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RELATING HRM AND MOT CAPABILITIES TO R&D INTENSITY

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Abstract / Résumé

R&D activities cannot be dissociated from the broader organizational capabilities developed by a firm. These capabilities may take the form of human resource management capabilities (HRM) or management of technology capabilities (MOT). In a study conducted in 126 manufacturing firms in the electrical energy sector in Quebec, the relationship between R&D intensity and HRM and MOT was investigated. Cluster analysis conducted on these firms revealed the presence of three distinct groups of firms with respect to the level of R&D intensity, firm size, and degree of process innovativeness. Further analysis on these groups show significant relationships between the level of R&D intensity and specific HRM and MOT capabilities all of which point to the importance of developing the more intangible capabilities in organizations and taking into account the specific organizational context.

La réalisation d'activités de R&D nécessite de la part des entreprises, un ensemble de compétences variées. Les entreprises doivent, entre autre, développer des habiletés en gestion des ressources humaines (GRH) et en gestion de la technologie (GT). La relation entre ces deux types de compétences et l'intensité des activités de R&D est explorée dans une étude menée auprès de 126 entreprises manufacturières québécoises du secteur de l'énergie électrique. L'analyse typologique permet d'identifier trois groupes distincts en fonction de l'intensité des activités de R&D, de la taille de l'entreprise et du degré innovateur des technologies en place (innovation de procédés). Les analyses des groupes démontrent l'existence de relations significatives entre le niveau d'intensité de la R&D et la présence de compétences spécifiques en GRH et en GT. Ces résultats font ressortir l'importance pour les entreprises de développer des compétences dites « intangibles » en tenant compte du contexte organisationnel qui leur est spécifique.

Key words : Organizational capabilities, R&D management, Management of Technology, human resource management, process innovation, new technology adoption.
Mots-clés : compétences organisationnelles, gestion de la R&D, gestion de la technologie, gestion des ressources humaines, innovation de procédés, adoption de nouvelles technologies.

1. INTRODUCTION

Effective R&D management has been a preoccupation of researchers and practitioners for many decades (Brockhoff and Pearson, 1992) and much emphasis has been placed upon organizing and structuring R&D activities and managing R&D teams. In particular, the concern for interfunctional integration of R&D, production and marketing has been stressed as essential to effective R&D management. More than ever before, this requires not only creating a culture and a structure which facilitate the integration of all functions and all employees but also developing even broader organizational capabilities. This paper focuses on exploring two essential dimensions of organizational capabilities which are supportive of R&D activities: human resource management (HRM) and management of technology (MOT) capabilities. As a first step, we will define the dimensions composing the organizational capabilities of a firm. Differences between firms carrying out R&D versus those not engaged in such activities will then be investigated. Since R&D intensity varies among enterprises, we will try to differentiate among organizational capabilities based on their relation to R&D intensity. Finally, an attempt will be made to identify those human resource management and management of technology capabilities that characterize firms with varying degrees of R&D intensity.

2. MANAGEMENT OF R&D IN A CHANGING ENVIRONMENT AND ORGANIZATIONAL CAPABILITIES

Globalization of markets and scientific and/or technological change have affected the environment in which firms compete, as has been acknowledged by the OECD (OECD, 1988). Firms have adapted to these changes and have tried to find new ways to compete and gain strategic advantages (Porter, 1990). In this changing environment, the notion that the success of organizations rests significantly on its internal capabilities is gaining both theoretical and empirical support. As reported by Ulrich and Lake (1991), "competing from the inside out" requires a continuous effort in building appropriate capabilities.

Although R&D activities have sometimes been compared to skunkwork (Quinn, 1979) and have often been "micromanaged" in an isolated environment (Wheelwright and Clark, 1992b), the common practice is to locate the R&D function within the firm where communication networks can best develop and ensure intergroup transfers (Allen, 1970). Therefore, the new competitive pressures are also affecting the R&D teams, both directly and indirectly. The necessity to reduce time to market, for instance, has forced a reduction in the product and/or process development cycle. Using new communications technologies, R&D teams need to work in collaboration with both marketing and plant employees, and even with suppliers and customers, to improve and accelerate the development cycle (Ettlie and Reza, 1992). Due to technological collaboration among companies, firms have enlarged their relationship network. For R&D teams, concurrent engineering and lateral or external networking communications are becoming common practices and there is a strong body of evidence that links good communications to successful product development (Barclay, 1992). These changes require an integrative and unifying culture (McDonald and Gandz, 1992) based in part on participation and employee empowerment coupled with more specific capabilities in the management of technology, all of which points to the increasing importance for organizations of developing the more intangible capabilities.

3. RELATING ORGANIZATIONAL CAPABILITIES TO R&D INTENSITY

According to Adler and Shenhar (1990), organizations respond to the innovation challenge by acquiring and developing a technological base which includes technological, organizational and external capabilities. Organizations need complementary assets or capabilities to support their basic core competencies (Ulrich and Lake, 1991). These capabilities include employee skills and know-how, working procedures and management practices, structure, strategy and culture (Adler and Shenhar, 1990). For the purpose of this study, organizational capabilities have been grouped into two categories (see table 1):

- human resources management capabilities (HRM)
- management of technology capabilities (MOT)

These categories reflect the embedded know-how within an organization with respect to the management of people and technology respectively, both of which are crucial factors for competitiveness.

3.1 HRM Capabilities

HRM capabilities strive to mobilize human capital as a productive and creative force. They focus on fostering an appropriate culture, implementing human resource management practices and training opportunities, and allowing for participative decision processes. All of these dimensions are important issues facing R&D-intensive firms.

Table 1 Organizational capabilities, theoretical justification and reliability

ORGANIZATIONAL CAPABILITIES	THEORICAL JUSTIFICATION[1]	NUMBER OF ITEMS	RELIABILITY OF CONSTRUCT[2]
HRM capabilities			
■ Culture	■ Covin & Slevin, 1990; Kanter, 1983.	6 items	0.62
■ HRM practices	■ Hornsby & Kuratko, 1990; Stalk & al., 1992.	8 items	0.79
■ Training practices	■ Rosanvallon, 1990; Debrinay, 1990.	5 items	0.77
■ Participative decision processes	■ Nebenhaus, 1990; Birley & Westhead, 1990.	6 items	0.82
MOT capabilities			
■ Environmental scanning practices	■ Kelley & Brooks, 1991; Miller & Friesen, 1984.	5 items	0.73
■ Management practices of technical projects	■ Larson & al., 1991; Might & Fisher, 1985.	3 items	0.54
■ Management control mechanisms	■ Miller & Friesen, 1982; Segev, 1989.	6 items	0.83
■ Manufacturing control mechanisms	■ Segev, 1989	3 items	0.63

[1] Constructs used are adapted from similar measures developed by the first author(s) cited for each dimension.
[2] Measured by Cronbach's alpha.

3.1.1 Culture

Culture can be viewed as a set of beliefs, dominant values and understandings shared by the employees of a particular firm. It affects the processes by which things get done (Peters, 1990) and is one of the major factors affecting employee morale. Kanter (1983) argues that an organic culture, as opposed to a mechanic culture, translates into open channels of communication, flexibility and openness towards new ideas, which are much needed for successful collaboration (Dodgson, 1993). The construct used in this study to measure organizational culture was developed by Covin and Slevin

(1990) and stresses the flexibility, openness, and liberty inherent in the modus operandi of an organic organization (Appendix 1).

3.1.2 HRM practices

HRM practices refer to the set of specific **actions** pursued by a firm with respect to its human resources. These actions include formal task analysis and job descriptions, selection and hiring practices, employee productivity evaluation and profit sharing practices. These different mechanisms have been identified in previous research (Hornsby and Kuratko, 1990; Stalk et al., 1992) as important indicators of workforce motivation.

3.1.3 Training practices

Training is undoubtedly one of the most important mechanisms firms adopt to better integrate new employees and update their competencies and know-how (Rosanvallon, 1990; Debrinay, 1990). Different practices were identified such as on-the-job training, in-house training and programs organized outside of the firm. The adoption of these practices is important for all firms but most of all for R&D units preoccupied with the continuous upgrading of technical and scientific knowledge.

3.1.4 Participative decision processes

Decision processes involving the active participation of employees in decision making, the organization of regular workshops or department meetings and the use of quality circles foster employee empowerment by ensuring that everyone shares the same beliefs and goals (Boynton et al., 1992; Nebenhaus, 1990). Active participation has long been considered an important success factor in the management of complexity, as in the case of most high-technology organizations and R&D environments (Von Glinow and Mohrman, 1990).

3.2 MOT capabilities

Since R&D is so closely linked to technological change, capabilities supporting the management of technology also assume great importance (Lefebvre et al., 1994). MOT capabilities in this study have been grouped into four distinct yet complementary sets of activities considered essential in a manufacturing environment.

3.2.1 Environmental scanning mechanisms

By performing environmental scanning activities, firms gain a better knowledge of commercial and technological threats and opportunities that could alter their ways of competing (Kelley and Brooks, 1991; Miller and Friesen, 1984). These activities comprise studying market opportunities, monitoring technological developments and conducting searches for new technologies, tracking competitors and compelling products and seeking client opinions. All of these activities should be considered important mechanisms that promote the firm's awareness of product and/or process innovation. R&D teams have usually been responsible for assuming the required technological scanning activities (Dodgson, 1993).

3.2.2 Management practices of technical projects

Wheelwright and Clark (1992a) and Larson et al. (1991) consider that using a specific methodology for managing technological projects is to be considered a critical success factor. Adler and Shenhar (1990) also identified project management practices as an important dimension of a firm's capabilities. These include the ability to plan and organize project activities and to ensure that goals and deadlines are met using specific project management techniques. They further involve the active participation and full responsibility of senior administrative officers in all technical projects.

3.2.3 Management control mechanisms

Management systems are implemented in order to control various activities of a firm (Miller and Friesen, 1982). In this study, we attempted to evaluate the extent to which formal budgetary control mechanisms, cost accounting procedures, quality control programs, and cost control activities were embedded in the overall processes of the firm. Further, the degree to which formal employee evaluation procedures were adopted by the firm was also assessed. Overall, this provides an indication of the level of formalization of the firm. Too much reliance of management on control mechanisms can compromise the creative and innovative process within a firm.

3.2.4 Manufacturing control mechanisms

In a manufacturing environment, firms develop specific capabilities to control inventories of raw materials and finished products, production costs and product quality (Segev, 1989). Although control mechanisms could be viewed as inhibiting innovation, they are also paradoxically considered as a means of institutionalizing technological learning (March, 1991; Leonard-Barton, 1992).

3.3 Combining HRM and MOT capabilities

Striking the right balance between the level of HRM and MOT capabilities may indeed be a difficult task. For example, too much control may alter the ability of the firm to learn and change, whereas too much of an organic culture or of participative decision processes could lead to anarchy and a lack of clear directions. Indeed, one might be tempted to look beyond balance and search for the appropriate mix of capabilities, assuming, for example, that not all forms of control mechanisms may be required, or that certain training practices may be more appropriate than others, in which case one should strive to define the right mix and balance of capabilities.

The basic premise of this paper is that the appropriate mix and balance of HRM and MOT capabilities varies with the level of R&D intensity and the specific organizational context.

4. RESEARCH METHODOLOGY

An empirical study was conducted among 345 firms in the province of Quebec. The responding firms share some common characteristics: all manufacture industrial equipment for producing, transporting and distributing electricity. Because of the rigourous climate, extremely long distances and the presence of abundant flowing waters, these firms have developed expertise in manufacturing industrial goods in the hydroelectric sector. A questionnaire was mailed directly to the chief executive officer (CEO) of all the companies. The CEO was selected because of his familiarity with all aspects of his company's management practices (Miller and Toulouse, 1986). The response rate was a little over 37%, which is quite satisfactory given that time is in short supply among CEOs.

4.1 Measurement of variables

Because of the intangible nature of HRM and MOT capabilities, the operational measures of the variables were chosen very carefully. Measures previously tested empirically were retained in order to ensure internal validity. Table 1 identifies the sources of the constructs for each HRM and MOT capability along with the Cronbach alphas obtained in this study. The alphas range from 0.54 to 0.83, which is quite satisfactory (Van de Ven and Ferry, 1980). The survey questionnaire listing all of the variables used to assess HRM and MOT capabilities is presented in Appendix 1. All the other research variables are based on factual measures. R&D intensity is measured as the percentage of sales allotted to research and development. Size of the firm is based on total annual sales. In order to assess process innovativeness, two innovative scores are used: they correspond to the number of information and production technologies adopted in the office or the plant (see Appendix 2), weighted by the relative innovative degree of each application as assessed by a panel of experts (Lefebvre and Lefebvre, 1992).

4.2 Statistical analysis

A comparative analysis was first conducted in order to assess differences in HRM and MOT capabilities in firms engaged in R&D activities and those that were not (Table 2). Since many significant differences were uncovered, we carried the analysis one step further. Using cluster analysis (Table 3), we identified three groups of firms using the following variables: (i) R&D intensity, as opposed to a dichotomous variable (R&D versus no R&D), should enable us to refine our understanding of the relationship between HRM and MOT practices and R&D; (ii) scores of process innovativeness since, in manufacturing firms, R&D intensity and innovative efforts are closely linked and generate a synergy effect (Lefebvre et al., 1993) that should modify the relationship with HRM and MOT capabilities; (iii) size, to take into account the fact that small firms cannot rely on the same financial and expertise resources as larger firms, but also, and more importantly, that small firms may not have the same HRM and MOT capabilities. A comparative analysis of the three groups of firms derived by cluster analysis was then performed in order to investigate differing HRM and MOT capabilities (Table 4) as well as specific relationships between these variables and the level of R&D intensity (Table 5). Finally, for the purpose of investigating the relative importance of the HRM and MOT capabilities, a discriminant analysis was performed using HRM and MOT capabilities as discriminating variables (Table 6).

5. RESULTS AND DISCUSSION

Table 2 shows significant differences between firms that perform R&D activities and those that do not. R&D firms demonstrate stronger HRM capabilities except for culture which is almost the same in non-R&D firms. Both types of firms have a fairly important organic culture (5.1 and 5.0) which may be partially explained by the rather small size of the responding firms (average of 81 employees). From these results, it is also apparent that the two groups of firms do not invest intensively in HRM practices or training and do not favor participative decision processes, as these variables barely reach 4.5 on a scale of 7. On the other hand, MOT capabilities appear to be strong (specially in terms of manufacturing control mechanisms) and are significantly higher in R&D firms.

Table 2 Differences in organizational capabilities between firms engaged in R&D activities and those that were not

Organizational capabilities[1]	Firms with no R&D (n = 26)	Firms with R&D (n = 100)	Level of significance of tests[2]
HRM capabilities			
■ Culture	5.1	5.0	ns[3]
■ HRM practices	3.5	4.5	0.000****
■ Training practices	3.1	4.3	0.000****
■ Participative decision processes	3.3	4.4	0.000****
MOT capabilities			
■ Environmental scanning practices	3.4	4.6	0.000****
■ Management practices of technical projects	4.2	4.8	0.031**
■ Management control mechanisms	4.2	5.1	0.004***
■ Manufacturing control mechanisms	5.4	6.0	0.005***

1 Measured on a 7-point Likert scale where 1 corresponds to the lowest level.
2 Mann-Whitney's non-parametric test where **** $p < 0.001$; *** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$.
3 Results are not significant (ns).

The results of the cluster analysis are displayed in Table 3. The first group can be clearly identified as R&D-intensive medium-sized manufacturing enterprises (SMEs). The second group can be labelled "not so R&D-intensive" small firms or micro-firms. Surprisingly, the last group consists of large firms which demonstrate a high degree of process innovativeness but little R&D activity. More details about these three groups of firms are given in Appendix 3. A size effect is noticeable with regard to organizational characteristics such as the average number of employees, the percentage of employees in a trade union, and the age of the firm. Size can definitively be considered a proxy for those other variables. Dependency on a few major customers and level of subcontracting activities do not differ significantly among the three groups.

Looking next at the capability base of each group (Table 4), we find significant differences among capability levels for all variables except culture, which confirms the results from Table 2. If capabilities were directly linked to a firm's size, we should be able to observe a gradual rise in level from Group 2 (average of 30.8 employees) to Group 1 (average of 118.7 employees) and finally to Group 3 (average as high as 289.4 employees). But this is not actually the case. The differences are found between the micro-firms and the two other groups. Statistical tests confirm that there are no significant differences in capability levels between medium and large size firms except in respect to HRM practices, which attain a slightly higher level in larger

Table 3 Variables used to generate the three clusters of firms

	GROUP 1 VERY R&D-I SMEs (N = 49)	GROUP 2 NOT SO R&D-I MICRO-FIRMS (N = 43)	GROUP 3 LEAST R&D-I LARGE FIRMS (N = 34)	LEVEL OF SIGNIFICANCE OF TESTS[1]
■ R&D intensity	4.6%	2.7%	2.2%	.055*
■ Innovative score for information technologies	37.5	21.2	37.9	.000****
■ Innovative score for production technologies	32.9	16.1	82.4	.000****
■ Size (total sales)[2]	23.9M$	3.5M$	58.7M$	.001****

[1] One way analysis of variance test where **** $p < 0.001$; *** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$.
[2] Measured in millions of canadian dollars.

companies. One explanation that comes to mind is the possibility that firms must attain a minimal level of capabilities, probably as they grow to over 50 employees or so. At that point, they need to institutionalize their learning and adopt formal processes and practices (March, 1991). The change of slope identifiable in Figure 1 probably reflects the fact that differences in organizational capabilities lessen as firm size gets larger. It can also be noticed that firms seem to invest proportionally more in capabilities directly related to the management of technology while maintaining human resource management capabilities at a lower but equidistant level from MOT capabilities.

Even among firms belonging to the same group, R&D intensity varies (standards deviations for R&D intensity are respectively 2.29%, 6.48% and 3.90% for groups 1, 2 and 3). Is R&D intensity closely linked to certain HRM and MOT capabilities depending on the group of firms? Results in Table 5 show the Pearson's correlation coefficients and the partial correlation coefficient allowing one to control for size in the relation between R&D intensity and each HRM and MOT capability.

In medium-sized R&D-intensive firms (Group 1), an open and cooperative culture is positively related to R&D intensity. Furthermore, increased environmental scanning, well-established project management practices and, when controlling for the size effect, the implementation of management control mechanisms are all related positively to R&D intensity. In not so R&D-intensive micro-firms (Group 2), results show that certain human resource practices have been adopted and are used more intensively by firms which make higher level of investments in R&D. Capabilities supporting the management of technology tend to replicate the profile described earlier for medium-sized enterprises with the difference that correlation coefficients are slightly, but significantly, higher. Again, when controlling for the size effect (even though all these micro-firms are small), a broader base of capabilities is positively associated with R&D intensity (six out of eight capabilities). However, an organic culture is negatively associated with R&D intensity. Since these very small enterprises are usually in the hands of owners, leadership is probably a more important success factor than cooperative management, as it has been acknowledged by Roberts (1991).

Results from Group 3, composed of larger and less R&D intensive firms, are more surprising. Variations in most capabilities are not significantly related to R&D intensity except for project management practices and manufacturing control mechanisms, and in those two cases the association is a negative one. A meaningful explanation for these contradictory results is discussed by Leonard-Barton (1992), who introduces the concept of "core rigidities". According to the author, capabilities have a downside that inhibits innovation. This paradox can be explained by the fact that, at one and the same time, an organization is struggling between maintaining versus renewing its core capabilities. The larger the firm, the greater the resistance to change. Since R&D activities are so critical to the innovation process, a high level of formalization of project management and control mechanisms might just have a negative effect on innovation and R&D activities.

Table 4 Differences in capabilities among groups derived by cluster analysis

ORGANIZATIONAL CAPABILITIES	GROUP 1 VERY R&D-I SMEs (N = 49)	GROUP 2 NOT SO R&D-I MICRO-FIRMS (N = 43)	GROUP 3 LEAST R&D-I LARGE FIRMS (N = 34)	LEVEL OF SIGNIFICANCE OF TESTS[1]
HRM capabilities				
■ Culture	5.0	5.0	5.1	ns[2]
■ HRM practices	4.5	3.7	4.9	0.000****
■ Training practices	4.4	3.2	4.7	0.000****
■ Participative decision processes	4.4	3.5	4.7	0.000****
MOT capabilities				
■ Environmental scanning practices	4.6	3.7	4.7	0.000****
■ Management practices of technical projects	4.8	4.3	4.8	0.077*
■ Management control mechanisms	5.0	4.5	5.5	0.024**
■ Manufacturing control mechanisms	6.0	5.6	6.2	0.047**

1 Kruskal-Wallis non-parametric one way Anova test where **** $p < 0.001$; *** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$.
2 Results are not significant (ns).

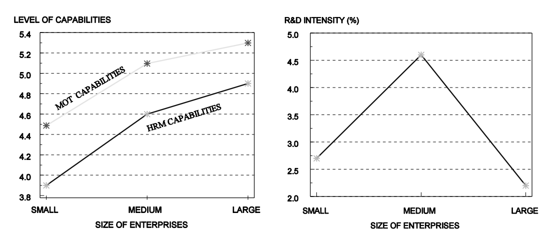

Figure 3 Comparison of capabilities and R&D intensity by size

Table 5 Correlation between R&D intensiveness and HRM and MOT capabilities for each group

	Group 1 VERY R&D-I SMEs (N = 49)		Group 2 NOT SO R&D-I MICRO-FIRMS (N = 43)		Group 3 LEAST R&D-I LARGE FIRMS (N = 34)	
	r [(1)]	partial r [(2)]	r [(1)]	partial r [(2)]	r [(1)]	partial r [(2)]
HRM capabilities						
■ Culture	0.24**	0.17*	ns[(3)]	-0.17*	ns	ns
■ HRM practices	ns	ns	0.45***	0.46****	ns	ns
■ Training practices	ns	ns	ns	0.16*	ns	ns
■ Participative decision processes	ns	ns	ns	0.21**	ns	ns
MOT capabilities						
■ Environmental scanning practices	0.22*	0.26**	0.36***	0.41***	ns	ns
■ Management practices of technical projects	0.27**	0.25**	0.34**	0.46****	ns	-0.18*
■ Management control mechanisms	ns	0.18*	0.25*	0.23**	ns	ns
■ Manufacturing control mechanisms	ns	ns	ns	ns	-0.31**	-0.30**

(1) Pearson's coefficient of correlation where **** $p < 0.001$; *** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$.
(2) Partial correlation controlling for size of firms.
(3) Results are not significant.

Even though these results tend to confirm that HRM and MOT capabilities vary according to the level of R&D intensity and the specific organizational context, one must also keep in mind that most HRM and MOT capabilities are positively related to the intensity of R&D activities. Table 6 presents the ordering of these capabilities by size of correlation coefficient in the discriminant function and points at training and human resource practices as the most discriminating capabilities. A company's relationship with its workforce has been identified by Wiktrom and Normann (1994) as an essential factor in handling knowledge and thus in maintaining and increasing competitive strength.

Table 6 Capabilities ordered by size of correlation in the discriminant function

1. Training practices	5. Management control mechanisms
2. Human resources practices	6. Management practices of technical projects
3. Environmental scanning practices	7. Manufacturing control mechanisms
4. Participative decision processes	8. Culture

The specific context of the firms studied here should also be taken into account when interpreting these results. Since these firms belong to a sector which is not considered to be a high-technology sector as would be the case for biotechnology and pharmaceutical sectors, R&D projects generally tend to emphasize commercial development rather than fundamental research and therefore the need for interfunctional coordination and integration is much greater. Furthermore, since the technologies in place have reached the maturity stage and the market is near saturation, the focus is more centered on quality and on customer satisfaction (Wheelwright and Clark, 1992b) both of which necessitate cross-functional integration and the underlying organizational capabilities. Therefore, it is possible that the relationships between R&D intensity and HRM and MOT practices are stronger here than they would be in very R&D-intensive sectors.

6. CONCLUSION

The results of this study have shed some light on the relation between HRM and MOT capabilities and R&D intensity. Obviously, the relationships are complex and non-linear and, as it has been partially demonstrated in this study, depend on many factors such as the size of the firm, which is a proxy for many other organizational characteristics, and other innovative efforts such as the level of process innovativeness attained by the firm. And in the particular case of SMEs, there is a strong indication that increased HRM capabilities are associated to R&D intensity. This is even more true when one considers the management of technology capabilities. All of them except manufacturing control mechanisms are associated positively with R&D intensity. This makes a strong case for the need to develop in SMEs the "intangible" capabilities which are required to support and enhance a firm's innovative efforts. In larger firms, we observe the reverse situation where too much of a good thing could turn out to have negative effects. Too much control and too much emphasis on project management practices may prove detrimental to the R&D activities of a firm. All in all, it may be a question of mix and balance which in itself constitutes an important technology management challenge.

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Appendix 1: Measures of organizational capabilities

1. HRM CAPABILITIES :

1.1 Culture

To what extent do you agree with the following statements?	Disagree — Agree
In this firm, we discuss financial or strategic matters quite freely	1 2 3 4 5 6 7
Our executive manager's are free to use the operating style of their choice	1 2 3 4 5 6 7
In this firm, we usually adapt quite easily to important changes	1 2 3 4 5 6 7
We favor a certain flexibility in getting things done even if it means disregarding formal procedures	1 2 3 4 5 6 7
We rely on voluntary cooperation for getting work done rather than formal controls	1 2 3 4 5 6 7
We have a strong tendency to let the requirements of the situation and the personality of the individuals define proper on-job behavior	1 2 3 4 5 6 7

1.2 HRM practices

To what extent do you use the following personnel management practices?	Rarely — Very often
Organization charts and formal job descriptions	1 2 3 4 5 6 7
Recruiting by posting job requirements	1 2 3 4 5 6 7
Interviews and tests for personnel selection	1 2 3 4 5 6 7
Formal pay scales	1 2 3 4 5 6 7
Employee productivity evaluation	1 2 3 4 5 6 7
Bonuses, commission and/or profit sharing	1 2 3 4 5 6 7
Additional social benefits over and above those required by law	1 2 3 4 5 6 7
Plans for recycling and/or retraining employees	1 2 3 4 5 6 7

1.3 Training practices

To what extent do you use the following manpower training practices?	Rarely — Very often
On the job training	1 2 3 4 5 6 7
Period of instruction/probation for new employees	1 2 3 4 5 6 7
Training sessions organized within the firm	1 2 3 4 5 6 7
Outside training sessions	1 2 3 4 5 6 7
Participation in government manpower training programs	1 2 3 4 5 6 7

1.4 Participative decision processes

To what extent do you use the following decision making mecanismes ?	Rarely — Very often
An executive committee	1 2 3 4 5 6 7
Meetings with department heads	1 2 3 4 5 6 7
Quality circles	1 2 3 4 5 6 7
Information meetings with all personnel	1 2 3 4 5 6 7
Workshop or department meetings	1 2 3 4 5 6 7
Active participation of employees to decision making	1 2 3 4 5 6 7

2. MOT CAPABILITES :

2.1 Environmental scanning practices
To what extent do you rely on the following procedures to gather information about the performance of your firm ?

	Rarely — Very often
Routine gathering of opinions from clients	1 2 3 4 5 6 7
Explicit tracking of the policies and tactics of competitors	1 2 3 4 5 6 7
Developing explicit profiles of sales, of customer preferences	1 2 3 4 5 6 7
Forecasting of new technologies	1 2 3 4 5 6 7
Special market research studies	1 2 3 4 5 6 7

2.2 Management practices of technical projects
To what extent do you agree with the following statements ?

	Disagree — Agree
We manage each technical project using a project management methodology	1 2 3 4 5 6 7
An executive officer takes full responsibility for all our technical projects	1 2 3 4 5 6 7
The project leader shares the managing responsability with all involved departments	1 2 3 4 5 6 7

2.3 Management control mechanisms
To what extent do you use the following control devices ?

	Rarely — Very often
Formal budgets to control your operations	1 2 3 4 5 6 7
Cost control by department or by activity	1 2 3 4 5 6 7
Profit and/or productivity targets by department or activity	
Quality control of operations by using sampling and other techniques	1 2 3 4 5 6 7
Cost control by fixing standard costs and analysing variations	1 2 3 4 5 6 7
Formal appraisal of personnel	1 2 3 4 5 6 7
	1 2 3 4 5 6 7

2.4 Manufacturing control mechanisms
To what extent do you exercise formal control over the following operation activities ?

	Rarely — Very often
Control over stocks of raw material and/or finished products	1 2 3 4 5 6 7
Control over manufacturing costs and/or cost accounting	1 2 3 4 5 6 7
Quality control of the products manufactured	1 2 3 4 5 6 7

Appendix 2: Measure of the scores for process innovativeness

Information technology applications[1]

- i_1 General accounting applications (accounts payable/receivable and/or payroll, billing)
- i_2 Management applications (sales analysis and/or decision support systems, personnel management)
- i_3 Electronic office applications (word processing and/or spreadsheet, data base management)
- i_4 Operations management (inventory management and/or cost accounting)
- i_5 Communication applications (voice mail system, local area network and/or fax)
- i_6 Telecommunication applications (electronic mail and/or conferencing, wide area network)

Production technology applications[1]

- i_1 Computer-assisted design (CAD)
- i_2 CAD output used to control manufacturing machines (CAD/CAM)
- i_3 Numerical control machines (NC)
- i_4 Direct numerical control machines (DNC)
- i_5 Automated material handling and/or automated guided vehicle system AGVS)
- i_6 Pick and place and/or other robots
- i_7 Bar code system
- i_8 Automated sensor-based inspection and/or test equipmment
- i_9 Materials-requirements and/or manufacturing resource planning (MRP, MRP II)
- i_{10} Wide area network with customers and/or suppliers for factory use (EDI)
- i_{11} Job order costing
- i_{12} Just-in-time
- i_{13} OPT (synchronized manufacturing)
- i_{14} Integrated flexible manufacturing cells and/or systems, artificial intelligence, expert-systems

Innovative scores for information and production technologies = $\sum i_j r_j$ where i_j = 0 or 1 depending of the adoption of innovation *j*, and r_j = degree of radicalness of innovation *j* as established by a panel of experts who ranked each innovation on 7 points Likert scales.

[1] Adapted from a typology produced by Statistics Canada (1989)

Appendix 3: Organizational profile of the three groups of firms

	GROUP 1 VERY R&D-I SMEs (N = 49)	GROUP 2 NOT SO R&D-I MICRO-FIRMS (N = 43)	GROUP 3 LEAST R&D-I LARGE FIRMS (N = 34)	LEVEL OF SIGNIFICANCE OF TESTS[1]
Organizational profile				
■ Number of employees	118.7	30.8	289.4	.001****
■ Employees in a trade-union	23.6%	20.6%	40.0%	.031**
■ Years of existence	32.7	25.4	37.9	ns[2]
■ Importance of commercial network				
- number of customers	511.0	161.0	685.7	ns
- number of suppliers	187.1	63.4	354.0	.004***
■ Sub-contracting activities	67.3%	74.4%	76.5%	ns
- % of total assets	8.7%	6.5%	7.8%	ns

[1] One way analysis of variance tests where **** $p < 0.001$; *** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$.
[2] Result of test is not significant (ns).