staff of the labs.

Thus, the research question posed above is thus broken down into five sub-questions as follows:

1. What is the relationship, if any, between the autonomy of subsidiary labs and the synergistic innovative capacity of these labs?
2. What is the relationship, if any, between the formalization of decision-making at the subsidiary labs and the synergistic innovative capacity of these labs?
3. What is the relationship, if any, between the shared corporate goals, values and culture and the synergistic innovative capacity of subsidiary labs?
4. What is the relationship, if any, between the level of communication between the HQ and subsidiary labs and the synergistic innovative capacity of subsidiary labs?

5. What is the relationship, if any, between the level of communication among subsidiary labs and the synergistic innovative capacity of subsidiary labs?

3.3 Research Model

Figure 3.1 shows the relationship between synergistic innovative capacity, the four structural elements identified, and the four variables which may moderate the relationship between synergistic innovative capacity and the structural elements. The remainder of this chapter discusses the model beginning with a description of synergistic innovative capacity, followed by the four structural dimensions and the four moderating variables.

3.3.1 *Synergistic Innovative Capacity*

The word synergy is derived from the Greek word *synergos*, which means "to work together" (Corning, 1998). It connotes combined effects or the outcomes of co-operative interactions. Though it is often associated with the slogan "the whole is greater than the sum of its parts," it would be more accurate to say that synergy refers to effects that the parts cannot achieve alone, effects that are interdependent. Wholes are not necessarily greater than the sum of their parts, they may just be different.

Extrapolating from this conceptualization of synergy, *synergistic innovative capacity* is defined as the ability of the MNC to create new knowledge or to recombine existing knowledge to create new products, processes and technologies more efficiently by exploiting the unique capabilities of its worldwide R&D labs. In this study, *synergistic innovative capacity* is measured by ascertaining the outcomes in each R&D lab that can be attributed to the labs working interdependently. A number of possible outcomes are discussed below.

First, through greater networking, the research labs could participate in a larger number of projects or even major projects in terms of resources, complexity and newness, which might otherwise not be possible if the labs were working independently of each other. In addition, subsidiary labs may be able to broaden the scope of their research efforts by

applying its R&D knowledge to expand its product range in terms of new or related products. For example, in one company, a lab with expertise in polymer and fiber technology has teamed up with another lab with expertise in chemical technology to develop a range of agricultural products. Hence, both labs were able to enter new lines of businesses because they combined their existing knowledge capabilities.

Second, advances in information and communication technologies (ICT), substantially increase the opportunities for greater networking among internationally dispersed R&D labs and could result in more efficient utilization of R&D resources. For example, discussions with an international R&D manager of an Ottawa-based high technology firm revealed that during the day the company's Canadian R&D labs use its transmission facilities to work on a project and downloads the results on a database at the end of the day. At nights, while the Ottawa lab is closed, the company's R&D lab in Bangalore, India, accesses the results on the database, uses the transmission facilities to continue working on the project, and then downloads its result on the database which is accessed the next day by the Canadian labs. Thus, the transmission facilities are used around the clock except for maintenance, a situation that may not have been possible without the interdependence between the labs. It is conceivable that this type of collaboration could result in a reduction of the development cycle time for the projects.

Third, a potential benefit resulting from subsidiary labs working interdependently is the sharing of complementary know-how, skills and technologies. Also, by networking closely with labs in other countries, a lab could access not only the MNCs internal knowledge networks but also the networks outside the MNC group. For example, the Ottawa-based R&D lab of a Canadian company may be able to access the knowledge networks established by its Bangalore R&D lab with other Indian companies, universities and government research institutes. The same possibility may exist for the Ottawa-based R&D lab to share in the knowledge networks established by its labs in China, Ireland, U.K., U.S.A., Malaysia, Brazil and France. Indeed, it is possible for all the subsidiary labs to access the networks established by each other. Tapping into these knowledge networks can allow a company to develop newer products more rapidly, to enter new markets with existing products or to improve their own internal production and administrative processes.

Summarizing the foregoing discussion, it is expected that networking among subsidiary R&D labs could produce the following synergistic innovative effects:

1. A higher *number of innovations* undertaken by subsidiary labs;
2. A higher *number of complex R&D projects* undertaken by subsidiary labs;
3. A wider *range/variety of innovations* undertaken by subsidiary labs;
4. Improvements in the *quality* of the labs existing product or technology;
5. Improvements in the *technical* aspects of the production process;
6. Improvements in the *managerial* aspects of the labs;

7. *More efficient utilization of R&D resources;*
8. *Higher impulse for new innovations;*
9. *Improvements in the success rate of new innovations;*
10. *Improvements in the technical capabilities of R&D staff;*
11. *Access to a wider number of new knowledge sources;*
12. *Reduced R&D costs; and*
13. *Faster development time for innovations.*

Each of the foregoing measures of synergistic innovative capacity is measured on a scale of 1 to 5 where:

- 1 = decreased substantially
- 2 = decreased
- 3 = no change
- 4 = increased
- 5 = increased substantially.

(The scale was reversed for the last two measures)

3.3.2 *Subsidiary Labs' Attributes*

As alluded to in the beginning of this chapter and as shown in Figure 3.1, the ability of a subsidiary R&D lab to enhance its innovative capacity largely depends on the following four dimensions as they relate to decision making in the labs:

1. *Autonomy;*
2. *Formalization;*
3. *Shared corporate goals, values and culture; and*
4. *Communication both among subsidiaries and with the HQ.*

3.3.2.1 Autonomy

In the context of subsidiary R&D labs, autonomy refers to the degree to which a subsidiary lab is able to make or influence the strategic and operational decisions of the lab. This definition recognizes the possibility that although a subsidiary lab may not have the legitimacy to make the decision, it may have considerable leverage to influence the decision in its favor (Mintzberg, 1979; Brooke, 1984; Medcof, 1997; Nohria and Ghoshal, 1997).

The effects of centralization or of its obverse, autonomy, on innovations have been studied extensively by organization theorists. The accepted view is that a high degree of bureaucratic control inhibits creativity and innovation (Thompson, 1967; Aiken and Hage, 1971; Amabile, 1988). Mohr (1982) points out that even intuitively it is obvious that a certain amount of freedom to experiment and to do things outside a formal role is necessary for innovation. Empirical research by Kanter (1988) provides support for this intuitive belief. Kanter (1988) identifies several organizations that have established a budget for experimental research and provided time-off for R&D staff to conduct experimental research. Some organizations even provide incentives for successful projects generated from such experimental research. Unsuccessful experimental ideas are not used in employees performance evaluations. In the context of the multinational organization, several researchers have found that greater levels of centralization have a negative impact on the innovativeness of subsidiaries (Gates and Egelhoff, 1986).

With respect to subsidiary R&D labs, the effects of greater autonomy on their innovativeness have not been tested empirically although a number of studies have inferred a positive relationship based on research at the corporate level. As noted in the literature review, many MNCs granted greater autonomy to their international R&D labs with the hope that this will enhance the innovative capacity of the multinational system. However, it has not been proven empirically that such autonomy has actually resulted in substantial improvements in the innovative capacity of the labs.

In this study, it is contended that managers of autonomous labs have greater freedom to establish formal or informal arrangements with other labs to work cooperatively on research projects that match their technical and organizational expertise. The incentive to collaborate would likely be greater in situations where the labs have complementary skills, the costs of the projects are more than what an individual lab could afford or the risk is too much for a single lab to undertake. Therefore, by networking with other labs within the multinational system, it is possible that the synergistic innovative capacity of participating labs could be enhanced substantially.

On the other hand, it is acknowledged that, because autonomy shifts the focus of power asymmetrically in favor of subsidiary labs, it can lead to situations where some labs may want to act opportunistically pursuing their own research projects independently rather than enter into networking arrangements with other labs. Such behaviors could reduce the

potential contribution to synergistic innovative capacity because the lab may pursue projects with limited applications elsewhere within the MNC group or the rest of the labs cannot benefit from the expertise of the lab.

Using the approach advanced by De Bodinat (1975), autonomy of subsidiary labs is measured by the extent of HQ or subsidiary labs' influence on the following decisions:

1. making significant changes to existing products;
2. modifying the production process of the lab;
3. restructuring the lab;
4. recruiting scientists and engineers for the lab;
5. deciding the career paths of scientists and engineers;
6. number of projects undertaken by the lab;
7. selecting the types of projects undertaken by the lab;
8. setting project priorities for the lab;
9. conducting joint R&D with other labs within the MNC group;
10. sharing information with other labs within the MNC group;
11. exchanging R&D staff with other labs within the MNC group; and
12. collaborating with organizations external to the MNC group;

The following 5-point scale was used to measure autonomy:

1 = The HQ decides alone

2 = The HQ decides, but the subsidiary lab can and does provide suggestions

3 = Both the HQ and subsidiary lab have roughly equal influence

4 = The subsidiary lab decides but the HQ can and does provide suggestions

5 = The subsidiary lab decides alone

3.3.2.2 Formalization

Formalization refers to decision-making based on formal systems, established rules, and prescribed procedures (Pugh *et al.*, 1963; Child, 1972; Mintzberg, 1979). Analyzing HQ-subsidiary relations of MNCs, Hedlund (1980, 1981) reported that formalization reduces the power of both the HQ and the subsidiaries as it constrains the exchange relation to an impersonal set of rules that may be used to curtail unwanted behaviors. Formalization could be used to reduce conflict among subsidiary labs by reducing ambiguity and providing a structured context for collaboration among labs. It may also be used as a mechanism to reduce opportunistic behavior on the part of subsidiary labs. Thus, it is expected that formalization would be positively correlated to situations of potential conflict among labs.

Mintzberg (1979) advocates that in adhocracies innovative organizations must avoid highly formalized behaviors as control and coordination mechanisms because they inhibit flexibility and informal interactions that are necessary to promote innovations. Kanter (1988) reported that empirical research supports the finding that formalization has a negative impact on creativity and innovation. Similarly, based on a review of the research on control and coordination in MNCs, Gates and Egelhoff (1986) concluded that formalization is negatively related to innovativeness in subsidiaries of MNCs.

According to Burgelman (1983), formalization is expected to increase with higher levels

of interdependence between HQ and subsidiaries to the extent that it provides a structured context for reciprocity of exchange. Although formalization is negatively associated with innovativeness, some amount of formalization may be necessary to regulate the behavior of subsidiaries that enter into collaborative arrangements involving innovative research. However, in highly uncertain environments, rules become a liability and reduce a lab's flexibility to respond to changing circumstances. This latter point is borne out by Håkanson (1993), who, following an empirical study of forty-nine R&D collaborations, concluded that detailed specifications of procedures for implementation should be avoided because they tend to reduce the flexibility required in uncertain innovative projects.

Because formalization shifts the focus of power asymmetrically in favor of those making the rules (Mintzberg, 1979) which in the case of the MNC organization would most likely be the HQ, subsidiary labs could either be restricted, forced or given the freedom to network with other labs. To the extent that formalization is used to restrict networking among subsidiary labs, it will have a dampening effect on synergistic innovative capacity of the labs. The HQ may feel it necessary to restrict a lab to network with another lab in a country where it may not have adequate control over the way R&D information is gathered and disseminated.

Adapting the approach developed by Aiken and Hage (1968) and modified by Nohria and

Ghoshal (1997), formalization of decision-making is measured by extent of truth or falsehood of the following statements:

1. The HQ has provided a fairly defined set of rules and policies governing collaborations among labs within the MNC group;
2. The HQ has provided a fairly defined set of rules and policies governing collaborations with organizations outside the MNC group;
3. The HQ has provided a fairly defined set of rules and policies to deal with conflicts among labs engaged in joint R&D; and
4. The HQ monitors the labs to ensure that rules and policies are observed.
5. Subsidiary labs must submit regular and formal progress reports to the HQ on the status of the collaboration in terms of problems, solutions and achievements.

The extent of truth or falsehood of each of the statement is measured on a 5-point scale where 1 = definitely true and 5 = definitely false.

3.3.2.3 Shared Corporate Goals, Values and Culture

Socialization refers to the process by which members of an organization learn the value system, norms and required behaviors of the organization (Schien, 1968). It is a process that is used by the HQ to control decision-making in worldwide subsidiary labs. It is based on the belief that subsidiary R&D managers whose values, beliefs and goals are closely aligned with that of the corporation would be more inclined to act in the interest of the overall corporation rather than that of their own labs (Ouchi, 1980). For example, if the corporate view is that joint R&D among labs would be beneficial to the organization, then R&D managers around the world would actively seek out opportunities to

collaborate with other labs. According to Kanter (1988), socialization facilitates the creation of innovation not only by motivating subsidiaries to be entrepreneurial but also by enhancing the HQ' responsiveness to subsidiary needs and initiatives.

Getting managers, scientists and engineers of internationally dispersed R&D labs to develop shared corporate goals, values and culture is a long, difficult and costly process (Neff, 1995; Gwynne, 1995; Krogh, 1994). Means used to socialize international R&D staff include constant travel, language training, conferences and seminars, social and sporting events, job rotation, exchange visits, corporate-sponsored training programs, frequent electronic communication, joint planning sessions involving R&D personnel from around the world, and using expatriate managers to lead overseas labs. Through these activities, R&D managers, scientists and engineers from around the world would become more knowledgeable about the work being done by the different labs and the expertise within the labs. They would also get to know their counterparts from other labs better and may be more willing to communicate with and trust each other. The expectation among HQ staff is that greater awareness, communication and trust will translate into stronger networking among the labs, and this will in turn enhance synergistic innovative capacity.

The extent to which the labs share similar corporate goals, values and culture is assessed by asking respondents to indicate what proportion of the labs they collaborated with

shared their goals, values and culture.

3.3.2.4 Communications with HQ

With internationally dispersed R&D labs, processing technical and scientific information is expected to be more complex and difficult because different labs are embedded in different cultures and may have different attitudes towards the development and flow of information. Consequently, effective communication among labs could ultimately determine the long-run value of a collaborative network of labs (Stock *et al.*, 1996). The facilitating role of communications on innovations is well established in the innovation literature (Allen, 1977; Mohr, 1982; Rogers, 1995; Tushman, 1988). Prior research shows that the effectiveness with which the members of an R&D group are able to communicate influences the performance of the group in innovative activities (Fischer, 1980).

Communication between the HQ and subsidiary labs represents the vertical flow of information within the R&D organization. The vertical flow of information is one of the ways the HQ exercises control over subsidiary labs. Communication with the HQ could be multilevel and multidimensional. It may involve communication between managers, scientists and engineers from both labs on issues ranging from routine reporting to extensive project collaboration. Communications with the HQ may be effected through electronic media or face-to-face meetings. Subsidiary labs performing joint R&D with the HQ are likely to have more frequent communications with the HQ.

Effective communications between the HQ and subsidiary labs could lead to a better understanding of each other's situations that could result in improved relations through trust and mutual respect. Greater trust may encourage subsidiary labs to work more cooperatively with the HQ voluntarily on joint innovations. Both labs may exploit technological complementarities existing between them. In this respect, communications between the HQ and subsidiary labs could result in the creation of new innovations.

Nohria and Ghoshal (1997) observed that dense HQ-subsidary communication facilitated the adoption of HQ's innovations by subsidiaries. They also noted that intense HQ-subsidary communication could facilitate the diffusion of innovations across the MNC group because the HQ could act as a clearinghouse for information on the projects, expertise and ideas of its worldwide labs which individual labs could access. For example, the HQ may learn about an innovative solution in one lab and may encourage its adoption in another lab where it knows managers are struggling with the same problem.

The HQ could also act as a coordination center to coordinate the activities of labs that are working collaboratively. It could use its knowledge of the entire organization to build teams to work on specific innovations. The HQ could play a useful role as a referee in conflicts among subsidiary labs that are working collaboratively. Effective performance of these roles by the HQ could have a positive effect on synergistic innovative capacity.

Following Marschan (1996), communication between the HQ and overseas subsidiary R&D labs is measured by the frequency of the following types of communications:

1. electronic communication between top managers;
2. electronic communication between project managers;
3. electronic communication between scientists;
4. in-person communication between top managers;
5. in-person communication between project managers; and
6. in-person communication between scientists.

A 5-point scale is used where:

- 1 = yearly
- 2 = quarterly
- 3 = monthly
- 4 = weekly
- 5 = daily

3.3.2.5 Inter-subsidary Labs Communications

Communications among subsidiary labs represent the horizontal flow of information within the international R&D organization. Horizontal communication systems function as integrating devices connecting the various subsidiary labs. Horizontal or lateral communications among subsidiary labs benefit from informal personal networks and, therefore tend to speed up, for instance, decision making processes and enhance trust among members (Marschan, 1996). Lateral networking encourages the sharing, developing and leveraging of knowledge, which could have a positive effect on synergistic innovative capacity.

Effective lateral communications among subsidiaries are critical for building trust, which is crucial for successful collaboration. Effective inter-subsidiary communications promote better understanding of the strengths, limitations and complementarities among subsidiary labs which could lead to resources being utilized more efficiently through enhanced coordination and reduced duplication. However, collaboration among labs may increase the demand on managerial resources due to increased coordination efforts.

Frequent communications among internationally dispersed subsidiary labs are possible by advanced communications technologies such as e-mail, videoconferencing, telephone, and fax. Håkanson and Zander (1988) observed that extensive communications among subsidiary labs are a primary contributing factor to achieving international coordination among foreign subsidiaries. By being in contact with several subsidiary labs, a lab can learn about interesting developments in other locations. Moreover, it can use its network connections to search more efficiently for the resources required for innovation.

Communications among subsidiary labs is measured in exactly the same way as communications between the HQ and subsidiary labs, mentioned in the preceding section.

3.3.3 Moderating Influences

International management researchers⁸ have identified several factors which influence the performance of subsidiaries. It can be inferred from this literature that some of these factors could have a moderating effect on synergistic innovative capacity. Four moderating factors are investigated in this study. These are cultural diversity among R&D labs, the level of trust among managers and R&D staff of overseas labs, the resource levels of the labs, and the environment in which the labs operate.

The impacts of these factors on the creation of synergistic innovation capacity are discussed next.

3.3.3.1 Cultural Diversity

Because R&D activities by their very nature are open-ended and involves a lot of creativity and experimentation by highly qualified professionals, the success of most R&D collaborations depend heavily upon the cultural context within which they are executed (Voisey, 1992). The cultural dimension takes on added significance in situations where the collaboration involve R&D labs from several culturally diverse countries even though the labs may belong to the same MNC group. Cultural differences among R&D labs exist both in terms of national culture and organizational culture. However, cross-

⁸ Voisey (1992); Ouchi (1980); Schein (1981); Bartlett and Yoshihara (1988); Maccoby (1995); Gwynne (1995); Neff (1995); Shane (1994); Kuemmerle (1997); Krogh (1995); Nohria and Ghoshal, (1997).

national studies support the primacy of national culture over corporate culture in explaining behavioral differences among people (Shane, 1994).

Anecdotal evidence demonstrates that cultural differences are a source of misunderstandings and conflicts in international R&D collaborations (Maccoby, 1995; Shane, 1994; Gwynne, 1995). Maccoby (1995) noted that cultural values could interfere with communications and cause distrust unless they are well understood. In a study of 4,000 managers from 32 countries in 8 organizations, Shane (1994) found that the styles used by managers to champion innovations vary significantly across cultures and that culturally appropriate styles are not always the ones that promote the most innovations. He argued that using a championing style in a country where the overarching cultural values are different could create conflicts that could reduce the innovativeness of organizations.

Cultural differences in management styles and the work ethics of scientists and engineers could also hinder the effectiveness of R&D collaborations and hence the ability of the MNC to create synergistic innovative capacity. For example, some R&D staff and even managers may avoid working with labs where the culture is different from their own because they feel uncomfortable or are unwilling to learn and adapt to another culture.

Language is another cultural artifact that may influence the outcome of collaborations

among labs that speak different languages because of the potential for misunderstandings. Numerous examples of how language differences exert a negative impact on international R&D collaborations are provided in the popular press and academic papers (Gwynne, 1995). Linguistic differences could also discourage some labs from participating in collaborative R&D. Opportunities for misunderstandings and miscommunications could become more evident when the communication is remote and the information is of a highly technical nature. Viewed from this angle, linguistic differences could conceivably reduce the synergistic effects from networking among R&D labs.

In order to counter the effects of cultural diversity on performance, many MNCs are utilizing a variety of approaches such as cross-national multi-functional project teams and cross-national management teams. Ancona and Caldwell (1992) noted that these teams are by definition designed with deliberate differences in ethnic and demographic diversity and technical specialization in mind. It is believed that diversity leads to greater variance in ideas, creativity, and innovation, thus, generating better group performance (Cox, 1993; Jackson *et al.*, 1995).

Research by Hambrick and Mason (1984) and Finkelstein and Hambrick (1996) on upper echelons theory show a link between the top management team diversity and a variety of organizational processes and outcomes. For example, top management team is used to predict strategic consensus or whether top management is acting on a common set of

strategic priorities, performance, strategic change, management turnover, and organizational innovation. Top management team diversity have been shown to influence the frequency, quantity and ease of communication, reduce misunderstandings, and foster innovations due to greater variance in ideas (Smith *et al.*, 1994; Wagner *et al.*, 1984). Top management team diversity could also lead to greater conflict and political activity (Eisenhardt and Schoonhoven, 1990; Pfeffer, 1981). Top management team diversity was found to be a strong indicator of the impact of cultural diversity in MNCs (Nohria and Ghoshal, 1997).

Thus, in this study, top management team diversity is used as a proxy measure for cultural diversity. Top management team diversity is ascertained by determining the proportion of the labs' top management team that is from⁹:

1. the country where the lab is located;
2. the home country of the parent company; and
3. a country other than where the lab is located or the country of the parent company.

⁹ Using Blau's (1977) Diversity Index given as: $-\sum_{i=1}^3 p_i \log p_i$

3.3.3.2 *Trust among R&D Labs*

Kuemmerle (1997) contended that the HQ could play a pivotal role in fostering networking among R&D labs by creating an environment in which managers feel comfortable to establish formal and informal relationships. A restrictive posture by HQ managers could severely restrict the willingness of labs to network with each other. HQ managers could encourage networking by, for example, sponsoring joint research projects, organizing and coordinating cross-cultural teams, organizing joint planning sessions and research seminars, and providing incentives to labs that engage in cooperative R&D (Neff, 1995; Nicholason, 1994; Gwynne, 1995; Zadoks, 1997).

R&D managers have a powerful impact not only on the culture of the lab but also on its long-term research agenda and performance. Consequently, managers who feel secure enough to allow their scientists and engineers to collaborate with their counterparts in other labs could play a positive role in enhancing the creative capacities of their labs. On the other hand, managers who are uncomfortable with collaborative relationships could inhibit the creation of synergistic innovative capacity because they may be less supportive of joint innovative projects (Bartlett and Ghoshal, 1994; Neff, 1995; Gwynne, 1995).

A wide range of measures for trust have been proposed in the literature, however, for reasons of parsimony, the influence of trust on synergistic innovative capacity is measured by the following five items:

1. **Technical competency of the other lab;**
2. **Complementarity of the labs' technology;**
3. **Collaboration experience with the other lab;**
4. **Willingness of the other lab to keep its promises; and**
5. **Trustworthiness of the other labs' R&D staff.**

A 5-point scale is used, where 1 = no influence at all and 5 = extremely influential.

3.3.3.3 Resource Levels

Numerous conceptual and empirical studies have shown that the level of resources available within an organization for creative activities is critical for innovations (Bartlett and Ghoshal, 1989; Nohria and Ghoshal, 1997). Subsidiaries with higher levels of resources tend to register higher performance than their counterparts with lower level resources. The level of R&D resources available to a lab could be expressed in two ways. First, whether or not the available resources are above or below the average for similar labs within the MNC group, and second, the amount of slack resources a lab possesses.

Slack resources refer to the pool of resources within the lab that are in excess of the minimum necessary to produce a given level of output (Nohria and Ghoshal, 1997). Some theorists argue that slack resources play a crucial role in allowing organizations to

innovate because they permit organizations to experiment with new innovations that might not ordinarily be approved in a more resource constrained environment (Galbraith, 1973; Nohria and Ghoshal, 1997). Opponents of slack resources argue that slack simply promotes undisciplined investment in R&D activities that rarely yield economic benefits (Antle and Fellingham, 1990). Slack is viewed as organizational inefficiency.

A study by Nohria and Ghoshal (1997) sought to reconcile these opposing views regarding slack. The authors argue that too much slack could lead to inefficiency and too little slack unnecessarily constrains the innovative ability of the organization. They proposed and tested a curvilinear, inverse U-shaped relationship between innovation and slack.

Based on the preceding arguments, it can be inferred that slack could have a positive effect on synergistic innovative capacity because labs with slack may be more likely to enter into collaborative partnerships. Also, through collaboration among labs, the MNC could harness its worldwide slack resources which could have a positive effect on the synergistic innovative capacity of the organization. Labs facing tight resources may not be willing to enter into collaborations out of concerns that existing projects may suffer.

The resource levels of labs were ascertained by asking respondents to indicate on a 5-point scale whether or not the resource levels of their labs were above or below the

average within the MNC group. Slack was measured by the extent to which a 10 percent reduction in the time spent by all scientists and engineers and a 10 percent reduction in the labs' operating budget will affect the labs ability to perform their work.

3.3.3.4 Environmental Complexity

Environmental complexity refers to rapidly changing or very unstable environments in terms of resource availability, innovations and markets. Lawrence and Lorsch (1967), Thompson (1967), Mintzberg (1979) and many others have argued that organizational units operating in complex environments require greater flexibility and freedom to make decisions in order to be able to respond to changes in a timely manner. Lack of freedom could lead to inflexibility and the inability to respond timely, which may result in missed opportunities.

Nohria and Ghoshal (1997) view environmental complexity as a stimulus for greater collaboration because of the increased vulnerability of the subsidiaries to rapid changes in the environment. Labs that cooperate with the HQ and other subsidiaries will be better equipped to manage the complexities. Through interdependence and collaboration subsidiaries can share information, personnel and other resources to their mutual benefit thereby reducing their vulnerability to environmental instability.

Thus, it seems that environmental complexity has a direct relationship to autonomy and

subsidiaries performance. That is, subsidiaries operating in more complex environments are likely to have greater autonomy in decision-making in order to be able to respond to rapid changes in the environment. Similarly, by collaborating with other subsidiaries, a subsidiary can reduce its dependence for resources from its immediate environment and may be able to secure these faster thereby increasing its performance. Also, subsidiaries operating in more complex environments are likely to be more innovative because they are 'forced' by environmental pressures to be innovative in order to maintain their competitive advantage. In less complex environments, the pressure to innovate is not as great and subsidiaries tend to be less innovative.

In this study, environmental complexity is determined by ascertaining the rate of changes in the following three items:

1. Intensity of competition within the industry in terms of market for products;
2. Intensity of competition within the industry in recruiting scientists and engineers; and
3. Rate of product/process innovations within the industry.

The scale for the first 2 items is 1 = not much competition and 5 = extremely intense competition. The scale for the last item is 1= very low and 5 = very high.

CHAPTER 4

RESEARCH METHODOLOGY

4.1 Data Collection

The study is based on a survey of 231 R&D labs belonging to forty-five Canadian, American, Japanese and European high technology manufacturing MNCs principally in the electrical and electronics, pharmaceuticals and chemicals, and automotive industries. According to the Organization of Economic Cooperation Development (OECD), these sectors are the most internationalized based on indicators such as the level of overseas R&D expenditure, the number of R&D employees overseas, and the number of foreign patents filed (OECD, 1998). The companies were selected through convenience sampling. The sample was drawn from Fortune 500 database, European Industrial Research Management Association (EIRMA) database, and the List of Top 100 Canadian R&D Performers, all of which are available on the internet.

The process began with a list of the names and telephone and fax numbers of the companies most senior R&D executives (Vice Presidents and Directors) in the United States, obtained from the web site of the Industrial Research Institute (IRI). Information on non-US labs was obtained from the web sites of the companies and in some cases through e-mail or telephone requests to individuals within the companies. In some cases

the R&D labs were listed as stand alone facilities while in other cases the R&D labs were part of a larger subsidiary which performed other functions such as production and marketing.

A number of R&D executives from the United States, United Kingdom and Sweden were contacted by telephone and e-mail to seek their participation in the study. In the majority of cases, the questionnaires were sent to the labs by fax to the contact name obtained through the search process described above. If there was no contact name available, the questionnaires were simply addressed to the Vice President of R&D.

Two versions of the questionnaire were developed and administered: one version for the executives of the subsidiary labs; and another version for the executives of the HQ lab. Both versions of the questionnaire were translated from English to French, German, and Japanese. The French and Japanese translations were done by students from the University of Ottawa and Carleton respectively, while the German translation was done by a reputable professional translation agency in Ottawa. In the case of the French and Japanese translations, the researcher met in person with the translator to review the translation. During the meeting, the translators explained each question in English by looking only at their translated version while the researcher double-checked the translation with the English version. This was not done with the German questionnaire because of the high cost charged by the agency. Following this, the French, Japanese and

German questionnaires were given to a different set of students who were then asked to re-translate the questionnaires into English orally. It is believed that this process has resulted in minimal discrepancies with respect to the meanings of questions and instructions (i.e. a high level of meaning equivalency was achieved).

The self-administered questionnaire consisted of a combination of rating scale, yes/no, quantitative questions and a couple of open-ended questions. The questionnaire sought information on a wide range of issues including the following:

- types of R&D activities the labs performed i.e. basic, applied, adaptive, etc.;
- level of autonomy of the labs to make strategic decisions affecting their operations;
- level of formalization of decision-making at the labs;
- extent to which the labs goals and management values are congruent with that of the HQ;
- communication patterns among the labs;
- resource levels of the labs;
- nature of the environment in which the labs operate;
- extent of networking with other labs and hindrances to effective networking;
- the impact of networking among the labs on their innovative capacity; and
- demographic data such as R&D budget, sales, industry sector, number of R&D employees, and their age, education and experience.

The questionnaire was pre-tested on three R&D executives; two Canadians and one American. These executives were told that in addition to filling out the questionnaire they should comment on its overall design, the appropriateness of the questions, and whether other questions should be included. Two respondents replied providing very detailed comments most of which were adopted since they were mainly editorial in nature. One respondent pointed out that in his view the underlying model of the questionnaire, where research labs are dichotomized into HQ labs and subsidiary labs may be inconsistent with the current practice of some companies. This suggestion was noted but not adopted since this would have required fundamental changes to the questionnaire.

In addition to the questionnaire, telephone interviews were conducted with seven very experienced R&D executives, some of whom had worked for several companies. These qualitative interviews provided in-depth information on the current practices in the organization and management of internationally dispersed R&D activities. Also, several respondents provided additional information such as conference papers they had presented, published research articles, and web site addresses where more information may be obtained. Although the additional information was quite interesting, some of it was not directly relevant to the current study. Additional demographic data of the entire MNC group were obtained from the Fortune 500 and the Top 100 R&D Canadian R&D Performers databases. This data which relate to worldwide revenues, profits, industrial sector, HQ location, and so on were used to develop a profile of the sample firms

included in the study. Descriptive statistics profiling the participating labs are presented in the first section of Chapter 5.

4.2 Data Analysis

Data was collected from subsidiary R&D labs for several reasons. First, subsidiary labs managers are more likely to have a better understanding of their roles in joint innovation projects and the impacts of such participation on their labs than someone from the HQ. Also, since synergistic innovative capacity involves the creation of new knowledge at the level of individual R&D labs, it would be appropriate to have respondents from the labs identify the new learning resulting from working interdependently with other labs.

Second, given the nature of information sought from respondents it is believed that subsidiary labs are likely to provide more complete and reliable information. It is highly unlikely to find a respondent within the HQ that will be able to provide adequate information on all of the worldwide R&D labs of the corporation. Although the HQ managers may be able to provide information on the effects of the labs working collaboratively at the overall corporate level, they would be unable to describe the nature of the informal linkages that the subsidiary labs have with each other.

Two principal multivariate analysis techniques, Ordinary Least Squares Regression (OLS)

and Partial Least Squares (PLS), are employed to estimate and test specific regression and PLS models. The results of these analyses are presented in Chapters 6 and 7. Prior to analyzing the data using regression analysis and PLS, a number of other preliminary statistical analyses were conducted in order to get an understanding of the nature of the data collected. Some of the statistics computed include means, correlations, Cronbach's alpha for multi-item constructs, t-test of difference of means and various cross tabulations. These statistics along with a brief discussion are presented in Chapter 5. Findings based on qualitative information obtained are presented in Chapters 8 and 9.

CHAPTER 5

DESCRIPTIVE STATISTICS

5.1 Introduction

This chapter presents a set of descriptive statistics in order to give some understanding of the structure of the data gathered and the types of labs participating in the study. The chapter begins with a description of the profile of sample labs that participated in the study. This is followed by an examination of the reliability of the multi-item scale measures, and the correlations among the key variables of this study.

5.2 Profile of Sample Companies and R&D Labs

Table 5.1 shows that a total of 231 labs were contacted to seek their participation in the study. Seventy-nine of the 231 labs responded to our request, yielding a response rate of approximately 35 percent. Of the 231 labs that were sent questionnaires, 104 are situated in North America, 90 in Europe, 22 in Japan, and 15 in other countries such as Australia, New Zealand, India and Singapore.

Although several Japanese labs situated within North America and Europe participated in the study, none of the 22 labs within Japan that were sent questionnaires responded, despite reminder notices sent to each lab. Although the precise reason for this situation is not clear, it is believed that the targeted R&D personnel (Managing Directors) at the labs may have never received the questionnaire. This belief is based on the fact that in no instance was the researcher allowed to talk directly to the Managing Directors and was told that requests such

as this usually go through the Managing Directors' secretaries who then decide whether or not to forward it to the Managing Directors. Also, some of the Managing Directors were on traveling assignments. It is also likely that many did not feel obliged to complete the questionnaire.

Five respondents who completed the questionnaire also volunteered to provide additional information via telephone interviews. Two other respondents who did not complete the questionnaire agreed to give only telephone interviews. These 7 respondents who provided qualitative information are very experienced and knowledgeable senior R&D executives who claimed to have over ten years experience at various levels in several companies.

Table 5.2 indicates that of the 79 responding labs, a total of 18 are owned by North American MNCs, 36 are owned by European MNCs, and 20 are owned by Japanese MNCs. Also, the majority of the labs (38) were established in the early 1990s and most of these (17) were Japanese labs within North America and Europe. This suggests that since 1985, Japanese and the European MNCs were more active than US MNCs in establishing overseas labs.

Table 5.1

Geographic Distribution of Sample Labs

	Labs Contacted	Labs Responded
Number of Labs Located in North America	104	35
Number of Labs Located in Europe	90	39
Number of Labs Located in Japan	22	0
Number of Labs Located in Other Countries	15	5
Total Labs	231	79*

* Includes 7 headquarter (parent) labs

Table 5.2**Year Labs Established by Region of Parent Company**

Region/Country	Prior to 1985	1985 – 1989	1990 – 1999[*]	Total
North America	10	2	6	18
Europe	8	14	14	36
Japan	0	3	17	20
Other	0	4	1	5
Total	18	23	38	79

* 3 Labs were established since 1997

Table 5.3 shows the distribution of responding labs by industry classification. Approximately one-half of the labs are from the electrical, electronics and telecommunications industry, just over one-quarter are from the pharmaceutical and chemical industry, and the remainder is from the automotive and 'other' industries.

Table 5.3
Industry Distribution of Labs

Industry Type	Responding Labs
Electrical/Electronics & Telecommunications	40
Pharmaceuticals & Chemicals	22
Automotive	10
Other (e.g., Biotechnology, Aerospace, Instruments)	7
Total	79

Table 5.4 shows that 63 of the responding labs (about 80 percent) have less than 400 R&D professionals while the remaining 16 labs (about 20 percent) have over 400 R&D professionals. Of the 16 labs with more than 400 R&D employees, 7 are HQ labs. The distribution of labs in this study is similar to the distribution of foreign R&D facilities in the US reported by Serapio and Dalton (1999). Serapio and Dalton (1999) identified 695 foreign

R&D facilities in the United States of which 15 have between 240–400 employees, and 20 have over 400 employees. In general, the responding labs in the present study represent a good distribution of small, medium and large size labs.

Table 5.4
Distribution of R&D Employees of Labs

Number of R&D Employees	Number of Labs
Less than 100	38
101 – 200	16
201 – 400	9
Over 400	16

n = 79.

Table 5.5 shows the distribution of labs according to the proportion of their R&D budget that is spent on basic R&D and applied R&D. It is observed that the majority of the labs (47) use more than 80 percent of their budget for applied R&D, while only 3 labs use more than 80 percent of their R&D budget to carry out basic R&D. Thus, it can be asserted that the majority of R&D labs in this study carry out applied or technology R&D (i.e., new product design and development, product adaptations, etc.) rather than scientific or basic R&D. The patterns towards greater applied R&D for overseas labs observed in this study are consistent with those reported in other studies (Patel and Pavitt, 1992; Pearce and Singh, 1992; Pearce and Papanastassiou, 1999; and Patel and Vega, 1999).

Table 5.5

Distribution of Basic and Applied R&D Expenditures of Labs

Percentage of Total R&D Budget	Basic R&D (Number of Labs)	Applied R&D (Number of Labs)
0%	24	0
1 – 20 %	26	7
21 – 40 %	7	7
41 – 60 %	8	6
61 – 80%	8	9
81- 99 %	3	23
100 %	0	24
Total*	76	76

* 3 missing observations

Table 5.6 shows the distribution of labs performing basic R&D by the geographic region of their parent companies. The data indicates that 12 labs belonging to Japanese MNCs spend more than 20 percent of their R&D budget on basic R&D overseas compared to 6 and 5 for North American and European MNCs respectively.

The statistical significance of the differences in the group means for basic R&D performed overseas was determined using pairwise comparison in MANOVA. The results displayed in Table 5.7 show that the average level of basic R&D expenditure performed overseas by Japanese labs is higher than that of European and North American labs. No significant difference was observed between North American-owned and European-owned labs.

Table 5.6**Basic R&D Expenditures Overseas by Region of Parent Company**

Percentage of R&D Budget Spent on Basic R&D	Number of R&D Labs of				
	North American MNCs	European MNCs	Japanese MNCs	Other Countries	Total
Less than 20	11	30	7	2	50
21 – 40	2	1	4	0	7
41 – 60	0	2	4	2	8
61 – 80	3	2	3	0	8
81 – 100	1	0	1	1	3
Total	17	35	19	5	76*

* 3 missing observations

Table 5.7**Pairwise Group Comparison of Basic Overseas R&D Expenditures**

Region	North America	Europe
Europe	3.479 ^a (.060) ^b	
Japan	1.461 ^a (.231) ^b	11.228 ^a (.001) ^b

a = t-statistic; b = level of significance; degrees of freedom = 1, 68

In order to determine the extent to which the findings of this study may be generalized beyond the responding MNCs, a one-way ANOVA test between responding and non-responding companies was conducted on four key characteristics which are frequently used in analyzing high-tech companies. Two of the four characteristics are corporate level measures (worldwide revenues and the number of employees worldwide) while the other two

are specific to the R&D function (i.e., R&D intensity¹ and the number of R&D labs the company has worldwide). The results of this analysis are presented in Table 5.8.

Table 5.8

**Revenues, Number of Employees, R&D Intensity and the Number of R&D labs
of Responding vs. Non-Responding MNCs
(Worldwide Figures)²**

Characteristic	Mean		t-statistic	Significance Level
	Responding MNCs (n = 27)	Non-Responding MNCs (n = 18)		
Revenues (US\$ Millions)	35,247.5	17,804.5	- 2.558	.037
Number of Employees	133,944	66,888	- 2.670	.025
R&D Intensity (%)	8.0174	7.9278	- .059	.951
Number of R&D Labs	13	12	- .229	.806

The results indicate that, at the corporate level, responding MNCs are substantially larger than non-responding MNCs in terms of revenues and number of employees since both of the tests are statistically significant ($\alpha < .05$). Interestingly, on both R&D level indicators, R&D intensity and the number of labs, no statistical difference was observed between responding and non-responding companies.

Intuitively, it seems somewhat surprising that companies that are substantially smaller would have approximately the same number of R&D labs as their larger counterparts. A frequency analysis of the data indicated that one of the larger non-responding companies had a relatively large number of labs compared to the rest of the non-responding companies. If this

¹ R&D Expenditure/Sales

² This data was obtained from the web site of individual companies.

company was excluded from the analysis, then the responding companies will be different from the non-responding companies with respect to all four indicators. Thus, using an aggregate measure such as the mean tend to mask this subtlety in the data. Caution should be exercised in generalizing the results of this study.

The data also revealed that on average the labs collaborated with 3 other labs within their organizations. Table 5.9 shows the type of collaboration the labs engaged in and the extent to which these collaborations were formal or informal. According to the average rating shown in the last column, it may be inferred that the collaboration tended to be mostly informal to semi formal since the ratings hovered around the mid-point.

Table 5.9
Nature of Collaboration among R&D Labs

Type of Collaboration	Informal 1	2	3	4	Formal 5	Average Rating
Scientific & Technological information exchange	13	20	11	21	8	2.88
Conducting joint research as equal partners	4	14	21	21	12	3.32
R&D personnel exchange	7	14	21	18	13	3.22
Regular visits to each others' labs	10	17	24	13	9	2.92
Sharing testing facilities, equipment, etc.	10	16	19	17	11	3.04
Joint brainstorming and planning meetings	9	18	16	21	8	3.01

6 missing responses

5.2.1 HQ Lab Participants

Of the 79 responding R&D labs in the study, 7 were HQ labs consisting of 2 Swedish, 1 German, 1 Canadian, and 3 American MNCs. One-way ANOVA between the 7 HQ labs and the subsidiary labs on several questions yielded no statistically significant results. Ordinarily, this would suggest that the responses from both HQ labs and subsidiary labs could be treated as one sample in further analysis. However, because of the extremely small number of HQ

labs, the power of the test to detect differences, particularly small differences, is very weak. Another approach used to examine whether HQ labs responses are statistically different from that of subsidiary labs involve performing certain analysis (e.g., regression and factor analysis) with and without HQ responses. Small differences were observed in a few cases mainly with respect to the magnitude of the estimates. However, these were not statistically different. It was not possible to report conclusively whether the observed changes were due to respondent differences or because of a further reduction in the sample when the HQ responses were removed.

Given the above circumstances and the already small sample size of this study, a choice had to be made between omitting HQ responses and giving up the information provided or include the information and run the risk of having some amount of bias, if the responses are in fact different. The decision was made to include the HQ responses in all further analysis³.

5.3 Reliability of Measurement Scales

Several of the constructs used in this study consist of multiple items measured on a 5-point scale. To determine the extent to which the items used in constructing the scale are internally consistent, Cronbach's alpha, the most commonly used test of scale reliability, was computed for each of the construct. Usually, a Cronbach alpha of .70 or greater is used as the benchmark for acceptable levels of reliability (Nunnally, 1978).

³ Since the questionnaire sent to HQ lab respondents is somewhat different from that sent to subsidiary lab's respondents, HQ responses were treated as missing in cases where the variables do not overlap. For example, the autonomy variable was measured differently and in regression analysis, HQ responses were treated as missing values.

Table 5.10 identifies the constructs based on the order in which they appear on the questionnaire, the number of items used for each construct, and the respective Cronbach's alpha. In every case, the Cronbach's alpha substantially exceeded the .70 threshold.

Table 5.10

Reliability Statistics for Multi-item Constructs

Question	Construct	Items	Cronbach's Alpha
4	Nature of Collaboration: Culturally similar labs	6	.9096
5	Nature of Collaboration: Culturally dissimilar labs	6	.9136
8	Nature of Collaboration with HQ	6	.9106
11	Trust	5	.7461
12	Synergistic Innovative Capacity	13	.8099
13	Inter-Subsidiary Labs Communication	6	.7391
14	Communication with HQ	6	.8699
15	Autonomy	12	.8889
16	Formalization	5	.7724
18&19	Environmental uncertainty	3	.7832

5.4 Correlation of Key Constructs

As described earlier in the theoretical framework, this study focuses on the relationship between *synergistic innovative capacity* (SIC) and *autonomy*, *formalization*, *socialization*, *HQ-Subsidiary labs communication*, and *inter-subsubsidiary labs communication*. Generally, simple correlation analysis provides an indication of the strength and direction of the relationship among the variables in a univariate sense. Simple correlations also provide an indication of possible multicollinearity when the variables are used together in a multivariate context.

Table 5.11 shows the correlations among the means of several variables⁴. In regression terminology, the construct synergistic innovative capacity is the dependent variable and the other five variables are the independent variables. The latter four variables in Table 5.11 are referred to in this study as moderating variables. According to Table 5.11, synergistic innovative capacity is significantly and positively correlated to autonomy, formalization and socialization but not to either of the communication variables. Autonomy is more strongly correlated to formalization than to socialization. Communication among overseas subsidiary labs is positively correlated with socialization. Despite the statistical significance of the correlation among the variables, it is observed that the absolute values of the correlation coefficients are small -- 0.30 or less for most variables. The implication of these correlations for regression analysis is discussed in the following chapter on regression analysis.

Table 5.11
Correlation of Means of Dependent and Independent Variables

Variable	1	2	3	4	5	6	7	8	9
1. Synergistic Innovative Capacity									
2. Autonomy	.287*								
3. Formalization	.244*	.460**							
4. Socialization	.310**	.237*	.296						
5. Communication: S-S	.198	.120	.037	.432**					
6. Communication: HQ	.029	.067	-.033	.171	.406**				
7. Resource Levels	.070	.192	.087	.063	.006	.134			
8. Environmental Uncertainty	.203	.226	.135	.037	.302**	.221	.299**		
9. Trust among Labs	.063	.138	.191	.088	.225	.230	.004	.190	
10. Cultural Diversity	.071	.109	.007	.029	.131	.117	.065	.388**	.126

** Significant at .01

* Significant at .05

⁴ Means are computed across variables and not over respondents (i.e., the mean of the ratings provided by each respondent to particular multi-item scale questions rather than the mean ratings obtained by adding all respondents on a particular question). For example, the construct synergistic innovative capacity has 13 items and the mean of the 13 items is computed for each respondent. This approach was used for other multi-item scale questions such as autonomy, communication, formalization, and environmental uncertainty.

CHAPTER 6

REGRESSION and FACTOR ANALYSIS

6.1 Overview of Data Analysis Strategy

This sub-section provides an overview of the data analysis strategy employed in this study. Basically, the data was analyzed using three multivariate statistical techniques, namely, regression analysis, factor analysis and partial least squares (PLS) analysis.

Initially, separate regression analyses were run between the dependent variable, *synergistic innovative capacity*, and the independent variables, *autonomy*, *formalization*, *socialization*, *HQ-subsidary labs communication*, and *inter-subsidary labs communication*. In these regressions, all the multi-item variables were treated as unidimensional constructs in the sense that the simple arithmetic means across the variables of the constructs were used as the measures of the constructs. For example, the construct *autonomy* consists of 12 items or variables and for each respondent the mean response over the 12 items was computed and this was used as the measure of autonomy. This same procedure was applied to other multi-item scaled variables including the dependent variable.

In the second step of the analysis, the dimensionality of multi-item constructs was explored using factor analysis. This analysis was undertaken because the multi-item constructs were employed in this study for the first time although some individual items may have been used in other situations. Once the dimensionality of the constructs was determined, the regression analysis was re-run with the new dimensions as additional variables in the model.

Following the regression and factor analyses, the data was analyzed using PLS analysis. PLS is an alternative analytical framework for analyzing the relationship between multiple dependent and independent constructs.

The PLS analysis was conducted in two steps. The first set of PLS analysis basically mimic the first set of regressions where the multi-item constructs were treated as unidimensional constructs. The second step of the PLS analysis involve runs with the multi-dimensionality of the constructs accounted for. The resulting PLS analysis yielded two competing models which are discussed in chapter 7.

Due to the different statistical properties, assumptions and algorithms between regression and PLS the results cannot be strictly compared. They provide a somewhat different but in some ways a complementary view of the relationship between the independent and dependent variables or constructs.

This chapter presents the results obtained from the various regression and factor analysis carried out. The following chapter presents the results of the PLS analysis. Chapters 8 and 9 present the results of the qualitative information obtained. Chapter 10 discusses the implications of the results from both the quantitative and qualitative analyses.

6.2 Regression Analysis

Multivariate regression analysis was employed to investigate the relationship between the dependent variable, *synergistic innovative capacity*, and five independent variables (*autonomy, socialization, formalization, HQ-Subsidiary communication, and inter-subsidiary communication*) and four moderating variables (*resource levels, environmental uncertainty, trust and cultural diversity*). Essentially, the focus is on the extent to which the combined effects of the independent variables provide adequate explanation of variations in the dependent variable.

Regression analysis was performed into two stages: At stage one, various regressions were executed with only the 5 independent variables (main model regressions). At stage two, a series of regressions were executed with the moderating variables included as interaction terms in the models. One limitation is that the number of interaction terms which can be included in any single regression model is limited because the sample size is small. Consequently, the interaction terms entered the models sequentially.

6.2.1 Main Model Regression

Table 6.1 presents the results of the main model regression involving only the independent variables as described in the theoretical framework in Chapter 3. Preliminary regression runs indicate that greater explanation is obtained when the two communication variables are grouped according to the communication media involved. Also, the variable *formalization*

was dropped because its incremental contribution to R^2 is negligible and its impact on the magnitude and direction of the remaining variables except autonomy is minimal.

Table 6.1
Main Model Regression

Variables	Beta	Std. Error	T	Sig. t	VIF	R ²	F	Sig. F
(Constant)			8.344	.000		.32	4.873	.000
1. Autonomy	.223	.063	2.004	.049	1.140			
2. Socialization	.266	.032	2.237	.029	1.303			
3. IPCOMHQ	-.396	.045	-2.757	.008	1.900			
4. ECOMHQ	.298	.061	2.095	.040	1.868			
5. ECOMSU	-.127	.071	-1.008	.317	1.460			
6. IPCOMSU	.365	.056	2.721	.008	1.656			

Dependent Variable: Synergistic Innovative Capacity

IPCOMHQ: In-person communication between HQ and subsidiary labs

ECOMHQ: Electronic communication between HQ and subsidiary labs

IPCOMSU: In-person communication among subsidiary labs

ECOMSU: Electronic communication among subsidiary labs

The results indicate that all the variables except for ECOMSU are statistically significant at the .05 level. The sign of the estimates for all variables in the model are as expected except for IPCOMHQ and ECOMSU. The model yielded an R^2 of 32 percent and a significant F-test of overall model fit. The fact that the β values for IPCOMHQ and IPCOMSU are so very similar in magnitude but opposite in sign suggests that they may be collinear. However, an examination of the variance inflation factor (VIF) does not reveal significant multicollinearity⁵. The interpretation, therefore, is that these two variables enter as a contrast between headquarter and subsidiary communications.

⁵ Stevens (1992 pp. 76-77) suggests using the *variance inflation factor* (VIF) as an index of multicollinearity. The VIF for a predictor indicates whether there is a strong linear association between it and all the remaining predictors. If there is a strong association, the variances will be inflated. As a rule of thumb, Stevens (1992) suggests that VIFs of 10 or more indicate multicollinearity.

Given the theoretical importance of these variables, both variables are retained in the model. The results shown in Table 6.1 are consistent with the relationships hypothesized in this study. The negative sign between IPCOMHQ may indicate that subsidiary labs perceive in-person visits to their labs as a form of monitoring analogous to “big brother is watching.” Alternatively, it may be interpreted as more HQ than subsidiary communication has one effect and more subsidiary than HQ communication as the other effect.

6.2.2 Moderating Variables Regressions

In this section, the effects of four moderating variables – resource levels, environmental uncertainty, trust, and cultural diversity – on synergistic innovative capacity are investigated. The approach employed involve adding various interaction terms to the main model regressions (e.g., socialization*trust, socialization*IPCOMHQ, etc.). Because of the small sample size, the interaction terms were included in the regression runs sequentially. As it is impractical to include all the results emerging from this second approach, the results of four models (i.e., one for each variable), is presented in Tables 6.2 to 6.5.

The results indicate that no interaction term was statistically significant in any of the regressions. Thus, there is no evidence that the four moderating variables – the level of trust among the labs, the resource levels of labs, the environmental uncertainty of the labs, and the cultural diversity among the labs – have a moderating effect on synergistic innovative capacity. It is, however, observed that the R^2 and the significant variables from these regressions are very similar to that obtained from the main model regression. This may be an artifact of the data.

Summarizing, the regression results suggest that three variables are statistically significant in explaining variations in synergistic innovative capacity. These variables are socialization, in-person communication among subsidiary labs and in-person communication between HQ and subsidiary labs. Despite the small sample size, the results obtained from the various regression runs are consistent in terms of the significant variables, the R^2 , and magnitude and direction of the parameter estimates. These results are consistent with the qualitative information obtained from respondents.

Table 6.2
Regression with Socialization and Cultural Diversity

Variables	Beta	Std. Error	T	Sig. t	VIF	R ²	F	Sig. F
(Constant)		.365	8.045	.000		.313	3.775	.002
1. Autonomy	.224	.065	1.905	.062	1.166			
2. Socialization	.331	.037	2.421	.019	1.582			
3. IPCOMHQ	-.408	.049	-2.570	.013	2.128			
4. ECOMHQ	.273	.065	1.763	.083	2.024			
5. ECOMSU	-.121	.074	-.899	.372	1.520			
6. IPCOMSU	.328	.063	2.189	.033	1.893			
7. SOCCDIV*	-.042	.027	-.327	.745	1.384			

Dependent Variable: Synergistic Innovative Capacity

* Interaction variable SOCCDIV = Socialization * Cultural Diversity

Table 6.3**Regression with Socialization and Trust**

Variables	Beta	Std. Error	T	Sig. t	VIF	R ²	F	Sig. F
(Constant)		.374	7.843	.000		.312	3.756	.002
Autonomy	.224	.066	1.879	.065	1.197			
Socialization	.341	.069	1.343	.184	5.426			
IPCOMHQ	-.395	.048	-2.548	.014	2.024			
ECOMHQ	.269	.065	1.741	.087	2.015			
ECOMSU	-.114	.074	-.857	.395	1.489			
IPCOMSU	.318	.061	2.174	.034	1.803			
SOCTRUST*	-.031	.018	-.120	.905	5.743			

Dependent Variable: Synergistic Innovative Capacity

* Interaction variable SOCTRUST = Socialization * Trust

Table 6.4**Regression with Socialization and Environmental Uncertainty**

Variables	Beta	Std. Error	T	Sig. T	VIF	R ²	F	Sig. F
(Constant)		.391	7.385	.000		.314	3.786	.002
Autonomy	.234	.068	1.927	.059	1.251			
Socialization	.333	.036	2.469	.017	1.537			
IPCOMHQ	-.409	.049	-2.592	.012	2.103			
ECOMHQ	.281	.066	1.784	.080	2.099			
ECOMSU	-.112	.074	-.842	.403	1.491			
IPCOMSU	.332	.063	2.203	.032	1.918			
SOCENV*	-.055	.028	-.398	.692	1.621			

Dependent Variable: Synergistic Innovative Capacity

* Interaction variable SOCENV = Socialization * Environmental Uncertainty

Table 6.5**Regression with Socialization and Resource Levels**

Variables	Beta	Std. Error	T	Sig. T	VIF	R ²	F	Sig. F
(Constant)		.369	7.669	.000		.334	4.154	.001
Autonomy	2.53	.065	2.148	.036	1.206			
Socialization	.637	.071	2.417	.019	6.056			
IPCOMHQ	-.381	.047	-2.495	.015	2.026			
ECOMHQ	.278	.064	1.833	.072	2.006			
ECOMSU	-.108	.073	-.829	.411	1.489			
IPCOMSU	.321	.060	2.238	.029	1.791			
SOCRES*	-.372	.018	-1.390	.170	6.252			

Dependent Variable: Synergistic Innovative Capacity

Interaction variable SOCRES= Socialization * Resource Levels

6.3 Factor Analysis

In the preceding regression analysis, all the scale variables used were treated as unidimensional constructs in the sense that the simple arithmetic mean of all the items for the respective constructs were used as the appropriate measures for the constructs. Since these scales in their exact format have not been used in previous studies, there are no test results regarding their reliability or dimensionality. Therefore, it was decided that the scales be tested for their dimensionality using factor analysis with varimax rotation. The results are displayed in Tables 6.6 to 6.9.

6.3.1 *Synergistic Innovative Capacity: The Dependent Variable*

Factor analysis on the dependent variable synergistic innovative capacity yielded four components based on items with eigenvalues greater than 1. The “scree test” (Stevens, 1992) would suggest removing components three and four from the analysis, particularly since the dataset is small. However, the four components are retained because of the consistency of these results with that obtained later with PLS. Also, the four components and the items comprising them are consistent with theoretical constructs in the management of technology area of research. The loadings of the items comprising each component are identified in bold in Tables 6.6 to 6.9. Together, these four components explain 68 percent of the variance in the construct.

The first component is named *Knowledge Creation and Management* because the four items comprising this component deal with issues involved in knowledge creation, transfer and

management within organizations (Inkpen, 1997; Nonaka, 1990; De Meyer, 1992; Pearce, 1999).

The second component is named *Managerial and Operational Efficiency* because the items comprising this component deals with issues relating to efficiency in the utilization of managerial and operational resources.

The third component indicates the increasing participation of subsidiary labs in a larger number of complex and sophisticated R&D projects as opposed to their traditional roles of simply adapting HQ generated products to local market conditions. In the international R&D literature this new role is often described as strategic R&D (Howells, 1990; Chisea, 1996; Medcof, 1998; Brockhoff and Schmaul, 1996). Consequently, this dimension is named, *Strategic R&D*.

The fourth component describes the capability of subsidiary R&D labs to develop innovations faster at lower costs. Together, these two seemingly contradictory dimensions of new innovations reflect the competencies of the labs in generating new and successful innovations proficiently. Thus, this component is named *Innovative Proficiency*.

Although the four components reported in this study are consistent with existing theories in the area of management of technology, further testing of the constructs using the same scale items are needed to validate the statistical properties of the constructs. Until such replication studies become available, it can be inferred from this study that the concept of synergistic

innovative capacity is not a unidimensional construct as hypothesized in this study. Also, the scale items used in this study provide a starting point for further investigation concerning the reliability and dimensionality of the concept.

Table 6.6

Factor Analysis on Synergistic Innovative Capacity: Dependent Variable

Total Variance Explained

Component	Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %
1	3.016	23.197	23.197
2	2.351	18.083	41.281
3	1.728	13.292	54.572
4	1.705	13.114	67.686

Rotated Component Matrix

Items	Component			
	1	2	3	4
Number of R&D projects	.189	1.106E-03	.815	.159
Number of complex projects	.130	.296	.724	-.2916E-02
Variety of projects	.473	.298	.441	-.130
Quality of products	.249	.649	.193	-.8.401E-02
Technical Production process	.234	.675	.153	-4.708E-02
Managerial aspects	-.191	.763	.196	.121
Efficiency of resources	.116	.757	-.118	.274
Impulse for innovations	.845	.242	-4.787E-02	-1.321E-02
Success rate of innovations	.783	.254	8.389E-02	.152
Competencies of staff	.805	-.106	.256	.228
Access to R&D resources & personnel	.750	-1.679E-02	.371	3.177E-02
Cost of R&D	1.947E-02	3.487E-02	-3.667E-02	.894
Development cycle time for new innovations	.183	.119	.139	.829

6.3.2 Autonomy

Three components emerged with eigenvalues greater than 1 from factor analysis on the construct autonomy. Together, these three components explained close to four-fifths of the

variance in the constructs. Table 6.7 shows the variance explained by each component and the items making up the components. The loadings of the items for each component are indicated in bold. It is observed that the items comprising the three components are closely aligned with theoretical constructs used in the management of technology literature.

The first component consists of items relating to the freedom to make decisions regarding a lab's project portfolio and project management approach. Consequently, this component is named *Autonomy in Project Management*. Numerous studies in the project management area use these components as indicators to predict the success or failure of projects or to benchmark good project management practice (Balachandra and Friar, 1997; Cooper and Klienschmidt, 1990; Kumar *et al.*, 1996).

The second component consists of items relating to collaboration with other labs within the MNC group. Thus, this component is named *Autonomy in Intra-lab Collaboration*. The third component consists of items relating to freedom to make decisions with respect to R&D professionals. This component could be conveniently named *Autonomy in Managing Knowledge Workers*.

Thus, it seems that the concept of autonomy to make strategic decisions, as measured in this study, when analyzed alone and not in combination with other variables, is a multidimensional construct, even though all the items in the scale pertain to strategic rather than operational decisions. However, further research in context similar to this study and possibly in other situations are needed to validate the findings reported here.

Table 6.7**Factor Analysis on Autonomy****Total Variance Explained**

Component	Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %
1	3.592	35.916	35.916
2	2.417	24.174	60.090
3	1.838	18.376	78.466

Rotated Component Matrix

Items	Component		
	1	2	3
Change an existing product	.838	.232	4.824E-02
Modify the production process	.877	7.766E-02	.100
Number of projects lab undertakes	.824	.141	.186
Type of projects undertaken	.768	.215	.188
Setting project priorities	.847	5.764E-02	-.108
Doing joint R&D with other labs in MNC group	.296	.829	.132
Sharing information with other labs	.142	.917	.165
Exchanging R&D staff with other labs	7.966E-02	.805	.327
Recruit scientists and engineers	.101	.218	.886
Deciding the career paths of scientists and engineers	9.923E-02	.254	.899

6.3.3 Trust and Formalization

Unlike the constructs *Autonomy* and *Synergistic Innovative Capacity*, which consists of 12 and 13 items respectively, *Trust* consists of only 5 items. Factor analysis indicates that the concept as measured in this study consists of two components (See Table 6.8). The first component is related to the technological aspects of collaborations while the second component more closely reflects the social aspects of collaborations. Thus, the components could be named *Technology-based Collaboration* and *Relationship-based Collaboration*. Since both components explain similar proportion of variance, they are retained as two distinct constructs.

The construct *Formalization* also consists of five items which yielded two components when factor analysis was employed (See Table 6.9). However, from a theoretical perspective, it is much more difficult to decompose the items for this construct. Thus, it is suggested that this construct should be retained as a single dimension construct as originally proposed.

Table 6.8

Factor Analysis on Trust

Total Variance Explained

Component	Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %
1	1.811	36.229	36.229
2	1.790	35.798	72.027

Rotated Component Matrix

Items	Component	
	1	2
Collaboration based on technical competency of lab	.900	.152
Collaboration based on complementary technology	.839	.109
Collaboration based on experience	.522	.605
Collaboration based on keeping promises	.142	.845
Collaboration based on trust	7.182E-02	.821

Table 6.9

Factor Analysis on Formalization

Total Variance Explained

Component	Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %
1	1.985	39.706	39.706
2	1.705	34.096	73.800

Table 6.9 Continued
Rotated Component Matrix

Items	Component	
	1	2
HQ: Rules for conflicts	.691	.481
HQ: Monitors lab	.891	5.430E-02
HQ: Lab submit report	.816	.176
HQ: Rules for external collaboration	.141	.867
HQ: Rules for internal collaboration	.167	.829

6.4 Application of Factor Analysis Results

Since the results of factor analysis revealed that the dependent variable *synergistic innovative capacity* and two of the independent variables, *autonomy* and *trust* have four, three and two components respectively, it was decided to re-run the regression analysis with these new larger set of variables. Thus, there are now nine independent variables in the main model regression – autoproj, autocollab, autoHR (the components of autonomy), formalization, socialization, IPCOMHQ, IPCOMSU, ECOMHQ, and ECOMSU. Regressions were run with these nine independent variables and each of the four dependent variables sequentially. The four dependent variables are the four components which emerged from the factor analysis on *synergistic innovative capacity*, the original unidimensional dependent variable. The names assigned to the four dependent variables are:

- Knowledge Creation and Management
- Managerial and Operational Efficiency
- Strategic R&D
- Innovative Proficiency

The regression results from this analysis are shown in Tables 6.10 to 6.12. As shown in Table 6.10, the regression with *Knowledge Creation and Management* as the dependent yielded three statistically significant variables at the 0.1 level. All three variables pertain to communication among research labs. It is observed that in-person communication among subsidiary labs has a positive effect on knowledge generation and management whereas in-person communication between the HQ and subsidiary labs is having the opposite effect. However, technologically supported communication between HQ and subsidiary labs has a positive effect on knowledge generation and management.

These results seem to suggest that knowledge creation and transfer among subsidiary labs is accomplished much more effectively in face-to-face settings than by technologically supported media. In particular, technical knowledge, a large part of which is considered tacit knowledge, is transferred more effectively when scientists and engineers meet in-person. At this point in time, it seems that technologically supported communication may be more effective in communicating explicit knowledge. The positive impact of electronic communication between HQ and subsidiary labs (ECOMHQ) could be interpreted as the HQ being quite effective as a clearinghouse for information generated throughout the MNC.

Table 6.11 shows that four variables: AutoHR, ECOMHQ, ECOMSU and IPCOMSU are having a positive and significant impact on *Strategic R&D* (at the 0.1 level). As defined earlier, strategic R&D refers to the ability of subsidiary labs to undertake a larger role in the more strategic aspects of their company's R&D activities. This role is measured by the extent

to which they are involved in a larger number of complex and sophisticated R&D projects. The results of this regression suggests that close communication among subsidiary labs facilitates the sharing of information among the labs, which tends to increase the participation rates of labs in more strategic R&D projects. Also, the role of HQ in disseminating information to labs regarding new projects, technical capabilities available within the MNC group, and so on is useful in getting the labs to become aware and even participate in a large number of strategic R&D projects.

Freedom of subsidiary labs to recruit and decide on the career paths of scientists, engineers and other technical personnel means that the labs can now hire and retain professionals with the required expertise which they may need in order to participate in strategic R&D projects.

Table 6.10
Regression on Knowledge Creation & Management

Variables	Beta	Std. Error	T	Sig. t	VIF	R ²	F	Sig. F
(Constant)		.647	4.786	.000		.193	1.703	.117
Autoproj	-.081	.086	-.559	.578	1.467	N = 65		
Autocollab	.176	.090	1.192	.238	1.543			
AutoHR	.132	.107	.882	.382	1.586			
Socialization	.173	.060	1.203	.234	1.489			
IPCOMHQ	-.431	.081	-2.555	.013	2.006			
ECOMHQ	.303	.112	1.759	.084	2.094			
ECOMSU	-.137	.131	-.893	.376	1.660			
IPCOMSU	.296	.104	1.843	.070	1.825			

autoproj = autonomy in project management

autocollab = autonomy in collaboration

autoHR = autonomy in human resources management

Table 6.11
Regression on Strategic R&D

Variables	Beta	Std. Error	T	Sig. t	VIF	R ²	F	Sig. F
(Constant)		.599	.784	.436		.422	5.199	.000
Autoproj	.189	.080	1.552	.126	1.467	N = 65		
Autocollab	-.162	.083	-1.295	.200	1.543			
AutoHR	.323	.099	2.544	.014	1.586			
Socialization	.066	.056	.544	.589	1.489			
IPCOMHQ	-.124	.075	-.870	.388	2.006			
ECOMHQ	.302	.104	2.074	.043	2.094			
ECOMSU	.246	.122	1.896	.063	1.660			
IPCOMSU	.312	.096	2.295	.025	1.825			

Table 6.12 shows that three variables are significant at the 0.1 level in explaining the ability of R&D labs to innovate in a timely and cost effective manner – innovative proficiency. Two of the variables relate to autonomy of the labs in making decisions while the other one relates to the extent to which the labs share the corporate goals, values and mission – socialization. The freedom of the labs to share information, personnel and other resources as well as the extent of socialization positively affect innovative proficiency. It seems that the social networks resulting from greater collaboration and socialization among the labs tend to increase the awareness of the labs about skills, expertise and resources available elsewhere in the MNC from which they can draw on. The ability to draw on these expertise and resources appears to be having a positive effect in reducing the time and costs of innovations.

The autonomy of the labs to decide on their project portfolios and priorities or to change an existing product/process or the production process, appears to have a negative effect on innovative proficiency. A closer examination of the ratings on these items show that the HQ takes the lead role in these decisions which may be a reflection of the intention of management to foster greater coordination and integration of R&D activities across the

corporation. However, regardless of the motivations, subsidiary labs seem to perceive the lack of freedom as constraining their ability to innovate timely and cost effectively.

Table 6.12
Regression on Innovative Proficiency

Variables	Beta	Std. Error	T	Sig. T	VIF	R ²	F	Sig. F
(Constant)		.704	4.528	.000		.252	2.404	.026
Autoproj	-.238	.094	-1.719	.091	1.467	N = 65		
Autocollab	.282	.098	1.984	.052	1.543			
AutoHR	-.050	.117	-.349	.728	1.586			
Socialization	.454	.065	3.280	.002	1.489			
IPCOMHQ	-.133	.088	-.820	.416	2.006			
ECOMHQ	-.001	.122	-.009	.993	2.094			
ECOMSU	-.087	.143	-.590	.558	1.660			
IPCOMSU	.113	.113	.733	.466	1.825			

CHAPTER 7

PLS ANALYSIS

7.1 Introduction

PLS is an alternative analytical framework for analyzing the relationship between the dependent variable, *synergistic innovative capacity*, and the five independent and four moderating variables identified earlier in the theoretical model shown in Figure 3.1. This chapter begins with a discussion of the value-added of using PLS over traditional regression and factor analysis, followed by a comparison of PLS and LISREL. Both PLS and LISREL are structural equation modeling techniques, each with its own distinct characteristics, however, since many researchers believe that LISREL is superior to PLS, some justification for using PLS over LISREL is in order. Also, since PLS is not yet a widely used data analysis technique in this field of study, the analytical framework of PLS is described. Finally, the results of two PLS models are presented and discussed.

7.2 The Case for PLS

Causal or structural equation models provide a way to **simultaneously** assess the reliability and validity of measures of theoretical constructs and estimate the relationships among constructs. LISREL, EQS and PLS are three widely known causal modeling techniques. According to Fornell (1982), by incorporating multiple dependent constructs, explicitly recognizing error terms, and explicitly integrating theory with empirical data, these techniques provide the capability to advance understanding to an extent not possible with traditional multivariate techniques such as multiple regression, factor analysis, principal components and cluster analysis.

For example, assume that a dependent variable consists of two dimensions and the researcher is interested in analyzing the relationship between the dependent variable and a set of predictors using multivariate regression. To analyze this relationship, two separate regressions would have to be undertaken – one with the first component of the dependent variable and another with the second component. In PLS this would not be necessary since PLS can simultaneously analyze the relationship between the predictors and both components of the dependent variable in a single model execution.

Other advantages of PLS over traditional multivariate techniques are illustrated using a study by Snell and Dean (1992), which examined the relationship between integrated manufacturing and human resource management. In the study, multiple measures were collected for the construct Advanced Manufacturing Techniques (18 items), Total Quality Management (10 items), and Just-in-Time inventory control (10 items). Principal components factor analysis with varimax rotation was employed to define three factors and remove 'weak' items (i.e. items with loading less than .30). Factor analysis was also used to refine 5 multiple-item human resources constructs (i.e. staffing, training, appraisal, externally equitable rewards, and individually equitable rewards). Once the dependent and independent factors were defined, Snell and Dean (1992), then formed aggregate variable (i.e. construct) scores by combining the scale items for the respective constructs. They then employed multiple regression to predict each human resource construct with the set of integrated manufacturing variables.

If Snell and Dean (1992) had used PLS with the same data and theoretical model, the measures and the relationship between the constructs would have been estimated simultaneously. With PLS it would have been unnecessary to aggregate the measures to form construct scores in an *a priori* fashion and the psychometric properties of the various scale constructs would have been reassessed each time the model was evaluated with a different dependent variable. This is in contrast to the two-stage process they used which separates data, from measurement, and from theory. Furthermore, assumptions regarding the appropriate way to combine items into construct scores would not have been made; PLS handles this.

In some ways, the approach used by Snell and Dean (1992) were employed in this study with respect to the data analysis reported in the previous chapter. In the regression analysis conducted in the preceding section, the scales for each of the constructs in the model were added to form a single variable, which was then employed in the regression. For example, the dependent variable, *synergistic innovative capacity*, was computed as follows: for each respondent, the mean score was obtained from the responses provided across the 13 items defining the construct. A similar procedure was employed for the other scale variables used in the model. This procedure assumes that the construct is unidimensional and, therefore, the items are additive. Although a high Cronbach alpha indicate good scale reliability, it does not indicate whether the construct is unidimensional or multidimensional. Simply aggregating scale items in a multi-item construct to form new variables without considering the dimensionality of the construct or its relationship to other constructs in the study is arbitrary and could lead to misleading results. Generally, for any linear model, it is necessary to decide

on the number of constructs there are and the relationships among them at the beginning of the study based on theory and empirical evidence.

PLS allows for a closer integration of data, measurement and theory. For example, take a construct like *trust*, which in this study consists of five items measured on a five-point scale. Assuming the researcher is interested in evaluating the relationship between levels of trust and synergistic innovative capacity using regression analysis, the researcher would have to add the five items and then artificially disaggregate the resulting variable into high, medium or low levels of trust before running the regression. It would be unlikely that the five items would have been used as five separate variables because of sample size considerations. In PLS, all five measures are used, the actual responses provided by respondents are used, and the underlying theory influencing the design of the construct is preserved. In these cases, PLS makes greater use of the actual data.

7.3 PLS and LISREL Compared

Some researchers suggest that PLS is complementary, even a precursor, to LISREL, the most widely known structural equation modeling technique (Barclay *et al.*, 1995; Judge, 1995; Chin, 1995). The aim of LISREL is to estimate causal model parameters (e.g., loadings and paths) such that the discrepancies between the initial empirical covariance data matrix, and the covariance deduced from the model structure and the parameter estimates are minimized. It is concerned with the entire covariance matrix. The emphasis is on overall **model fit**. The objective of PLS, on the other hand, is to maximize the variance explained in constructs and/or variables, depending on model specification. This difference in objective makes

LISREL “closer to the model, more confirmatory and more data analytic, and PLS closer to the data, more explorative and more data analytic” (Lohmöller, 1989). While LISREL and PLS use full information, usually in the maximum likelihood sense, PLS estimates parameters via a sequence of regressions, each of which uses partial information, hence the name Partial Least Squares.

There are other features of LISREL which are theoretically more compelling than PLS but may not apply to the current research. For example, LISREL is more elegant with respect to the types of models that can be proposed. It handles non-recursive relationships, allows the testing of nested models, permits the comparison of the fit of a model between groups, and allows for the modeling of correlated error terms. The current version of PLS used in this study does not allow for these specifications and assumes uncorrelated errors as in regression (Barclay *et al.*, 1995).

LISREL offers a number of measures of overall ‘fit’ such as the χ^2 goodness-of-fit; PLS does not have these overall measures, relying instead on variance explained, R^2 , as an indicator of how well PLS has met its objective. In PLS, the constructs are weighted linear aggregates of their indicators, completely defined by their indicators, and capable of producing component scores. In LISREL the estimation approach is usually based on Maximum Likelihood. Data is thus assumed to be multivariate normal and interval-scaled, and sample size must be relatively large. Other estimation procedures⁶ recently built-in to LISREL are less stringent with respect to data requirement but can generate parameter estimates with less than optimal

⁶ Generalized Least Squares (GLS), Unweighted Least Squares (ULS), and Weighted Least Squares (WLS)

properties. Chin (1995) notes that even with distributional violation, the MLE procedure for LISREL can be quite robust and may possibly produce better estimates of the population parameters than PLS.

It is noted that LISREL based on maximum likelihood may not converge when sample sizes are small because the likelihood surface in this case may be flat and because some parameters (e.g., variances) may be close to their boundary values (i.e., 0). This is a sign that the sample size is too small or that the model is wrong. PLS, however, will produce answers. Provided that the model is reasonable and provided that jack-knifed variances are produced, PLS can be useful. PLS can be thought of as an exploratory step towards a more rigorous and complete analysis. Given replicated studies with larger sample sizes, the results can be validated with LISREL and other causal modeling techniques.

PLS is a distribution-free approach to parameter estimation. It can be used effectively with small samples and complex causal models. According to Barclay *et al.* (1995); Chin (1995); and Hulland (1999), the parameter estimates from PLS approximate those obtained from LISREL only under the joint condition of a large number of measures per construct and large sample sizes.

Regarding the capability of PLS to accommodate small sample studies, Lohmöller (1982) presents examples where a model with 27 variables was appropriately estimated with only 10 data cases, and a model with 96 indicators and 26 constructs was estimated with 100 cases. As noted above, only under the joint condition of a large sample size and a large number of

indicators per construct will estimates of the loadings and structural paths approximate that of LISREL. Otherwise, the loadings in PLS tend to be overestimated and the structural paths, conversely, underestimated. Chin (1995) suggests that this becomes less of a concern if the objective is to account for multivariate variance in a predictive sense, and in studies where theoretical knowledge is low, the more conservative estimate of a model's structural paths may be more appropriate. Two sample re-use techniques, *jack-knifing* and *bootstrapping*, can be used in PLS to test the statistical significance of the loadings and paths.

Often it has been stated that on practical grounds, PLS is considered to be superior to LISREL. For example, PLS is computationally more efficient in the same sense as a component analysis is faster than a MLE factor analysis. LISREL estimation time increases dramatically as the number of indicators increase. However, with the kind of computing power available today, this is less of a concern.

In this study, PLS is used because of sample size considerations.

7.4 Analytical and Interpretive Framework of PLS

To facilitate a proper understanding of the results generated from PLS analysis, a simple PLS model consisting of three constructs is presented in order to illustrate the conceptual and analytical underpinnings of the PLS framework (Figure 7.1).

Figure 7.1

An Illustrative PLS Model

ξ_1 and ξ_2 : exogenous constructs

η : endogenous construct

$x_1 \dots x_3$: x variables, measures or indicators

$y_1 \dots y_3$: y variables, measures, or indicators

$\pi_1 \dots \pi_3$: regression weights

$\lambda_1 \dots \lambda_3$: loadings

$\epsilon_1 \dots \epsilon_3$: error terms $(1 - \lambda_m^2)$

μ : residual in the structural model

b_1, b_2 : path coefficients or simple regression coefficient between ξ and η

As shown in Figure 7.1, a PLS model consists of two related components (i.e., the measurement or outer model and the structural or inner model). The measurement model consists of the variables that define the constructs (x_s and y_s) and the structural model consists of the paths linking the exogenous and endogenous constructs (b_s). The indicators of construct ξ_1 are called formative measures while the indicators of ξ_2 are referred to as reflective measures. Decisions on whether the measures are formative or reflective should be based on theory but reflective indicators are generally used especially in exploratory studies or where theoretical knowledge is low.

Although the measurement and structural models are estimated together, a PLS model is usually analyzed and interpreted sequentially in two stages. The first stage involves assessing the reliability and validity of the measurement model, and the second stage involves assessing the structural model. This sequence ensures that reliable and valid measures of the measurement model are first obtained before attempting to draw conclusions about the structural relationships among the constructs. The measurement model is assessed by evaluating individual item reliabilities, internal consistency⁷, and the discriminant validity⁸.

7.4.1 Measurement (Outer) Model Assessment

Individual item reliability is assessed by examining the loadings, or simple correlations of the measures with their respective constructs (the π , θ and λ). A rule of thumb is to accept loadings of .70 or more, which implies more shared variance between construct and its measures than error variance. However, Grant and Higgins (1991) suggest that individual

⁷ Often used interchangeably with convergent validity or composite reliability of scale items.

⁸ Often used interchangeably with average item reliability or average variance extracted by each construct.

item reliabilities of .50 or more is also acceptable. **Internal consistency** is a measure of reliability similar to Cronbach's alpha except that it is computed from the loadings within the PLS model. The threshold of .70 suggested for Cronbach's alpha by Nunnally (1978) also applies for internal consistency. It is computed as the sum of the loadings, all squared, divided by the sum of the loadings, all squared, plus the sum of the error terms⁹. In mathematical terms it is given by the following formula:

$$\text{Internal Consistency} = \frac{(\sum \lambda_{y_i})^2}{(\sum \lambda_{y_i})^2 + \sum \text{var}(\varepsilon_i)}$$

Discriminant validity indicates the extent to which a given construct is different from other constructs, that is, whether ξ_1 is different from ξ_2 . In PLS, one criterion for adequate discriminant validity is that a construct should share more variance with its measures than it shares with other constructs in a model. For adequate discriminant validity, Fornell and Larcker (1981) suggest the use of the measure Average Variance Extracted (i.e., the average variance shared between a construct and its measures). This measure should be greater than the variance shared between the construct and other constructs in the model (i.e., the squared correlation between two constructs). Grant and Higgins (1991), suggest that the average variance extracted should exceed .50. Mathematically, discriminant validity is given by the following formula:

⁹ Hulland (1999) argue that strictly speaking, the issue of individual item reliability and internal consistency can only be applied to measures that are reflective, rather than formative.

$$\text{Average variance extracted} = \frac{\sum \lambda_i^2}{\sum \lambda_i^2 + \sum \text{var}(\varepsilon_i)}$$

7.4.2 Structural (Inner) Model Assessment

The adequacy of the structural model is determined by looking at the significance of the path coefficients and the R^2 values for the endogenous constructs. Sample reuse techniques such as jack-knifing and bootstrapping are used in PLS to evaluate the statistical significance of the path coefficients. In this study, bootstrapping is used to evaluate the statistical significance of the path coefficients. Generally, for a two-tailed test, t-values of 2 or more indicate that the path estimates are significant at the 5 percent level (Chin, 1999).

Bootstrapping is a sample reuse method that is used in variance approximations. Conceptually, with bootstrapping, the computer generates a number of with-replacement random sub-samples from the existing database and for each sub-sample computes a variance estimator usually called a *pseudoestimate*. The pseudoestimates generated from all the sub-samples are then averaged to arrive at a single estimate of the variance from which a t-statistic is computed and compared with a theoretical t-value. The number of with-replacement random sub-samples to be generated is set by the analyst. However, the larger the number of sub-samples, the more accurate is the test. For this study the number of bootstrap sub-samples was set at 500.

7.5 Results of PLS Analysis

In order to evaluate the extent to which the five structural variables chosen for this study (i.e., autonomy, socialization, formalization, HQ-subsidary labs communication, and inter-subsidary communication) provide adequate explanation for variations in the outcome variable *synergistic innovative capacity*, a systematic analysis of various PLS models was carried out. Through successive model refinement based on theoretical plausibility and statistical soundness two models have been selected for further analysis. Before analyzing these two models, a digression is made to briefly describe the procedure used in developing and evaluating various PLS models.

The initial model consisted of nine exogenous or independent constructs and the four endogenous or dependent constructs. The nine exogenous constructs are autonomy, formalization, socialization, HQ-subsidary labs communication, inter-subsidary labs communication, resource level of labs, uncertainty of labs operating environment, trust, and cultural diversity. Although, factor analysis performed earlier indicated that the constructs *autonomy*, *formalization* and *trust* are not unidimensional, in this analysis they are retained as unidimensional constructs since preliminary PLS analysis indicate unidimensionality. The four endogenous constructs which are components of *synergistic innovative capacity*, the original dependent construct, are similar to those obtained in factor analysis – *Knowledge Creation and Management*, *Strategic R&D*, *Managerial and Operational Efficiency*, and *Innovative Proficiency*. The number of indicators defining each construct is shown in Table 7.1.

Table 7.1
Indicators of Measurement (Outer) Model

Question Number on Questionnaire	Number of Items	Name of Construct
12	13	Synergistic Innovative Capacity
15	12	Autonomy
16	5	Formalization
3	2	Socialization
14	6	HQ-Subsidiary Communication
13	6	Subsidiary-Subsidiary Labs Communication
21-23	3	Resource Level of Labs
18&19	3	Environmental Uncertainty
11	5	Trust Among Labs
17	3	Cultural Diversity

A careful analysis of the loadings of the indicators of the measurement models of several PLS models indicate that the endogenous construct, *synergistic innovative capacity*, is not unidimensional as hypothesized in this study based on the low item reliabilities of some of the indicators. Further examination of these indicators which are candidates for removal show a pattern which closely reflect the four components generated from factor analysis conducted earlier. Therefore, in all subsequent PLS analysis, *synergistic innovative capacity* was treated as four endogenous constructs. The four components and the items comprising each component are shown in Table 7.2.

Table 7.2
Four Components of Synergistic Innovative Capacity

Component	Indicators	Name of Dimension
1	Number of R&D Number of Complex R&D Projects	Strategic R&D Synergy (SR&DS)
2	Managerial Efficiency Efficiency in R&D resource utilization	Managerial & Operational Synergy (MOS)
3	Access to R&D resources Technical Competencies Impulse for Innovations Success of New Innovations	Knowledge Creation & Management Synergy (KCMS)
4	Cost of R&D Development Cycle Time	Innovative Proficiency Synergy (IPS)

It is also observed that substantial improvements are obtained in both the measurement and structural models when the two communication constructs are re-grouped into four constructs based on the communication medium. That is, when headquarter-subsidary communication and subsidiary-subsidary communication are separated into electronic communication and in-person communication. Thus, further PLS modeling was done using these four constructs to represent the nature of communication among R&D labs of MNCs.

7.5.1 PLS Model 1

As mentioned above, two PLS models were selected for further investigation. Model 1 is shown in Figure 7.2 and the relevant statistical results are shown in Tables 7.3 and 7.4. According to the loadings displayed in Table 7.3, all the indicators of the constructs are substantially higher than the .70 benchmark except for two with respect to resource levels and two for cultural diversity. The construct measuring trust has four indicators in the .63 to .68 range which are still acceptable but slightly below the .70 threshold.

The internal consistency measures for the constructs resource levels, trust and cultural diversity are lower than the .7 threshold (See Table 7.4). This is not surprising since the internal consistency measure is derived from the indicator loadings obtained from the model. The internal consistency for the construct innovative proficiency is marginally below the threshold while all those of the other remaining constructs are above the threshold.

Figure 7.2

PLS Model 1

Table 7.3**Individual Item Reliability: PLS Model 1**

Constructs	Loadings	Constructs	Loadings	Constructs	Loadings
Autonomy		Formalization		Trust	
Q15-1	0.81	Q16-1	0.84	Q11-1	0.64
Q15-2	0.83	Q16-2	0.82	Q11-2	0.65
Q15-3	0.87	Q16-3	0.93	Q11-3	0.74
Q15-4	0.90	Q16-4	0.90	Q11-4	0.63
Q15-5	0.90	Q16-5	0.92	Q11-5	0.68
Q15-6	0.87				
Q15-7	0.87	Socialization		Resource Levels	
Q15-8	0.78	Q3-1	0.97	Q21	0.99
Q15-9	0.89	Q3-2	0.98	Q22	0.32
Q15-10	0.93			Q23	0.39
Q15-11	0.89				
Q15-12	0.78				
Ipsu		Esu		Cultural Diversity	
Q13-4	0.95	Q13-1	0.97	Q17-1	0.97
Q13-5	0.96	Q13-2	0.98	Q17-2	0.30
Q13-6	0.89	Q13-3	0.97	Q17-3	0.42
Iphq		Ehq		Environmental uncertainty	
Q14-4	0.94	Q14-1	0.97	Q18-1	0.96
Q14-5	0.97	Q14-2	0.98	Q18-2	0.97
Q14-6	0.95	Q14-3	0.97	Q19	0.95
Strategic R&D Synergy		Managerial & Operational Synergy		Knowledge Creation & Management Synergy	
Q12-1	0.80	Q12-6	0.85	Q12-8	0.75
Q12-2	0.85	Q12-7	0.87	Q12-9	0.74
				Q12-10	0.89
				Q12-11	0.89
Innovative Proficiency Synergy					
Q12-12	0.70				
Q12-13	0.75				
Q12-5	0.85				

Esu = electronic communication among subsidiary labs

Ehq = electronic communication between HQ and subsidiary labs

Ipsu = in-person communication among subsidiary labs

Iphq = in-person communication between HQ and subsidiary labs

Table 7.4
Correlation of Constructs: PLS Model 1

	IC*	Auto	Soc	Form	Esu	Ehq	Res	Env	Trust	CDiv	SR&D	MOS	KCMS	IPS	Ipsu	Iphq
Auto	.78	.87														
Soc	.97	0.21	.99													
Form	.81	0.67	0.17	.89												
Esu	.97	0.59	0.22	0.45	.98											
Ehq	.96	0.43	0.22	0.50	0.59	.98										
Res	.50	0.53	0.16	0.59	0.56	0.60	.65									
Env	.93	0.70	0.25	0.58	0.69	0.59	0.65	.97								
Trust	.55	0.01	0.01	0.04	0.02	0.02	0.01	0.00	.68							
CDiv	.43	0.55	0.20	0.56	0.56	0.53	0.53	0.53	0.02	.61						
SR&DS	.73	0.00	0.01	0.03	0.02	0.04	0.02	0.00	0.09	0.01	.83					
MOS	.77	0.13	0.09	0.03	0.16	0.06	0.12	0.13	0.04	0.16	0.07	.86				
KCMS	.72	0.01	0.03	0.03	0.01	0.05	0.02	0.00	0.03	0.04	0.18	0.01	.83			
IPS	.66	0.01	0.01	0.08	0.00	0.00	0.03	0.00	0.08	0.03	0.09	0.10	0.13	.77		
Ipsu	.89	0.51	0.11	0.35	0.60	0.29	0.32	0.54	0.00	0.31	0.02	0.07	0.02	0.01	.94	
Iphq	.92	0.31	0.10	0.28	0.30	0.59	0.34	0.39	0.03	0.25	0.03	0.04	0.01	0.00	0.36	.96

For adequate discriminant validity, the numbers on the main diagonal (shown in borders) should be greater than the off-diagonal elements in the respective columns

$$\bullet \text{ IC} = \text{Internal consistency} = \frac{\left(\sum \lambda_{y_i}\right)^2}{\left(\sum \lambda_{y_i}\right)^2 + \sum \text{var}(\epsilon_i)}$$

$$\text{Discriminant Validity} = \frac{\sum \lambda_i^2}{\sum \lambda_i^2 + \sum \text{var}(\epsilon_i)}$$

Auto = autonomy
Soc = socialization
Form = formalization
Esu = electronic communication among subsidiaries
Ehq = electronic communication between HQ and subsidiary labs
Ipsu = in-person communication among subsidiary labs
Iphq = in-person communication between HQ and subsidiary labs

SRDS = strategic R&D synergy
MOS = managerial & operational synergy
KCMS = knowledge creation and management synergy
IPS = innovative proficiency synergy
Res = resource levels
Env = environmental complexity
CDiv = cultural diversity

Table 7.4 shows the correlation matrix of the constructs for Model 1 derived by using the formula for discriminant validity. The diagonal elements are the square roots of average variance extracted (i.e., the average variance shared between a construct and its measures) and the off-diagonal elements are the squared correlations between two constructs (i.e., the variance shared between the construct and other constructs in the model). For adequate discriminant validity, the diagonal elements should be greater than the off-diagonal elements. In addition, Grant and Higgins (1991) suggest that the value of the diagonal elements should exceed .50. Using both of these criteria, it is observed that there is adequate discrimination among the constructs except for resources where the diagonal element is equal to the element for the correlation between resource level and environmental uncertainty.

Overall, it can be concluded that the measurement model provides fairly reliable and valid estimates of their underlying constructs. Thus, the analysis now focuses on evaluating the structural model.

As shown in Figure 7.2, Model 1 provides an overall explanation, R^2 , of 27 percent with individual R^2 for the four endogenous constructs ranging from 22 to 33 percent. The statistical significance of the path estimates was determined via bootstrapping with 500 sub-samples. The results revealed six statistically significant paths. Table 7.5 shows the path estimates of the structural model.

Table 7.5**Path Estimates of Structural Model: PLS Model 1**

	Auto	Soc	Form	Esu	Ehq	Ipsu	Iphq	Res	Env	Trust	CDiv
SR&DS	.228	-.175	-.220	-.332	-.275	.172	.065	.008	.193	.272	.245
MOS	.218	-.116	-.503*	.241	-.364	-.162	.167	.282	.054	.108	.421
KCMS	.012	-.177	-.043	-.655	.888*	.682*	-.472*	.218	-.705*	-.012	.206
IPS	.239	-.162	-.551*	.108	.036	-.225	.229	-.174	.213	.138	-.124

* Significant at $\alpha \leq .05$

7.5.2 PLS Model 2

Following theoretical arguments presented by Pfeffer and Salancik (1978); Edstrom and Galbraith (1977); Ghoshal and Bartlett (1991); Nohria and Ghoshal (1997); Lawrence and Lorsch (1967); and Thompson (1967), regarding the relationship between resource levels, environmental uncertainty and autonomy, on the one hand, and between trust, cultural diversity and socialization, on the other, an alternative model was tested. This model, referred to as Model 2, is shown in Figure 7.3 below.

Essentially, this second model is based on the notion that the level of autonomy of a lab is influenced by the amount of resources at the disposal of the lab. That is, labs with higher level resources will have greater autonomy. This argument is rooted in the resource dependency theory of organizations advanced by Pfeffer and Salancik (1978); Edstrom and Galbraith (1977); Ghoshal and Bartlett (1991); and Nohria and Ghoshal (1997). Similarly, it is argued that environmental uncertainty is positively associated with the level of autonomy. That is, labs operating in more complex and uncertain environments will have greater autonomy than those operating in more stable environments. This reasoning is consistent with the external environment perspective of organizational relationships advanced by Lawrence and Lorsch (1967), and Thompson (1967). Both of these propositions were

empirically verified by Pfeffer and Salancik (1978) and Nohria and Ghoshal (1997). Trust and cultural diversity were also shown to be critical elements in fostering the socialization process in multi-unit global corporations like MNCs (Schein, 1968; Ouchi, 1980; Ring and Van de Ven, 1992; Nohria and Ghoshal, 1997; Edstrom and Galbraith, 1977). Essentially, when trust is established among the various organizational units there is increased socialization. Similarly, when cultural diversity is low, there is greater socialization. However, when cultural diversity is high, socialization will take place but would require more deliberate policies and efforts to achieve.

Figure 7.3

PLS Model 2

Table 7.6 gives the relevant statistics for evaluating the measurement model of Model 2. It is observed that the individual item reliabilities for most constructs exceeded the .70 threshold and have shown substantial improvements over the previous model with respect to the three constructs resource levels, cultural diversity and trust. The indicators of internal consistency portray a similar picture. The matrix of correlations of the constructs indicate strong discriminant validity on all constructs. That is, the diagonal elements for all constructs are substantially larger than the off-diagonal elements. Unlike the first model where the diagonal element for the construct *resource levels* is equal to the off diagonal element for *resource levels* and *environmental uncertainty* (.65), the second model shows adequate discrimination between the two constructs.

Table 7.6

Loadings, Internal Consistency and Correlation of Constructs: PLS Model 2

	IRR*	IC**	Auto	Soc	Form	Esu	Eq	SRDS	MOS	KGMS	IPS	Ipsu	Iphq	Res	Env	Trust	CDiv
Auto	.80-.91	.77	.86														
Soc	.98	.97	0.19	.99													
Form	.82-.93	.81	0.68	0.17	.89												
Esu	.97-.98	.96	0.58	0.22	0.45	.98											
Eq	.97-.98	.96	0.42	0.22	0.50	0.59	.98										
SR&DS	.82-.83	.73	0.00	0.01	0.03	0.02	0.04	.83									
MOS	.85-.87	.77	0.11	0.09	0.03	0.16	0.06	0.06	.86								
KGMS	.76-.89	.73	0.00	0.03	0.02	0.01	0.05	0.18	0.01	.83							
IPS	.70-.86	.66	0.01	0.01	0.09	0.00	0.00	0.09	0.10	0.14	.80						
Ipsu	.89-.96	.89	0.52	0.11	0.35	0.60	0.29	0.02	0.07	0.02	0.01	.94					
Iphq	.94-.97	.92	0.31	0.10	0.28	0.30	0.59	0.03	0.04	0.01	0.00	0.36	.96				
Res	.65-.92	.64	0.41	0.17	0.46	0.56	0.65	0.01	0.09	0.01	0.00	0.32	0.36	.76			
Env	.96	.93	0.69	0.24	0.59	0.69	0.60	0.00	0.12	0.00	0.00	0.54	0.39	0.65	.97		
Trust	.72-80	.64	0.01	0.17	0.03	0.01	0.01	0.08	0.04	0.00	0.07	0.00	0.03	0.00	0.01	.76	
CDiv	.60-.72	.56	0.55	0.31	0.48	0.53	0.60	0.00	0.08	0.02	0.00	0.31	0.35	0.58	0.65	0.00	.68

For adequate discriminant validity, the numbers on the main diagonal (shown in borders) should be greater than the elements in the off-diagonal in the respective columns

*IRR = Individual Item Reliability **IC = Internal consistency =

$$\frac{\left(\sum \lambda_{y_i}\right)^2}{\left(\sum \lambda_{y_i}\right)^2 + \sum \text{var}(\epsilon_i)} \quad \text{Discriminant Validity} = \frac{\sum \lambda_{y_i}^2}{\sum \lambda_{y_i}^2 + \sum \text{var}(\epsilon_i)}$$

Auto = autonomy
 Soc = socialization
 Form = formalization
 Esu = electronic communication among subsidiaries
 Eq = electronic communication between HQ and subsidiary labs
 Ipsu = in-person communication among subsidiary labs
 Iphq = in-person communication between HQ and subsidiary labs

SR&DS = strategic R&D synergy
 MOS = managerial & operational synergy
 KGMS = knowledge creation and management synergy
 IPS= innovative proficiency synergy
 Res = resource levels
 Env = environmental complexity
 CDiv = cultural diversity

In contrast to the Model 1, the overall explained variance, R^2 , for Model 2 is substantially higher (38 percent) as shown in Figure 7.3. This is due primarily to the high R^2 associated with the two endogenous constructs, autonomy and socialization. In addition, there are more significant path estimates in Model 2 (See Table 7.7). However, the R^2 for the two constructs Strategic R&D Synergy and Innovative Proficiency Synergy has declined somewhat.

Table 7.7

Path Estimates of Structural Model: PLS Model 2

	Auto	Soc	Form	Esu	Ehq	Ipsu	Iphq	Res	Env	Trust	Mdiv
SR&DS	.481*	.235	-.325	-.055	-.246	.206*	.005				
M&OS	-.385*	.142	.348*	-.546*	.201	.252*	-.132				
KC&MS	-.187	.124*	.051	.653*	.814*	.530*	-.456				
IPS	.363*	-.204	-.757*	.136	-.023	-.180	.205*				
Auto								-.076	.894*		
Soc										.380*	-.532*

* Significant at $\alpha \leq .05$

These results support the theory that the level of autonomy research labs have is influenced by the resource levels of the labs and uncertainty of the environment in which they operate. That is, labs with greater resources and operate in more uncertain environments will have greater autonomy than those with less resources and operate in more stable environments. The model also confirms previous academic research which argues that higher levels of trust and greater cultural diversity will facilitate greater socialization among partners in a collaboration.

The results also indicate that Model 2 formulation is statistically more appealing in that it provides greater explanation – the overall R^2 is 11 percent more than Model 1 – and a larger number of path estimates are statistically significant.

In terms of the four dimensions of synergistic innovative capacity, the following statistically significant relationships are observed:

- *Strategic R&D Synergy* (SR&DS) is positively related to autonomy, socialization and in-person communication among subsidiaries
- *Managerial and Operational Synergy* (M&OS) is negatively related to autonomy and electronic communication among subsidiaries but positively related to formalization and in-person communication among subsidiaries
- *Knowledge Creation and Management* (KC&MS) is positively related to socialization, communication with HQ (both electronic and in-person) and in-person communication among subsidiaries
- *Innovative Proficiency Synergy* (IPS) is positively associated with autonomy and socialization and negatively to formalization

In addition, some path estimates are not statistically significant while a few others are close to zero. In strictly statistical terms, these paths can be eliminated from the model since their contribution to explaining the variations in the dependent variables are insignificant. Also, because of the small sample size, statistical power to detect some non-zero paths may be too low. Statistically insignificant paths do not mean that these paths are not theoretically

important. On the contrary, it means that they do not add further explanation over and above that of the significant paths. However, these paths are retained because they lend greater theoretical plausibility to the model and are consistent with previous studies.

A detailed analysis of the reasons for and implications of these findings in relation to the research question of this study is deferred to chapter 10 (*Discussion and Implications*) where both the quantitative and qualitative findings can be incorporated.

7.6 Summary of PLS Findings

The preceding PLS analysis have produced several important findings regarding the nature of the relationship between the dependent variable, *Synergistic Innovative Capacity*, and the five independent variables (*Autonomy, Socialization, Formalization, HQ-subsidary Communication, and inter-subsidary Communication*) and the four moderating variables (*Resource Levels, Environmental Uncertainty, Levels of Trust, and Cultural Diversity*). For convenience and at the risk of being repetitive, these findings are summarized below.

First, it is noted that the statistical properties (individual item reliabilities, internal consistency and discriminant validity) of the PLS models are above commonly used threshold levels. This implies that the PLS measurement models are both reliable and valid and therefore inferences can be drawn regarding the structural relationships among the constructs. In other words, valid inferences can be drawn regarding the relationship between the dependent, independent and moderating variables used in the analysis.

Second, it is observed that the dependent variable, *Synergistic Innovative Capacity*, is comprised of four components, which together provide a relatively good description of the construct. The four components are *Strategic R&D Synergy*, *Managerial and Operational Synergy*, *Knowledge Creation and Management Synergy*, and *Innovative Proficiency Synergy*.

Third, the four moderating variables appear to have greater explanatory effect when they are treated as antecedents instead of moderators as shown in *Model 2*. Not only is *Model 2* statistically more appealing, it is also theoretically plausible.

Fourth, the independent variable *Socialization* has a strong and positive impact on three of the four components of synergy, namely, *Strategic R&D Synergy*, *Knowledge Creation and Management Synergy*, and *Innovative Proficiency Synergy* (Table 7.8). In the regression analysis, *Socialization* had a similar effect on these components.

Fifth, the independent variable *Autonomy* has a positive influence on *Strategic R&D Synergy* and *Innovative Proficiency Synergy* but a negative influence on *Managerial and Operational Synergy* (Table 7.8).

Sixth, the independent variable *Formalization* has a positive impact on *Managerial and Operational Synergy* but a negative impact on *Innovative Proficiency Synergy* (Table 7.8).

Finally, both in-person and technologically supported communication are important with respect to *Strategic R&D Synergy*, *Managerial and Operational Synergy*, and *Knowledge Creation and Management Synergy*. In-person communication among subsidiaries had a positive effect on all three components while technologically supported communication among subsidiaries had a negative impact. HQ-Subsidiary communication, both in-person and technologically supported, had a strong, positive influence on *Knowledge Creation and Management Synergy* (Table 7.8).

Table 7.8

Relationship Between Independent Variables and Synergistic Innovative Capacity

Dimensions of Synergy	Auto	Soc	Form	IPComSu	EComSu	IPComHQ	EComHQ
Strategic R&D	+	+		+			
Managerial & Operational	-		+	+	-		
Knowledge Creation & Management		+		+		+	+
Innovative Proficiency	+	+	-				

This Table only shows the statistically significant relationships from PLS Model 2.

Chapter 8

Organization of International R&D

8.1 Introduction

Chapters 8 and 9 discuss the strategies MNCs use to organize and coordinate their international R&D activities. Some of the strategies overlap and are interdependent. However, to streamline the discussion, they are presented in two separate chapters. This chapter presents the findings on how MNCs organize their international R&D activities. The next chapter discusses the strategies MNCs use to coordinate and integrate their international R&D activities. The discussion draws heavily on information provided by the respondents who were interviewed by telephone.

Several respondents stated that a critical issue in effectively organizing global R&D is being able to maintain an appropriate balance between centralized and decentralized research. This, they argue, is perhaps the most challenging and elusive goal facing international R&D managers, and academic researchers are also struggling to propose strategies to achieve this balance in a practical way. Three concerns were raised by some participants of this study regarding the organization of international R&D. These are as follows:

1. What research activities should be done overseas and what should be done at home?
2. How to integrate central R&D and overseas R&D into a seamless whole?

3. How to integrate global R&D with the overall corporate strategy of the MNC group (i.e. with Strategic Business Units (SBUs) and divisions)?

The first two issues are addressed in this chapter and the latter issue is addressed in Chapter 9.

8.2 Organizational Structure of International R&D

This study finds that MNCs employ a range of formal and informal structures to organize their international R&D in order to create synergy. Basically, the formal structure is used to control and coordinate the types of R&D projects assigned to overseas subsidiary labs, and less formal structures are used to assign and coordinate activities involving more than one lab. The discussion that follows focuses on three broad types of organizational structures, namely, formal structures, quasi-formal structures, and contract research.

8.2.1 Formal R&D Organizational Structures

In the subsidiary questionnaire, respondents were presented with the three structural types shown in Figure 8.1 and were asked to identify the one that best reflects the R&D structure of their company, and if none applied, to sketch it on a separate sheet of paper. Table 8.1 gives a breakdown of the responses to this question. Twenty-two respondents classified their R&D organizations as closer to the hub and network structures each – models B and C, while 18 respondents classified their labs as belonging to the competence structure – model A. Thirteen respondents provided graphical representations of their companies' R&D organizations. These are displayed in Figure 8.4 at the end of this chapter.

Figure 8.1

Structural Types of Global R&D Organization

Table 8.1

Distribution of R&D Labs by Organizational Structural Types

Organization Structure	North America	Europe	Japan	Total
Cluster (A)	5	9	4	18
Hub (B)	3	12	7	22
Network (C)	6	11	5	22
User Defined	5	5	3	13

In addition, HQ respondents were asked to report the number of labs within their group whose main role (60% or more of the labs' activities) was product modification/adaptation, product design and development, applied research, basic research, and technical information gathering (or listening posts). Further, all respondents were asked to report the proportion of their R&D budget that was spent on applied research and basic research. The responses

reveal that only a small number of labs spend 60 percent or more of their R&D budget on basic research while the overwhelming majority perform applied research - a combination of product design and development, product adaptations, and technology scanning -- listening posts (See Table 8.2).

It was found that most of the labs within the hub structure performed mainly product adaptations or act as listening posts for the rest of the corporation within a specific region. They gather technical, market and other business information which are then filtered to the HQ lab, which in turn disseminates it to other labs. These labs tend to be closely integrated with, and are closely monitored by, the HQ and have little interaction with other labs.

Labs within the cluster or competence model were involved in projects with greater value added. That is, they tend to concentrate more of their efforts on basic R&D activities. A few cluster labs also engaged in product design and development activities. The majority of network labs performed a combination of product design and development work as well as basic research. These findings are largely consistent with those reported by Brockhoff and Schmaul (1996), Chiesa, (1996) and Gassman and Zedtwitz (1998; 1999).

Table 8.2

Distribution of R&D Labs by Principal Type of Research Activity

Type of R&D	Network	Cluster	Hub	Total (%)
60% or more of R&D budget on applied research	21	14	17	52 (69%)
60% or more of R&D budget on basic research	3	4	4	11(15%)

The R&D organization charts depicted in Figure 8.4 indicate that in order to organize their global R&D activities effectively, MNCs have created various types of labs around a particular technology or technology platform. The types of labs range from corporate labs for a particular country, to regional labs, to divisional labs and ultimately individual labs. These charts show the vertical links or reporting relationships of the labs but rarely shows the horizontal or lateral links among the labs. This is because the lateral links among corporate labs, regional labs, divisional labs and individual labs are primarily less formal and usually take place outside the formal structure.

8.2.2 Quasi Formal Organizational Structures

In addition to using the formal structure to coordinate and integrate global R&D, MNCs also use a number of less formal or quasi-formal organizational structures. These structures do not fall within the strict purview of either the formal or informal structures but lie somewhere between these two points. These structures pertain to the use of multifunctional, cross-national project teams and segmenting the corporate research agenda according to strategic focus and assigning various projects to different groups.

The uniqueness of these quasi-formal structures is that they tend to happen outside the formal structure in the sense that they have limited life span, and authority is mostly based on the technical expertise and personality of those involved. For example, when a multi-functional team is formed to work on a specific project with a limited life span, the project team usually operates as a relatively independent group, and the authority of the project leader or team is

based on their technical expertise, personality and strategic significance of the project. They do not have line authority and are not usually placed under line authority.

Many sample labs have multi-functional cross-national teams that work on dedicated projects which benefit not only their lab but also other labs within the MNC group. These projects tend to have a limited life span and team members may return to their original jobs or are transferred to another department or project.

Several labs indicated that their companies have prioritized their corporate R&D agendas according to strategic focus in order to facilitate coordination and integration of R&D on a global scale. For example, one Japanese company classifies all its R&D projects into either “global projects” or “local contribution projects.” In this company, global projects usually involve the HQ lab and several overseas labs. Local contribution projects are usually product modification R&D for the local market which may be a region, for example, Asia or South America. In this company, one local contribution lab located in Singapore is serving the product needs of all the company’s production facilities in Asia.

In another company, global R&D is broken down into three categories, strategic projects, core projects and product development projects. Strategic projects involve more basic research, have a life span of 10-15 years, draw on the expertise of a wide range of labs and R&D people, are usually larger than any single lab can handle, and top management is the champion of the projects. These projects are intended to set new strategic directions for the company. Core projects, on the other hand, tend to be of shorter duration and is used to

coordinate the development of several technologies. These projects tend to cut across technology fields and departments and are aimed at creating new technologies using the existing expertise of the company. Product development R&D relates to the refinement of existing technologies and products to new trends in the market.

Another company uses the concept of “core technologies” to guide its research agenda. In this company, the technology platform is developed at the HQ lab or at one of its corporate lab and then transferred to other labs where small variations may be effected. To ensure standardization, those R&D labs wishing to modify the platform must provide adequate justification of the changes in terms of resources, capability, and market potential.

Several labs in this study reported that the Chief Technology Officer (CTO) plays a critical role in the coordination and integration of their global R&D program. A number of corporate labs indicated that their CTOs are very senior persons assigned from corporate HQ to ensure the overseas labs are adequately equipped to do their job and to maintain close contact with the HQ. In a couple of Japanese corporate labs, the CTO for both the United States and Europe are board members of the corporation. Regular meetings among the heads of the corporate labs and the HQ lab help ensure effective planning and coordination of research programs.

8.2.3 *Contract Research*

Apart from the formal and quasi-formal structures described above, labs in this study also reported that they perform contract or sponsored research for various business units within

the company on a routine basis. With contract or sponsored research the Strategic Business Units (SBUs) or divisions request that specific research projects be carried out for them by R&D, and the SBUs or divisions making the request usually pays for the research. Since R&D labs do not start projects autonomously, they are actively encouraged to compete for projects from the SBUs. In one North American MNC, the company's corporate labs must compete with external organizations for the R&D contracts of SBUs because SBUs are now allowed to acquire technology by either doing their own R&D, or going to a university, to a government lab, or even to a competitor. The only restriction is that the SBUs must not cut their funding to the corporate labs by more than 20 percent in any one year.

In the sample of firms in this study, contract research appears to be more widespread among North American and European MNCs than among Japanese MNCs. Most Japanese MNCs still perform mainly independent research as opposed to contract research. However, one respondent thinks that this practice would likely change as R&D budgets get tighter. Among some North American and European R&D labs, contract research represents about 50 to 70 percent of their funding. Only a few of labs that perform contract research exclusively. One prominent Japanese company recently reduced the level of contract research from 70 to 55 percent.

Contract research is consistent with decentralized R&D structures because decisions regarding R&D is delegated to individual business units. From a corporate perspective, contract research of the type described here could increase the complexity of managing the R&D activities of business units because of the freedom to choose R&D partners. Despite

these challenges, many MNCs are experimenting with new ways to organize international R&D activities and to assist them in deciding what activities should be done in-house within the company, what should be contracted out, and what should be done overseas.

8.2.4 Recentralization of R&D

In the introduction to this study, it was stated that the trend towards internationalization of R&D really began around 1985 and since then it has been on the increase. Not only were the level of R&D expenditures and the number of R&D employees overseas increasing sharply for most MNCs but so did the number of R&D labs also. Japanese MNCs were seen to be the ones leading the trend in establishing R&D labs in Europe, North America and Asia, particularly in the early 1990s. However, since around 1997, a slowdown in the trend towards the establishment of new labs was observed (Gassman and Zedwitz, 1999; Patel, 1998).

According to interview respondents the slowdown in the number of overseas R&D labs has to do with the attempt by MNCs to rationalize their international R&D facilities into a few leading centers to make them more effective and efficient. Coordination problems, escalating costs and time overruns are the main drivers of this new trend. Many of the smaller labs were closed, merged with other labs or divested, and larger labs were being created. These are now called corporate labs.

An examination of the R&D organization charts presented in Figure 8.4 reveal that most companies have corporate labs covering an entire country or region and they tend to focus on a specific technology group or platform. For example, the company represented by the chart shown in Figure 8.4.1 now has 7 corporate labs compared to dozens of small R&D facilities which were previously located in profit-centers around the world. Similarly, the company represented by chart 8.4.2 has two regional labs – one in Europe and one in Japan and both of these labs do all the R&D for their respective regions on both of the company's two technology platforms. The company represented by Figure 8.4.3 has two corporate labs – the Central Research Lab and the Advanced Research Lab, three major research centers, and 20 R&D labs around the world instead of 35 small labs which it had previously.

In many of the companies, the corporate labs work on platform technologies which are then transferred to other local labs which do the adaptive R&D to suit the culture of the local market. For example, in one automotive MNC, the R&D for the chassis and other key 'invisible parts' are done at the HQ and the local labs perform regional differentiation of the 'visible parts'.

8.2.5 Organizational Structures Revisited

It is reasonable to question whether the organization charts presented in Figure 8.4.1 to 8.4.11 are really different or they seem different due to different graphics. It is contended here that, although there may be some similarities, there are fundamental differences among the structures. For example, the R&D organizations represented by Figures 8.4.1 and 8.4.2

share the common element of having corporate labs organized by country and technology. However, in Figure 8.4.2 there is another layer of labs, some of which tend to perform work across more than one technology platform and country. These labs tend to have a more global rather than local focus and may report to another individual at HQ depending on the strategic significance of the projects the labs are involved in.

Also, it is acknowledged that some of the organization structures described above share elements that are characteristic of the hybrid structure, matrix structure and project structure, and this could lead one to characterize the labs as such. It is not unusual for the R&D organization of a MNC group to display characteristics of the hybrid, matrix and project structure simultaneously. Consequently, it is contended here that the organization structures described above are much more complex than either the hybrid, matrix or project structures. The following arguments are advanced in support of this view.

First, the labs tend to combine features from a variety of structures in order to create flexibility and to increase their effectiveness and efficiency. So while the R&D organization chart shows corporate labs according to geographic location and technology platforms, the labs may employ ad hoc international project teams for specific technologies that may or may not be related to the technology platform of the country where the team is located. For example, one Japanese corporate lab in the U.K. whose primary focus is fundamental research into future semiconductor technologies became responsible for a group of scientists who were located in another part of the U.K. but were working on a European Union

ESPRIT project involving MITI¹, several European partners and the lab's scientists. The project was initiated in Japan but the U.K. lab became partly responsible for the project because of its proximity to the European partners. The project was not in semiconductor technology and was mostly applied R&D. In this example, the appropriate structure to describe this arrangement is unclear.

Second, in one company all its scientists and engineers from across the world are placed in an international pool headed by a single director who then assigns them to projects in different parts of the world. Regardless of where they are located, the scientists and engineers report to the director of the international pool. Upon completion of the project, the engineers and scientists return to the pool and is subsequently reassigned to another usually more significant project. This is really a virtual pool because the scientists are located in their home country and may also report their home lab. In some instances, the scientists may report to the project leader, the R&D manager of the lab, and the director of the international pool, depending on the project they are assigned. In this setting, there is no 'fixed' structure as such.

Third, the rate at which these ad hoc international project teams are created and disbanded as well as the composition and reporting relationships of team members rarely fit either the project, hybrid or matrix structure as described in standard organization theory texts (Daft, 1998). The fluidity of the structures coupled with the mix of formal and informal structures are unique features of these newer forms of structures. It is not unusual to find that in a single lab some of the scientists and engineers are working on local projects and reporting to the

¹ Japan's Ministry of Trade and Industry.

lab's managers while another set located at the same lab is working on a global project and reports to someone else in another lab.

Summarizing the preceding discussion, it is argued here that the superimposition of a wide array of informal structures on the formal structures tend not only to blur the distinction among the various formal structures but also to increase the complexity of the resulting structures. This then raises an issue regarding the appropriateness of existing organization theories as analytical tools for understanding modern R&D organizations; an issue which is considered to be outside the scope of the present study.

Figure 8.4 Sample R&D Organizational Charts

Figure 8.4.1

Figure 8.4.2

VPs are co-located at HQ labs, but travel a lot.

Figure 8.4.3

Figure 8.4.4

Figure 8.4.5

Figure 8.4.6

Figure 8.4.7

Figure 8.4.8

Figure 8.4.9

Former Organization	Company 1	Company 2	Company 3
New Organization	One platform per product classification		
	Platform 1	Platform 2	Platform 3
Each company has its individual			
Design	X	X	X
CAD System	X	X	X
Technological Know How	X	X	X
Launching	X	X	X
SE Structure	X	X	X
TC Structure	X	X	X
Goal	Individual products with high quality and low cost		

Figure 8.4.10

Figure 8.4.11

Figure 8.4.12

Chapter 9

Coordination Structures in International R&D

9.1 Coordination Issues and Structures

The previous chapter describes some of the structures MNCs use to organize their international R&D activities. This chapter extends the discussion by examining a broader range of strategies used by MNCs to *coordinate and integrate* their international R&D. Basically, this chapter focuses on how decentralized labs and projects are brought back together into a well-functioning whole.

MNCs employ a host of formal, informal and quasi-formal strategies to coordinate and control their international R&D activities. Table 8.9 combines information obtained from the survey questionnaire, telephone interviews, supplementary information provided by some respondents, and information downloaded from the web sites of the companies and labs in order to give a flavor of the array of strategies employed.

Table 9.1

Coordination and Integration Structures of International R&D

Formal Structures:	
<i>Organization Structures:</i>	Reporting relationships and control of decision-making process.
<i>Coordinating Bodies:</i>	Strategy groups, cross-national committees, liaison persons, integrators, integrating departments or teams, overseas R&D office, executive VP for overseas R&D, Central Project Management office, International Project Management Department.
<i>Formalization:</i>	R&D policies, project management manuals, job descriptions, progress reports on projects, routine reporting on labs' activities, 'workbooks' with the specs and request for changes for a technology system.
<i>Strategic Planning:</i>	Setting short- and long-range R&D priorities and programs, allocating R&D funds to labs, allocating R&D projects to labs, establishing R&D portfolios for labs, global human resource planning, virtual project management pool.
<i>Operational Control:</i>	Controlling R&D projects schedule and budget, evaluation of R&D programs of labs, controlling flow of R&D information.
<i>Contract Research:</i>	Deciding which labs do contract research and which do independent research and to what extent.
Quasi-Formal Structures:	
Multi-functional, cross-national R&D teams.	
Special teams with specific mandate and limited life span.	
Strategic projects, core projects, technology platforms and contribution projects.	
Promoters	
Technology clubs	
Visiting Researcher Program	
Informal Structures:	
<i>Informal Networking:</i>	Personal contacts among R&D managers, scientists and engineers Exchange visits among labs' managers, scientists and engineers Yellow pages, who-is-who lists, knowledge maps, gatekeeper meetings Science and technology fairs Conferences, seminars and workshops Exchange of R&D staff
<i>Socialization:</i>	Shared goals, missions, values, norms and strategies Job rotation, rewards and incentives, social and cultural events Training and personal development, language training, cultural sensitivity

According to interviewees, some companies have used some of these structures quite successfully, while others have been less than successful. They contended that companies should not employ a particular technique or imitate the strategy of another company just because it was used successfully in the other company. Instead, managers should carefully study and understand their company and then select structures that are compatible with their own systems, processes, and corporate culture. Top management support and dedicated resources are necessary for successful implementation. Thus, it seems that the success of any of the strategies described in Table 8.9 is contingent upon how the particular strategy is implemented, among other considerations.

Many interviewees were also emphatic in stating that companies with the most successful international R&D programs are those that are able to complement their formal structures with appropriate informal and quasi-formal structures. Almost all of the participating companies in this study made extensive use of quasi-formal and informal structures to coordinate and integrate their global R&D activities. Japanese companies tended to rely more on formal structures than either European or North American MNCs. Decision making among Japanese companies is much more centralized and a larger proportion of sensitive R&D is kept at home. According to one respondent, Japanese companies make greater use of coordinating committees with senior R&D and corporate personnel and hold more regular meetings. It has been his experience that the President of a Japanese MNC attends some of the strategy meetings on a regular basis.

Another respondent observed that many European MNCs underestimate the importance of informal and quasi-formal mechanisms in coordinating their international R&D programs. Instead, they rely more on internal contract research with their SBUs and divisions as a means to coordinate research efforts.

It is important to note that the labs made extensive use of electronic communication technologies throughout all organizational levels (i.e., top management, project managers, and scientists and engineers). Face-to-face communication was also used at all levels but with less frequency. These communication efforts were complemented with regular visits to each other's labs and exchange of R&D personnel. Although, no discernable pattern was detected in the rating of the extent to which some of these elements were used formally or informally, labs of North American MNCs tended to be more informal than those of Japanese MNCs. According to one very experienced respondent, face-to-face communication is an important prerequisite for the effective use of electronic communication media – it helps when you can attach a face to a voice.

The survey questionnaire asked respondents to report the problems they experience in collaborating with other labs within the MNC group. The majority stated that linguistic difference, time zones and lack of knowledge about subtle aspects of other labs' culture are the main problems. For instance, one American respondent reported that in his experience "the French scientists sometimes prefer more narrowly defined, systematic projects to broader, open-ended projects which many Americans prefer." The same respondent also noted that "it is extremely difficult to buy people off in Japan." Many respondents stated that

substantial progress has been made in reducing cultural problems, through the implementation of various training programs. Such programs include language training, holding debriefing sessions with staff members upon their return from overseas visits, having external consultants (e.g., university professors provide cultural training sessions to their employees), and having a more cross-national interdisciplinary top management team. One respondent noted that the experience gained from having several interdisciplinary, cross-national teams working together has virtually eliminated all the squabbles they had which was attributed to cultural differences.

9.2 Modeling Coordination Structures

An interesting observation emerging from this study is that the majority of companies represented by the organization charts displayed in Figure 8.4 in the preceding chapter characterize their R&D organization as a network. Yet, the charts look more like hierarchies than networks as portrayed in Chiesa (1996), Medcof (1998) and Gassman and Zedwitz (1999).

According to one R&D vice president, hierarchies evolve over time and cannot be dismantled overnight without putting the organization at risk. Restructuring is a painful and demoralizing experience and many MNCs only go that route when they are “forced” to do so. In his view, because managers are not always willing to get rid of hierarchies for fear of loss of control, they look for other ways to complement the hierarchy. Hence, the proliferation of informal structures. He believed that it is the pervasiveness of these informal and quasi-formal structures across all levels in the organization that has led to the description of the

network organization. Not that the hierarchy has been replaced with a new structure called the network structure.

If this reasoning is accurate, then it seems that researchers ought to, then, keep in mind what “network structure” really means and not to ascribe to it characteristics that it does not possess. It would appear from this study that the network structure as described in the international R&D literature or even the international management literature is more an idealized state and different organizations are at different states in moving towards that idealized state.

Figure 9.1 depicts the basic elements of the coordination structure of international R&D emerging from this study. This model suggests that there are four inter-linked and interdependent elements to be considered in managing international R&D in the multinational corporations. The first element, the globe, indicates the global character of R&D, the second element, the hierarchical structure, explicitly recognizes the existence of formal structures in establishing and organizing international R&D, the third and fourth elements, the two boxes, are complementary to and superimposes on formal structures. The ellipses are symbolic of the interactions and networking among globally dispersed R&D units. In essence, this model recognizes that international R&D is a very complex activity arising from different time zones, cultures, geography, and other conditions, and that reliance alone on a formal structure is an ineffective way to manage these complexities. MNCs could achieve greater efficiency and effectiveness in their efforts to leverage their worldwide

capabilities by complementing the formal structure with informal and quasi-formal structures.

The uniqueness of the modeling framework depicted in Figure 9.1 is that it represents a major shift in the fundamentals of organizational analysis away from the bureaucratic model of command and control through the formal structure to substantially less formal structures. Also, unlike more recent formulations that are based on the network structure, this model framework presents a more realistic and practical way of analyzing organizations. The explicit recognition of the formal bureaucratic structure upon which is superimposed the informal structure stands in contrast to the notion that the network structure has somehow replaced the formal structure. This conceptualization is not supported in this study.

Figure 9.1

Model of Coordination Structures in International R&D

Chapter 10

Discussion and Implications of Results

10.1 Introduction

This study investigated the relationship between certain structural features used by MNCs to organize, coordinate and control their internationally dispersed R&D activities and the extent to which these structural elements have enhanced the capacity of MNCs to generate synergistic innovations. Several important findings have emerged from this study. These findings and their implications for research and the management of international R&D in MNCs are discussed in this chapter. The findings are not presented in any particular order of importance. Discussion of the statistical results are based on PLS Model 2.

10.2 Importance of Structural Elements

The key question addressed in this research is the extent to which four structural elements of subsidiary R&D labs – autonomy, formalization, socialization, and communication - together provide reasonable explanation of variations in synergistic innovative capacity. The results of this study indicate that approximately 40 percent of the variation in synergistic innovative capacity is accounted for by these four structural elements. This finding, thus, underscores the importance of these structural elements in the management of international R&D activities. It is believed that this result is quite impressive since other factors which may impact synergistic innovative capacity was not included in the study. These factors include external collaborations that the MNC may have with other external organizations,

collaborations between R&D labs and other SBUs and divisions of the MNCs, research intensity, and size.

The relationship between the four structural elements and synergistic innovative capacity is discussed below.

10.3 Synergistic Innovative Capacity

This study proposed and empirically tested the validity of the notion that synergistic innovative capacity in large, complex MNCs with internationally distributed R&D activities can be measured as a single construct. The findings indicate that synergistic innovative capacity has four distinct dimensions which together describe the innovative capabilities resulting from greater collaboration among R&D labs (See Figure 10.1)¹. The four dimensions can be thought of as four indices of innovative capacity. Thus, researchers can now use these indices rather than relying on single measures or a couple of unrelated measures to analyze innovative capacity. Although more studies may be needed to validate and refine the indices, this study provides a useful starting point for further research. Each of the four indices of innovative synergy is discussed below.

10.3.1 Strategic R&D Synergy

Strategic R&D synergy is defined as the extent to which collaborations among R&D labs have resulted in increased participation by these labs in a larger number of complex projects

¹ Figure 10.1 is identical to Figure 7.2 which was discussed at length in Chapter 7. It is shown here again for the convenience of readers in following the discussion on the implications of the Findings.

instead of projects involving product adaptations or modifications. For the majority of companies, complex projects usually involve cutting- edge technologies which have

Figure 10.1
Empirical Model of Synergistic Innovative Capacity

implications for the future directions and competitiveness of the companies. The three variables that impacted positively on the ability of research labs to create strategic R&D synergy are socialization, autonomy and in-person communications. These three variables can be viewed as being mutually reinforcing because socialization and communication tend to increase awareness regarding the range of available projects within the MNC group while autonomy gives labs the flexibility to choose projects and partners it wants to be associated

with. Also, greater socialization and in-person communication imply greater interactions among labs which tend to open-up new opportunities for the labs to get a better idea of how the work they do complement each other and how they can foster closer collaborative relationships.

Socialization and in-person communication are important for building-up a lab's social capital, that is, the extent of its informal networks. These informal networks generally make it easier for labs to share their R&D resources and ideas for their mutual benefit. Also, when labs have closer and wider informal networks they can access resources much more quickly and easily because they can call on their contacts any time for help with the technical aspects of projects. Through these informal networks, labs can learn of other projects in which they would like to participate in. For instance, the New York lab of an American film company launched a project to develop a high speed, high quality film but were having difficulties with their holographic images. The project was stalled for a while until one team member recalled that he had met a scientist in their lab in Germany who has worked on this technology previously. He contacted the scientist in Germany by telephone and within a few days he was at the New York lab trying to get the project back on track. Through this experience, the two labs began collaborating on other advanced projects in this area.

Although the findings reported here regarding the relationship between strategic R&D synergy and the three variables are not strictly comparable to those reported in other studies, a strong, positive association between innovative activities, autonomy, socialization and inter-unit communication among subsidiaries of MNCs was reported in Bartlett and Ghoshal

(1990), Brikshaw and Morrison (1995), Brockhoff and Schmaul (1996), and Pearce and Papanastassiou (1996).

10.3.2 Managerial and Operational Synergy

Managerial and operational synergy is defined as the extent to which the efficiency of a lab's managerial and operational resources are enhanced as a consequence of working collaboratively with other labs. Formalization and in-person communication among subsidiary labs appear to have had a positive effect while autonomy and electronic communication had a negative effect. This suggests that greater synergy in resource utilization is achieved when collaboration is conducted within a structured context. That is, when the procedures for collaboration and reporting are defined. A structured context for collaboration combined with personal interactions seem to facilitate improved understanding and trust among the labs which in turn has minimized conflicts and unnecessary delays to resolve conflicts. In these circumstances, greater synergy is achieved because the labs feel more comfortable working with the other labs and are more willing to share information, resources, and personnel with each other. By sharing knowledge, resources and personnel, the labs are able to minimize delays in trying to locate needed resources or personnel. One respondent opined that networking, if done properly, can direct a development project along new paths, or highlight the impossibility of others, which in turn saves time, costs, efforts, and frustration. In another company, the collaborating labs created several specialized databases based on the project they were working on. This database resulted in substantial savings when it was used subsequently by other project teams. The combined effects of all of these have resulted in the labs realizing greater managerial and operational synergy.

The negative impact of autonomy on managerial efficiency is consistent with the view that autonomy is intended to give labs the flexibility needed to deal with uncertainty and complexity rather than to increase their efficiency. According to transaction costs theory greater efficiency is achieved in centralized organizations as opposed to decentralized organizations because of reduced transaction costs (Mintzberg, 1979; Brooke, 1992; Stopford and Wells, 1992; Rugman, 1994). Since autonomous labs have greater freedom to decide whether or not to collaborate or the nature of their role in a collaborative partnership, they may be more selective in their collaborative projects choosing only those ones that is most beneficial to them and rejecting the others irrespective of efficiency considerations. Under these circumstances, the impact on managerial and operational synergy may be limited.

The negative effect of electronic communication among subsidiary labs suggest that either it is an ineffective communication medium or that subsidiary labs have not yet mastered the art of using technologically supported communication to their advantage. An examination of the frequency of technologically supported communication revealed that labs communicate by electronic media on a daily basis across all three organizational levels (i.e., managers, project leaders, and scientists and engineers). E-mail communication is by far the most common and the least costly technologically supported method of communication. The ease of communicating by e-mail has encouraged excessive and unwarranted communication resulting in managers, project leaders and scientists spending an inordinate amount of time reading and responding to e-mails, thus reducing the amount of time spent working on projects. According to some interviewees, it is not unusual for them to receive in excess of 50 e-mails each day in addition to faxes and telephone calls. Previous research has also found

that it is much more difficult to communicate technical information and tacit knowledge through technologically supported media (Stock *et al.*, 1996; Inkpen, 1997; Reger, 1999).

10.3.3 Knowledge Creation and Management Synergy

Knowledge creation and management synergy is defined as the extent to which collaboration has increased the ability of R&D labs to create new knowledge and to harness that knowledge for the creation of new products and competencies. It is the ability of labs to leverage knowledge, ideas, people, technology, and organizational competencies and systems for the creation of new, more successful innovations. This study found that knowledge creation and management synergy is facilitated through greater socialization and communication among the labs. Both face-to-face and technologically supported communications are important in this process.

Greater interaction, particularly in-person interaction, is touted as the most effective way to transfer tacit knowledge. Explicit knowledge such as blueprints, databases, and written reports are more effectively and efficiently transferred through technologically supported media. Greater socialization among managers, scientists and engineers of internationally dispersed labs builds trust and facilitates the sharing of information, ideas, technologies and people among collaborating partners. Knowledge generation is fostered through job rotation, exchange visits, top management team diversity, language training and other approaches that bring people together.

Knowledge sharing creates a heightened awareness among labs regarding the range of expertise, projects, and collaborative opportunities present within the MNC group. This awareness has resulted in many successful collaborative partnerships as evidenced by the high rating given by respondents on the question relating to the extent to which collaboration has increased the success rate of new products. The high rating on questions regarding the extent to which the quality of the labs' products and production processes have improved indicate the extent to which the labs were successful in leveraging knowledge from across the MNC group.

Interviewees also provided several examples where the MNC group was able to successfully develop and launch several new products which would not have happened if they were not able to harness the expertise from several of their labs from across the world. Interviewees provided several anecdotal stories of how Japanese MNCs have used their US and European labs to leapfrog into the area of digital technology when they realized that they were behind the US and Europe in this technology field. Despite the success of the labs in creating knowledge management synergy, one respondent opined that MNCs have not been able to realize the full potential of their collaborative efforts. In his view, MNCs are good at creating new knowledge and disseminating this knowledge but they have not invested the time and resources to protect this knowledge; it goes out the door every time an employee leaves the company. Also, only a small fraction of the knowledge generated gets translated into new innovations. He expressed serious reservations regarding the efficiency of the approaches used by many MNCs to manage their knowledge resources and intellectual capital.

10.3.4 Innovative Proficiency Synergy

Innovative proficiency synergy is defined as the extent to which collaboration has increased the capability of R&D labs to generate new and successful innovations quicker and at lower costs. Autonomy of subsidiary labs and socialization among managers and employees of worldwide labs had a positive effect on innovative proficiency synergy, while formalization had a negative impact. These results are consistent with existing findings concerning the drivers of innovative proficiency. For example, Nohria and Ghoshal (1997), Bartlett and Ghoshal (1989), Medcof (1998), and Asakawa (1996) show how too much formalization reduces the flexibility of an organization to respond to rapid changes in dynamic, complex environments. The negative relationship observed here suggests that the level of formalization in the form of monitoring and reporting is perceived by the labs to be excessive and is, therefore, reducing their ability to respond quickly to changes in their environments.

The positive effect of socialization in creating synergy in innovative proficiency suggests that labs have successfully used their informal networks to generate new ideas and products more proficiently. This may be possible through timely access to necessary resources, referrals, and expertise within their MNC group. Knowing who in the company has what expertise which the lab needs and having the relationship to access the expertise can certainly reduce search time and costs. It is also not unusual for labs to access very specialized and costly expertise at very low costs from partner labs through their informal networks or personnel exchange programs. This could result in project stoppage or delays for these reasons to be minimized. The example of the American film company described earlier is also instructive here.

The positive effect of autonomy on innovative proficiency synergy indicates that labs which are free to make decisions regarding their project portfolio, human resources, and collaborative partners are likely to be more proficient at generating new and successful innovations. Labs with this freedom will have greater flexibility to decide which ideas or projects to pursue, the resources to commit to the projects, the personnel to be assigned to the projects, and when to modify, shelve or abandon the projects. Also, knowing that they have this freedom, labs may have a greater impulse to explore new ideas and technologies which it may not be able to pursue otherwise. Labs without this freedom may have to wait for instructions, approval and resources from someone other lab and this could result in long delays or potentially good projects not being approved. This finding is consistent with those reported by Nohria and Ghoshal (1997), Brockhoff and Schmaul (1996) and Birkinshaw and Morrison (1995) regarding the positive relationship between innovations and autonomy of subsidiaries of MNCs.

The positive effect of autonomy on innovative proficiency synergy indicates that autonomous labs did not used their autonomy to work on projects of their own choice independently. Instead, it appears that the labs have recognized the mutual benefits of working interdependently with other labs and have actually pursued collaborative projects which turned out to be successful. The data indicate that the labs have had extensive formal and informal working relationships with several other labs. On average, the labs in this study indicated that they have collaborated with 3 other labs, sharing technological and scientific information, visiting each others' labs, and exchanging R&D personnel.

10.3.5 Moderating Variables

In the theoretical model of this study, it was proposed that four constructs, trust, cultural diversity, environmental uncertainty and the resource levels of the labs would have moderating effects on synergistic innovative capacity. This proposition was not supported by the statistical analysis. In fact, it appears that the effects of these constructs on synergistic innovative capacity are better accounted for through their effects on two other exogenous constructs, namely, autonomy and socialization. Within the conceptual framework of this study, there is greater statistical support for treating these variables as antecedents to synergistic innovative capacity as displayed in PLS Model 2.

A review of the literature on organizational design indicates that from the point of view of resource dependency theory and contingency theory, autonomy is determined by the level of resources at the disposal of the organizational unit and the complexity of its environment. Similarly, trust and cultural diversity are important in facilitating socialization. In light of the statistical results and the theoretical plausibility of the model tested in this study, the initial theoretical model is refined accordingly (Figure 10.1).

10.4 Coordination and Control Structures

This study finds that MNCs use a wide array of formal, informal and quasi-formal structures to coordinate and control their international R&D activities. The notion that MNCs replace their companies' hierarchical structure in favor of the network structure is not supported by the findings of this study. Instead, most, if not all, MNCs seem to retain their hierarchical

structure but complement it with a variety of quasi-formal and informal structures. This finding calls into question the appropriateness of the much touted 'network model' as an analytical tool for analyzing the R&D organizations of MNCs. Alternatively, as stated earlier, this suggests that researchers ought to be careful not to assign characteristics to the 'network model' which it does not possess. It seems that a more realistic analytical framework is one that explicitly incorporates the complementary role of quasi-formal and informal structures in supporting and transcending the hierarchy.

It is not the intention of this study to suggest that MNCs have not made changes to the hierarchy to make it more effective and efficient. However, the notion that they have replaced it is simply not tenable. The characterization of the MNCs R&D organization as a network in the popular press and by some academics could be attributed to the widespread use of informal networks to an extent never seen before, rather than fundamental structural changes in the hierarchy.

10.5 Re-centralization of R&D Activities

This study finds evidence supporting the view that a new trend towards re-centralization of international R&D activities has been emerging over the last couple of years. After establishing several small R&D labs in many countries, MNCs from all regions are perhaps finding it extremely difficult to effectively coordinate them. Duplication and waste is another major driver of the trend towards re-centralization. A large number of MNCs in this study have either closed, divested or merged many of their smaller R&D labs and have created several larger labs, called corporate labs, in specific countries or regions and around specific

technology or technology platforms. It is the contention of this study that the trend towards the recentralization of R&D activities has more to do with the inability of MNCs to generate the synergy expected from their global operations than merely duplication or waste of resources. In other words, duplication and waste of resources is merely the symptom and lack of synergy is the real problem.

Finally, the *HQ-Subsidiary* characterization of the R&D organization used in this study is increasingly becoming irrelevant. Future studies involving MNCs R&D organization should reflect the new and growing taxonomies being used to describe the MNCs R&D organization (i.e. central research, corporate labs, regional labs, individual labs, support labs, etc).

10.6 Future Research

As stated in the beginning, this research represents one of the earliest attempts to study the link between certain organizational characteristics of internationally dispersed R&D labs and the innovative performance of these labs. Consequently, more studies along the lines of this study using MNCs from other industries and larger samples are needed to confirm the findings of this study, and to extend the body of knowledge on this issue. In-depth case studies of leading-edge organizations could also prove quite useful. Future studies should also ‘experiment’ with different data collection and analysis approaches.

There is a need for more conceptual research models in order to provide greater understanding of how and why MNCs decentralize their R&D activities globally. A review

of literature revealed the imbalance of the research focus and a bias towards empirical research.

Despite the volume of research on how MNCs organize and manage their global R&D activities, several managers indicated that still there are very few studies that have resulted in practical solutions to their management dilemma. Studies with a more managerial rather than academic focus, it seems, will help in this area. Studies aimed at benchmarking best practices in international R&D management may be quite useful.

In response to competitive pressures, MNCs in the early 1980s have moved away from the centralized approach to more decentralized approaches in organizing their R&D activities. It was found that since the mid-1990s MNCs have begun to re-centralize their R&D. The drivers of this trend and the future directions of the MNC R&D organization will make for interesting research.

More studies are needed to develop appropriate measures to evaluate the innovativeness of overseas R&D in order to provide a concrete basis to judge the effectiveness of internationalizing R&D activities. Several managers expressed skepticism believing that this is yet another marketing gimmick and the benefits do not justify the effort and costs of internationalizing R&D.

Although this study did not address the public policy implications of global R&D, there are many public policy challenges that require further investigation. The impact on the

competitiveness of the country of foreign takeover of local R&D labs and when local companies do the bulk of their R&D offshore are two such issues.

CHAPTER 11

BENEFITS AND LIMITATIONS

11.1 Benefits

This study contributes to on-going academic research on the internationalization of R&D in several ways. First, this study is the first to empirically investigate the link between the structural attributes of subsidiary R&D labs and the synergistic innovative capacity of these labs using a cross-section of research-intensive MNCs. The results of this study underscore the importance of these variables in understanding how MNCs leverage their worldwide capabilities to create synergy among its globally distributed R&D labs. The study also points to the need to explore other constructs such as collaborations with external organizations, internal collaborations between R&D and other SBUs and divisions of the MNCs, and R&D intensity. This study also provides confirmatory support for a number of propositions advanced by other studies, particularly with respect to the relationship between the structural variables and innovations.

Second, this study is the first to develop and empirically test the validity of the idea that a single index can be used to measure synergistic innovative capacity, rather than a series of ad hoc and sometimes unrelated measures. Most commonly used single measures in previous studies include cost of innovations, newness of innovations, number of innovations, and type of innovations. The finding that synergistic innovative capacity is a multi-faceted construct with four key dimensions is instructive and could be used as a starting point to study innovations in a broader, more rigorous way. Further research to refine the individual measures of each of the four dimensions and the four dimensions themselves are needed.

Third, this study is the first to adopt a structural equation modeling approach to analyze the relationship between synergistic innovative capacity and various structural variables. Most other studies used traditional multivariate techniques such as regression, factor and cluster analysis or are based on qualitative analysis. PLS analysis adopted in this study is statistically more appealing than the traditional multivariate techniques particularly when sample sizes are small; a situation that is so characteristic of research in technology management, and international R&D in particular.

Fourth, this study provides an alternative analytical framework to the network model for understanding and analyzing MNCs R&D organization. The framework explicitly allows for the incorporation of the hierarchy in the analysis instead of assuming it does not exist.

Fifth, this study provides useful ideas that can be adopted in the design of future studies in the area of international R&D. For example, the growing irrelevance of the description *HQ-Subsidiary Labs* can be avoided and some of the more current taxonomies adopted. Similarly, the empirical model derived from the PLS analysis can be a starting point guiding future analysis. The range of research topics emerging from this study could guide future investigation in the area of international R&D management.

From a practical point of view, this study presents managers with findings which could be used to structure and better coordinate their global R&D activities. For example, knowledge of how the structural constructs affect the innovative capacity of R&D labs could be used to decide on what are the most appropriate coordination structures for labs with certain characteristics.

11.2 Limitations

The time and cost involved in conducting this study imposed severe constraints on what can be done within a realistic timeframe and budget. One of the outcomes of these constraints is the relatively small sample size, which, in turn, proved to be a major constraint in conducting certain types of quantitative analyses. For example, it was not possible to conduct regression analysis with the appropriate number of interaction terms in a single regression model.

The small number of HQ respondents also restricted the ability to perform analysis between HQ respondents and subsidiary lab respondents. Thus, some of the evidence presented here may not directly apply to HQ labs.

Also, since the study participants were mainly from large research-intensive MNCs in only three sectors, it cannot be stated with any confidence whether the findings apply to smaller MNCs within these industries or to MNCs from other industries.

Finally, since this study investigated only the structural aspects of the R&D organization of MNCs, it was limited in its capability to explain the impact of other related constructs such as inter-firm collaboration and R&D labs collaboration with other business units and divisions of the MNC group. Both of these dimensions could influence synergistic innovative capacity.

Chapter 12

Conclusion

This research examined the extent to which networking among R&D labs enhances the synergistic innovative capacity of MNCs. Networking includes both the formal and informal relationships among the labs of an MNC. In complex, multi-unit organizations such as MNCs, these relationships can be expressed in terms of the degree of autonomy, formalization (Pugh *et al.*, 1967), socialization (Schein, 1967; Ouchi, 1980; Edstrom and Galbraith, 1977), and communication among the labs (Thompson, 1967; Bartlett and Ghoshal, 1986; Nohria and Ghoshal, 1997). Communication was analyzed as communication between HQ and subsidiary labs and communication among subsidiary labs.

Four variables were investigated as having a moderating effect on the relationship between the structural elements and synergistic innovative capacity. These are the level of trust among the labs, cultural diversity, resource levels of the labs, and uncertainty of the labs operating environment. Synergistic innovative capacity was conceptualized as a unidimensional construct comprising of 13 items identified from the innovation management literature.

This study was based on a sample of 79 R&D labs owned by North American MNCs, European MNCs, and Japanese MNCs. These labs were from the electrical, electronics, telecommunications, computing, pharmaceutical, chemical, and automotive industries. The data was collected through a survey questionnaire but was complemented with qualitative and archival data provided by respondents.

The principal data analysis methods used were ANOVA, MANOVA, multivariate regression, factor analyses, and Partial Least Squares (PLS) analysis. Although the results from PLS are not strictly comparable to that obtained from regression and factor analyses, there is a fair amount of consistency of the results obtained from the different analyses. Essentially, they portray a similar picture.

The results indicate that the dependent construct, *synergistic innovative capacity*, is multi-dimensional and not unidimensional as was initially conceptualized. Basically, networking among internationally dispersed R&D labs resulted in the achievement of four distinct types of synergy, as follows:

1. Strategic R&D Synergy
2. Managerial and Operational Synergy
3. Knowledge Creation and Management Synergy
4. Innovative Proficiency Synergy

Together, the four structural elements characterizing R&D labs explains just under 40 percent of changes in synergistic innovative capacity. The analysis also suggests that the effects of the four moderating variables are much more substantial when they are treated as antecedents to the independent variables. In particular, when the moderating variables, *resource levels* and *environmental uncertainty*, are analyzed as influencing autonomy, and *trust* and *cultural diversity*, as influencing socialization.

It was found that the independent variable *socialization* has a strong, positive impact on *strategic R&D synergy*, *knowledge creation and management synergy*, and *innovative proficiency synergy*. In the regression analysis, *socialization* had a similar effect on these four components. *Autonomy* had a positive influence on *strategic R&D synergy* and *innovative proficiency synergy* but a negative influence on *managerial and operational synergy*. *Formalization* had a positive impact on *managerial and operational synergy* but a negative impact on *innovative proficiency synergy*.

Both in-person and technologically supported communication were important in creating *strategic R&D synergy*, *managerial and operational synergy*, and *knowledge creation and management synergy*. In-person communication among subsidiaries had a positive effect on all three components while technologically supported communication among subsidiaries had a negative impact. HQ-Subsidiary communication, both in-person and technologically supported, had a strong, positive influence on *knowledge creation and management synergy*.

The qualitative data revealed that MNCs applied a wide array of informal structural mechanisms to complement the formal structure. The hierarchy still exists in various forms but is complemented and transcended by these informal structures. The pervasiveness of the informal mechanisms across all levels of the organizations has probably led many to describe the R&D organizations as network. The notion that MNCs have replaced the formal bureaucratic structure with a *network structure* was not supported in this study. Researchers should, therefore, be more cautious not to ascribe characteristics to the *network organization* which it does not have.

Like most empirical study in technology management, this study has some limitations which tend to limit its generalizability. One limitation is the relatively small sample size which to some extent reflect the difficulties of conducting a study of this nature given time and budget constraints. The small sample size imposed certain limitations on the type of analyses which was possible. Also, since the labs in this study are from large MNCs within the high-technology sector, care must be exercised in generalizing the findings to MNCs from other sectors or of smaller size.

Despite these limitations, this study is the first to examine the relationship between the structural elements of R&D labs and the innovative performance of the labs in terms of creating synergy. There are still many unanswered questions. This study is only the beginning but its findings could be instructive in guiding future research in this area. The PLS method used in this study demonstrate that even with small samples, researchers can conduct fairly rigorous statistical analyses of multi-item, multi-faceted constructs.

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APPENDIX 1

SUBSIDIARY SURVEY – ENGLISH VERSION

**Creating Innovations through Global Partnerships: A
Survey of the World's Leading Companies**

Dear Sir or Madam:

My name is Ajax Persaud. I am a PhD candidate in the School of Business at Carleton University, Ottawa, Canada. My area of specialization is Management of Technology. I am currently working on my thesis research which examines the extent to which collaborations among the research labs (or units/facilities) of multinational corporations (MNCs) enhance their ability to generate innovations quickly and efficiently.

Reports in the popular press and in academic journals indicate that collaborations among worldwide units of MNCs, if done correctly, could result in substantial benefits to these companies. These same reports also suggest that few companies have been able to organise their global operations successfully. The results of this study could provide valuable insights into how companies manage their global research activities, and the factors that account for their success or failure. Preliminary discussions with managers of some companies reaffirm the need for research of the kind proposed here.

Your company is one of the leading MNCs I have selected to participate in this study. I am *asking that you participate in this study by completing the following questionnaire*. All information provided will be treated in strict confidence. Responses will be aggregated so that no individual person, lab or company will be identified in the final reporting. Your participation will significantly enhance my ability to complete the study in a timely fashion.

Should you need further information, please contact me by phone at (613) 520-2600 ext. 1017 or by e-mail – apersaud@business.carleton.ca. You are also welcome to contact my thesis supervisor, Professor Vinod Kumar, at 520-2379 for further information. A copy of the findings of the study will be sent to interested participants.

Thank you for taking the time to participate in this study. **Please send your reply either by fax or mail.**

Fax: (613) 260-2642

Mail: Ajax Persaud
School of Business, Carleton University
Ottawa, Ontario
K1S 5B6, Canada

Sincerely,
Ajax Persaud

SECTION A

Note: For the purposes of this study, research labs are divided into two categories -- headquarter labs (HQ) and sister labs. HQ lab refers to the parent lab while sister labs refer to all other labs within the company.

1. Over the last two years, has your lab collaborated with other labs within your own company on any R&D project?

1. No → Please go directly to **Question 14** on page 4

2. Yes

2. How many sister labs within your company did your lab collaborate with? _____ (if none, go to question 7)

3. Of all the sister labs you collaborated with over the last two years, in your opinion, how many:

1. Share the culture of your lab in terms of work habits, attitudes and behavior? _____

2. Hold similar goals and management values as your lab? _____

4. Of the labs that share a *similar culture* as your lab, indicate the type of collaborations your lab had with them.

	Informal			Formal		
1. Scientific and technological information exchange	1	2	3	4	5	N/A
2. Joint research as equal partners	1	2	3	4	5	N/A
3. R&D personnel exchange	1	2	3	4	5	N/A
4. Regular visits to each others' labs	1	2	3	4	5	N/A
5. Sharing testing facilities, equipment and so on	1	2	3	4	5	N/A
6. Joint brainstorming and planning meetings	1	2	3	4	5	N/A

5. Of the labs that share a *different culture* as your lab, indicate the type of collaborations your lab had with them.

	Informal			Formal		
1. Scientific and technological information exchange	1	2	3	4	5	N/A
2. Joint research as equal partners	1	2	3	4	5	N/A
3. R&D personnel exchange	1	2	3	4	5	N/A

4. Regular visits to each others' labs	1	2	3	4	5	N/A
5. Sharing testing facilities, equipment and so on	1	2	3	4	5	N/A
6. Joint brainstorming and planning meetings	1	2	3	4	5	N/A
6. What problems would you attribute to cultural differences between your lab and the sister labs you have collaborated with? (Please explain)

7. Did your lab collaborate with the HQ lab?

1. No → Please go to **Question 10** below

2. Yes

8. What has been the nature of the collaboration between your lab and the HQ lab?
Informal

Formal

1. Scientific and technological information exchange	1	2	3	4	5	N/A
2. Joint research as equal partners	1	2	3	4	5	N/A
3. R&D personnel exchange	1	2	3	4	5	N/A
4. Regular visits to each others' labs	1	2	3	4	5	N/A
5. Sharing testing facilities, equipment and so on	1	2	3	4	5	N/A
6. Joint brainstorming and planning meetings	1	2	3	4	5	N/A

9. How complementary is the technology of the HQ lab to the technology of your lab?

Very Little Complementarity
Complementarity

Very High

1 2 3 4 5

10. How many of the labs you collaborated with, did you experience major disagreements/conflicts regarding:

1. Contribution of resources and personnel to the collaboration	_____
2. Ownership of a technology resulting from the collaboration	_____
3. Usage of a technology resulting from the collaboration	_____

11. Please indicate the level of influence the following factors had on your decision to collaborate with another lab within your company.

	No Influence at all Influential			Extremely	
1. Technical competency of the other lab	1	2	3	4	5
2. Complementary nature of the lab's technology to your lab	1	2	3	4	5
3. Your collaboration experience with the other lab	1	2	3	4	5
4. Willingness of the lab to keep its promises	1	2	3	4	5
5. Trustworthiness of the lab's scientists and engineers	1	2	3	4	5

12. (a) Please indicate the *impact* of collaboration on your lab in terms of the following factors:

	Decreased Substantially ↓	Decreased ↓	Not Changed ↓	Increased ↓	Increased Substantially ↓
1. The <i>number</i> of R&D projects your lab undertook has	1	2	3	4	5
2. The <i>number of complex</i> R&D projects your lab undertook has	1	2	3	4	5
3. The <i>range/variety</i> of R&D projects your lab undertook has	1	2	3	4	5
4. The <i>quality</i> of your lab's products has	1	2	3	4	5
5. The <i>technical</i> aspects of your production processes have	1	2	3	4	5
6. The <i>managerial</i> aspects of your operations have	1	2	3	4	5
7. The <i>efficiency</i> of your R&D resources has	1	2	3	4	5
8. The <i>impulse</i> for innovative activities in your lab has	1	2	3	4	5
9. The <i>success rate</i> of new innovations in your lab has	1	2	3	4	5
10. The <i>technical competencies</i> of your R&D staff have	1	2	3	4	5
11. Your lab's <i>access</i> to R&D resources and personnel has	1	2	3	4	5

12. (b) Please indicate the *impact* of collaboration on your lab in terms of the following factors:

	Increased Substantially ↓	Increased ↓	Not Changed ↓	Decreased ↓	Decreased Substantially ↓
1. The <i>cost</i> of R&D in your lab has	1	2	3	4	5
2. The <i>development time</i> for new innovations in your lab has	1	2	3	4	5

13. Please indicate the frequency of communication between your lab and other sister labs.

	Yearly	Quarterly	Monthly	Weekly	Daily
Electronic communication between top managers	1	2	3	4	5
Electronic communication between project managers	1	2	3	4	5
Electronic communication between R&D Staff	1	2	3	4	5
In-person communication between top managers	1	2	3	4	5
In-person communication between project managers	1	2	3	4	5
In-person communication between R&D Staff	1	2	3	4	5

14. Please indicate the frequency of communication between your lab and the HQ lab.

	Yearly	Quarterly	Monthly	Weekly	Daily
Electronic communication between top managers	1	2	3	4	5
Electronic communication between project managers	1	2	3	4	5
Electronic communication between R&D Staff	1	2	3	4	5
In-person communication between top managers	1	2	3	4	5
In-person communication between project managers	1	2	3	4	5
In-person communication between R&D Staff	1	2	3	4	5

15. Please indicate how the following decisions are usually made at your lab:

- 1 = HQ decides alone
 2 = HQ decides, but your lab provides suggestions
 3 = both HQ and your lab have roughly equal influence
 4 = your lab decides, but the HQ provides suggestions
 5 = your lab decides alone

	HQ Decides Alone				Your Lab Decides Alone
1. Making significant changes to an existing product	1	2	3	4	5
2. Modifying a production process at your lab	1	2	3	4	5
3. Restructuring your lab	1	2	3	4	5
4. Recruiting scientists and engineers for your lab	1	2	3	4	5
5. Deciding on the career paths of scientists and engineers	1	2	3	4	5
6. Number of projects undertaken by your lab	1	2	3	4	5
7. Selecting the type of projects undertaken by your lab	1	2	3	4	5
8. Setting project priorities for your lab	1	2	3	4	5
9. Conducting joint R&D with other labs in your company	1	2	3	4	5

10. Sharing information with other labs	1	2	3	4	5
11. Exchanging R&D staff with other labs	1	2	3	4	5
12. Collaborating with organizations <u>outside</u> your company	1	2	3	4	5

16. Please indicate the extent to which each of the following statements apply to your lab:

- | | Definitely
True | | | | Definitely
False |
|--|--------------------|---|---|---|---------------------|
| 1. HQ has provided a set of rules and policies governing collaborations among labs <u>within</u> your company | 1 | 2 | 3 | 4 | 5 |
| 2. HQ has provided a set of rules and policies governing collaborations with organizations <u>outside</u> your company | 1 | 2 | 3 | 4 | 5 |
| 3. HQ has provided a set of rules and policies to deal with conflicts among R&D labs engaged in joint R&D | 1 | 2 | 3 | 4 | 5 |
| 4. HQ monitors your lab to ensure that policies are observed | 1 | 2 | 3 | 4 | 5 |
| 5. Your lab must submit <i>formal</i> progress reports on its <u>overall activities</u> to HQ | 1 | 2 | 3 | 4 | 5 |

17. What percent of your lab's top management:

1. Is from the country where your lab is located? _____ %
2. Is from the home country of your parent company? _____ %
3. Is from a country other than your country or the country of your parent company? _____ %

18. Rate the intensity of competition within your industry in terms of:

- | | Not Much
Competition | | | | Extremely Intense
Competition |
|--|-------------------------|---|---|---|----------------------------------|
| 1. The market for your products | 1 | 2 | 3 | 4 | 5 |
| 2. Recruiting scientists and engineers | 1 | 2 | 3 | 4 | 5 |

19. Indicate the rate of product/process innovations within your industry (not your lab specifically):

- | | Very
Low | | | | Very
High |
|---|-------------|---|---|---|--------------|
| Rate of product/process innovation within our industry is | 1 | 2 | 3 | 4 | 5 |

20. Rate the intensity of competition among the labs of your company for internal corporate resources.

Not Much
Competition

1

2

3

4

Extremely Intense
Competition

5

21. Relative to the average within your company, please rate the overall level of resources available to your lab.

Significantly Lower

1

2

3

Significantly Higher

4

5

22. If due to some sudden development, the total time spent by all your scientists and engineers on R&D were to be reduced by 10%, how seriously will your lab's work be affected?

Output will not be affected: ☐

Output will be reduced by _____ %

23. If due to some similar development, the annual operating budget of your lab were to be reduced by 10%, how seriously will your lab's work be affected?

Output will not be affected: ☐

Output will be reduced by _____ %

24. Which of the following figures best reflect the R&D organization structure of your company? If none applies, please sketch your company's R&D organization structure on an additional sheet of paper.

SECTION B

Demographic data about your lab

25. Home country of your parent company: _____
26. Industry category that best describes the business of your company. (Circle your answer)
1. Electronics/Electrical	2. Telecommunications/Computing	3. Pharmaceutical	
4. Chemical	5. Biotechnology	6. Scientific instruments	7. Aerospace
8. Automotive			
9. Other, Please specify: _____			
27. Country in which your lab is located: _____
28. Year in which your lab was established: _____
29. Total number of R&D employees in your lab in 1998: _____
30. Number of scientists and engineers in your lab with: PhD Degrees: _____ Master's Degrees: _____
31. Number of scientists and engineers with the following experience in their field:
- ☐ Less than 5 years ☐ Between 5 to 10 years ☐ More than 10 years
32. Total R&D budget of your lab in 1998: (in your currency) _____ millions
- Percent of R&D budget spent on: Basic Research _____ % Applied Research _____ %
33. How many patent applications did your lab file within the last 5 years? _____
34. Please provide any other information which you think may improve our understanding of the issues/challenges facing managers in managing global research labs/facilities.

Your contribution to this effort is very greatly appreciated. If you would like a summary of the results, please print your name and e-mail address below.

Your name and e-mail: _____

Please **fax** or **mail** the completed questionnaire to:

Fax: Ajax Persaud (613) 260-2642 (available 24 hours and on weekends)

Mail: Address below.

APPENDIX 2
HEADQUARTER SURVEY- ENGLISH VERSION

**Creating Innovations through Global Partnerships: A
Survey of the World's Leading Companies**

Dear Sir/Madam:

My name is Ajax Persaud. I am a PhD candidate in the School of Business at Carleton University, Ottawa, Canada. My area of specialization is Management of Technology. I am currently working on my thesis research which examines the extent to which collaborations among the research labs (or units/facilities) of multinational corporations (MNCs) enhance their ability to generate innovations quickly and efficiently.

Reports in the popular press and in academic journals indicate that collaborations among worldwide units of MNCs, if done correctly, could result in substantial benefits to these companies. These same reports also suggest that few companies have been able to organise their global operations successfully. The results of this study could provide valuable insights into how companies manage their global research activities, and the factors that account for their success or failure. Preliminary discussions with managers of some companies reaffirm the need for research of the kind proposed here.

Your company is one of the leading MNCs I have selected to participate in this study. I am *asking that you participate in this study by completing the following questionnaire*. All information provided will be treated in strict confidence. Responses will be aggregated so that no individual person, lab or company will be identified in the final reporting. Your participation will significantly enhance my ability to complete the study in a timely fashion.

Should you need further information, please contact me by phone at (613) 520-2600 ext. 1017 or by e-mail – apersaud@business.carleton.ca. You are also welcome to contact my thesis supervisor, Professor Vinod Kumar, at 520-2379 for further information. A copy of the findings of the study will be sent to interested participants.

Thank you for taking the time to participate in this study. **Please send your reply either by fax or mail.**

Fax: (613) 260-2642

Mail: Ajax Persaud
School of Business, Carleton University
Ottawa, Ontario
K1S 5B6, Canada

Sincerely,

Ajax Persaud

SECTION A

The questions in this section seek information on the nature of collaboration between the HQ lab and other research labs within your company over the last two years.

1. How many research labs are there within your company (including those in foreign countries)? _____
2. How many of these research labs did your lab collaborated with on any R&D project? _____
3. How many of the collaborations involve the following:

Scientific and technological information exchange	_____
Joint research as equal partners	_____
Joint research where your lab was the lead partner	_____
Joint research where the other lab was the lead partner	_____
R&D personnel exchange	_____
Sharing testing facilities, equipment and so on	_____
Joint project planning sessions	_____
Regular visits to each others' labs	_____
4. How many of the labs you collaborated with share a similar culture as your lab in terms of work habits and attitudes? _____
5. How many of the labs you collaborated with hold goals and management values that are similar to your lab? _____
6. What problems would you attribute to *cultural difference* between these labs and your lab? (Please explain)

7. How many of the labs you collaborated with over the last two years, did you experience major disagreements/conflicts regarding:

1. Contribution of resources and personnel to the collaboration _____
2. Ownership of a technology resulting from the collaboration _____
3. Usage of a technology resulting from the collaboration _____

8. How influential were the following factors on your decision to collaborate with another lab within your company.

	No Influence at all			Extremely Influential	
1. Technical competency of the other lab	1	2	3	4	5
2. Complementary nature of the lab's technology to your lab	1	2	3	4	5
3. Your collaboration experience with the other lab	1	2	3	4	5
4. Willingness of the lab to keep its promises	1	2	3	4	5
5. Trustworthiness of the lab's scientists and engineers	1	2	3	4	5

9. Please indicate the *impact* of collaboration on your lab in terms of the following factors:

	Increased Substantially ↓	Increased ↓	Not Changed ↓	Decreased ↓	Decreased Substantially ↓
1. The <i>number</i> of R&D projects your lab undertook has	1	2	3	4	5
2. The <i>number of complex</i> R&D projects your lab undertook has	1	2	3	4	5
3. The <i>range/variety</i> of R&D projects your lab undertook has	1	2	3	4	5
4. The <i>quality</i> of your lab's products has	1	2	3	4	5
5. The <i>technical</i> aspects of your production processes have	1	2	3	4	5
6. The <i>managerial</i> aspects of your operations have	1	2	3	4	5
7. The <i>efficiency</i> of your R&D resources has	1	2	3	4	5
8. The <i>impulse</i> for innovative activities in your lab has	1	2	3	4	5
9. The <i>success rate</i> of new innovations in your lab has	1	2	3	4	5
10. The <i>technical competencies</i> of your R&D staff have	1	2	3	4	5
11. Your lab's <i>access</i> to R&D resources and personnel has	1	2	3	4	5
12. The <i>cost</i> of R&D in your lab has	1	2	3	4	5
13. The <i>development time</i> for new innovations in your lab has	1	2	3	4	5

10. In your opinion, how many of the labs within your company perform:

Product modifications/adaptations as their main role (represents 60% or more of their activities)? ____

Product design and development as their main role (represents 60% or more of their activities)? ____

Applied research as their main role (represents 60% or more of their activities)? ____

Basic research as their main role (represents 60% or more of their activities)? ____

Technical information gathering as their main role (represents 60% or more of their activities)? ____

11. In your opinion, how many labs within your company have the freedom or autonomy to make the following decisions exclusively on their own without any influence from either the HQ lab or another lab?

Decisions:

Number of labs:

1. Making significant changes to an existing product	_____
2. Modifying a production process at their lab	_____
4. Recruiting scientists and engineers for their lab	_____
5. Deciding on the career paths of scientists and engineers	_____
6. Number of research projects undertaken by their lab	_____
7. Selecting the type of projects undertaken by their lab	_____
8. Setting project priorities for their lab	_____
9. Conducting joint R&D with other labs within the company	_____
10. Sharing information with other labs within the company	_____
11. Exchanging R&D staff with other labs within the company	_____
12. Collaborating with organizations <u>outside</u> the company	_____

12. Which of the following figures best reflect the R&D organization structure of your company? If none applies, please sketch your company's R&D organization structure below or on an additional sheet of paper.

SECTION B

Demographic data about your lab

13. Home country of your parent company: _____
14. Industry category that best describes the business of your company. (Circle all that applies)
1. Electronics/Electrical	2. Telecommunications/computing	3. Pharmaceutical	4. Chemical
5. Biotechnology	6. Scientific instruments	7. Aerospace	
8. Other, Please specify: _____			
15. Year your lab was established: _____
16. Total number of R&D employees in your lab in 1998: _____
17. Number of scientists and engineers in your lab in 1998 with:
PhD Degrees: _____	Master's Degrees as their highest degree: _____
Less than 5 years experience in their field: _____	
Between 5-10 years experience in their field: _____	
More than 10 years experience in their field: _____	
18. Total R&D budget of your lab in 1998: (in your country's currency) _____ millions
- Percent of R&D budget spent on: Basic Research: _____ % Applied Research: _____ %
19. How many patent applications did your lab file within the last 3 years? _____
20. Please provide any other information which you think may improve our understanding of the issues/challenges facing managers in managing global R&D.

Your contribution to this effort is very greatly appreciated. If you would like a summary of the results, please print your name and e-mail address below.

Your name and e-mail: _____

Please fax or mail the completed questionnaire to:

Fax: Ajax Persaud (613) 520-2532

Mail: Address below.

APPENDIX 3
SUBSIDIARY SURVEY – FRENCH VERSION

“Création d’innovations à travers le partenariat global: Une enquête sur les compagnies tête de file à travers le monde.”

Monsieur/Madame:

Je me nomme Ajax Persaud. Je suis un candidat au programme de doctorat au “School of Business” à l’Université de Carleton, Ottawa, Canada. Ma spécialization est la gestion de technologie. Je développe présentement la recherche de ma thèse qui examine comment la collaboration entre les différents laboratoires de recherche des corporations multinationales (CMN) améliorent rapidement et efficacement leur capacité à produire des innovations.

Les rapports dans la presse populaire et dans les journaux académiques indiquent que les collaborations adéquates entre les différentes unités des CMN peuvent entraîner des bénéfices considérables pour ces compagnies. Ces mêmes rapports suggèrent que très peu de compagnies ont été capables d’organiser leur opérations globales avec succès. Les résultats de cette recherche pourraient apporter un éclairage précieux sur la façon qu’ont les compagnies de gérer leur activités GLOBALES de recherche et les facteurs qui expliquent leur succès ou leur échec. Les discussions préliminaires avec les gérants de certaines compagnies réaffirment le besoin d’une telle recherche.

Votre compagnie est l’une des CMN que j’ai sélectionnée pour participer à cette recherche. Je sollicite votre participation en vous demandant de compléter le questionnaire suivant. Toute information donnée sera traitée dans la plus stricte confidentialité. Les réponses seront compilées de façon à ce qu’aucun individu, laboratoire ou compagnie ne puissent être identifiés dans le report final. Votre participation me permettra de compléter plus facilement cette recherche dans un délai raisonnable.

Pour de plus amples renseignements, vous pouvez me rejoindre par téléphone au (613) 520-2600 poste 1017 ou par courriel à apersaud@business.carleton.ca. Vous pouvez également communiquer avec mon directeur de thèse, Vinod Kumar, au (613) 520-2379. Les résultats de cette recherche seront envoyés sur demande à tous les participants intéressés.

Je vous remercie de votre collaboration. **Vous pouvez faire parvenir votre réponse soit par fax ou par courrier.**

Fax: (613) 260-2642

Poste: Ajax Persaud
School of Business, Carleton University
Ottawa, Ontario
K1S 5B6, Canada

Sincèrement,

Ajax Persaud

Partie A

Note: Pour les buts de cette étude, les laboratoires de recherche sont divisés en deux catégories : laboratoire de la maison mère (MM) et laboratoire associés (LA). Les laboratoires associés (LA) désignent les autres laboratoires à l'intérieur de la compagnie.

1. Au courant des deux dernières années, votre laboratoire a-t-il collaboré à des projets RD avec d'autres laboratoires à l'intérieur de votre compagnie. (LA)
 1. No (allez directement à la question 12 à la page 4)
 2. Oui (continuez le questionnaire)
2. Avec combien de LA à l'intérieur de votre compagnie avez-vous collaboré? (aucun, allez à la question 7) _____
3. Selon vous, combien des LA avec laquelle vous avez collaborés durant les 2 dernières années:
 1. Partagent la culture de votre laboratoire en termes d'habitudes, d'attitudes et de comportement? _____
 2. Partagent des objectifs et des valeurs administratives semblables à celles de votre laboratoire? _____
4. Indiquez le type de collaboration votre laboratoire a eu avec les laboratoires qui partagent une *culture semblable* à celle de votre laboratoire

	informel				formel
Echange d'information scientifique et technologique	1	2	3	4	5
Recherche conjointe à titre de partenaires égaux	1	2	3	4	5
Echange de personnel en RD	1	2	3	4	5
Visites régulières aux autres laboratoires	1	2	3	4	5
Partage d'installations de testing, d'équipement, etc.	1	2	3	4	5
Brainstorming conjoint et planification des réunions	1	2	3	4	5

5. Indiquez le type de collaboration votre laboratoire a eu avec les laboratoires qui ont une *culture différente* de la vôtre.

	informel				formel
Echange d'information scientifique et technologique	1	2	3	4	5
Recherche conjointe à titre de partenaires égaux	1	2	3	4	5
Echange de personnel en RD	1	2	3	4	5

Visites régulières aux autres laboratoires	1	2	3	4	5
Partage d'installations de testing, d'équipement, etc.	1	2	3	4	5
Brainstorming conjoint et planification des réunions	1	2	3	4	5

6. Quels problèmes attribuez-vous aux différences culturelles entre votre lab et les LA avec lesquelles vous avez collaborés (Expliquez)

7. Avez-vous collaboré avec le lab de la maison mère (MM)?

1. Non (Allez à la question 10)

2. Oui (Continuez le questionnaire)

8. Quelle était la nature de la collaboration entre votre laboratoire et le laboratoire de la MM?

	informel				formel
Echange d'information scientifique et technologique	1	2	3	4	5
Recherche conjointe à titre de partenaires égaux	1	2	3	4	5
Echange de personnel en RD	1	2	3	4	5
Visites régulières aux autres laboratoires	1	2	3	4	5
Partage d'installations de testing, d'équipement, etc.	1	2	3	4	5
Brainstorming conjoint et planification des réunions	1	2	3	4	5

9. Quelle complémentarité existe-t-il entre la technologie de la MM et la technologie de votre laboratoire?

Très peu de complémentarité

Beaucoup de complémentarité

1 2 3 4 5

10. Avec combien des laboratoires avez-vous eu des expériences négatives ou des conflits majeurs en ce qui concerne:

- Contribution des ressources et du personnel à la collaboration _____
- Droit de propriété d'une technologie résultant de cette collaboration _____
- Usage d'une technologie résultant de cette collaboration _____

11. Quelle influence les facteurs suivants ont-ils eu sur votre décision de collaborer avec un autre laboratoire à l'intérieur de votre compagnie.

	Aucune Influence				Beaucoup d'influence
La compétence technique de l'autre laboratoire	1	2	3	4	5
La complémentarité de la technologie de ce laboratoire par rapport au vôtre	1	2	3	4	5
Votre expérience de collaboration avec l'autre Laboratoire	1	2	3	4	5
La volonté du laboratoire de garder ses promesses	1	2	3	4	5
La fiabilité des scientifiques et des ingénieurs du laboratoire	1	2	3	4	5

12. (a) S'il vous plaît, indiquez l'*impacte* de cette collaboration sur votre laboratoire selon les facteurs suivants:

	diminué considérablement	diminué	aucun changement	augmenté	augmenté considérablement
1. Le <i>nombre</i> de projets RD que votre laboratoire a entrepris a ...	1	2	3	4	5
2. Le <i>nombre de projets complexes</i> de RD que votre laboratoire a entrepris a ...	1	2	3	4	5
3. La <i>gamme/variété</i> de projets RD que votre laboratoire a entrepris a ...	1	2	3	4	5
4. La <i>qualité</i> des produits de votre laboratoire a...	1	2	3	4	5
5. Les aspects <i>techniques</i> de vos procédés de production ont...	1	2	3	4	5
6. Les aspect <i>gestionnaires</i> de vos opérations ont...	1	2	3	4	5
7. L' <i>efficacité</i> de vos ressources de RD a...	1	2	3	4	5
8. La <i>motivation</i> pour des activités innovatrices dans votre laboratoire a...	1	2	3	4	5
9. Le <i>taux de succès</i> des nouvelles innovations dans votre laboratoire a...	1	2	3	4	5

9. Les *compétences techniques* de votre personnel de RD ont... 1 2 3 4 5

10. L'*accès de votre laboratoire* aux ressources de RD et au personnel a... 1 2 3 4 5

12. (b) S'il vous plaît, indiquez l'*impacte* de cette collaboration sur votre laboratoire selon les facteurs suivants:

	augmenté considérablement	augmenté	aucun changement	diminué	diminué considérablement
1. Le <i>coût</i> de RD dans votre laboratoire a...	1	2	3	4	5
2. Le <i>temps de développement</i> pour des innovations nouvelles dans votre laboratoire a...	1	2	3	4	5

13. Indiquez la fréquence de communication entre votre laboratoire et les LA.

	Annuel	Semestriel	Mensuel	Hebdomadaire	Quotidienne
Communication électronique entre cadre supérieur	1	2	3	4	5
Communication électronique entre gérants de projet	1	2	3	4	5
Communication électronique entre personnel RD	1	2	3	4	5
Communication directe entre cadre supérieur	1	2	3	4	5
Communication directe entre gérants de projet	1	2	3	4	5
Communication directe entre personnel RD	1	2	3	4	5

14. Indiquez la fréquence de communication entre votre laboratoire et le laboratoire de la MM

	Annuel	Semestriel	Mensuel	Hebdomadaire	Quotidienne
Communication électronique entre cadre supérieur	1	2	3	4	5
Communication électronique entre gérants de projet	1	2	3	4	5

Communication électronique entre personnel RD	1	2	3	4	5
Communication directe entre cadre supérieur	1	2	3	4	5
Communication directe entre gérants de projet	1	2	3	4	5
Communication directe entre personnel RD	1	2	3	4	5

15. Indiquez comment les décisions suivantes sont généralement prises à votre laboratoire

- 1- MM décide seul
- 2- MM décide, mais votre laboratoire fait des suggestions
- 3- MM et votre laboratoire ont une influence à peu près égale sur la décision
- 4- Votre laboratoire décide mais la MM fait des suggestions
- 5- Votre laboratoire décide seul

	MM decide seul			Votre laboratoire decide seul	
1. Faire des changements significatifs au produit existant	1	2	3	4	5
2. Modifier un processus de production à leur laboratoire	1	2	3	4	5
3. Restructurer votre laboratoire	1	2	3	4	5
4. Recruter des scientifiques et des ingénieurs pour leur laboratoire	1	2	3	4	5
5. Décider du plan de carrière des scientifiques et ingénieurs	1	2	3	4	5
6. Le nombre de projets de recherche entrepris par leur laboratoire	1	2	3	4	5
7. Sélectionner le type de projets entrepris par leur laboratoire	1	2	3	4	5
8. Déterminer les priorités du projet pour leur laboratoire	1	2	3	4	5
9. Diriger des efforts conjoints de RD avec d'autres laboratoires à l'intérieur de la compagnie	1	2	3	4	5
10. Partager l'information avec d'autres laboratoires à l'intérieur de la compagnie	1	2	3	4	5
11. Echanger du personnel RD avec d'autres laboratoires à l' <u>intérieur</u> de la compagnie	1	2	3	4	5
12. Collaborer avec des organismes à l' <u>extérieur</u> de la compagnie	1	2	3	4	5

16. Indiquez dans quelle mesure les énoncés suivants s'appliquent à votre laboratoire

	Absolument vrai			Absolument faux	
1- MM a rédigé les lois et règlements qui gouvernent les collaborations entre les laboratoires à <u>l'intérieur</u> de votre compagnie	1	2	3	4	5
2- MM a rédigé les lois et règlements qui gouvernent les collaborations avec les organismes <u>extérieurs</u> à votre compagnie	1	2	3	4	5
3- MM a rédigé les lois et règlements pour gérer les conflits entre les laboratoires RD emmagés dans des projets conjoints	1	2	3	4	5
4- MM surveille votre laboratoire pour s'assurer que les politiques sont appliqués	1	2	3	4	5
5- Votre laboratoire doit soumettre à la MM des rapports <u>formels</u> des progrès de <u>toutes ses activités</u>	1	2	3	4	5

17. Quel pourcentage des cadre supérieur de votre laboratoire

- 1- Est originaire du pays où votre laboratoire est situé _____
- 2- Est du même pays que la maison mère _____
- 3- Est d'un autre pays que le vôtre ou celui de la MM _____

18. Indiquez le niveau d'intensité de la compétition à l'intérieur de votre industrie en terme de:

	Peu de compétition		Compétition extrêmement intense		
1- Le marché pour vos produits	1	2	3	4	5
2- Recrutement des scientifiques et ingénieurs	1	2	3	4	5

19. Indiquez le niveau d'innovation de produits/processus à l'intérieur de votre industrie (pas nécessairement votre laboratoire)

	Très bas			Très élevé	
Niveau de d'innovation de produits/ processus à l'intérieur de votre industrie est	1	2	3	4	5

- Peu de compétition 1 2 3 4 5 Compétition extrêmement intense

- Significativement bas** **Significativement élevée**
1	2	3	4	5

- Production ne serait pas affecté _____ Production serait réduite de _____ %

Production ne serait pas affecté _____ Production serait réduite de _____ %

- N.B. MM = Laboratoire de la maison mère**

Partie B

Données démographiques concernant votre laboratoire

25. Pays d'origine de la maison mère de votre compagnie _____
26. Catégorie qui décrit le mieux les affaires de votre compagnie (Encerclez tout ce qui s'applique)
1. Electronique/Electrique	2. Télécommunications/Informatique	3. Pharmaceutique	
4. Chimique	5. Biotechnologie	6. Instruments scientifiques	7. Aérospatiale
8. Autre (spécifiez, s'il vous plaît) _____			
27. Pays où se trouve votre laboratoire _____
28. L'année que votre laboratoire fut établi _____
29. Nombre total d'employés RD dans votre laboratoire en 1998 _____
30. Nombre total de scientifiques et d'ingénieurs dans votre laboratoire en 1998 avec:
Doctorat _____	Maîtrise _____
31. Nombre total de scientifiques et d'ingénieurs dans votre laboratoire en 1998 avec:
Moins de 5 ans d'expérience dans leur domaine _____
Entre 5-10 ans d'expérience dans leur domaine _____
Plus de 10 ans d'expérience dans leur domaine _____
32. Budget total de RD de votre laboratoire en 1998 (en monnaie de votre pays) _____ millions
-	
--
Pourcentage du budget RD dépensé pour la recherche de base _____ %
La recherche appliquée _____ %
33. Combien de demandes de brevet est-ce que votre laboratoire a enregistré au cours des trois dernières années? _____
34. S'il vous plaît inclure tout autre information qui pourrait améliorer notre compréhension des questions/défis auxquels sont confrontés les gérants dans la gestion globale des laboratoires de recherche.

Votre contribution à cet effort est grandement apprécié. Si vous voulez un résumé des résultats, s'il vous plaît imprimez votre nom et adresse électronique.

Nom et courriel:

Faxez ou postez le questionnaire complété à Ajax Persaud
Fax : (613) 260-2642 (disponible 24 heures et les fins de semaines)

APPENDIX 4
HEADQUARTER SURVEY- FRENCH VERSION

“Création d’innovations à travers le partenariat global: Une enquête sur les compagnies tête de file à travers le monde.”

Monsieur/Madame:

Je me nomme Ajax Persaud. Je suis un candidat au programme de doctorat au “School of Business” à l’Université de Carleton, Ottawa, Canada. Ma spécialisation est la gestion de technologie. Je développe présentement la recherche de ma thèse qui examine comment la collaboration entre les différents laboratoires de recherche des corporations multinationales (CMN) améliorent rapidement et efficacement leur capacité à produire des innovations.

Les rapports dans la presse populaire et dans les journaux académiques indiquent que les collaborations adéquates entre les différentes unités des CMN peuvent entraîner des bénéfices considérables pour ces compagnies. Ces mêmes rapports suggèrent que très peu de compagnies ont été capables d’organiser leur opérations globales avec succès. Les résultats de cette recherche pourraient apporter un éclairage précieux sur la façon qu’ont les compagnies de gérer leur activités GLOBALES de recherche et les facteurs qui expliquent leur succès ou leur échec. Les discussions préliminaires avec les gérants de certaines compagnies réaffirment le besoin d’une telle recherche.

Votre compagnie est l’une des CMN que j’ai sélectionnée pour participer à cette recherche. Je sollicite votre participation en vous demandant de compléter le questionnaire suivant. Toute information donnée sera traitée dans la plus stricte confidentialité. Les réponses seront compilées de façon à ce qu’aucun individu, laboratoire ou compagnie ne puissent être identifiés dans le report final. Votre participation me permettra de compléter plus facilement cette recherche dans un délai raisonnable.

Pour de plus amples renseignements, vous pouvez me rejoindre par téléphone au (613) 520-2600 poste 1017 ou par courriel à apersaud@business.carleton.ca. Vous pouvez également communiquer avec mon directeur de thèse, Vinod Kumar, au (613) 520-2379. Les résultats de cette recherche seront envoyés sur demande à tous les participants intéressés.

Je vous remercie de votre collaboration. **Vous pouvez faire parvenir votre réponse soit par fax ou par courrier.**

Fax: (613) 260-2642

Poste: Ajax Persaud
School of Business, Carleton University
Ottawa, Ontario
K1S 5B6, Canada

Sincèrement,

Ajax Persaud

Partie A

Les questions de cette partie recherchent de l'information sur la nature de la collaboration entre le laboratoire de la maison mère et les autres laboratoires de recherche à l'intérieur de votre organisme au courant des deux dernières années.

1. Combien de laboratoires de recherche y a-t-il dans votre compagnie (incluant ceux à l'étranger) _____
2. Avec combien de ces laboratoires de recherche votre laboratoire a-t-il collaboré pour _____
des projets de Recherche et Développement (RD)
3. Combien de ces collaborations impliquent les points suivant:
 - Echange d'information scientifique et technologique _____
 - Recherche conjointe à titre de partenaires égaux _____
 - Recherche conjointe où votre laboratoire a assumé le leadership _____
 - Recherche conjointe où un autre laboratoire a assumé le leadership _____
 - Echange de personnel en RD _____
 - Partage d'installations de testing, d'équipement, etc. _____
 - Projets conjoints de sessions de planification _____
 - Visites régulières aux autres laboratoires _____
4. Combien des laboratoires avec lesquels vous avez collaboré partagent une culture semblable en termes d'habitudes de travail et d'attitudes? _____
5. Combien des laboratoires avec lesquels vous avez collaboré ont des objectifs et des valeurs de gestion semblable au vôtre? _____
6. Quels problèmes attribuez-vous aux *différences culturelles* entre ces laboratoires et le vôtre? (Expliquez)
7. Avec combien de ces laboratoires avez-vous eu des expériences négatives ou des conflits majeurs au courant des deux dernières années en ce qui concerne:
 1. Contribution des ressources et du personnel à la collaboration _____
 2. Droit de propriété d'une technologie résultant de cette collaboration _____
 3. Usage d'une technologie résultant de cette collaboration _____

8. Quelle influence les facteurs suivants ont-ils eu sur votre décision de collaborer avec un autre laboratoire à l'intérieur de votre compagnie.

	Aucune Influence			Beaucoup d'influence	
1. La compétence technique de l'autre laboratoire	1	2	3	4	5
2. La complémentarité de la technologie de ce laboratoire par rapport au vôtre	1	2	3	4	5
3. Votre expérience de collaboration avec l'autre laboratoire	1	2	3	4	5
4. La volonté du laboratoire de garder ses promesses	1	2	3	4	5
5. La fiabilité des scientifiques et des ingénieurs du laboratoire	1	2	3	4	5

11. S'il vous plaît, indiquez l'*impacte* de cette collaboration sur votre laboratoire selon les facteurs suivants:

	augmenté considérablement	augmenté	aucun changement	diminué	diminué considérablement
1. Le <i>nombre</i> de projets RD que votre laboratoire a entrepris a ...	1	2	3	4	5
2. Le <i>nombre de projets complexes</i> de RD que votre laboratoire a entrepris a ...	1	2	3	4	5
3. La <i>gamme/variété</i> de projets RD que votre laboratoire a entrepris a ...	1	2	3	4	5
4. La <i>qualité</i> des produits de votre laboratoire a...	1	2	3	4	5
5. Les aspects <i>techniques</i> de vos procédés de production ont...	1	2	3	4	5
6. Les aspect <i>gestionnaires</i> de vos opérations ont...	1	2	3	4	5
7. L' <i>efficacité</i> de vos ressources de RD a...	1	2	3	4	5
8. La <i>motivation</i> pour des activités innovatrices dans votre laboratoire a...	1	2	3	4	5
9. Le <i>taux de succès</i> des nouvelles innovations dans votre laboratoire a...	1	2	3	4	5

12. <i>Les compétences techniques</i> de votre personnel de RD ont...	1	2	3	4	5
13. <i>L'accès de votre laboratoire</i> aux ressources de RD et au personnel a...	1	2	3	4	5
12. Le <i>coût</i> de RD dans votre laboratoire a...	1	2	3	4	5
13. Le <i>temps de développement</i> pour des innovations nouvelles dans votre laboratoire a...	1	2	3	4	5

10. Selon vous, combien des laboratoires dans votre compagnie ont comme tâche première:

Modifications/adaptations de produits (60% ou plus de leurs activités)? _____

Design et développement de produits (60% ou plus de leurs activités)? _____

Recherche appliqué (60% ou plus de leurs activités)? _____

Recherche de base (60% ou plus de leurs activités)? _____

Cueillette d'information technique (60% ou plus de leurs activités)? _____

11. Selon vous, combien des laboratoires à l'intérieur de votre compagnie ont suffisamment de liberté ou d'autonomie pour prendre seuls les décisions suivantes sans l'influence de la maison mère ou d'un autre laboratoire?

Décisions:

Nombre de laboratoires:

1. Faire des changements significatifs au produit existant	_____
2. Modifier un processus de production à leur laboratoire	_____
3. Recruter des scientifiques et des ingénieurs pour leur laboratoire	_____
4. Décider du plan de carrière des scientifiques et ingénieurs	_____
5. Le nombre de projets de recherche entrepris par leur laboratoire	_____
6. Sélectionner le type de projets entrepris par leur laboratoire	_____
7. Déterminer les priorités du projet pour leur laboratoire	_____

8. Diriger des efforts conjoints de RD avec d'autres laboratoires à l'intérieur de la compagnie _____
9. Partager l'information avec d'autres laboratoires à l'intérieur de la compagnie _____
10. Echanger du personnel RD avec d'autres laboratoires à l'intérieur de la compagnie _____
11. Collaborer avec des organismes à l'extérieur de la compagnie _____
12. Laquelle des figures suivantes reflète le mieux la structure d'organisation RD de votre compagnie? Si aucune de ces figures ne s'applique, s'il vous plaît dessinez la structure d'organisation RD de votre compagnie.

N.B. MM = Laboratoire de la maison mère

Partie B

Données démographiques concernant votre laboratoire

13. Pays d'origine de la maison mère de votre compagnie _____
14. Catégorie qui décrit le mieux les affaires de votre compagnie (Encerclez tout ce qui s'applique)
1. Electronique/Electrique	2. Télécommunications/Informatique	3. Pharmaceutique
4. Chimique	5. Biotechnologie	6. Instruments scientifiques
7. Aérospatiale	8. Autre (spécifiez, s'il vous plaît)	
15. L'année que votre laboratoire fut établi _____
16. Nombre total d'employés RD dans votre laboratoire en 1998 _____
17. Nombre total de scientifiques et d'ingénieurs dans votre laboratoire en 1998 avec:
Doctorat _____	Maîtrise _____
Moins de 5 ans d'expérience dans leur domaine _____	
Entre 5-10 ans d'expérience dans leur domaine _____	
Plus de 10 ans d'expérience dans leur domaine _____	
18. Budget total de RD de votre laboratoire en 1998 (en monnaie de votre pays) _____ millions
Pourcentage du budget RD dépensé pour: la recherche de base	_____ %
La recherche appliquée	_____ %
19. Combien de demandes de brevet est-ce que votre laboratoire a enregistré au cours des trois dernières années?

20. S'il vous plaît inclure tout autre information qui pourrait améliorer notre compréhension des questions/défis auxquels sont confrontés les gérants dans la gestion globale de la Recherche et Développement.

Votre contribution à cet effort est grandement apprécié. Si vous voulez un résumé des résultats, s'il vous plaît imprimez votre nom et adresse électronique.

Nom et courriel: _____

Faxez ou postez le questionnaire complété à
Fax: Ajax Persaud (613) 520-2532

APPENDIX 5

SUBSIDIARY SURVEY – GERMAN VERSION

**Innovationen durch globale Partnerschaft:
Eine Untersuchung über die führenden Unternehmen in der Welt**

Males: Sehr geehrter Herr + last name,
Females: Sehr geehrte Frau + last name,
If you do not know the name: Sehr geehrte Damen und Herren,

mein Name ist Ajax Persaud. Ich bin Doktorand an der School of Business an der Carleton University in Ottawa, Kanada. Mein Schwerpunktgebiet ist Technologiemanagement. Ich arbeite zur Zeit an meiner Dissertation, die sich mit dem Thema beschäftigt, inwieweit die Zusammenarbeit zwischen Forschungslaboren (oder -abteilungen/-einrichtungen) multinationaler Unternehmen bessere Bedingungen für die schnelle und effiziente Entwicklung von Innovationen schafft.

Berichten in der Presse und akademischen Fachblättern ist zu entnehmen, daß die Zusammenarbeit zwischen weltweiten Einrichtungen von multinationalen Unternehmen, wenn diese entsprechend durchgeführt wird, für diese Unternehmen einen enormen Nutzen haben könnte. Diesen Berichten ist darüber hinaus zu entnehmen, daß es bisher nur wenigen Unternehmen gelungen ist, ihre weltweiten Operationen erfolgreich zu strukturieren. Die Ergebnisse dieser Studie könnten wertvolle Informationen darüber liefern, welche Strategien Unternehmen bei ihrer globalen Forschungstätigkeit einsetzen und Aufschluß über die Faktoren geben, die zum Erfolg oder Mißerfolg beitragen. Mit Führungskräften einiger Unternehmen geführte Vorgespräche haben bekräftigt, daß Studien dieser Art notwendig sind.

Ihr Unternehmen gehört zu den führenden multinationalen Unternehmen, die ich für die Teilnahme an dieser Studie ausgewählt habe. Ich *bitte Sie, an dieser Studie teilzunehmen, indem Sie den beigefügten Fragebogen ausfüllen*. Alle Informationen werden streng vertraulich behandelt. Die Antworten werden als Gesamtheit ausgewertet, so daß keine Einzelperson und kein einzelnes Labor oder Unternehmen im Abschlußbericht bezeichnet wird. Ihre Teilnahme wird es mir ermöglichen, die Studie in einem angemessenen zeitlichen Rahmen abzuschließen.

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Ich danke Ihnen vielmals für Ihre Teilnahme an dieser Studie. **Bitte übersenden Sie den ausgefüllten Fragebogen entweder per Fax oder Post.**

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Mit freundlichen Grüßen

Ajax Persaud

ABSCHNITT A

Hinweis: Im Rahmen dieser Studie werden Forschungslabore in zwei Gruppen unterteilt - Hauptlabore (HL) und Schwesterlabore. Das Hauptlabor wird als "HL" bezeichnet, wobei unter Schwesterlaboren alle anderen Labore des Unternehmens zu verstehen sind.

1. Hat Ihr Labor in den vergangenen zwei Jahren mit anderen Laboren innerhalb des eigenen Unternehmens an einem Forschungs- und Entwicklungsprojekt zusammengearbeitet?

Nein → Bitte weiter mit Frage 7 auf Seite 4

Ja ☐

2. Mit wie vielen Schwesterlaboren innerhalb des eigenen Unternehmens hat Ihr Labor zusammengearbeitet? _____ (Bei keinen bitte weiter mit Frage ?)

3. Betrachtet man alle Schwesterlabore, mit denen Sie in den vergangenen zwei Jahren zusammengearbeitet haben, wie viele davon haben Ihrer Meinung nach

den selben Arbeitsstil wie Ihr Labor verfolgt, womit Arbeitsgewohnheiten, -einstellung und -haltung gemeint sind? _____

ähnliche Ziele und Managementstrategien wie Ihr Labor verfolgt? _____

4. Geben Sie hinsichtlich der Labore, die einen *ähnlichen Arbeitsstil* wie Ihr Labor verfolgen, die Arten der Zusammenarbeit mit Ihrem Labor an.

	Informell			Formell			Nicht Zutreffend
Wissenschaftlicher und technologischer Informationsaustausch	1	2	3	4	5		NZ
Gemeinsame Forschung als gleichwertige Partner	1	2	3	4	5		NZ
Austausch von Mitarbeitern im Bereich Forschung und Entwicklung	1	2	3	4	5		NZ
Regelmäßige Besuche zwischen den beiden Laboren	1	2	3	4	5		NZ
Beiderseitiger Zugriff auf Testeinrichtungen, Anlagen usw.	1	2	3	4	5		NZ
Gemeinsames Brainstorming und geplante Zusammenkünfte	1	2	3	4	5		NZ

5. Geben Sie hinsichtlich der Labore, die einen *anderen Arbeitsstil* wie Ihr Labor verfolgen, die Arten der Zusammenarbeit mit Ihrem Labor an.

	Informell			Formell			Nicht Zutreffend
Wissenschaftlicher und technologischer Informationsaustausch	1	2	3	4	5		NZ
Gemeinsame Forschung als gleichwertige Partner	1	2	3	4	5		NZ
Austausch von Mitarbeitern im Bereich Forschung und Entwicklung	1	2	3	4	5		NZ
Regelmäßige Besuche zwischen den beiden Laboren	1	2	3	4	5		NZ

11. Inwieweit haben folgende Faktoren Ihre Entscheidung beeinflußt, mit einem anderen Labor innerhalb des eigenen Unternehmens zusammenzuarbeiten?

	Gar keinen Einfluß			Sehr großen Einfluß	
Technische Kompetenz des anderen Labors	1	2	3	4	5
Gegenseitige Ergänzung der Technologien der Labore	1	2	3	4	5
Ihre Erfahrungen bei der Zusammenarbeit mit dem anderen Labor	1	2	3	4	5
Bereitschaft des Labors, Versprechen einzuhalten	1	2	3	4	5
Glaubwürdigkeit der Forscher und Ingenieure des Labors	1	2	3	4	5

12. (a) Bitte geben Sie die *Auswirkungen der Zusammenarbeit auf Ihr Labor* unter Berücksichtigung der folgenden Faktoren an:

	Beträchtlich abgenommen	Abgenommen	Unverändert geblieben	Zugenommen	Beträchtlich zugenommen
Die <i>Anzahl</i> der von Ihrem Labor übernommenen Forschungs- und Entwicklungsprojekte hat/ist	1	2	3	4	5
Die <i>Anzahl komplexer</i> , von Ihrem Labor übernommenen Forschungs- und Entwicklungsprojekte hat/ist	1	2	3	4	5
Die <i>Palette/Art</i> der von Ihrem Labor übernommenen Forschungs- und Entwicklungsprojekte hat/ist	1	2	3	4	5
Die <i>Qualität</i> der Produkte Ihres Labors hat/ist	1	2	3	4	5
Die <i>technischen</i> Aspekte Ihrer Produktionsverfahren haben/sind	1	2	3	4	5
Die <i>verwaltungstechnischen</i> Aspekte Ihres Betriebes haben/sind	1	2	3	4	5
Die <i>Effizienz</i> Ihrer Ressourcen in der Forschung und Entwicklung hat/ist	1	2	3	4	5
Das <i>Verlangen</i> nach innovativen Aktivitäten in Ihrem Labor hat/ist	1	2	3	4	5
Die <i>Erfolgsquote</i> bei neuen Innovationen in Ihrem Labor hat/ist	1	2	3	4	5
Die <i>technische Kompetenz</i> Ihrer Mitarbeiter im Forschungs- und Entwicklungsbereich hat/ist	1	2	3	4	5
Der <i>Zugriff</i> Ihres Labors auf Mitarbeiter und Ressourcen im Forschungs- und Entwicklungsbereich hat/ist	1	2	3	4	5

12. (b) Bitte geben Sie die *Auswirkungen der Zusammenarbeit auf Ihr Labor* unter Berücksichtigung der folgenden Faktoren an:

	Beträchtlich zugenommen	Zugenommen	Unverändert geblieben	Abgenommen	Beträchtlich abgenommen
Die <i>Kosten</i> für Forschung und Entwicklung in Ihrem Labor haben/sind	1	2	3	4	5
Die <i>Entwicklungszeit</i> für neue Innovationen in Ihrem Labor hat/ist	1	2	3	4	5

13. Bitte geben Sie die Häufigkeit der Kontaktaufnahme zwischen Ihrem Labor und anderen Schwesterlaboren an.

	Jährlich Täglich	Vierteljährlich	Monatlich	Wöchentlich	
Elektronische Kommunikation zwischen leitenden Führungskräften	1	2	3	4	5
Elektronische Kommunikation zwischen Projektleitern	1	2	3	4	5
Elektronische Kommunikation zwischen Mitarbeitern im Forschungs- und Entwicklungsbereich	1	2	3	4	5
Persönliche Kommunikation zwischen leitenden Führungskräften	1	2	3	4	5
Persönliche Kommunikation zwischen Projektleitern	1	2	3	4	5
Persönliche Kommunikation zwischen Mitarbeitern im Forschungs- und Entwicklungsbereich	1	2	3	4	5

14. Bitte geben Sie die Häufigkeit der Kontaktaufnahme zwischen Ihrem Labor und dem HL an.

	Jährlich Täglich	Vierteljährlich	Monatlich	Wöchentlich	
Elektronische Kommunikation zwischen leitenden Führungskräften	1	2	3	4	5
Elektronische Kommunikation zwischen Projektleitern	1	2	3	4	5
Elektronische Kommunikation zwischen Mitarbeitern im Forschungs- und Entwicklungsbereich	1	2	3	4	5
Persönliche Kommunikation zwischen leitenden Führungskräften	1	2	3	4	5
Persönliche Kommunikation zwischen Projektleitern	1	2	3	4	5
Persönliche Kommunikation zwischen Mitarbeitern im Forschungs- und Entwicklungsbereich	1	2	3	4	5

15. Bitte geben Sie an, wie in Ihrem Labor gewöhnlich Entscheidungen getroffen werden:

- 1 = HL entscheidet allein
 2 = HL entscheidet, doch Ihr Labor macht Vorschläge
 3 = Das HL und Ihr Labor haben einen etwa gleichwertigen Einfluß
 4 = Ihr Labor entscheidet, doch das HL macht Vorschläge
 5 = Ihr Labor entscheidet allein

	HL entscheidet allein			Ihr Labor entscheidet allein	
Vornahme von wesentlichen Änderungen an einem bestehenden Produkt	1	2	3	4	5
Modifizierung eines Produktionsverfahrens in Ihrem Labor	1	2	3	4	5
Neustrukturierung Ihres Labors	1	2	3	4	5
Einstellung von Wissenschaftlern und Ingenieuren für Ihr Labor	1	2	3	4	5
Entscheidungen über die Laufbahn von Wissenschaftlern und Ingenieuren	1	2	3	4	5
Anzahl von Projekten, die in Ihrem Labor durchgeführt werden	1	2	3	4	5
Auswahl der Art der Projekte, die von Ihrem Labor durchgeführt werden	1	2	3	4	5
Entscheidung über Prioritätenliste für die Projekte in Ihrem Labor	1	2	3	4	5
Durchführung gemeinsamer Forschungs- und Entwicklungsprojekte mit anderen Laboren in Ihrem Unternehmen	1	2	3	4	5
Informationsaustausch mit anderen Laboren	1	2	3	4	5
Austausch von Mitarbeitern im Forschungs- und Entwicklungsbereich mit anderen Laboren	1	2	3	4	5
Zusammenarbeit mit Organisationen <u>außerhalb</u> Ihres Unternehmens	1	2	3	4	5

16. Bitte geben Sie an, inwieweit jede der folgenden Aussagen auf Ihr Labor zutreffen:

	Eindeutig richtig			Eindeutig falsch	
Das HL hat Vorschriften und Strategien festgeschrieben, die die Zusammenarbeit zwischen Laboren <u>innerhalb</u> Ihres Unternehmens regeln	1	2	3	4	5
Das HL hat Vorschriften und Strategien festgeschrieben, die die Zusammenarbeit mit Laboren <u>außerhalb</u> Ihres Unternehmens regeln	1	2	3	4	5
Das HL hat Vorschriften und Strategien festgeschrieben, die Konflikte zwischen Laboren im Forschungs- und Entwicklungsbereich regeln, die gemeinsam an Forschungs- und					

Entwicklungsprojekten arbeiten	1	2	3	4	5
Das HL kontrolliert Ihr Labor, um zu gewährleisten, daß die Regeln eingehalten werden.	1	2	3	4	5
Ihr Labor muß dem HL <i>formelle</i> Fortschrittsberichte über seine <u>Gesamtaktivitäten</u> zur Verfügung stellen	1	2	3	4	5

17. In Prozent ausgedrückt - Wie viele der leitenden Führungskräfte in Ihrem Labor stammen aus dem Land, in dem das Labor angesiedelt ist?

stammen aus dem Heimatland Ihrer Muttergesellschaft?

stammen aus einem Land, das weder Ihr Land noch das Heimatland der Muttergesellschaft ist? _____

18. Bewerten Sie die Intensität der Konkurrenz innerhalb Ihrer Branche in Bezug auf

	Keine große Konkurrenz			Extrem starke Konkurrenz	
den Markt für Ihre Produkte	1	2	3	4	5
die Einstellung von Wissenschaftlern und Ingenieuren	1	2	3	4	5

19. Bewerten Sie das Tempo bei Produkt-/Verfahrensinnovationen innerhalb Ihrer Branche (nicht speziell für Ihr Labor):

	Sehr niedrig			Sehr hoch	
Das Tempo, mit dem Produkt-/Verfahrensinnovationen innerhalb unserer Branche entwickelt werden, ist	1	2	3	4	5

20. Bewerten Sie die Intensität der Konkurrenz zwischen den Laboren Ihres Unternehmens um interne betriebliche Ressourcen.

Keine große Konkurrenz			Extrem starke Konkurrenz	
1	2	3	4	5

21. Wie würden Sie die Gesamtheit der Ressourcen einschätzen, die Ihrem Labor im Verhältnis zum Durchschnitt innerhalb Ihres Unternehmens zur Verfügung stehen?

Deutlich niedriger			Deutlich höher	
1	2	3	4	5

22. Wenn aufgrund einer plötzlichen Veränderung die gesamte Zeit, die von allen Ihren Wissenschaftlern und Ingenieuren für die Forschung und Entwicklung aufgewendet wird, um 10%, gekürzt würde, inwieweit würde sich das ernsthaft auf die Arbeit Ihres Labors auswirken?

Hätte keine Auswirkungen auf den Ausstoß: _____ Der Ausstoß würde reduziert um: _____

23. Wenn aufgrund einer ähnlichen Veränderung das Jahresbudget für den Betrieb Ihres Labors um 10% gekürzt würde, inwieweit würde sich das ernsthaft auf die Arbeit Ihres Labors auswirken?

Hätte keine Auswirkungen auf den Ausstoß: _____ Der Ausstoß würde reduziert um: _____

24. Welche der folgenden Darstellungen kommt der Struktur des Forschungs- und Entwicklungsbereichs Ihres Unternehmens am nächsten? Falls keine dieser Darstellungen zutreffen sollte, werden Sie gebeten, die Struktur des Forschungs- und Entwicklungsbereichs Ihres Unternehmens auf ein separates Blatt Papier zu zeichnen.

ABSCHNITT B

Demographische Daten über Ihr Labor

25. Heimatland Ihrer Muttergesellschaft: _____

26. Industriezweig, dem Ihr Unternehmen am ehesten zugeordnet werden kann. (Bitte eine Antwort umkreisen)

1. Elektronik/Elektrotechnik

2. Telekommunikation/Informatik

3. Pharmazie

4. Chemie

5. Biotechnologie

6. Wissenschaftliche Instrumente

7. Luftfahrt 8. Kraftfahrzeugwesen

9. Sonstige (bitte angeben): _____

27. In welchem Land befindet sich Ihr Labor? _____

28. In welchem Jahr wurde Ihr Labor eingerichtet? _____

29. Über wie viele Mitarbeiter im Forschungs- und Entwicklungsbereich verfügte Ihr Labor im Jahre 1998? _____

30. Wie viele Wissenschaftler und Ingenieure in Ihrem Labor verfügen über:

Dokortitel: _____

Diplom: _____

31. Wie viele Wissenschaftler und Ingenieure verfügen über die folgende Erfahrung in ihrem jeweiligen Fachgebiet?
Weniger als 5 Jahre: _____ 5 bis 10 Jahre: _____ Über 10 Jahre: _____

32. Wie hoch belief sich im Jahre 1998 das gesamte Budget für Forschung und Entwicklung in Ihrem Labor?

(In Ihrer Währung): _____ Millionen

Prozentsatz des Budgets für Forschung und Entwicklung, der aufgewendet wurde für:

Grundlagenforschung: _____

Zweckforschung: _____

33. Wie viele Patentanmeldungen hat Ihr Labor in den vergangenen 5 Jahren eingereicht? _____

34. Bitte machen Sie alle weiteren Angaben, von denen Sie annehmen, daß sie uns zu einem besseren Verständnis für die Herausforderungen verhelfen, denen sich Manager in der Bewältigung der globalen Forschung gegenüber sehen.

Ich bedanke mich sehr herzlich für Ihren Beitrag zu dieser Studie. Wenn Sie an einer Zusammenfassung der Ergebnisse interessiert sind, führen Sie bitte unten Ihren Namen und Ihre E-Mail-Adresse an.

Name und E-Mail-Adresse: _____

Bitte übersenden Sie den ausgefüllten Fragebogen entweder per Fax oder Post an:

Fax: Ajax Persaud

001 613 260 2642 (rund um die Uhr, auch an Wochenenden)

Post: Siehe Anschrift unten

APPENDIX 6

HEADQUARTER SURVEY – GERMAN VERSION

**Innovationen durch globale Partnerschaft:
Eine Untersuchung über die führenden Unternehmen in der Welt**

Males: Sehr geehrter Herr + last name,
Females: Sehr geehrte Frau + last name,
If you do not know the name: Sehr geehrte Damen und Herren,

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Ajax Persaud

ABSCHNITT A

Die Fragen in diesem Abschnitt befassen sich mit der Art der Zusammenarbeit zwischen dem HL und anderen Forschungslaboren innerhalb Ihres Unternehmens im Verlauf der vergangenen zwei Jahre.

1. Über wie viele Forschungslabore verfügt Ihr Unternehmen (einschließlich derer, die sich im Ausland befinden)? _____
2. Mit wie vielen dieser Forschungslabore hat Ihr Labor an Forschungs- und Entwicklungsprojekten zusammengearbeitet?

3. Wie viele der gemeinsamen Projekte umfaßten folgendes:
 - Wissenschaftlicher und technologischer Informationsaustausch? _____
 - Gemeinsame Forschung als gleichwertige Partner? _____
 - Gemeinsame Forschungsprojekte, bei denen Ihr Labor eine führende Stellung einnahm? _____
 - Gemeinsame Forschungsprojekte, bei denen das andere Labor eine führende Stellung einnahm? _____
 - Austausch von Mitarbeitern im Bereich Forschung und Entwicklung? _____
 - Regelmäßige Besuche zwischen den beiden Laboren? _____
 - Beiderseitiger Zugriff auf Testeinrichtungen, Anlagen usw.? _____
 - Gemeinsames Brainstorming und geplante Zusammenkünfte? _____
4. Wie viele der Labore, mit denen Sie zusammengearbeitet haben, verfolgen den selben Arbeitsstil wie Ihr Labor in bezug auf Arbeitsgewohnheiten und -einstellungen? _____
5. Wie viele der Labore, mit denen Sie zusammengearbeitet haben, verfolgen Ziele und Führungsstile, die denen Ihres Labors ähneln? _____
6. Welche Probleme würden Sie auf die Tatsache zurückführen, daß Ihr Labor einen *anderen Arbeitsstil* verfolgt als diese Labore? (Bitte näher erläutern)
7. Mit wie vielen der Labore, mit denen Sie zusammengearbeitet haben, gab es größere Meinungsverschiedenheiten/Konflikte über:
 - Die Bereitstellung von Ressourcen und Mitarbeitern für die Zusammenarbeit _____
 - Die Besitzverhältnisse bei einer im Rahmen der Zusammenarbeit entwickelten Technologie _____
 - Die Verwendung einer im Rahmen der Zusammenarbeit entwickelten Technologie _____
8. Inwieweit haben folgende Faktoren Ihre Entscheidung beeinflußt, mit einem anderen Labor innerhalb des eigenen Unternehmens zusammenzuarbeiten?

Gar keinen Einfluß

Sehr großen Einfluß

Technische Kompetenz des anderen Labors	1	2	3	4	5
Gegenseitige Ergänzung der Technologien der Labore	1	2	3	4	5

Ihre Erfahrungen bei der Zusammenarbeit mit dem anderen Labor	1	2	3	4	5
Bereitschaft des Labors, Versprechen einzuhalten	1	2	3	4	5
Glaubwürdigkeit der Forscher und Ingenieure des Labors	1	2	3	4	5

9. (a) Bitte geben Sie die *Auswirkungen der Zusammenarbeit auf Ihr Labor* unter Berücksichtigung der folgenden Faktoren an:

	Beträchtlich abgenommen	Abgenommen	Unverändert geblieben	Zugenommen	Beträchtlich zugenommen
Die <i>Anzahl</i> der von Ihrem Labor übernommenen Forschungs- und Entwicklungsprojekte hat/ist	1	2	3	4	5
Die <i>Anzahl komplexer</i> , von Ihrem Labor übernommenen Forschungs- und Entwicklungsprojekte hat/ist	1	2	3	4	5
Die <i>Palette/Art</i> der von Ihrem Labor übernommenen Forschungs- und Entwicklungsprojekte hat/ist	1	2	3	4	5
Die <i>Qualität</i> der Produkte Ihres Labors hat/ist	1	2	3	4	5
Die <i>technischen Aspekte</i> Ihrer Produktionsverfahren haben/sind	1	2	3	4	5
Die <i>verwaltungstechnischen Aspekte</i> Ihres Betriebes haben/sind	1	2	3	4	5
Die <i>Effizienz</i> Ihrer Ressourcen in der Forschung und Entwicklung hat/ist	1	2	3	4	5
Das <i>Verlangen</i> nach innovativen Aktivitäten in Ihrem Labor hat/ist	1	2	3	4	5
Die <i>Erfolgsquote</i> bei neuen Innovationen in Ihrem Labor hat/ist	1	2	3	4	5
Die <i>technische Kompetenz</i> Ihrer Mitarbeiter im Forschungs- und Entwicklungsbereich hat/ist	1	2	3	4	5
Der <i>Zugriff</i> Ihres Labors auf Mitarbeiter und Ressourcen im Forschungs- und Entwicklungsbereich hat/ist	1	2	3	4	5

9 (b) Bitte geben Sie die *Auswirkungen der Zusammenarbeit auf Ihr Labor* unter Berücksichtigung der folgenden Faktoren an:

	Beträchtlich zugenommen	Zugenommen	Unverändert geblieben	Abgenommen	Beträchtlich abgenommen
Die <i>Kosten</i> für Forschung und Entwicklung in Ihrem Labor haben/sind	1	2	3	4	5
Die <i>Entwicklungszeit</i> für neue Innovationen in Ihrem Labor hat/ist	1	2	3	4	5

10. Wie viele der Labore innerhalb Ihres Unternehmens befassen sich Ihrer Ansicht nach mit folgendem:

Hauptsächlich Produktmodifizierungen oder -adaptionen (umfaßt mindestens 60% des Aufgabengebiets)?	_____
Hauptsächlich Produktdesign und -entwicklung (umfaßt mindestens 60% des Aufgabengebiets)?	_____
Hauptsächlich Zweckforschung (umfaßt mindestens 60% des Aufgabengebiets)?	_____
Hauptsächlich Grundlagenforschung (umfaßt mindestens 60% des Aufgabengebiets)?	_____
Hauptsächlich Erfassung von Daten (umfaßt mindestens 60% des Aufgabengebiets)?	_____

11.

Vornahme von wesentlichen Änderungen an einem bestehenden Produkt	_____
Modifizierung eines Produktionsverfahrens in Ihrem Labor	_____
Neustrukturierung Ihres Labors	_____
Einstellung von Wissenschaftlern und Ingenieuren für Ihr Labor	_____
Entscheidungen über die Laufbahn von Wissenschaftlern und Ingenieuren	_____
Anzahl von Projekten, die in Ihrem Labor durchgeführt werden	_____
Auswahl der Art der Projekte, die von Ihrem Labor durchgeführt werden	_____
Entscheidung über Prioritätenliste für die Projekte in Ihrem Labor	_____
Durchführung gemeinsamer Forschungs- und Entwicklungsprojekte mit anderen Laboren in Ihrem Unternehmen	_____
Informationsaustausch mit anderen Laboren	_____
Austausch von Mitarbeitern im Forschungs- und Entwicklungsbereich mit anderen Laboren	_____
Zusammenarbeit mit Organisationen <u>außerhalb</u> Ihres Unternehmens	_____

12. Welche der folgenden Darstellungen kommt der Struktur des Forschungs- und Entwicklungsbereichs Ihres Unternehmens am nächsten? Falls keine dieser Darstellungen zutreffen sollte, werden Sie gebeten, die Struktur des Forschungs- und Entwicklungsbereichs Ihres Unternehmens auf ein separates Blatt Papier zu zeichnen.

ABSCHNITT B

Demographische Daten über Ihr Labor

13. Heimatland Ihrer Muttergesellschaft: _____
14. Industriezweig, dem Ihr Unternehmen am ehesten zugeordnet werden kann. (Bitte eine Antwort umkreisen)
1. Elektronik/Elektrotechnik	2. Telekommunikation/Informatik	3. Pharmazie	4. Chemie
5. Biotechnologie	6. Wissenschaftliche Instrumente	7. Luftfahrt	
8. Kraftfahrzeugwesen	9. Sonstige (bitte angeben):		
15. In welchem Jahr wurde Ihr Labor eingerichtet? _____
16. Über wie viele Mitarbeiter im Forschungs- und Entwicklungsbereich verfügte Ihr Labor im Jahre 1998? _____
17. Wie viele Wissenschaftler und Ingenieure in Ihrem Labor verfügen über:
Dokortitel: _____	Diplom: _____
Weniger als 5 Jahre: _____	
5 bis 10 Jahre: _____	
Über 10 Jahre: _____	
18. Wie hoch belief sich im Jahre 1998 das gesamte Budget für Forschung und Entwicklung in Ihrem Labor?
- (In Ihrer Währung): _____ Millionen
- Prozentsatz des Budgets für Forschung und Entwicklung, der aufgewendet wurde für:
Grundlagenforschung: _____	Zweckforschung: _____
19. Wie viele Patentanmeldungen hat Ihr Labor in den vergangenen 5 Jahren eingereicht? _____
20. Bitte machen Sie alle weiteren Angaben, von denen Sie annehmen, daß sie uns zu einem besseren Verständnis für die Herausforderungen verhelfen, denen sich Manager in der Bewältigung der globalen Forschung gegenüber sehen.

Ich bedanke mich sehr herzlich für Ihren Beitrag zu dieser Studie. Wenn Sie an einer Zusammenfassung der Ergebnisse interessiert sind, führen Sie bitte unten Ihren Namen und Ihre E-Mail-Adresse an.

Name und E-Mail-Adresse:

Bitte übersenden Sie den ausgefüllten Fragebogen entweder per **Fax** oder **Post** an:

Fax: Ajax Persaud 001 613 260 2642 (rund um die Uhr, auch an Wochenenden)

Post: Siehe Anschrift unten

APPENDIX 7

SUBSIDIARY SURVEY- JAPANESE VERSION

**世界的な協力を通してイノベーション創造
:ワールドリーディングカンパニーに対するアンケート**

マイヤー様

拝啓

御社増々の御清栄の事とお慶び申し上げます。

私はエイジャックス=パーサウドと申します。現在カナダのオタワに在りますカールトン大学ビジネススクールにて博士課程に在学し、テクノロジーマネジメントを専攻しています。最近の研究内容は、多国籍企業の研究所内の共同作業における技術革新の効率化かつ高速化です。

現在のトレンドでは、多国籍企業の研究所内の世界的規模な共同作業が正確に出来るなら、これらの企業での実質的な利益が結果に現れるであろう、と言われて来ております。またこれらの企業の同調査によると、世界的な経営を組織的に成功させることが出来る企業はあまり存在していない、とも報告されています。本研究結果は、これら企業の世界的研究活動を推進する方法、また成功または失敗の要因の価値ある洞察力を供給することが出来ます。御社を含め優秀な企業のトップマネジメントとの予備的な論議にて、本研究の需要が再確認されます。

御社は本研究にて私が選ばせて頂いたその多国籍企業の一つに数えさせて頂きました。本書面にて、以下にございますアンケートに御答えして頂くよう御願い申し上げます。

頂いた全ての情報は秘密厳守で取り扱わせて頂きます。

回答は最終報告にて、個人名、研究所名、企業名が特定出来ないようにして回収させて頂きます。御社の参加により本研究の成果が向上することでしょう。御質問等が御座いましたら御手数ですが、電話若しくはイーメールにて御連絡して頂ければ幸いです。

電話番号: (613) 520-2600 内線番号 1017

イーメール: apersaud@business.carleton.ca

また、私の指導教授ヴィノッド=クマールも質問等の問い合わせに喜んで御受け致します。(電話番号: (613)520-2379)

関心のある参加者の方には本研究内容のコピーを送らせて頂きます。

御忙しい中本研究に御協力頂き誠に有り難うございます。御回答終了後、以下に表記してございますファックスかイーメールにて御返事頂くよう御願い申し上げます。

Fax: (613) 260-2642

Mail: Ajax Persaud
School of Business, Carleton University
Ottawa, Ontario
K1S 5B6, Canada

敬具

Ajax Persaud

セクション A

Note: この研究の目的のために、研究所は、以下の 2 種類に種類分けされます。--中央研究所と姉妹研究所。
中央研究所は

1. 最近 2 年間で、御社内で全ての R&D に関して、御研究所は他の研究所と共同研究をされたことは御座いますか。

1. いいえ → 5 ページの Question 14 に移動してください

2. はい

2. 御社内で御研究所と共同研究された姉妹研究所は何所御座いますか? _____ (該当しない場合、7 に移動してください)

3. 御研究所の考えの中で、2 のうち姉妹共同研究所は以下の項目にそれぞれ何所該当しますか?..

1. 労働習慣、態度、行動といったカテゴリーで御研究所と同じ文化持っている _____

2. 御研究所と同じ目的と経営価値を保有している _____

4. 御研究所と似た文化を共有している研究所のうち、御研究所との共同作業の形式はどのようなものでしょうか。

	非公式的				公式的	
1. 科学的技術的情報の交換	1	2	3	4	5	N/A
2. 同等の共同研究	1	2	3	4	5	N/A
3. R&D の個人的な情報交換	1	2	3	4	5	N/A
4. 互いの研究所の正式訪問	1	2	3	4	5	N/A
5. 研究設備の共同使用	1	2	3	4	5	N/A
6. 共同開発計画会議	1	2	3	4	5	N/A

5. 御研究所とは異なる文化を共有している研究所のうち、御研究所との共同作業の形式はどのようなものでしょうか。.

	非公式的				公式的	
1. 科学的技術的情報の交換	1	2	3	4	5	N/A
2. 同等の共同研究	1	2	3	4	5	N/A
3. R&D の個人的な情報交換	1	2	3	4	5	N/A
4. 互いの研究所の正式訪問	1	2	3	4	5	N/A
5. 研究設備の共同使用	1	2	3	4	5	N/A
6. 共同開発計画会議	1	2	3	4	5	N/A

6. 御研究所と共同作業をされた研究所の間の文化的相違はどんな問題原因があると思われますか。
(以下の余白内に説明してください。)

7. 御研究所は中央研究所と共同研究をされたことがありますか。?

1. いいえ Question 10 に移動してください

2. はい

8. 中央研究所と御研究所の間においての共同作業の性格はどのようなものですか。

	非公式的				公式的	
1. 科学的技術的情報の交換	1	2	3	4	5	N/A
2. 同等の共同研究	1	2	3	4	5	N/A
3. R&D の個人的な情報交換	1	2	3	4	5	N/A
4. 互いの研究所の正式訪問	1	2	3	4	5	N/A
5. 研究設備の共同使用	1	2	3	4	5	N/A
6. 共同開発計画会議	1	2	3	4	5	N/A

9. 御研究所にとって中央研究所の技術はどのくらい技術を補われますか。

あまり補われない

とても助かっている

1 2 3 4 5

10. 最近 2 年間の内、御研究所が共同作業をした研究所の中で、以下の内容が原因で、主立った意見の異なったり、また意見の衝突を何個所の研究所と経験されましたか？。

1. 資源、人材の共同作業への貢献 _____
2. 共同作業から得られた技術の所有権 _____
3. 共同作業から得られた技術の使い方 _____

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11. 以下の1～5は御社内の研究所との共同作業をする決め手となる要因です。影響度を1から5まで御記入ください。

	影響なし				影響度大
	1	2	3	4	5
1.他研究所との互いの技術の 認め合い					
2. 技術補充	1	2	3	4	5
3. 他研究所との共同研究の経験値向上	1	2	3	4	5
4.約束を守る他研究所の心構え	1	2	3	4	5
5. 他研究所の科学者と技術者への信頼	1	2	3	4	5

12. 御研究所の共同作業による影響を以下の1から5にランク分けしてください

	大幅に 増加 ↓	増加 ↓	変化 なし ↓	減少 ↓	大幅に 減少 ↓
1. 御研究所内での R&D プロジェクトの数が	1	2	3	4	5
2. 非常に高度な技術を持つ御研究所内 での R&D プロジェクトの数が	1	2	3	4	5
3. 御研究所内での R&D プロジェクトの種類の数が	1	2	3	4	5
4. 御研究所の製品の質が	1	2	3	4	5
5. 製造過程での技術的見地が	1	2	3	4	5
6. 作業管理的見地が	1	2	3	4	5
7. R&D の素材使用能率が	1	2	3	4	5
8. 御研究所内での技術革新の推進力が	1	2	3	4	5
9. 御研究所内での新技術革新の成功率が	1	2	3	4	5
10. 御研究所内の R&D スタッフの互いの技術 の認め合いの数が	1	2	3	4	5
11. 御研究所の R&D の素材及び人材への結びつきが	1	2	3	4	5
12. 御研究所内 R&D のコストが	1	2	3	4	5
13. 御研究所内での新技術革新に費やす時間が	1	2	3	4	5

13. 御研究所は他の姉妹研究所とのコミュニケーションはどのくらい行っていますか

	1 年毎	3 ヶ月毎	1 ヶ月毎	一週間毎	毎日
トップマネージャーとの電話,E-メール等	1	2	3	4	5
プロジェクトマネージャーとの電話,E-メール等	1	2	3	4	5
R&D スタッフとの電話,E-メール等のコミュニケーション	1	2	3	4	5
トップマネージャーとの個人的に面談	1	2	3	4	5
プロジェクトマネージャーとの個人的な面談	1	2	3	4	5
R&D スタッフとの個人的な面談	1	2	3	4	5

14. 御研究所は中央研究所とのコミュニケーションはどのくらい行っていますか

	1 年毎	3 ヶ月毎	1 ヶ月毎	一週間毎	毎日
トップマネージャーとの電話,E-メール等	1	2	3	4	5
プロジェクトマネージャーとの電話,E-メール等	1	2	3	4	5
R&D スタッフとの電話,E-メール等のコミュニケーション	1	2	3	4	5
トップマネージャーとの個人的に面談	1	2	3	4	5
プロジェクトマネージャーとの個人的な面談	1	2	3	4	5
R&D スタッフとの個人的な面談	1	2	3	4	5

15. 御研究所では平常決定を下す際、以下の 1 から 12 ではどのように判断を下されますか。

1 = 中央研究所の独断

2 = 中央研究所決定、しかし御研究所は提案することが可能

3 = 決定には中央研究所と御研究所とは同等に影響在り

4 = 御研究所が決定しかし、中央研究所は提案することが可能

5 = 御研究所の独断

	中央研究所 の独断				御研究所の 独立した決定
1. 既存製品への重要な変化を行う	1	2	3	4	5
2. 製造過程の修正	1	2	3	4	5
3. 御研究所の再構成	1	2	3	4	5
4. 研究所での科学技術者の採用	1	2	3	4	5
5. 科学者技術者の進路決定	1	2	3	4	5
6. 御研究所による研究プロジェクトの数	1	2	3	4	5
7. 御研究所によるプロジェクトのタイプの選択	1	2	3	4	5
8. 御研究所のためのプロジェクトの優先順位	1	2	3	4	5
9. 御社内での他の研究所と接合した R&D を行う	1	2	3	4	5
10. 御社内での他の研究所との情報交換	1	2	3	4	5
11. 御社内での他の研究所との R&D スタッフの交換	1	2	3	4	5
12. <u>御社外</u> の組織との共同研究	1	2	3	4	5

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16. 以下の文章は御社の説明に適していますか。

	絶対真実				絶対偽
1. 中央研究所が御社内で全研究所内での共同作業の規則を供給	1	2	3	4	5
2. 中央研究所が御社外の組織との共同作業の規則、及び政策を供給	1	2	3	4	5
3. 中央研究所が共同 R&D に従事している R&D 研究所同士の衝突に関する規則を供給	1	2	3	4	5
4. 中央研究所は御研究所の政策の行き渡りを観察していますか。	1	2	3	4	5
5. 御研究所は全活動を公式レポートで中央研究所に報告しなければなりませんか。	1	2	3	4	5

17. 御研究所のトップマネジメントは以下の項目に何パーセントずつ該当されますか。:

1. 御研究所の存在する国出身です _____ %
2. 御研究所の親会社の母国の出身です _____ %
3. 御研究所の母国でも親会社の母国出身です _____ %
4. 中央研究所で以前御勤めされていた _____ %

18. 御社の属する産業内での競争度を以下に示してください。

	競争少なし				競争多し
1. 御社の製品のための市場	1	2	3	4	5
2. 科学者技術者の採用	1	2	3	4	5

19. 御社の属する産業内で、(特に御研究所を除く) 製造過程の技術革新の割合を示してください。

	非常に低い				非常に高い
御社の属する産業内での製造過程での技術革新	1	2	3	4	5

20. 企業内的資源の獲得を巡る御社の国内の研究所の間での競争度を示してください。

	競争なし				競争多い
	1	2	3	4	5

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21. 御社内での平均と比べると、御研究所への役立つ資源の流れはどのような感じですか。

極めて悪い

極めて良い

1

2

3

4

5

22. 突然の開発のために R&D の全科学者と全技術者の 10%がその仕事にまわらざるをえなくなった場合、御研究所の仕事はどのくらい影響を受けますか。

アウトプットは影響を受けない: ☐

アウトプットは ____ %減る

23. 同類の開発のため、御研究所の年間予算が 10%減少した場合、御研究所はどのくらいの影響を受けますか。

アウトプットは影響を受けない: ☐

アウトプットは ____ %減る

24. 御社内での R&D の組織構造を反映するのは次のモデルのうち、どのモデルですか。もし以下にない場合、下の余白に御社の R&D の組織構造を御書きください。

(HQ 中央研究所 Regional 地域研究所(ラテンアメリカ、北アメリカ) Local 国別研究所)

御研究所についての組織構造的データ

25. 御社の親会社の出身国はどちらでしょうか.: _____
26. 御社の産業は以下の何に該当しますが。(該当するものには○を御記入ください。)
1. 電気メーカー 2. 情報産業 3. 医療産業 4. 化学メーカー
5. バイオテクノロジー 6. 科学装置 7. 航空宇宙産業 8. 自動車
9. その他: _____
27. 何時御研究所は設立されましたか.: _____
28. 1998 年御研究所の R&D スタッフは全部で何人いらっしゃいましたか.: _____
29. 1998 年御研究所の科学者技術者は何人いらっしゃいましたか.:
博士号: _____ 修士号(博士号取得者を除く: _____
彼らの分野で 5 年以内の経験者: _____
彼らの分野で 5 年から 10 年の経験者: _____
彼らの分野で 10 年以上の経験者: _____
30. 1998 年の御研究所の R&D にかけられた全予算は幾らかかりましたか.: (通貨単位: 円)
_____ 百万円
R&D 予算に費やされた割合: 基本研究 _____ % 応用研究: _____ %
31. ここ三年間で御研究所は何個特許取得の応募をされましたか. _____
32. 世界規模の R&D 管理の中で、現在直面している出来事、挑戦に関して、我々の研究に役立つ情報がございましたら、以下に御書きください。

御協力有り難う御座いました。本研究の結果を御望みでございましら、以下に E-メールアドレスを御書きください。後にお送りさせていただきます。
貴方のお名前と E-メールアドレス: _____

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御手数をおかけ致しますが、本アンケートを以下のところへファックスでお送りください:

Fax: **Ajax Persaud** **(613) 520-2532 (24 時間何時でも受け付けております。)**

Mail: **Ajax Persaud**
 School of Business, Carleton University, Ottawa, Ontario, K1S-5B6 Canada

Ajax Persaud, School of Business, Carleton University, Ottawa, Ontario, K1S 5B6, Canada

APPENDIX 8

HEADQUARTER SURVEY – JAPANESE VERSION

**世界的な協力を通してイノベーション創造
:ワールドリーディングカンパニーに対するアンケート**

マイヤー様

拝啓

御社増々の御清栄の事とお慶び申し上げます。

私はエイジャックス=パーサウドと申します。現在カナダのオタワに在りますカールトン大学ビジネススクールにて博士課程に在学し、テクノロジー・マネジメントを専攻しています。最近の研究内容は、多国籍企業の研究所内の共同作業における技術革新の効率化かつ高速化です。

現在のトレンドでは、多国籍企業の研究所内の世界的規模な共同作業が正確に出来るなら、これらの企業での実質的な利益が結果に現れるであろう、と言われて来ております。またこれらの企業の同調査によると、世界的な経営を組織的に成功させることが出来る企業はあまり存在していない、とも報告されています。本研究結果は、これら企業の世界的研究活動を推進する方法、また成功または失敗の要因の価値ある洞察力を供給することが出来ます。御社を含め優秀な企業のトップマネジメントとの予備的な論議にて、本研究の需要が再確認されます。

御社は本研究にて私が選ばせて頂いたその多国籍企業の一つに数えさせて頂きました。本書面にて、以下にございますアンケートに御答えして頂くよう御願い申し上げます。

頂いた全ての情報は秘密厳守で取り扱わせて頂きます。

回答は最終報告にて、個人名、研究所名、企業名が特定出来ないようにして回収させて頂きます。御社の参加により本研究の成果が向上することでしょう。御質問等が御座いましたら御手数ですが、電話若しくはイーメールにて御連絡して頂ければ幸いです。

電話番号: (613) 520-2600 内線番号 1017

イーメール: apersaud@business.carleton.ca

また、私の指導教授ヴィノッド=クマールも質問等の問い合わせに喜んで御受け致します。(電話番号: (613)520-2379)

関心のある参加者の方には本研究内容のコピーを送らせて頂きます。

御忙しい中本研究に御協力頂き誠に有り難うございます。御回答終了後、以下に表記してございますファックスかイーメールにて御返事頂くよう御願い申し上げます。

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敬具

Ajax Persaud

セクション A

本セクションでは、最近2年間、御社内での中央研究所とその他の諸研究所間においての共同作業の本質について御質問させていただきます。

1. 御社は研究所を何箇所保有していらっしゃいますか(外国も含めて)?。 _____
2. R&D (研究と開発)プロジェクトにおいて御研究所と共同作業された研究所及び共同作業されている研究所は何箇所存在しますか?。 _____
3. 2.のうち、何箇所の研究所が以下の内容を行っていますか?。

科学的技術的情報交換

同等立場を貫いた共同研究

御研究所がリードする共同研究

他研究所がリードする共同研究

R&D スタッフの交換

実験施設の共同使用

共同プロジェクト計画会議

互いの研究所への正式訪問

4. 労働習慣内で、御研究所と同じ文化を共有している研究所は、御研究所が共同作業している研究所中で、何箇所存在しますか?。 _____
5. 御研究所と同じ経営目的及び価値を所有している研究所は、御研究所が共同作業している研究所中で、何箇所存在しますか?。 _____
6. 御研究所及び 4, 5 で挙げられた研究所の間で、文化的相違による問題にはどのような問題が存在しますか?。(以下に御記入ください)

7. 最近 2 年間の際、御研究所が共同作業をした研究所の中で、以下の内容が原因で、主立った意見の異なったり、また意見の衝突を何個所の研究所と経験しましたか？。

1. 資源、人材の共同作業への貢献 _____
2. 共同作業から得られた技術の所有権 _____
3. 共同作業から得られた技術の使用 _____

8. 以下の 1～5 は御社内の研究所との共同作業をする決め手となる要因です。影響度を 1 から 5 まで御記入ください。

	影響なし			影響度大	
1. 他研究所との互いの技術の認め合い	1	2	3	4	5
2. 技術補充	1	2	3	4	5
3. 他研究所との共同研究の経験値向上	1	2	3	4	5
4. 約束を守る他研究所の心構え	1	2	3	4	5
5. 他研究所の科学者と技術者への信頼	1	2	3	4	5

9. 御研究所の共同作業による影響を以下の 1 から 5 にランク分けしてください。

	大幅に 増加 ↓	増加 ↓	変化 なし ↓	減少 ↓	大幅に 減少 ↓
1. 御研究所内での R&D プロジェクトの数が	1	2	3	4	5
2. 非常に高度な技術を持つ御研究所内で の R&D プロジェクトの数が	1	2	3	4	5
3. 御研究所内での R&D プロジェクトの種類が	1	2	3	4	5
4. 御研究所の製品の質が	1	2	3	4	5
5. 製造過程での技術的見地が	1	2	3	4	5
6. 作業管理的見地が	1	2	3	4	5
7. R&D の素材使用能率が	1	2	3	4	5
8. 御研究所内での技術革新の推進力が	1	2	3	4	5
9. 御研究所内での新技術革新の成功率が	1	2	3	4	5
10. 御研究所内の R&D スタッフの互いの技術 の認め合いの数が	1	2	3	4	5
11. 御研究所の R&D の素材及び人材への結びつきが	1	2	3	4	5
12. 御研究所内 R&D のコストが	1	2	3	4	5
13. 御研究所内での新技術革新に費やす時間が	1	2	3	4	5

10. 貴方の意見内で、御社の研究所の何所が以下に該当すると思われるでしょうか。

メインな役割として(活動で 60%以上) 製品調整を行っている研究所	_____
メインな役割として(活動で 60%以上) 製品デザインと開発を行っている研究所	_____
メインな役割として(活動で 60%以上) 応用研究を行っている研究所	_____
メインな役割として(活動で 60%以上) 基本研究を行っている研究所	_____
メインな役割として(活動で 60%以上) 技術情報収集を行っている研究所	_____

11. 貴方の意見内で、御社の研究所の内、何所が以下の決め事について、自由を持っていると思われるか。(中央研究所若しくは他の研究所からの影響を除いた決め事を除く)

決定:	研究所数
1. 既存製品への重要な変化を行う	_____
2. 製造過程の修正	_____
4. 御研究所での科学技術者の採用	_____
5. 科学者技術者の進路変更	_____
6. 御研究所による研究プロジェクトの数	_____
7. 御研究所によるプロジェクトのタイプの選択	_____
8. 御研究所のためのプロジェクトの優先順位	_____
9. 御社内での他の研究所と接合した R&D を行う	_____
10. 御社内での他の研究所との情報交換	_____
11. 御社内での他の研究所との R&D スタッフの交換	_____
12. <u>御社外</u> の組織との共同研究	_____

12. 御社内での R&D の組織構造を反映するのは次のモデルのうち、どのモデルですか。もし以下にない場合、下の余白に御社の R&D の組織構造を御書きください。
(HQ 中央研究所 Regional 地域研究所(ラテンアメリカ,北アメリカ) Local 国別研究所)

セクション B

御研究所についての組織構造データ

13. 御社の親会社の出身国はどちらでしょうか.: _____
14. 御社の産業は以下の何に該当しますが。(該当するものには○を御記入ください。)
1. 電気メーカー	2. 情報産業	3. 医療産業	4. 化学メーカー
5. バイオテクノロジー	6. 科学装置	7. 航空宇宙産業	8. 自動車産業
9. その他: _____			
15. 何時御研究所は設立されましたか.: _____
16. 1998 年御研究所の R&D スタッフは全部で何人いらっしゃいましたか.: _____
17. 1998 年御研究所の科学者技術者は何人いらっしゃいましたか.: _____
- 博士号: _____ 修士号(博士号取得者を除く): _____
- 彼らの分野で 5 年内の経験者: _____
- 彼らの分野で 5 年から 10 年の経験者: _____
- 彼らの分野で 10 年より長期間の経験者: _____
18. 1998 年の御研究所の R&D に向けられた全予算は幾らかかりましたか.: (通貨単位: 円)
- _____ 百万円
- R&D 予算に費やされた割合: 基本研究 _____ % 応用研究: _____ %
19. ここ三年間で御研究所のファイルは何個特許取得の応募をされましたか. _____
20. 世界規模の R&D 管理の中で、現在直面している出来事、挑戦に関して、我々の研究に役立つ情報がございましたら、以下に御書きください。

御協力有り難う御座いました。本研究の結果を御望みでございましら、以下に E-メールアドレスを御書きください。後にお送りさせていただきます。

貴方のお名前とイーメールアドレス: _____

御手数をおかけ致しますが、本アンケートを以下のところへファックスでお送りください:

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