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Canadian R&D abroad management practices

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Abstract

In the 1980s, Canadian industrial R&D abroad has grown substantially. In 1995, R&D expenditures by Canadian affiliates, only in the United States, represented some US$1.4 billion and employed some 6300 persons. Nearly 60 Canadian-owned and -controlled corporations conduct overseas R&D, mostly in the US, Western Europe, Japan, and Australia. Canadian corporations are performing commercial R&D abroad in order to support their manufacturing subsidiaries and to come closer to customers and markets. A secondary motivation is to hire skilled personnel, monitor foreign technological development and increase the inflow of new ideas into the corporation. They also chose friendly socio-political environments from a regulatory point of view. Technology transfer and adaptation to local markets is also an important mission of the foreign R&D establishment. Foreign R&D activities of Canadian firms are fairly decentralized and autonomous. Most of the foreign subsidiaries undertook R&D abroad before they were acquired by the Canadian corporation; also the number of Canadian managers was reduced and the R&D projects were usually decided in the affiliate. Three main types of expatriate R&D were found: a majority of the subsidiaries were producing goods in the same or related industries as in Canada (such as machines, transportation equipment or housing equipment). A second group of firms were vertically integrated firms, that conducted process research in Canada and advanced materials and final products research abroad, closer to the markets for this type of goods; they were active in the chemical and metal industries. Only one truly global corporation was found, with an international division of labor among its many foreign laboratories. The degree of autonomy varied across the three types of expatriate R&D units. In the last 10 years, the internationalization of industrial research and development has increased very rapidly. Foreign-affiliated corporations operating in the United States represented some 9.3% of all company-funded R&D in that country in 1987, and close to 18% in 1995 (Dalton and Serapio, in this issue). Similarly, foreign R&D expenditures by US-affiliated companies abroad have more than tripled. Canadian industrial R&D abroad has grown at a similar pace. It now includes over 100 research facilities owned by some 60 Canadian corporations, with subsidiaries in the United States, western Europe, Japan, Australia, and several developing countries (China, Brazil, India, Mexico, and Turkey). However, little is known about the characteristics of this foreign R&D: missions, managerial practices, budgets or innovative activity. This study is the first to present original data from a survey of these facilities, complemented by secondary material from annual reports and the financial and technical press. It follows a previous study of Canadian patents abroad, which concluded that diversification into related activities was the overseas strategy of Canadian multinational corporations (MNCs) with foreign R&D activities [Niosi, J., 1997. The globalization of Canadian R&D, Management International Review 37 (4) (in print).]. The first section of this paper presents (1) a short summary of some relevant literature on the management of foreign R&D, (2) the design of the study, (3) the results, and (4)

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a comparison of theories with Canadian data. It offers conclusions about the existence of three distinctive types of internationalization in Canadian R&D, each with different strategies and outcomes.

Keywords: Canadian R&D; Foreign R&D; Subsidiaries

1. The management of international R&D

In spite of a certain neglect before the 1990s (Cheng and Bolon, 1993), the literature on the internationalization of R&D and the management challenges that it creates, is growing quickly. This increase in writing follows the rapid expansion of foreign R&D by multinational corporations (MNCs). This section summarizes some of the main issues in the literature.

1.1. Determinants of centralization and decentralization

Technology production has usually been centralized in the host country of the MNCs (Patel and Pavitt, 1991). Many factors dictate this pattern of behavior: desire to reduce the costs of communication and control, economies of scale in R&D, better coordination between central productive facilities and R&D units, better protection of strategic technical knowledge, easier access to home-country governments than to foreign ones, more experience with domestic than with overseas markets in the launching of new products (Terpstra, 1985).

However, more and more corporations are creating or acquiring foreign laboratories and conducting expatriate R&D. The many reasons for this growing decentralization of R&D can classified into three main groups: demand-side, supply-side and environmental factors (Granstrand et al., 1992). Demand-side factors include increasing the subsidiary's competitiveness through the transfer of technology from the parent company (which requires at least some adaptive R&D capabilities in the former), subsidiary pressures to enhance its status within the corporation, greater access and sensitivity to local markets, and proximity to customers. Supply-side factors include hiring foreign and (usually) barely mobile highly skilled labour, increasing the inflow of ideas from dynamic markets and innovative milieux, and monitoring development of technological fields abroad. Environment factors include a friendly regulatory legislation for intellectual property (which is key in industries such as pharmaceuticals and electronics), tax advantages, subsidies for R&D, and government pressures to improve the subsidiary's capabilities beyond the simple assembly of proven products and into innovative activities.

1.2. Classifying R&D activities

The analysis of the functions of expatriate R&D activity has evolved, following a parallel evolution in the foreign technological activities of MNCs. The first writings emphasized adaptive R&D and technology transfer from the parent company to the subsidiary. In a landmark study on US R&D overseas, Mansfield et al. (1979) concluded that ''the principal purpose in most, but not all, firms has been to help transfer technology abroad.'' At the same time, Ronstadt (1977, 1984) arrived to a similar conclusion: US MNCs had established foreign R&D units to transfer and adapt their home technology to foreign markets. He found, however, an evolution of some of these technology-transfer units (TTUs) towards indigenous technology units (ITUs), developing new products for local markets. In time, however, some of these ITUs would move into more advanced activities—design of products for global markets (global technology units, GTUs) and generation of new ideas for the corporate parent (corporate technology units, CTUs). Similarly, Hewitt (1980) found that foreign R&D could be classified into three main types—adaptive, local market-oriented and global. Like Mansfield, Ronstadt and others, Hewitt found that the first type was predominant.

More recent studies emphasize the increasing role of innovation in foreign subsidiaries. Pearce (1992) insisted on the significance of locally relevant innovation: support for local manufacturing was found to be the major activity of expatriate R&D establishments. In his study of the world pharmaceutical industry, Taggart (1991, 1993) suggested that pharmaceutical MNCs are increasingly creating knowledge abroad, through what Ronstadt has called GTUs and CTUs. In the same direction, Casson and Singh (1993) have pointed out that large MNCs have in some industries such as pharmaceuticals, computer and telecommunications equipment, created global networks of laboratories. Similarly, on the basis of an in-depth study of a sample of MNCs in four industries (chemicals, petrochemicals, telecommunications, and electronics), Chiesa (1996) (21) found that there was an increasing division of labor among central and foreign technology units, ''making distinctive contributions to centrally coordinated programs.''

1.3. Subsidiary autonomy vs. parent control

Linked to these issues is the degree of autonomy of the expatriate R&D facility. Both the technology-transfer (TTUs) and global models (GTUs) require some coordination and support of the expatriate laboratory from the parent company. In addition, the TTU stage is coherent with significant numbers of home-country personnel in the foreign R&D establishment, while the GTUs require only some expatriate top level personnel to improve coordination with headquarters. Conversely, the corporate parents are inclined to grant more autonomy to the overseas ITUs: local marketing units and expatriate production managers have a decisive say in the ideas and the choice of R&D projects when the mission of the laboratory is designing products for foreign markets. Similarly, the autonomy of the subsidiary is larger when the mission of the overseas laboratory is exploring new basic ideas for future products. Also, the proportion of expatriate personnel is expected to be smaller, in these two latter types of foreign R&D facility, than in the two former types.

1.4. National differences in corporate R&D strategies

For many decades, countries have differed in the scale of their expatriate R&D (Cantwell, 1995). Large firms based in several smaller industrial countries, such as Belgium, Canada, The Netherlands, Sweden, and Switzerland, conduct a large share of their total R&D abroad. The search for larger markets and larger pools of talent has probably spurred many national firms of several smaller industrial nations to develop overseas operations, including those related to technological innovation. This pattern is not general: Denmark, for example, displays much less internationalization of manufacturing and R&D than the above-mentioned smaller nations.

Large industrial countries have on average a smaller overseas commitment to R&D, but their propensity to conduct foreign R&D is also variable. British MNCs have major foreign R&D activities: over 50% of recent patents of British firms are the result of research located abroad; conversely, Italian and Japanese firms conduct a larger share of their technological innovation at home. American, French, and German MNCs find themselves somewhere between these two poles.

These different national trajectories have been interpreted in diverse ways. Håkanson (1992) found that the heavy and early involvement of Swedish MNCs in foreign R&D was pulled by demand factors, such as market potential and market adaptation, more than by supply-related factors associated with high host-country R&D intensity or sizeable pools of highly skilled scientists and engineers. In 1988, Swedish MNCs performed a major proportion of their foreign R&D in the larger European Union countries. Geographical proximity and the search for larger markets seem crucial determinants for the overseas R&D activities of Swedish firms. Similarly, Pearce (1992) found that demand factors—for both adaptation of existing products and development of new ones—were key in explaining foreign R&D by the world's largest MNCs. Supply-side factors (aspects of host-country technological capacity) ranked second.

An evolutionary model was suggested for the development of foreign R&D in Swedish enterprises (Håkanson, 1990). The first stage was that of the centralized hub of laboratories, with a central unit producing all the major innovations and a network of small, foreign, auxiliary R&D units providing technical assistance in the adaptation and transfer of that technology from the parent company to the subsidiary. A second, 'polycentric' stage would be that of the decentralized federation of laboratories, with a group of R&D units performing different tasks, including innovative research abroad. The final, present stage involves a globalized approach, with more communication and coordination organized by the parent company's labs, but more autonomy in the overseas R&D establishments.

Japanese MNCs are very different from the Swedish in terms of foreign R&D. Up to the 1980s, Japanese MNCs were slowly expanding their overseas research and development, and they still lag behind those of other Western countries as a proportion of total R&D (Graham, 1992; Sakakibara and Westney, 1992; Okimoto and Nishi, 1994; Papanastassiou and Pearce, 1994; Odagiri and Yasuda, 1996). However, by mid-1990s, they were rapidly increasing their overseas R&D commitments, both in absolute terms and as a share of total R&D. Even if product development and product adaptation were their most important missions, Japanese laboratories abroad were relatively more committed to basic research than those of other countries. Japan's catching-up period is now over, and its corporations need to produce their own radical innovations in order to compete in Western markets. Interaction with Western science is now essential for their long-term competitiveness. In this direction, Sakakibara and Westney (1992) suggested that Japanese R&D abroad has evolved through five stages: (1) technology scanning (by small units collecting scientific and technical information abroad for use by the corporate parent in Japan), (2) technology-transfer units, (3) technical cooperation units for adaptation of products with local suppliers and customers, (4) local product-development units, and (5) basic research units (or the addition of basic-research missions to existing foreign R&D facilities).

2. Design of the study

In the early 1990s, fragmentary evidence showed that Canadian R&D abroad was substantial. By 1995, in the United States alone, affiliates of Canadian corporations spent some US$1.4 billion and employed over 6000 persons in R&D (Dalton and Serapio, in this issue). Some well-known Canadian MNCs also conducted R&D in western Europe, Australia, and Japan. In the 1992–1994 period, nearly 40% of the patents of Canadian MNCs were obtained as a result of their expatriate R&D (Niosi, 1997). The management practices of these research activities remained, however, totally unknown by scientific observers.

At the end of 1995, the population of Canadian subsidiaries with foreign R&D capabilities was determined through several sources. All foreign subsidiaries patenting abroad the results of their own research were included; there were 46 of these. Also, the overseas subsidiaries of Canadian companies listed in the *Directory of American Research and Technology 1995* (Bowkker, 1995) were included—21 firms with 39 research facilities. Among these, two-thirds had already been identified. This source thus added seven new companies. Finally, some eight other corporations with subsidiaries abroad were identified through other sources, such as the financial press, annual reports, and technical publications.

The population of Canadian firms with foreign subsidiaries conducting R&D is changing constantly. In early 1996, Ottawa-based telecommunications-equipment producer Mitel bought the integrated circuit maker ABB Hafo, based in Sweden, from Asea Brown Boveri. In 1995, the world leader of flight simulators, Montreal-based CAE, sold its American subsidiary Link, with substantial R&D activities in the United States. Several new subsidiaries could not be included in the study, as the future organization of their R&D activities was probably still undecided, and their present R&D layout depended on their previous owner. Also, several R&D facilities of Canadian companies that were recently sold to foreign interests had to be left out.

We sent questionnaires to the research-active subsidiaries of some 60 Canadian corporations, mostly in the United States (56), but some in western Europe (15, but 12 of them were also active in the United States), Japan (three, all of them active in the United States) and Australia (three, including two already active in the United States). Some of these subsidiaries responded that they had recently been sold to firms of other nationalities. Six explicitly declined to participate, and a few questionnaires were returned because of companies having moved elsewhere. In all, 22 questionnaires were returned fully completed or were filled out personally by myself during the pre-test, representing 18 different corporations. (The R&D-active foreign subsidiaries of a large Canadian corporation filled out four questionnaires, and foreign R&D units of another one completed two).

Most (48) of these 60 corporations were large, including almost all the large Canadian MNCs. The other 12 were small and medium-sized enterprises (SMEs). The respondents included the foreign R&D units of 16 large and two medium-sized corporations (fewer than 500 employees, but over 250 employees worldwide).

The questionnaire included 24 questions (with some 60 variables) covering personnel, budgets (amounts and origins), areas of R&D, circumstances under which R&D activities started, missions, reasons for overseas activities, origins of R&D projects' initiatives, difficulties and role and importance of Canadian parent companies and expatriate managers.

The final sample included thus 22 questionnaires from 18 different Canadian-owned and controlled firms, including five laboratories from the United Kingdom, three from Germany, 13 from the United States, and one from China. This small sample represents the underlying population approximately in terms of both geographical distribution of expatriate R&D units and the size of corporations with overseas R&D.

The 18 Canadian enterprises included six active in the production of electronic hardware and software, three machinery manufacturers, two metal producers, two chemical companies, one biotechnology producer, one printing firm, one pulp and paper company and two in other manufacturing industries.

3. Canadian R&D activities abroad

This section presents some of the most important results of the survey, with an emphasis on the similarities of the 22 Canadian-owned R&D facilities abroad.

3.1. Origins

A majority of the foreign subsidiaries had been acquired by the Canadian corporation while they were already in operation. In only five cases out of 22 (23%), the subsidiaries had been founded by the Canadian parent firm, confirming the Canadian tendency to conduct foreign direct investment via acquisition instead of greenfield investments (Solocha et al., 1990; Solocha and Soskin, 1994).

Most often, the R&D activities of the foreign subsidiaries had started before Canadian acquisition. This was the case in 12 subsidiaries (55%). In five other cases, R&D activities started after acquisition. In the five remaining cases, R&D started with the founding of the subsidiary by the Canadian firm.

3.2. Position within MNCs

Seven of 18 Canadian corporations (39%) had their central R&D laboratories abroad. In four cases, the enterprises had no R&D activity whatsoever in Canada. In three others, the corporations conducted R&D abroad for a specific type of product or process, while they undertook parallel R&D in Canada on a separate list of products or processes. Two of the four companies conducting R&D exclusively in the United States—and not in Canada—were medium-sized (fewer than 500 employees worldwide). The remaining 11 companies (61%) had only divisional units abroad, with specific local and/or global mandates for the line of products developed overseas. Their main R&D activities were, however, located in Canada.

3.3. Number of countries

On average, each corporation performed R&D in three countries, but when a large MNC with research facilities in eight nations was subtracted, the result boiled down to 2.5 countries, including Canada. Fourteen corporations (out of 18) conducted R&D in Canada; also, 14 did so in the United States and 10 in one or more countries of western Europe: seven in the United Kingdom, four in Germany, two in France and one each in Ireland, Italy, Luxembourg, and Switzerland). Also, R&D was conducted in Japan (by two different Canadian corporations), and Australia (by one).

There were also a few R&D establishments in several developing countries—two in India and one each in Brazil, China, Mexico, and Turkey (see Table 1). In all, the corporations in our sample were active in 16 countries (five developing and 11 developed), including Canada.

Table 1
Geographical distribution of foreign R&D activities in the sample

Country	Countries where R&D was conducted
Canada	14
United States	14
Western Europe	17
United Kingdom	7
Germany	4
France	2
Ireland	1
Italy	1
Luxemburg	1
Switzerland	1
Japan	2
Australia	1
Developing countries	6
India	2
Brazil	1
China	1
Mexico	1
Turkey	1

3.4. Organization

A majority (12 out of 22) of the foreign R&D facilities were conducting permanent, in-house research programs, and three other were undertaking R&D programs with outside partners in the laboratories of the latter. Another 25% (six out of 22), were regularly conducting R&D, but on an ad hoc basis; they started R&D activities to develop a new product (for example, a new machine) or to improve an existing one and substantially reduced them once the product was in the market. Adaptation of the product to different customers or product improvement and refinement sustained some permanent, but variable level of R&D. One Canadian corporation had an independent R&D subsidiary abroad, entirely devoted to R&D, but in all the other cases, manufacturing accompanied research. This evidence points again to foreign R&D as being closely related to overseas manufacturing.

3.5. Size of establishments

In 1992, the average total number of personnel employed in the R&D overseas facility was 112; in 1995, it was 126. By 1995, the R&D facilities in the sample thus represented in all close to 2800 R&D employees, of whom over 2200 were scientists and engineers. Few changes occurred within the sample in the 1992–1995 period: four corporations increased and two decreased the number of employees in their foreign R&D, and in 1994, one smaller firm started R&D in the United States, and one larger corporation launched R&D activities in China.

In 1995, the ad hoc research and development units employed on average eight persons; in the more permanent facilities, the average was 170. However, in companies with ad hoc R&D, all staff members were devoted to this activity, while in the permanent facilities, the average number of scientific and technical personnel was only 128; the remaining 25% of employees was supporting, mostly clerical staff.

4. Managerial practices

4.1. Missions

The conduct of commercial and pre-commercial R&D and product development were the most important activities of the foreign subsidiaries. Commercial applied R&D was the most frequent case: 12 companies designated it as the single most important R&D activity and all, but three of the 22 R&D units were active in this area. Product development in the same industries as in Canada was the second choice: nine companies mentioned it as being the most important and eight as an important activity. Pre-commercial applied research ranked third—14 subsidiaries conducted it, including two that had it as their most important mission, and seven as an important one.

Other notable activities were support to the parent company's marketing efforts in the host country (important or the most important for 11 companies), development into new or related industries (six firms providing technical assistance to the parent company (five), and supporting the parent company's technology transfer from Canada to the host country (five). The less crucial missions were those of providing technological assistance to external firms and organizations (two) or to governments (two), basic research

Table 2
Missions of overseas R&D units

Mission	Most important	Important	Little importance	Not a mission
Commercial applied R&D	12	5	2	3
Development in same industry as in Canada	9	8	1	4
Pre-commercial applied research	2	7	5	8
Support parent company's marketing efforts in host country	3	8	0	11
Development into new or related industries	0	6	5	11
Technical assistance to parent company	1	4	3	14
Support parent company's technology transfer from Canada	1	4	3	14
Technical assistance to industry	0	2	3	17
Technology transfer to government	1	1	2	18
Basic research	1	0	2	19
Technology transfer to industry	0	0	4	18
Other	1	0	0	21

Multiple choice question.

(one) and other ($n = 1$) (see Table 2). Only four subsidiaries were transferring any technology back to Canada, and five were transferring to other local subsidiaries of the Canadian company.

In sum, Canadian R&D units abroad are supporting local manufacturing in the host countries through innovative activities such as commercial and pre-commercial R&D, together with product and process development. This finding supports the demand-side explanations and tends to contradict older hypothesis of technology transfer and adaptation of home technology to the host country as principal activities of the expatriate R&D laboratory.

In the same vein, foreign subsidiaries were targeting both global and local markets for those new or improved products. Most (82%) expatriate labs were targeting the world market. Eighteen R&D units (77%) were also aiming at the local market. A group of 10 affiliates (46%) designed products to be manufactured abroad and sold in the Canadian market. In Ronstadt's classification, Canadian R&D abroad is composed mostly of units with both local and global mandates.

4.2. Reasons

The reasons given for the establishment, acquisition, or continuation of foreign R&D operations were many and were consistent with the above-mentioned missions, as well as with the patent study (Niosi, 1997). The questionnaire presented a list with multiple choices with four main groups of determinants proposed—demand (D), supply (S), technology transfer from home country (TT), and environmental factors (E) (see Table 3).

First, demand-side determinants (D) stricto sensu appeared to be the most important. Also, they were linked with one another: the Canadian corporation was moving closer to customers and markets, responding of the demands of its foreign subsidiary, and/or supporting local manufacturing. All these reasons indicate that R&D was above all related to the productive operations of the Canadian company abroad.

The second group of factors point towards supply of technology (S) and are also mutually related—increasing the inflow of new ideas, recruiting highly skilled personnel, and monitoring technical fields abroad. They indicate that corporations seek innovative milieux in order to learn. Also, some 50% of Canadian firms conducting R&D in western Europe and over 60% of those active in the United States pointed to these supply-related reasons.

The third group of reasons was related to technology transfer from Canada (TT). Six out of the eight R&D facilities in Europe (75%) pointed out these reasons as being important, as well as one in the United States (8%) and one in China—our only response from a developing country. Canadian companies—particularly in high technology—seem to benefit from some kind of technology gap vis-à-vis

Table 3
Reasons for establishing R&D abroad

Reasons	Score[a]	Number of times mentioned as important[b]
Proximity to customers, markets (D)	3.8	18
Responding to demands of foreign subsidiary (D)	3.3	15
Supporting local manufacturing (D)	3.0	14
Recruiting highly skilled personnel (S)	2.1	11
Monitoring technical fields abroad (S)	2.1	11
Increasing inflow of new ideas (S)	2.0	10
Adaptation of Canadian products to local market (TT)	2.0	9
Facilitating technology transfer to host country (TT)	2.0	9
Responding to demands of host governments (E)	1.8	11
Cost factors (wages, taxes, etc.) (S/E)	1.8	8
Proximity to suppliers (S)	1.6	8
Cooperation in local R&D projects (S)	1.3	5
Tax advantages/subsidies for R&D (E)	1	4
Difficulties in closing down R&D in acquired firms (E)	0.9	3
Other	0.7	1

[a]Scores: 5, extremely important; 4, very important; 3, important; 2, somehow important; 1, little importance; 0, unimportant.
[b]Scores of 3 and over.

Western Europe, which does not manifest itself vis-à-vis the United States. Technology transfer appears important then in the European questionnaires, but not in those originating from the United States.

Western European governments seemed more eager to request local R&D from Canadian corporations: 75% of the R&D units operating in Europe considered the demands of their host governments as major location factors, but only 38% of Canadian R&D facilities in the United States did so.

Fourth, cost factors (E) followed, including wages, taxes, and subsidies for R&D. However, they were less significant determinants for establishing foreign R&D facilities; some executives even indicated that Canada was, in terms of R&D costs, more convenient than the United States or western Europe. Also, there was no difference between western Europe and the United States in terms of R&D costs and other advantages.

These findings fit with a major result of our previous paper: Canadian subsidiaries tend to locate themselves in the most populous US states, and in large countries, and in those with the larger innovative infrastructure. The main goals of their foreign operations are markets and sales; R&D supports these sales. Technically based supply factors are second: ideas and highly skilled personnel attract Canadian firms to the United States and western Europe.

Host governments are less significant, both as demanders of R&D activities in foreign subsidiaries and, of course, as purveyors of these tax advantages and subsidies that a majority of the companies consider major incentives to conducting R&D. If the first group of factors points to market factors, this group relates to (less critical) public policy determinants.

4.3. Inputs

The average budget of the foreign R&D facility was constantly increasing, from $13 million in 1992 to $25 million in 1995. Except in two cases, it was growing in every R&D unit. However, the dispersion was considerable: 1995 budgets, for instance, ranged between $120 million (highest value) and $0.3 million (lowest). The medians were $1 million in 1992 and $2 million in 1995. R&D budgets represented, on average, some 4.2% of sales, reflecting the role of high-technology industries among those with expatriate R&D labs.

Most often, these budgets came from the internal resources of the subsidiary: in 18 cases, this was the

Table 4
Budget allocation in R&D units by mission

Mission	Number of firms allocating funds	Average budget devoted to mission (%)
Commercial applied R&D	17	38
Development	17	39
Technical assistance to local subsidiary	13	9
Pre-commercial applied research	11	8
Basic research	5	4
Technical assistance to outside organization	5	1
Technology transfer to government or firms	5	1
Other	1	n.
Total		100

n = Negligible.

first and usually the only source of funds for R&D. Transfer for the parent company in Canada was the second largest source: in two instances, it was the principal origin of funds, and in one, it provided 50% of the R&D money. In one case, R&D contracts from external firms provided 50% of the funds. Local or home-country governments, sister companies within the MNC, or other sources were not important.

Budgets corresponded to the explicit missions of the labs. They were allocated most often to commercially applied R&D (in 17 labs), development (17), technical assistance to the subsidiary (13) and pre-commercial applied research (11). For the whole sample, these four missions received over 90% of budget allocations. All other destinations were by far less important (Table 4).

However, established R&D labs and the other types of R&D units (ad hoc R&D groups, R&D subsidiaries and the like) differed in budget allocation to their two most important missions. Established R&D units devoted, on average, over 50% of their budgets to product and process development, and other types of units only devoted 22%; conversely, established R&D labs devoted only 26.3% of budgets to commercially applied R&D as against other types of units (Table 5) at 51%. Product and process development (a more demanding activity) thus seems to be almost exclusively conducted in established R&D facilities.

Table 5
Types of R&D establishment and main R&D activity as per budget

	Mean	Standard deviation	Cases
Commercially applied research			
R&D laboratories	26.25	26.72	12
Other R&D organizations	51.00	42.02	10
Within group total	37.5	34.46	22
$F = 2{,}8141$; $df = 1$; significant = 0,1090			
Development			
R&D laboratories	53.50	29.27	12
Other R&D organizations	22.00	31.55	10
Within group total	39.18	30.32	22
$F = 5{,}8871$; $df = 1$; significant = 0,0248.			

4.4. Outputs

These foreign R&D activities were producing different types of outputs. On the whole, the results were coherent with missions and reasons for going abroad, as well as budget allocation figures (Table 6).

Prototype devices, pilot plants and materials were the principal output in a majority of the overseas R&D establishments (82% of were producing them, and nearly half of the budgets was spent in this area); algorithms and software were second in terms of budgets (20%), but only 10 companies (mainly in electronics and machinery) were producing them; internal reports (55% of the foreign units, consuming 15% of the budgets) and other outputs followed.

Patents did not represent a major type of output for any R&D unit. In fact, during the four years for which patent information was requested, four units obtained none at all. For the remainder, the average number of patents per year was 1.7. The R&D unit with the most patents had been granted some 20 of them for the period 1992–1995; on the opposite side of the distribution, four companies had obtained only one patent in four years. The subsidiaries with the largest number of patents were active in chemical and composite materials R&D; those with no patents operated in the machinery and telecommunications-equipment industries. This finding confirms the high variability in use of patents according to industry found by Winter (1989).

Patents were, more often than not, the property of the foreign subsidiary: in 13 labs out of 22 (59%), intellectual property stemming from expatriate R&D was granted to the overseas affiliate: intellectual property was so closely connected to the other assets of the subsidiary that it had little value for the Canadian parent company. In only three cases was the controlling corporation in Canada the owner; in two other instances, the owner of the patents was a foreign affiliate (not incorporated in Canada). The remaining four subsidiaries had requested no patents.

Finally, licences were almost nonexistent: only two companies had licensed any technology to outside organizations. One company mentioned using patents as a 'war chest', in order to obtain other companies' technologies through cross-licensing. On the whole, however, these foreign R&D units produced technology for their own use in manufacturing, not for sale or licensing as such.

All these figures are consistent with a picture of fairly independent Canadian subsidiaries abroad conducting R&D to support local manufacturing, including locating technological activities closer to markets, customers, and suppliers. The results of this R&D being beneficial to the subsidiaries (and exploited by them), intellectual property in them was also allocated to the foreign affiliate.

4.5. Links with the parent company

Foreign R&D units of Canadian corporations were quite autonomous from their Canadian headquarters. First, they are run by local personnel. Canadian citizens represented only 4%, on average, of R&D managers; 12 of the 22 R&D facilities had no

Table 6
Outputs of foreign R&D units

Outputs	Units mentioning (percentage of total)	Average share of outputs (%)
Prototype devices and materials	18 (82%)	47
Internal reports	12 (55%)	11
Algorithms and software	10 (45%)	22
Patents and licences	9 (41%)	4
Papers for presentations	11 (50%)	4
Demonstration of devices	10 (45%)	5
Publication	4 (18%)	1
Other	2 (9%)	3
Total	22 (100%)	100

Multiple choice question.

Table 7
How R&D projects are determined in foreign R&D units

Method	Number of firms using practice	Firms using practice exclusively
Only major projects are submitted to Canadian headquarters for approval.	14	5
R&D projects are designed by subsidiary and submitted for approval to Canadian headquarters.	11	4
No project is submitted to the Canadian parent company.	8	4
R&D projects are determined by the Canadian parent company.	5	2
Other	1	1

Multiple choice question.

Canadian manager at all, and only one had 30% (highest figure) of Canadian citizens among its top R&D officers.

Second, the foreign units also enjoyed a high level of autonomy vis-à-vis the Canadian parents in the area of project approval and selection (Table 7). The most common situation (14 out of 22) was that they submitted only major R&D projects for approval to the Canadian parent company. In only two cases, did the Canadian head office exclusively determine the R&D projects of the affiliate, but in some instances, no project was ever submitted to the overseas parent.

Third, ideas and initiatives for R&D projects came most often from local customers, and local production and marketing units, as well as from foreign customers' production and marketing units (Table 8). This finding is consistent with Canadian subsidiaries' conducting R&D for local and world markets. Parent companies were seldom a major source of projects.

Initiatives sometimes came from local collaborative firms, and less frequently from local universities or public laboratories in the host country, and from foreign production units. Looking for foreign skills and university ideas seems a minor consideration for Canadian companies conducting R&D abroad. Conversely, the data confirm the picture of local subsidiaries solidly linked to the local and world customers and markets that they serve, and from which they gather useful ideas and initiatives for R&D projects.

Most subsidiaries experienced difficulties. Only five declared no problems in operations (Table 9). Most of these difficulties were of the 'transaction-cost' type; coordination with Canadian headquarters and technology transfer from Canada were the most important. The small size of the expatriate R&D unit was the most widespread problem

These findings are consistent with the existing literature on Canadian MNCs and with a previous study on overseas R&D by Canadian firms based on

Table 8
Origins of initiatives in foreign R&D units

Origin	R&D units using source	R&D units using as major source
Local customers	21	20
Local marketing units	17	14
Foreign customers	19	10
Local production units	18	13
Foreign marketing units	13	9
Foreign production units	13	6
Parent company	11	3
Local collaborative research with firms	11	4
Local university, public laboratory	7	1
Other (market intelligence)	2	2

Multiple choice question.

Table 9
Difficulties of foreign R&D units

Difficulties	Times mentioned (percentage of units)	Average importance (all firms)	Average importance[a]
Small size of the R&D unit	14 (64%)	2.5	3.5
Coordination with Canadian parent	10 (45%)	2.1	4.7
Technology transfer from Canada	8 (36%)	1.5	4.1
Other	2 (9%)	0.3	3.5

[a]Among the units having indicated the difficulty.

patents (Niosi, 1997). Acquisition was the preferred mode of entry into foreign markets and usually into foreign R&D. Often, the acquired firm already possessed R&D facilities. The mission of these foreign laboratories was commercial R&D and development either in the same or in related industries as in Canada. Demand factors were key to explaining foreign R&D—the need to be closer to larger local and international markets and customers and responding to the demands of the overseas subsidiary. As in the Swedish case, supply factors came second, with the recruitment of host-country highly skilled personnel crucial. Environmental factors were much less important, Canada being a competitive country in terms of R&D costs, tax credits and other advantages. Six companies had central laboratories abroad. Four had no R&D in Canada at all. The median company had R&D facilities in 2.5 countries, typically the United States and Canada, but in some cases, in the United States and the United Kingdom or another Western European country.

These expatriate R&D units were fairly autonomous: their budgets came most often from the internal revenues of the subsidiary, their managers were most commonly local residents and their research initiatives and decisions were mostly local. They had received mandates to develop products for both the local and the global markets.

5. Three models

Section 4 has emphasized the similarities among the Canadian laboratories abroad. In the present section, we differentiate among three types of expatriate laboratories.

The first group of laboratories corresponds to the strategy of related diversification (Table 10). Typically, these manufacture specialized machinery, transportation equipment, or metal products and they own R&D facilities for different types of related products. Thirteen R&D units can be classified under this model. More than half of them are ad hoc R&D groups constantly being renewed, the rest being either R&D labs or R&D subsidiaries. Their average size is around 28 full-time employees. Each facility—either Canadian or foreign—has a global mandate and creates new or improved products in its specific line of business. These overseas R&D units develop products for both the local and the global (including the Canadian) markets, and they thus exhibit some of the characteristics of both the indigenous technology units (ITUs) and the global technology units (GTUs) of Ronstadt's typology. Their mission does not include assisting foreign governments, supporting technology transfer from Canada, or assisting the Canadian parent in marketing. Their autonomy, from a technological point of view, is great in terms of personnel (almost no Canadian managers), and project management: typically, Canadian parents were never behind the initiative or the determination of R&D projects. Also, the R&D budgets came entirely from the revenues of the subsidiary. The units' most important outputs are prototype devices and materials.

The second type of overseas R&D is that of the internationally vertically integrated firm (Table 11). These MNCs were typically metal producers, forest products or chemical companies conducting primary-metals or basic-chemicals R&D in Canada and advanced-materials R&D abroad, closer to the main markets for these types of products. The R&D

Table 10
Related diversifiers

Characteristics	Pearson correlation coefficient significance
Most often conduct R&D on an ad hoc basis	0.10746
R&D existed in subsidiary before the acquisition.	0.07543
Technology transfer to governments is not a mission,	0.05206
... nor is supporting parent marketing activities,	0.00705
... nor is supporting technology transfer from Canada.	0.01460
They develop products for the local markets,	0.10648
... but seldom for the Canadian markets.	0.02018
Initiatives for R&D seldom come from parent company	0.04908
... from local universities or public labs in host country,	0.02708
... but sometimes from foreign marketing units.	0.06728
They typically have less than thirty full-time R&D employees.	0.01245
No R&D funding comes from parent company	0.08380
... but 99% of their R&D budget come from internal resources of the subsidiary (sales).	0.01240
Their most important output are prototype devices and materials (66%).	0.00930
Canadian managers represent only 2% of R&D staff.	0.00280

labs have typically been acquired with the subsidiary. Autonomy was here also very large, but somewhat less than in the previous group: the Canadian parent initiated or determined some R&D projects, some budgets came from parent or sister companies within the MNC, and, on average, 2% of their managers were Canadian expatriates. Their main source for R&D funds was the sales by the subsidiary (where 72% of budgets originated). Outputs were typically internal reports and prototypes.

Finally, there was only one case of a truly global R&D strategy (close to Ronstadt's GTUs), where the company conducted R&D in different countries on various related and compatible types of electronic

Table 11
Vertically integrated firms

Characteristics	Pearson correlation coefficient significance
More often have R&D laboratories than other R&D unit	0.10746
R&D existed in subsidiary before the acquisition.	0.07543
Technology transfer to governments has little importance,	0.05206
... but supporting parent's marketing efforts is key,	0.00705
and they support technology transfer from Canada.	0.01460
They develop products for local markets	0.10648
... and for Canadian markets.	0.02018
Initiatives for R&D sometimes come from parent company	0.04908
and from local universities and public labs in hosts	0.02708
... but often from foreign marketing units.	0.06728
They typically have over 45 employees in R&D.	0.01245
On average 20% of their budget comes from parent company	0.08380
... but 72% of their budget comes from internal resources of the subsidiary (sales).	0.01240
Their most important outputs are technical reports (34%), followed by prototypes (32%).	0.00930
Canadian managers represent only 1% of R&D staff.	0.00280

Table 12
The global corporation

Characteristics	Pearson correlation coefficient significance
Only type of R&D organization abroad are R&D labs.	0.10746
R&D created with foreign subsidiary.	0.07543
Technology transfer to governments has little importance,	0.05206
...but supporting parent's marketing efforts is key,	0.00705
and they support technology transfer from Canada.	0.01460
They develop products for local markets	0.10648
...and for Canadian markets	0.02018
Initiatives for R&D often come from parent company	0.04908
...a few from local universities and public labs in hosts	0.02708
...and often from foreign marketing units.	0.06728
They typically have over 100 employees in R&D.	0.01245
Close to 38% of their budget comes from parent company	0.08380
and only 44% of their R&D budgets comes from the internal resources of the subsidiary (sales).	0.01240
Their most important outputs (68%) are algorithms and software.	0.00070
Canadian managers represent over 13% of staff.	0.00280

equipment (Table 12). Missions included technology transfer from Canada and supporting marketing efforts from Canadian parent. Here, international coordination and communication were key, with the parent more closely supervising activities of the network of foreign labs. A larger percentage of the R&D budget (close to 38%) came from parent or sister companies. Over 13% of R&D managers were Canadian citizens. The Canadian parent was usually a major source of ideas and initiatives for R&D projects. These affiliates had typically been founded by the parent company, instead of being acquired from third parties while already in operation. They were large R&D laboratories, with hundreds of employees. Algorithms and software were major outputs.

Compared to the industrial-research facilities of other countries, Canadian overseas R&D seems less global and more bi-national (typically oriented to the United States, or the United Kingdom or both). Few corporations have research subsidiaries in other countries. This observation recalls the 'cultural proximity' factor that has appeared in some literature on overseas R&D: corporations tend to locate their foreign R&D facilities in countries with some cultural—basically linguistic and or legal—affinity. Geographical and cultural proximity seems thus important to explaining the location of Canadian R&D abroad.

Also, Canadian R&D abroad is centred more on commercial R&D and development for local and world markets, and less on basic research or technology transfer from Canada or towards Canada. The literature on foreign R&D units as listening posts for transferring back to the home country ideas produced abroad does not apply to Canadian MNCs.

6. Conclusion

There are some 60 Canadian-owned and -controlled firms conducting foreign R&D. Their subsidiaries are fairly decentralized and autonomous, and they are looking for dynamic markets and innovative milieux. These milieux are not universities or public laboratories so often as innovative private customers and suppliers.

This study confirms some aspects of the existing literature on Canadian MNCs—the role of acquisition as a method for conducting foreign direct investment and for starting foreign R&D.

This paper adds new dimensions to our knowledge of Canadian MNCs. Expatriate R&D facilities of Canadian-owned and -controlled corporations differed markedly from Japanese foreign labs, in that they were conducting principally commercial and pre-commercial applied R&D, and seldom any basic research. Technology transfer to Canada was a minor mission of a few labs, and only one-third of them received any technology from the Canadian parent.

We found some similarities between Canadian and Swedish MNCs (Zander, 1994). In both countries, expatriate R&D by large MNCs is important as a proportion of total national industrial R&D, and demand-side factors are key: the search for larger markets and customers and pressures from the local subsidiaries are the main explanatory factor for expatriate R&D. Supply-side factors (recruitment of skilled personnel, monitoring of technical development abroad and inflow of new ideas into the company) were second. The MNCs of both countries also follow a strategy of related diversification and are seldom full-fledged conglomerates (see a similar conclusion by Cantwell and Janne in this issue). Both Canada and Sweden are smaller industrial nations with restricted internal markets, similar resource endowments, and a highly skilled population. Both countries belong to the same historical wave of industrialization, in the last decades of the 19th century. However, Canadian R&D abroad started later than Swedish, mostly after 1945, while Swedish R&D started in the late 19th century. Also, this study confirms Pearce's findings about the relative importance of demand over supply-side factors in expatriate R&D (Pearce, 1992).

The paper shows some differences from Ronstadt's evolutionary model: technology-transfer units with adaptive missions, and corporate technology units with a strong basic-research mandate were nonexistent. Canadian foreign subsidiaries with R&D capabilities had both local-market and global-market product mandates, making them akin to both indigenous and global technology units in Ronstadt's classification. However, global mandates arrive early in the evolution of the expatriate R&D units of Canadian MNCs, not as the result of a long process with different stages, as suggested by Ronstadt.

These large MNCs show less central coordination and control than found in previous studies (Chiesa, 1996). Foreign R&D by Canadian corporations is fairly autonomous. Only one large Canadian MNC shows a similar degree of internal coordination to that of the world's largest firms, within a global R&D program orchestrated by the parent company. There is, however, a marked division of labour between the Canadian central laboratory and the foreign R&D units. Compared to Chiesa's vertically integrated firms, Canadian ones are, on average, less hierarchical, with large influences coming from overseas subsidiaries and markets.

Users and customers are major sources of R&D ideas and initiatives in international corporations. Foreign markets and foreign customers may well increasingly be the initiators of new products and processes. Some of the ideas on customers as suppliers of ideas (von Hippel, 1988) and on learning by using (Rosenberg, 1982) may well prove useful in the analysis of international R&D operations.

In a previous study, it was found that Canadian companies with foreign R&D were following a strategy of related diversification (Niosi, 1997). We can now split them into three groups, according to the degree of technological autonomy of their subsidiaries. Companies with a strategy of related diversification stricto sensu are in the majority; they allow the highest level of autonomy to their subsidiaries: managers in the subsidiaries are local residents, R&D budgets originate in the internal revenues of the subsidiary, and project initiatives are locally made, inspired by local and foreign markets. From this decentralized model, problems in R&D coordination and communication between the Canadian parent and the foreign subsidiary were absent. This looks pretty much like the decentralized federation (stage II) in Håkanson's evolutionary model (Håkanson, 1990).

The vertically integrated MNCs are somewhere in the middle: some of their research managers are Canadians, some initiatives for R&D projects come from the Canadian parent, which provides some funds for R&D to the foreign subsidiary. A few coordination and communication problems surfaced between the parent and the R&D unit. This type of international network does not show similarities to any other type of structure that other studies have found.

Finally, only one truly global MNC appeared, with a coordinated world R&D program. In this MNC, the parent company often contributed to the research budgets of the subsidiaries and usually had a say in the initiative and the final determination of R&D projects. Canadian managers were more numerous in the top layer of the subsidiary's R&D organization. Many of the problems and characteristics ascribed to global networks within MNCs in the earlier literature (Håkanson, 1990; Chiesa, 1996) appeared in this case.

The degree of autonomy of expatriate R&D units thus depends on the allocation of corporate activities across countries—related diversification, with different products located in various countries results in R&D establishments abroad that are fairly autonomous. Vertical integration through borders requires a somewhat higher degree of coordination and technology transfer among units. A global network of R&D labs is much more constraining, requiring higher levels of coordination and international flows of R&D personnel, budgets, technology, and initiatives from the parent company to its foreign R&D establishments.

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