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CRITICAL CAPABILITIES AND PERFORMANCE OF THE SMALL SUBCONTRACTING FIRMS IN THE AEROSPACE INDUSTRY*

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Abstract / Résumé

Although they are often considered to be more flexible and adaptable than their larger counterparts, small and medium-sized firms now evolve in a rather uncertain environment which may, more than ever, impede their capacity to compete internationally. In this context, and in order for those firms to continuously improve themselves, it is believed that they need to acquire and develop particular capabilities. The objective of this paper is therefore to identify some of the "critical capabilities" that characterize successful SMEs in industries where significant added value is created. The results presented are drawn from a large research project carried out among manufacturing subcontractors in the aerospace industry in Canada.

Bien que les petites et moyennes entreprises soient souvent reconnues pour leur flexibilité et leur plus grande capacité d'adaptation par rapport aux plus grandes, elles n'en demeurent pas moins soumises plus que jamais à un contexte économique incertain qui risque de gêner leurs efforts d'expansion sur les marchés internationaux. Dans ce contexte, et dans le but d'améliorer leur situation, il est suggéré que ces firmes doivent acquérir et développer des compétences particulières. L'objectif de cet article est d'identifier certaines de ces compétences critiques qui caractérisent les PME à succès dans une industrie à haute valeur ajoutée. Les résultats présentés sont tirés d'une vaste recherche sur les sous-traitants de l'industrie aérospatiale/aéronautique canadienne.

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1. Introduction

Since the beginning of the 1980's, there have been profound changes in industrial structures on a world scale, and especially an intensification of collaboration activities between firms such as joint ventures, consortiums, licensing agreements, various types of partnerships and subcontracting. The focus of this article is on industrial subcontracting, usually visualized as a pyramidal model based on cooperation among parties at several levels, each of which is responsible for the completion of an assembly, a sub-assembly, a part or a component of the finished product.

In most sectors of industrial activity, from the more traditional industries such as textiles (Lorenzoni & Ornati, 1988) and automobiles (Flynn, 1987; Barberis, 1990; Rosegger, 1991) to the high technology industries such as telecommunications and aeronautics (Friar and Horwitch, 1986; Powell, 1987; Jorde and Teece, 1989), subcontracting is a reality which must be dealt with. Subcontracting allows prime contractors to focus on and specialize in those activities that are crucial to the performance of their firms. In that respect, the vast networks of suppliers of products, services and technologies have become essential to support the specific activities or competencies of these companies and to maintain and increase their competitive stance. The importance of these networks and reporting systems has been demonstrated in many countries (Porter, 1990). Prime contractors in isolation cannot remain competitive without having an appropriate support structure made up of suppliers and subcontractors. The absence or near absence of such structures in certain sectors constitutes a major curb on the competitiveness of prime contractors and their development on the international scene.

Two premisses will guide our discussion. First, subcontracting companies are now seen as important links in the chain of production and, as such, are powerful forces for the development of solid national infrastructures. Given the current climate of world-scale rivalry, subcontracting firms are increasingly becoming an important consideration in prime contractors' decision concerning where to locate, and as a result, they constitute a potentially important competitive advantage for host countries. Second, the performance of subcontracting firms in terms of meeting prime contractors' requirements depends to a great extent on the investments they can make in terms of both human and material resources. In response to a demand for better quality, flexibility, price and delivery times, these firms must aim at continuously developing a wide range of capabilities which we will categorize as being either technological or organizational. Both these premisses will be investigated in the specific context of the Canadian aerospace industry.

2. Subcontracting in the aerospace industry and world class performance

The very nature of global competitiveness profoundly changed the role of subcontracting firms, leading companies to concentrate on high-value-added functions, while outsourcing those for which they have little competitive advantage (Patry, 1994). In a context of increased segmentation, where product design and quality become competitive assets of the utmost importance, a large company is obligated to change the nature of its relationships with its downstream partners, suppliers and subcontractors. When competitiveness was based essentially on cost, it was perfectly fair to try to exploit the effects of independence, choosing the subcontractor who offered the lowest costs. However, when product quality and design or speed become the essential competitive weapons, it is vital to promote partners' longevity in order to benefit from high-quality service and know-how, as well as the innovative ideas that stem from increased specialization.

The nature of the relationships between prime contractors and subcontractors has in fact changed profoundly. Many companies have drastically reduced their base of suppliers and subcontractors, limiting themselves to one or two subcontractors for each type of specific activity, and in the process developing closer and longer-lasting relationships. The resulting stability and climate of trust enables subcontractors to feel more secure and thus to contemplate making the investments in resources required to meet the prime contractor's demands, such as the acquisition of high-performance technologies, the use of appropriate management methods, and continuous enhancement of their technical and administrative skills and know-how.

The challenges facing subcontractors in the aerospace industry are numerous given the characteristics of the industry. First, the industry must continuously keep abreast of developments in new technologies which mainly take place outside of the industry but which must be integrated rapidly. This stems from the many strict constraints on aerospace production (lightness, reliability, performance, etc.) which compound with each other to produce exceptionally strict specifications.

Second, the aerospace industry is subject to numerous environmental constraints, in part due to the many risks involved. The competition is especially fierce because of the major cutbacks in the military domain, and in particular the termination of certain space programs in the United States. The shutdown or, at the very least, shrinkage of government defense programs has intensified the competition even more. In the aeronautical branch, the appearance of competition from companies in the Pacific Rim represents a significant threat when one also considers that a large proportion of world demand for aircraft carriers in the next ten years will originate from that region of the

world. This explains the plethora of alliances in this sector which are being formed between the traditional producers in North America and Europe.

Third, the industry must continuously adjust to a cyclical demand as was experienced in the late 80's and early 90's, and which is in many respects very sensitive to political issues. Fourth, the aerospace industry has specific constraints which differ from those of the automobile industry, for example, where the main characteristics can be described in terms of mass production and the search for economies of scale. In the aerospace industry, the main characteristics relate to the small volumes and high degree of precision required in the manufacturing and assembling of equipment, and to the stricter technical demands and quality standards than in most other sectors.

Finally, the aerospace industry is the prototype of the new industrial hubs, which are conceived less and less on a regional scale and more as networks of subcontactors linked together across the whole planet. It is a truly global industry and leading firms seek competent subcontractors irrespective of where they may be in the world. Local subcontractors must therefore possess the required levels of skills and competencies to make them "world class" producers. Failure to comply with these requirements can be fatal, even in the very short run.

3. Profile of the Canadian industry

In spite of the serious turmoil which has afflicted the aerospace industry over the last few years, the Canadian industry has managed to keep its production ouput relatively unchanged, mainly because of its rather low level of defense production in comparison to that of other countries and because of the type of products it relied on, namely smaller aircraft. Overall, according to recent figures issued by Industry Canada (1993), net sales for the whole aerospace industry have remained almost identical for the 1991-1993 period at about $8.4 billion. Civil sales have always represented the largest share of Canadian production and, according to government officials, we should expect an increase in annual sales up to $9.9 billion in 1997. Defense production is expected to remain within the range of $2.8 to $3.0 billion (ISC, 1993) thus accounting for more or less a quarter of total production.

The importance of the aerospace industry for Canada must also be evaluated in terms of the types of jobs created as well as the levels of expenditures spent on R&D activites. In 1993, total employment reached 56,335 employees, 20 % of whom were engineers and scientists. When combined with the almost $800 billion spent in R&D (68 % of all investments) during the same year, it clearly indicates the important role aerospace firms play in the overall technological activities conducted in Canada.

Exports are very important for this industry, as they are for the Canadian economy as a whole. The relatively small size of the domestic market has forced companies to look elsewhere. Recent free-trade agreements such as NAFTA[1] are generally most welcome events in this industry, where the level of exports had already reached 72 % of net sales in 1993. In fact, this amount is expected to reach 77 % by 1997 (ISC, 1993).

The heavy reliance on exports has led the major prime contracting firms[2] operating in Canada to become highly competitive and to expect world-class performance from subcontracting firms. Given the irreversible trend towards globalization, we felt it important to investigate the dimensions which define a world-class subcontrator according to the definitions and requirements of the industry. This paper reports on the results of such a study.

4. Methodology

Data Collection

The results presented in this paper are part of a research project carried out among manufacturing subcontractors in the aerospace industry that are actively in operation in Canada. Questionnaires were sent to the CEOs of all subcontracting firms across Canada. Lists of firms were established using the most up-to-date information provided by government agencies and the Aerospace Industries Association of Canada. The questionnaire was pre-tested with 11 persons including eight CEOs. Data analysis was conducted on the 149 responding manufacturing firms, which are all SMEs (with fewer than 200 employees).

Research Variables

The Dependent Variable. The firm's performance is the dependent variable selected for this research. In the context of selecting subcontractors, prime contractors usually retain firms that produce the highest scores on the dimensions of price, quality, flexibility of production and delivery times. In order to approximate this measure, CEOs were asked to evaluate their company's main assets in comparison to those of their closest competitors on these four dimensions. The resulting composite score constitutes our dependent variable.

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[2] North American Free Trade Agreement.

The Independent Variables. Independent variables were divided into three groups. The first one deals with two main organizational characteristics: size and export performance. Size is closely associated with the availability of financial and non-financial resources, which are in part necessary to achieve the level of performance required by prime contractors. The percentage of sales realized on foreign markets by a particular firm gives an indication of its international experience and its dynamism. Considering the intensity of today's competition, as described previously, it is believed that presence in foreign markets may be a valid indication of how much effort is expended within firms on maintaining and upgrading specific competencies which are required to enter those markets. In this context, we chose to include the ratio of export sales over total sales as this is the most common measure of a firm's export performance (Cavusgil and Zou, 1994; Aaby and Slater, 1989).

The second group relates to the firm's technological capabilities and includes five variables. Expenditures on research and development as a ratio of annual sales is a common ratio used for estimating a firm's commitment to technological activities. It has therefore been retained as the first variable related to technological capabilities.

In order to capture the full variety of a firm's technological efforts, recent research has proposed going beyond strict R&D evaluation and considering other variables such as the penetration of technologies within the firm. The number of computer-based technologies adopted by a firm may reveal its expertise as well as its commitment and ability to better meet clients' requirements. We therefore propose to consider the number of those technologies in use as a second (factual) measure of a firm's technological capabilities.[3] The third variable captures the extent to which firms are sensitive to their technological environment. In a high-tech industry such as aerospace, with competition originating from all over the world, it is generally recognized that firms must remain aggressive in the search for new ways of making better products at a better price (Kelley and Brooks, 1991). This is precisely what our third variable, technological scanning, is meant to measure. It specifically refers to the ability of a firm to identify opportunities, to understand and foresee competitors' strategies as well as to evaluate emerging technologies. As in the case of the other perceptual measures used in this research, technological scanning was assessed using Likert scales.

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[3] The list of computer-based manufacturing and management technologies comprises the following: General Accounting Applications, Costing, Inventory Management, Net Needs Planning (MRPI) and Manufacturing Resource Planning (MRPII) Systems, Job Order Costing, Electronic Data Interchange (EDI), Computer-Assisted Design (CAD), Integrated CAD/CAM, Computerized Numerical Control (CNC) Tools, Direct Numerical Control (DNC) Tools, Automated Handling, Bar Code System, and Computerized Quality Inspection and Control. Manufacturing improvement programs include: Just-in-Time (JIT) Systems, Statistical Process Control (Control Cards) and Employee Accountability.

In a context where specialization gradually becomes the only way of getting business from the prime contractors, subcontracting firms cannot avoid upgrading the skills of their employees while maintaining a stimulating environment for continuous learning. Not only should those skilled employees ease adoption of innovation (Daly *et al.*, 1985; Steedman and Wagner, 1989) but they should also stimulate and facilitate the creation of specific know-how and/or new products. Two more variables were therefore considered for the global evaluation of technological capabilities: technical skills of employees and the level of exclusive know-how related to products.

The third group of variables represents organizational capabilities. Previous work has pointed out the importance of complementary assets in maintaining competitiveness on foreign markets (Lefebvre *et al.*, 1993a). Significant investments in R&D or technology acquisition need to be supported by less tangible efforts which can be referred to as organizational capabilities (Presutti, 1991) and which comprise management skills, marketing efforts, financial stability, and manufacturing improvement programs, the latter being a reflection of a firm's unceasing preoccupation with quality enhancement. Finally, networking efforts, assessed here as the degree to which subcontracting firms have a beneficial networking relationship with customers and suppliers, are particularly crucial in the aerospace industry (Lefebvre *et al.*, 1993b).

5. Results and discussion

Table 1 summarizes the results of multiple regression analyses where each group of independent variables is entered one by one (models 1, 2 and 3). The fourth model represents the complete model where all independent variables are taken into account simultaneously. The organizational characteristics (model 1) contribute marginally to the explained variance (4.11 %). However, technological capabilities (model 2) and organizational capabilities (model 3) account for much larger percentages of explained variance (30.10 % and 22.48 % respectively). Hence, technological capabilities have a stronger explanatory power than any other group of independent variables. Finally, the organizational characteristics, technological capabilities and organizational capabilities (model 4) cumulatively account for 49.65 % of the variation ($p=0.0000$) in performance, which is highly satisfactory.

Table 1: Summary of results obtained from multiple regression analysis (n=149)

Groups of Independent Variables	Model 1	Model 2	Model 3	Model 4
Organizational Characteristics	✓			✓
Technological Capabilities		✓		✓
Organizational Capabilities			✓	✓
Adjusted R^2	4.11 %*	30.10 %****	22.48 %****	49.65 %****

*p < 0.10 ; ** p < 0.05 ; *** p < 0.01 ; **** p < 0.001

Basic assumptions for conducting regression analysis are met: because of the large sample size, the assumption of multivariate normality is not rejected; the independent variables are not highly correlated; finally, the analysis of residues indicated no violation of basic assumptions.

The values of the standardized betas in model 4 reveal some interesting insights. As indicated in Table 2, size is negatively related to performance, which is a surprising result although it does indicate that, in SMEs, bigger is not necessarily better. The composite measure of performance, which does not focus strictly on cost leadership, may partially explain this result: smaller firms thrive more on differentiation through increased product quality, greater flexibility, faster customer response and a higher degree of customization than strict cost leadership. International experience is positively related to performance, suggesting that global industrial competition does impose higher competitive pressures on subcontracting firms. The technical skills of employees at all levels are undoubtedly the strongest determinants of performance (β=0.46, $p< 0.0001$). This points to the importance of mobilizing human capital, especially in the form of specialized labor, in subcontracting manufacturing firms. Exclusive know-how related to products (parts or components), R&D intensity and technological scanning are all positively and significantly related to performance and go hand in hand with the technical skills of employees.

Table 2: Results of multiple regression analysis for Model 4 (n=149)

Independent Variables	β^1
Organizational Characteristics:	
▪Size	-0.19***
▪Export Performance	0.32*****
Technological Capabilities:	
▪R&D Intensity	0.26*****
▪Technological Penetration	0.03
▪Technological Scanning	0.16***
▪Technical Skills of Employees	0.46******
▪Exclusive Know-How Related to Product	0.08*
Organizational Capabilities	
▪Management Skills	0.36******
▪Marketing Efforts	0.08*
▪Financial Stability	0.02
▪Manufacturing Improvement Programs	0.05
▪Networking Efforts with Suppliers	0.03
▪Networking Efforts with Customers	0.07*
Adjusted R^2=49.65 % p=0.0000	

* p<0.10 ; ** p<0.05; *** p<0.01; **** p<0.001

(1) Standardized betas reported

Basic assumptions for conducting regression analysis are met: because of the large sample size, the assumption of multivariate normality is not rejected; the independent variables are not highly correlated; finally, the analysis of residues indicated no violation of basic assumptions.

The effect of managerial skills on performance is also positive and highly significant. Managerial skills are the second strongest determinant of performance (β=0.36, p<0.001), whereas the effect of marketing efforts and networking with customers on performance are positive and significant. In that respect, organizational capabilities, although somewhat less tangible than the traditionally identified sources of competitiveness such as R&D investments and technology acquisition, are important dimensions in the pursuit of improved competitiveness.

6. Conclusion

The results of this study reveal a number of interesting aspects of firm performance in the aerospace industry in Canada. Subcontracting firms which are assessed as "better than competitors" on four important dimensions of manufacturing performance, namely price, quality, delivery, and flexibility, also possess distinctive characteristics which are associated with their performance. Our prime explanatory factor associated with performance has to do with the acquired technical skills of employees. This is

an important finding given that it provides a clear indication that a technical culture, which is definitely associated with the technical scanning abilities of these firms as well as their propensity to carry on R&D activities and their retention of exclusive know-how related to products, becomes essential when a firm seeks to improve itself and become a world-class competitor. The fact that technical skills and management skills are the strongest indicators of firm performance points to the crucial role of human resources in achieving, maintaining and improving firm performance. Finally, past experience on export markets also allows one to explain a firm's performance. The more stringent competitive pressures imposed on a firm which operates both at home and on international markets may force it to develop more and better capabilities.

Since the search for competencies on the part of prime contractors in the aerospace industry relies partly on the strong productive capabilities provided by a large array of subcontracting firms, individual firms can no longer confine themselves to passively carrying out production tasks. In order to play the full role expected of them, they must acquire world-class capabilities by constantly innovating and upgrading skills and competencies. This is a tall order, but subcontracting firms have no choice but to meet the demands inherent in today's business environment.

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