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Global Strategic Benchmarking, Critical Capabilities and Performance of Aerospace Subcontractors*

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Résumé / Abstract

L'industrie aérospatiale est aux prises avec une concurrence intense à l'échelle mondiale, notamment avec la venue de nouveaux concurrents de la région Asie-Pacifique. Cette situation impose une pression supplémentaire sur la sous-traitance actuelle dans ce secteur. Dans ce contexte, il apparaît essentiel de mieux comprendre ce qui caratérise les sous-traitants de classe mondiale. Pour répondre à cette préoccupation, une étude comparative de 384 entreprises sous-traitantes fut réalisée aux États-Unis, au Royaume-Uni et au Canada, en faisant appel au concept de « benchmarking » et à une des perspectives d'alignement retrouvée dans la théorie de la contingence et connue sous le nom de « déviation du profil idéal ». Un profil distinct semble émerger en ce qui a trait aux compétences technologiques et managériales détenues par les entreprises les plus performantes. Les compétences critiques qui sont communes aux entreprises sous-traitantes de classe mondiale provenant des trois pays sont intangibles, difficiles à imiter, ou difficilement transférables. Ceci laisse entrevoir que les sous-traitants actuels de calibre international possèdent des compétences qui seront difficilement reproductibles dans le court terme. Ce ne serait pas le cas pour les sous-traitants moins performants qui seront aux prises dans un avenir prochain avec la venue de nouveaux concurrents en provenance des pays en voie d'industrialisation.

The aerospace industry faces fierce and rapidly changing competition worldwide which exercises a considerable amount of strain on its manufacturing subcontractors. In this context, it becomes essential to gain a better understanding of what constitutes the most critical capabilities of the world-class subcontractors. Drawing heavily on the concept of benchmarking and of fit as profile deviation, this paper allows to identify the most critical capabilities of the best performing firms. Results are derived from an international comparison of 384 subcontracting firms operating in the U.S.A., the U.K. and Canada. A very distinct profile emerges from the best subcontractors in terms of their acquired technological and managerial capabilities. The most critical capabilities which are common to subcontractors of all three countries are either intangible, difficult to imitate or not easily transferable. This leads us to believe that the best subcontractors hold a partcular competitive advantage which will be difficult for

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others to replicate, at least in the short term. This is not however the case for the less performing subcontractors who could well be subjected in the not too far future to the competitive pressures arising from the new industrializing countries.

Mots Clés : Aérospatiale, sous-traitance, compétences critiques, globalisation

Keywords : Aeronautics, subcontractors, critical capabilities, globalization

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1. Introduction

For most nations, the aerospace industry represents a key strategic sector as it is viewed as a symbol of competence and pride, an incubator of advanced technologies, a generator of highly specialized jobs and, most of all, an engine of growth and wealth. As a result, the aerospace industry is heavily subsidied by most governments and faces fierce and rapidly changing competition worldwide. The arrival of powerful new players is drastically increasing the already high levels of competition. New players are created by mergers such as those between Martin-Marietta and Lockheed, Boeing and Rockwell and, more recently, Boeing and McDonnell Douglas. The emergence of newly industrialized nations, such as Brazil, China, Japan, Korea, Indonesia, India and Singapore, which are eager to develop their own aerospace industries is also adding to the list of new players.

If competition is fierce among prime contractors, aerospace subcontractors also operate in a very difficult and competitive environment. Strong pressures are obviously placed on subcontractors by prime contractors that have rationalized and sometimes drastically reduced their local subcontracting base. However, the main pressures come from the existence of an ever-increasing global network of high-performing subcontractors. The erosion of the traditional local subcontracting base is, to a large extent, due to the growth in demand in the big emerging markets. Colossal demand for products and services is being experienced in every subsector of the industry, whether in civilian aeronautics as a result of the flow of travellers from, to and within the Asia-Pacific region, which is expected to amount to half the world's traffic by the year 2000 [1], or in the defence sector where countries such as Singapore, Thailand, Indonesia, the Philippines and Malaysia are actively engaged in military build-up [2]. This is also the case in the space sector, where spending is increasing rapidly in countries such as Japan, China or India although, as yet, total spending in that particular sector is still largely concentrated in the U.S.A. [3]. With such enormous purchasing power, Asian countries can exert considerable influence on Western prime contractors with regard to the choice of location for their subcontracting activities. In fact, Asian countries are already part of a global network. For example, Japan, Korea, Taiwan, Singapore and Indonesia ship major components and sub-assemblies directly to airframe and engine manufacturers in Europe and North America. Asian subcontractors from these countries are gradually acquiring the capabilities which will enable them to undertake more complex tasks. Can Western subcontractors really compete in such a context? The answer depends to a significant extent on the willingness of Western subcontractors to build and maintain world-class capabilities.

This paper will therefore focus on the most critical capabilities of the best performing manufacturing subcontractors in the aerospace industry. The specific objectives are as follows:

(i) to propose, analyze and define a set of critical technological and managerial capabilities for aerospace subcontractors;

(ii) to identify the critical capabilities of the best performing subcontractors;

(iii) to assess the gaps between the best and the other subcontractors in order to provide a better understanding of the most critical capabilities required by aerospace subcontractors.

Since aerospace is a global industry, these three objectives will be pursued from an international perspective. We will thus present empirical evidence from 384 small and medium-sized subcontractors (upper limit of 500 employees) operating in the U.S.A. (140), the U.K. (109) and Canada (135).

2. Main conceptual issues

The above-mentioned objectives clearly require one to specify the meaning of such concepts as capabilities and performance. Furthermore, the presence of capabilities and, in particular, the relationship between capabilities and performance are modified by factors such as the size of the subcontracting firms and the types of relationships the prime contractors have with their subcontractors. We will briefly discuss these conceptual issues.

2.1 Looking for critical capabilities

While the term “resources” usually refers to financial, technological, physical and human assets, “capabilities” comprise an organization's capacities to deploy its own resources. Firm’s capabilities which are broadly based, encompassing the entire value chain [4: 66], can be centered within one function such as production, R&D or marketing or within several functions, as would be the case with Total Quality Management (TQM), for instance, and must combine the effective use of several types of resources. Critical capabilities of aerospace subcontractors were first assessed on the basis of a thorough literature review and then validated in 22 case studies.

Technological superiority is certainly a key driver of long-term performance in the aerospace industry and, as such, technological capabilities are essential. R&D investments are quite indicative of the absorptive capacity of subcontractors [5], while technological scanning is probably the second-best means of acquiring and maintaining the required levels of knowledge and skills [6]. Employees' technical and scientific expertise constitutes one of the most strategic organizational assets in subcontractors' technological base, especially in a high-technology sector. The use of advanced computer-based technologies is linked to competitive dimensions such as quality, time, flexibility and cost [7], as are manufacturing improvement programs such as TQM or Just-In-Time (JIT). In this study, we did not retain the level of use and mastery of specific high-potential technologies such as superplastic forming, metallic powder, lost wax molding or precision forming since they are not generic across the industry; instead we consider the degree of perceived exclusiveness of know-how related to the firm's product. This capability allows for comparisons of firms within the industry.

Possessing technological capabilities is an *a priori* and necessary but not sufficient condition for ensuring high levels of competitiveness, as these capabilities must be managed optimally. Successful technological innovation therefore depends on critical managerial capabilities. In particular, managerial skills, especially in terms of the coordination and integration of activities and functions [8], the ability to ensure durable relationships with customers and suppliers, and marketing skills [9] are obviously essential. Equally important are self-reinforcing capabilities which depend on historical settings and past performance such as the positive reputation of the subcontracting firm among customers and suppliers and its financial stability. Although the last two capabilities are no guarantee of future performance in all cases [10], they introduce a favorable bias in the awarding of contracts which, in turn, contributes to the gradual building of capabilities.

2.2 Identifying the underlying dimensions of performance

The competitive stance of aerospace manufacturing subcontractors is based mainly on five dimensions. First of all, quality is an overriding, non-negotiable requirement: the highest standards must be met. This is a fact of life in the aerospace industry. Second, quality of customer service is clearly important to maintain long-term relationships with prime contractors. Moreover, prime contractors may ask their subcontractors to give technical support directly to final customers such as airlines [9]. Third, time-based competition is omnipresent in any industry and, although it presents very long lead times (for instance, for commercial airplanes), the aerospace industry is no exception [11]. Fourth, flexibility, i.e. the ability to switch quickly and/or adapt to special conditions or requirements, whether in terms of product, layout, skills, variations of volume or use of equipment, is also required from subcontractors. Fifth, cost also constitutes a prime competitive advantage, especially with the increased competition of subcontractors located in low-cost production countries. Indeed underbidding[1] and questionable government subsidies[2] are still current and controversial issues since, other things being equal cost is often the bottom line. In fact, no clear-cut trade-offs can be allowed between these five competitive dimensions: the best-performing aerospace subcontractors are expected to excel on each of these dimensions[3] or, at least, to improve on all dimensions, although the relative rates of improvement may well differ from one dimension to the next [12].

2.3 Controlling for other factors

When assessing the relationship between critical capabilities and a firm's performance, several factors which could modify this relationship should be controlled for. Among these factors (or control variables) let us mention size, which still plays a role, even in SMEs, the number of large customers and the percentage of sales they represent, the level of prime contractors' expectations in terms of the adjustments required from the subcontracting firms (difficulty, variability, magnitude and time horizon for these changes) and the level of prime contractors' direct influence over decisions made by subcontractors such as the adoption and implementation of new technologies or the training of employees.

3. Analytical and methodological issues

Strategic benchmarking, defined as "the continuous search for and application of significantly better practices that lead to superior competitive performance" [13: 2], strongly suggests the need to identify the critical capabilities of best manufacturing subcontractors in the aerospace industry. In contingency theory, the perspective of "fit as profile deviation" [14] requires one to demonstrate that the degree of

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[1] Underbidding is certainly a way to gain market share, as it forces direct competitors to make a difficult decision: lose a sale or lower prices below cost. Financial packages such as the "Walk Away Lease" or the "Deferred Seat Plan" also place the financial burden on prime contractors who, in turn, shift the pressure to the subcontractors.

[2] The question of subsidies has long been a bone of contention between the U.S.A. and Europe. For example, the Americans claim that Airbus Industrie got more that $25 billion in subsidies over the last two decades whereas the Europeans estimate that military and space contracts account for $41 billion of indirect subsidies to American firms [18].

[3] As one subcontractor summarizes the situation: "the prime contractors are simply pushing down all of their own pressures on us". In almost all 22 case studies, subcontractors from Europe and North America felt they had to excel on all five dimensions and, for some, the demands from prime-contractors were unrealistic.

adherence (fit or alignment) to an ideal profile has positive implications for performance. We will draw heavily on these two approaches, both of which call for the development of an ideal profile of critical capabilities.

3.1 Development of an ideal profile

In order to arrive at an ideal profile, previous studies used the mean scores of a "calibration sample", usually defined as the top 10 percent of high-performing companies [see, for example, 15]. Such an empirically derived profile is not only close to the concept of strategic benchmarking, but is also rather straightforward and intuitively appealing. Nevertheless, it must overcome some difficulties if it is to become credible. First, since the aerospace industry is a global industry relying on global outsourcing, the best subcontractors cannot be identified from a single-country perspective. Second, the best subcontractors (calibration sample) should display a significantly different set of critical capabilities from the other subcontractors (study sample). Finally, the various capabilities should carry different weights depending on their relative importance. The development of an ideal profile therefore requires careful attention to the stability, robustness and validity of the empirical results and, consequently, imposes stringent conditions on the research design and statistical analyses.

3.2 The degree of adherence to the ideal profile

The closer a subcontracting firm is to the ideal profile, the better it is expected to perform. Likewise, significant deviations from this ideal profile should result in poor performance. The overall degree of adherence to the ideal profile corresponds to the multivariate perspective of fit as profile deviation, and its classical measure is the weighted Euclidian distance between two vectors [15, 16]. The graphical representation is given in Figure 1 and its mathematical equivalent is as follows:

$$\sum_{i,j=1}^{n,m} \beta_i (x_{Sij} - \overline{x}_{ci})^2$$

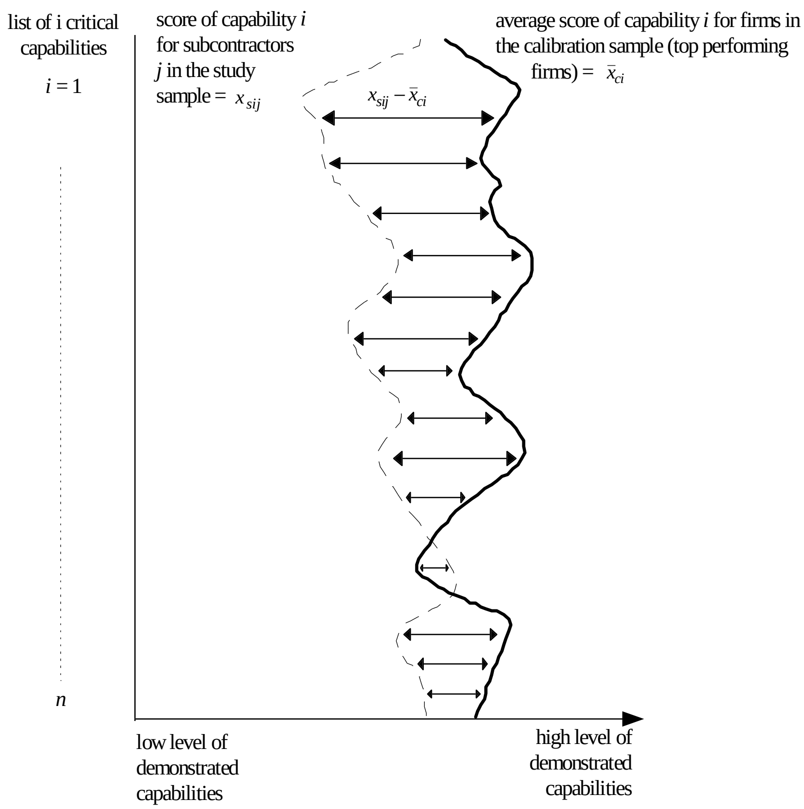
where

x_{Sij} represents the score for each critical capability *i* for the subcontractor *j* that pertains to the study sample;

$\overline{x}_{ci}$ represents the ideal profile or the mean scores for each critical capability *i* for the best-performing subcontractors (i.e. all firms pertaining to the calibration sample);

β_i consists of standardized beta coefficients for each capability *i* in the multiple regression conducted in the calibration sample.

Figure 1
Graphical representation of "fit as profile deviation"



Source: adapted from Venkatraman [14]

The overall degree of adherence, which would more correctly be termed the overall degree of misalignment, indicates the contribution of all critical capabilities to the performance of subcontracting firms. Yet it fails to indicate the relative importance of the score for a specific capability, which is a prime concern from both a practical and a theoretical perspective. We will therefore also examine more closely the degree of adherence for each capability.

3.3 Research design

The choice of variables and the operationalization of their measures were thoroughly pre-tested in previous case studies: 22 subcontracting firms were investigated in Europe (7), Canada (10) and the U.S.A. (5). More specifically, the performance of these subcontractors was assessed by one prime contractor and then subjected to a self-evaluation by the top manager of each firm. The correspondence between the two assessments[4] was astonishingly high (Kendall's test of agreement, $p = 0.8975$ where $p = 1$ indicates perfect agreement).

A large-scale survey was then carried out in three countries that differ widely with respect to their aerospace subcontracting base[5]: the U.S.A., the U.K. and Canada. Three well-known universities (one per country) mailed out the questionnaires addressed to the top managers of manufacturing subcontracting firms. The survey design allowed for quota sampling and the pre-set objective was to obtain at least 120 questionnaires from each country in order to carry out the necessary comparative multivariate analysis. With 156, 148 and 151 firms responding from the U.S.A., the U.K. and Canada, respectively, the objective was met and no follow-up was done. In order to carry out meaningful benchmarking, the responding firms had to be representative of the population, and comparable goodness of fit tests revealed no particular bias with respect to size or regional coverage within one country[6].

Could comparisons or benchmarking be conducted between all of these firms? Several steps were followed to ensure that comparisons were adequate. First, all

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[4] The prime contractor had ranked its own subcontractors from "the best" to "the worst". The self evaluation of each subcontractor (although the scores for all five dimensions were slightly higher in absolute terms) resulted in a similar ranking; "the best" still being "the best" and "the worst" still being "the worst". Poor performers were quite candid about their own weaknesses: in particular delivery times, flexibility and cost in particular received very low scores.

[5] For example, the total number of subcontracting firms varies quite drastically from country to country.

[6] Various official directories in each country provide the basic information for carrying out these tests.

responding firms were manufacturing firms actively involved as subcontractors in the aerospace industry. Second, an upper limit of 500 employees was set to limit the analysis to SMEs (small and medium-sized enterprises). As a result of this second step, the number of firms retained for all subsequent analyses dropped slightly to 140, 109 and 135, respectively, for the U.S.A., the U.K. and Canada, giving us a total sample of 384 firms. Third, several variables were included in all statistical analyses as control variables since some of the firms' characteristics (such as size) as well as contextual factors (such as the degree of influence of prime contractors over decisions made by the subcontracting firms) may have had an impact on the relationship between capabilities and performance.

4. Results and discussion

Statistical analyses were conducted in three distinct and consecutive phases. First, the mean scores on the critical capabilities of firms from the calibration sample allowed for the development of an ideal profile which must to be significantly different from the profile of remaining firms in the study sample (table 1). We then turned to the second phase, where we examined the relationship between the degree of overall correlation with the ideal profile and the performance of firms in the study sample (table 2). Significant negative correlation coefficients were expected since large variations from the ideal profile would normally result in poor performance. In the third and final phase, relationships between performance and the degree of adherence for each capability to the ideal profile were analyzed (table 3); this provides a better understanding of the relative contribution of each capability to firm performance.

4.1 The ideal profile of best aerospace subcontractors

Two subsamples are derived from our final sample of 384 firms (Figure 2). The best-performing firms (n_1 = 37) represent the calibration sample[7]. The study sample consists of all the remaining firms with the exception of the bottom 10 percent: removal of the worst-performing firms is necessary to obtain an unbiased sample domain. The size of the study sample (n_2) is therefore 309 firms[8].

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[7] This is actually slightly less than the 10 top percent as a sharp decrease in performance is observed between the 37th firm and the 38th firm.

[8] 384 firms minus 37 firms (best-performing firms) minus 38 firms (worst-performing firms).

Figure 2
Study sample vs. calibration sample ($n = 384$)

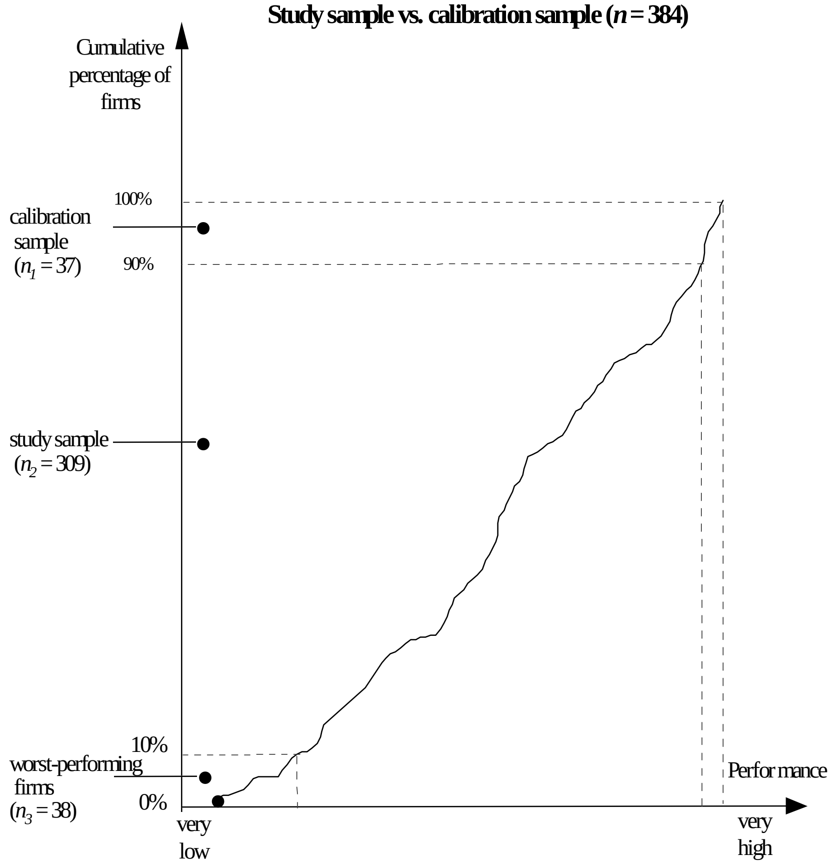

Table 1 presents the profiles of firms in the two subsamples (calibration vs. study samples) as well as levels of significance of bivariate tests for the difference in means (Mann-Whitney). As hypothesized, firms in the calibration sample display significantly higher mean scores for the majority of capabilities (8 out of 12). However, the scores for four critical capabilities, namely R&D, levels of adoption of computer-based administrative applications and advanced manufacturing technologies, and the stability of networks with customers/suppliers, are higher in the study sample than in the ideal profile, although not significantly. This rather surprising result is explained by the fact that some capabilities are linked to a firm's size. In fact, as we turn to the control variables (last four rows in table 1), we notice that the best-performing firms are significantly smaller. This is no more the case

Table 1

Profiles of firms in the calibration sample (ideal profile) and in the study sample

	Mean scores		Level of significance for unilateral tests	
	Calibration sample (n_1 = 37)	Study sample (n_2 = 309)	Without size as a control variable P (M-W)[1]	With size as a control variable P (ANCOVA)[6]
Critical capabilities:				
• Technological capabilities				
- R&D investments	2.87%	3.52%	NS	NS
- Technological scanning[2]	5.28	5.16	0.0938*	0.0010***
- Level of employees' technical/scientific expertise[2]	6.32	5.32	0.0000****	0.0000****
- Level of adoption of computer-based administrative applications[3]	3.59	3.64	NS	0.0000****
- Level of adoption of advanced manufacturing technologies[3]	2.27	2.67	NS	0.0000****
- Level of adoption of manufacturing improvement programs[3]	1.62	1.33	0.0683*	0.0000****
- Exclusive and unique know-how related to firm's products[2]	5.84	5.14	0.0014***	0.0065***
• Managerial capabilities				
- Management skills[2]	6.29	4.96	0.0000****	0.0000****
- Marketing skills[2]	4.75	4.27	0.0704*	0.0225**
- Stability of networks with customers/suppliers[2]	3.92	4.90	NS	NS
- Financial stability[2]	5.91	4.96	0.0001****	0.0000****
- Reputation[2]	6.68	5.94	0.0000****	0.0000****
Control variables				
- Size[4]	14.87	15.71	0.0015 ***	NS
- Level of dependency[5] on prime contractors	32.40	31.40	NS	NS
- Level of expectations[2] from prime contractors	4.37	4.51	NS	NS
- Level of influence[2] of prime contractors	2.99	2.90	NS	NS

NS Not significant * $p < 0.10$ ** $p < 0.05$ *** $p < 0.01$ **** $p < 0.001$

1 The Mann-Whitney test (non-parametric test of differences in means) is used here since the

two subsamples vary drastically in size. T-tests give similar results.

2 Based on 7-point Likert scales.

3 Based on the actual number of technologies/programs being implemented (respectively 4, 6 and 3 for administrative applications, advanced manufacturing technologies and manufacturing improvement programs). See note [9] at the bottom of the page for more information.

4 Expressed as the natural logarithm of total annual sales in order to normalize this variable.

5 Percentage of sales realized from 1, 2 or 3 major customers.

6 See note [10] at the bottom of the page for more details.

when size is controlled for. Values for all of the four variables not only become greater for firms in the calibration sample, they are also significantly different from firms in the study sample. In fact, the ideal profile becomes significantly different for the two capabilities linked to the levels of adoption of new technologies ($p = 0.0000$) once size is controlled for (ANCOVA test). This confirms previous results that size still plays a major role with respect to increased automation even within SMEs [17]. This strongly suggests that one should systematically include the effect of size as a prime control variable. Notice that the three remaining control variables are not significantly different across the two sub-samples.

Are the results in table 1 credible enough to carry out subsequent statistical analyses? First, discriminant analysis further validates in a multivariate manner the differences between the profiles of firms found in the two subsamples as displayed in table 1. The discriminant function is highly significant ($p < 0.0000$) and yields to a perfect classification rate for the best-performing firms (100%) and a highly satisfactory classification rate (87.7%) for the firms in the study sample. Second, the results are stable based either on the "slipt-half method" or the "jackknife method"[11]. Third, a three-group analysis (best performers $n_1 = 37$; study sample

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[9] Computer-based administrative and production technologies are as follow: General accounting applications (accounts payable/receivable, payroll, billing, etc); costing; inventory management; net needs planning (MRP I) and manufacturing resource planning (MRP II) systems; job order costing; electronic data interchange (EDI) with outside organizations or companies; computer-assisted design (CAD); integrated CAD/CAM; computerized numerical control (CNC) tools; direct numerical control (DNC) tools; automated handling; bar code system; computerized quality inspection and control. Manufacturing improvement programs include: Just-in-time (JIT) system; statistical process control (control cards); employee accountability.

[10] One-way analysis of covariance (ANCOVA) is an extension of analysis of variance (ANOVA) and is designed to assess the effects of independent variable(s) on a single dependent variable after the effects of one or more covariates (here, size) are accounted for.

[11] For the slipt-half method, the 384 firms are randomly split in two sub-samples of equal size. For the "jackknife method", samples are repeatedly drawn from to the original sample of 384 firms on the "leave-one-out" principle. The same bivariate tests (Mann-Whitney and ANCOVA) and multivariate analysis (discriminant analysis) allow one to test the significant differences between the two groups based on subsamples derived from either method. Even with the "slipt-half method", which is the most

$n_2 = 309$; worst performers $n_3 = 38$) also yields significant differences between the means on a three-group basis (Kruskal-Wallis and ANCOVA tests). Furthermore, the inclusion of the bottom 10% of firms in the study sample obviously results in lower scores for all critical capabilities than those observed for the study sample alone, suggesting that the differences revealed in table 1 between the two subsamples of firms are in fact conservative. Finally, the best-performing subcontractors are not confined to one country but distributed across the three countries (17 for the U.S.A., 11 for Canada and 9 for the U.K.), as is to be expected for an industry with a global subcontracting base. Based on these observations, the results are judged to be stable and valid enough to turn to the next phase of the statistical analysis.

4.2 The degree of overall adherence to the ideal profile as an indicator of performance

Table 2 summarizes the relationships between the overall degree of adherence to the ideal profile and performance for all firms from the study sample and for each of the three countries involved.

This table reveals some interesting results. First, all correlation coefficients are negative, as hypothesized, and most are significant: the more firms diverge from the ideal profile, the lower their performance. Second, the degree of correlation with the ideal profile for managerial capabilities shows stronger links to performance than is observed for technological capabilities. This is true for all three countries pooled together and for each country taken separately. Technological capabilities may be considered as *a priori* conditions for dealing with prime contractors. Once these are acquired, managerial capabilities may very well make the difference and lead to superior performance. Continued excellence therefore depends not only on technological capabilities but also on strong managerial capabilities, even in a high-technology industry such as aerospace. Third, some differences are observed between the U.S.A. and U.K., on one hand, and Canada, on the other hand, given that weaker correlation coefficients are observed for Canadian subcontractors. However, these differences are not statistically significant (last column of table 2).

Table 2

Relationships[1] between performance and the overall degree of adherence to

demanding, results are stable.

the ideal profile (study sample n_2 = 309)

Overall degree of adherence	All three countries	U.S.A.	U.K.	Canada	P
All critical capabilities	- 0.34 ****	- 0.42 ****	- 0.38 ****	- 0.32 ***	NS
Technological capabilities	- 0.17 **	- 0.29 ***	- 0.30 ***	- 0.18	NS
Managerial capabilities	- 0.31 ****	- 0.35 ****	- 0.33 ****	- 0.29 ***	NS

1 Spearman correlation coefficients (controlling for size). See note [12] at the bottom of the page.

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

2 N.S. non significant; Using one-tailed Fisher's z transformed test. See note [13] at the bottom of the page.

4.3 Strategic benchmarking across the three countries: the most critical capabilities

[12] When controlling for size, correlation coefficients (table 2) are calculated as follows:

$$r_{po.k} = \frac{r_{po} - r_{kp} - r_{ko}}{\sqrt{(1 - r_{kp}^2)(1 - r_{ko}^2)}}$$

where p = performance; 0 = overall degree of adherence to the ideal profile and k = control variable (i.e. size).Similarly, correlation coefficients between each critical capability and performance allows one to control for the effect of size in table 3.

[13] The correlation coefficients are not significantly different at p = 0.10 between the countries taken two by two (table 2) on the basis of the one-tailed Fisher's z transformed test $(z = \frac{1}{2}\ln(\frac{1+r}{1-r}))$.

Table 3 sheds some additional light on the relationship between performance and the observed deviations from the ideal profile. In order to effectively display the results, only the five most significant and largest negative correlation coefficients are ranked in decreasing order (where rank 1 represents the strongest negative correlation coefficient). This is done for all firms in the study sample and for American, British and Canadian subcontractors separately. Managerial skills seem

Table 3

Most critical capabilities – Strategic benchmarking

	Ranks[1]			
Critical capabilities:	All countries	U.S.A.	U.K.	Canada
• Technological capabilities				
- Level of adoption of computer-based administrative applications	4	4	4	4
- Level of adoption of manu-facturing improvement programs	-	5	5	-
- Exclusive and unique know-how related to firm's products	2	2	3	5
• Managerial capabilities				
- Managerial skills	1	1	1	2
- Stability of networks with customers/suppliers	3	3	-	3
- Reputation	5	-	2	1

[1] Ranks are here based on the correlation coefficients (controlling for size effect). See note 12 at the bottom of page 13.

Rank 1: first strongest negative correlation coefficient

Rank 5: fifth strongest negative correlation coefficient

to be the most critical capabilities, as deviations from the level of managerial skills observed in the best-performing firms are systematically related to poorer performance in all countries. Deviations from a very unique and exclusive know-how also have a significant negative impact on performance, although a bit less so for Canadian subcontractors, which are known to be operating in niche markets. Surprisingly, the adoption of computer-based administrative applications such as inventory management, MRP I and II, job order costing or EDI with external organizations is the fourth most critical capability, while the adoption of advanced manufacturing technologies does not play a significant role. Finally, the stability of networks with customers and suppliers seems to be more important in a large domestic market such as the United States while reputation has a more predominant role in Canada and U.K.

5. Conclusion

Both strategic benchmarking and fit as deviation profile allow us to identify and measure the gaps between the best and the other subcontractors and to increase our understanding of the critical capabilities needed by aerospace subcontracting firms. These two concepts are useful for the aerospace industry where competitive excellence is constantly subjected to worldwide competitive pressures and to the entry of new competitors from the new emerging markets. As a given level of excellence observed at a particular point in time tends to degrade naturally over time, the ideal profile derived from the calibration sample is, without a doubt, time-sensitive and will need to be continuously recalibrated. Thus, the next calibration sample should include other foreign subcontractors, in particular Asian ones which are in the process of building world-class capabilities[14].

This paper focuses on today's demonstrated world-class capabilities of Western aerospace manufacturing subcontractors and provides strong empirical evidence supporting four broad observations. First, the best-performing aerospace subcontractors, which are not necessarily the largest firms, display a significant set of stronger critical capabilities. Second, the overall degree of adherence to the ideal profile (best subcontractors) is a good indicator of performance: the closer firms adhere to this ideal profile, the better they perform. Third, although technological superiority is essential to aerospace subcontractors' performance, large deviations with respect to managerial capabilities are linked more strongly to weaker

[14] Because of their purchasing power and lower costs of production, subcontract manufacturing will increasingly take place in Asian countries. For example, the Korean Manufacturing Program, covering 120 F-16 aircraft, illustrates how capabilities are gradually being acquired by the recipient countries: "*Stage 1 consists of 12 aircraft bought off-the-shelf, stage 2 covers 36 aircraft assembled; and Stage 3 includes license production of 72 aircraft by Samsung Aerospace (...) Koreanisation of the F-16 will represent 40% of the total engine, 33% of avionics and 52% of undercarriage*" [19].

performance. Fourth, subcontractors from the U.S.A., the U.K. and Canada differ slightly in terms of the degree of adherence to the ideal profile but share a common set of most critical capabilities, which in turn provides an additional demonstration of the internationalization of the aerospace industry.

Some findings are of particular interest and have profound implications. The most critical capabilities subcontractors need to acquire in order to compete with the best are either intangible such as managerial skills, difficult to imitate such as exclusive and unique know how, or not easily transferable such as reputation and stability of upstream and downstream business networks, which is often the result of historical trustworthy relationships. Furthermore, a close look at the prevailing technologies indicates that the adoption of the so-called "soft" and more difficult to implement technologies such as manufacturing improvement programs or computer-based administrative applications constitutes a more important gap to fill by the less performing firms than the adoption of "hard" manufacturing technologies such as computerized numerical control tools (CNC) or automated handling. This suggests that the learning cycle for the acquisition of these most critical capabilities may be longer to achieve than would be the case for a straightforward buildup of existing resources such as additional machinery or manpower and thus constitutes an important barrier for existing firms or new entrants aiming at competing with the best Western subcontractors.

In the short term, for those firms identified as the best subcontractors and possessing the above-mentioned capabilities, it translates into a strong competitive positioning. On the other hand, competitive pressure on the worst-performing firms will increase considerably as new entrants from the emerging markets will be able to offer comparable capabilities in the rather near future. This, coupled with the fact that, in the coming years, selection of subcontractors will be motivated by considerations that go beyond geographical proximity, leads us to think that, in this new order of doing business, only the best will survive.

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