R&D-Related Capabilities as Determinants of Export Performance

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ABSTRACT. Empirical evidence from a sample of independent and privately held specialized suppliers all of which are engaged in formal R&D activities shows that specific R&D-related capabilities are determinants of different types of export performance. The major contribution of this paper is to take into account traditional measures of R&D activities as well as a broad range of R&D-related capabilities to further our understanding of the export behavior of SMEs in terms of volume and final destination of sales. Results suggest that the set of determinants varies with firms' internationalization process. In particular, determinants associated with the more global firms are significantly at odds with our traditional conception of a small firm and appear to be more aligned with the behavior generally found in proactive large exporters.

1. Introduction

International markets can be very attractive for small manufacturing enterprises (SMEs) as they represent significant opportunities for growth. Although incentives to export may vary, and in spite of arguments against exporting such as limited resources, numerous studies have reported examples of SMEs active outside their national borders and capable of facing international competition [Bonaccorsi, 1992; Samuels et al., 1992]. While showing dynamism and a willingness to engage in international activities, those firms cannot, however, escape today's technology-oriented competition.

For all the rich literature published on export performance in the last two decades, only a limited number of studies have addressed technological issues. In the case of small businesses, previous studies have failed to produce consistent results in examining the relationship between technology and export performance and, more specifically, between research and development (R&D) and export performance. This may be because the measure usually used, namely R&D as a percentage of sales, remain too limited to provide any significant discriminatory power. It is argued here that more investments in R&D activities, although crucial, are not sufficient to gain a competitive advantage on export markets without also relying on other R&D-related capabilities. These capabilities correspond to the level of investment in human capital in the form of highly qualified technical and scientific personnel, the relative emphasis placed on the various R&D strategies, the extent of the different forms of R&D collaboration with external partners and the extent of use of the various sources of information for R&D activities. A closer analysis of these R&D-related capabilities may well shed some light on the previous contradictory results concerning R&D and SMEs' export performance.

The focus of the present study is therefore clearly directed towards considering a wide variety of R&D-related capabilities and assessing their relationship with SMEs' export performance. More specifically, we will attempt to address the following research questions:

i) Which R&D-related capabilities (including R&D intensity) best discriminate the non-exporters from the active exporters? Further, which of these capabilities discriminate exporters based upon the final destination of the exports?
ii) Which R&D-related capabilities are the

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strongest determinants of export intensity according to different export destinations?

Some answers to these questions are provided, based on a detailed study conducted on a sample of small independent firms engaged in R&D activities which correspond to the profile of firms described by Pavitt (1984) as "specialized suppliers". These firms were chosen for three main reasons. First, if innovative efforts are assumed to go beyond R&D investments, all firms, for the sake of comparison, should have a common denominator and should therefore be actively engaged in R&D activities. Second, when studying efforts related to technological innovation, firms should belong to the same "technological family" (Pavitt et al., 1989, p. 85) based on sectors of production and use of innovation. Third, specialized suppliers play a major role in industrialized economies, especially small ones where scale-intensive firms cannot rely on a large domestic market.

2. Study background

2.1. *Technological innovation and export performance*

Past empirical research on the determinants of export performance is extremely rich and covers a wide spectrum of issues from the relative importance of a firm's demographic characteristics such as size (Wagner, 1995) to the impact of managerial characteristics such as the beliefs and perceptions of key decision-makers (Bijmolt and Zmart, 1994), organizational capabilities such as market intelligence (Cavusgil, 1984) or export stimulus measures such as export assistance or incentive programs (Crick and Czinkota, 1995). As highlighted by the thorough literature reviews carried out by certain authors (see, for example, Chetty and Hamilton, 1993), technological issues have received much less attention than the above-mentioned factors, in spite of the large number of empirical studies carried out. We will therefore focus on the role of technology as a determinant of export performance.

As far back as 1982, Walsh noted that for American firms "technology intensive products are not only our most export-competitive products, but they are also the single largest group of potential exports" (Walsh, 1982, p. 72). Yet, attempts to link various aspects of technological innovation to export performance have yielded rather contradictory results. Competitive advantage in the form of a unique product/technology or technological superiority of the product (Cooper and Kleinschmidt, 1985), advanced technology (Wagner, 1995) and number of owned patents (Moini, 1995) are all positively linked to export success. On the other hand, Sriram et al. (1989) observed a negative relationship between technology and export intensity and Reid (1986) found little relationship between technology and export performance. Overall, such inconsistent results may be explained in part as follows.

In the first place, there is a "measurement problem" as the studies have not systematically used the same measures of export performance. For example, some studies have considered the simple dichotomy of exporters vs. non-exporters based on the mere presence of export activities whereas others have used export intensity as a measure of export performance. Few studies have considered the final destination of exports although proximity or distance to markets may be a significant factor.

Secondly, failing to concentrate on firms of similar size may also lead to unstable and contradictory results. For example, SMEs have been shown to contribute disproportionately to technological innovation (Acs and Audretsch, 1988) and to be more apt to take advantage of their technological edge than their larger counterparts. In fact, SMEs thrive on product differentiation by promoting unique products (or products with differential advantages) and by addressing niche markets (Julien, 1993). SMEs are therefore expected to perform differently on export markets especially if the competition is increasingly technology-based.

Finally, export performance depends not on technology itself but rather on how firms profit from technological innovation by enhancing knowledge, skills and capabilities. Technological development has in fact reached such a level of complexity that most firms have no alternative but to adopt a comprehensive and coherent approach, including clear R&D strategies and focused access to external sources of information and technology (Link and Bauer, 1989).

In light of the above comments, it is proposed that:

i) export performance is multidimensional and must be accurately defined;
ii) the specific context in which SMEs operate may lead to different sets of significant determinants of export performance;
iii) firms' commitment to technological innovation is multifaceted.

2.2. *R&D-related capabilities as determinants of export performance*

The central focus of this study is on R&D and its related capabilities, which constitute a crucial dimension of technological innovation. The main premise rests on the following argument: more investments in R&D projects or R&D personnel are not sufficient in themselves since firms must also develop complementary capabilities in order to fully benefit from these investments (Lefebvre et al., 1993). Such R&D-related capabilities can be divided into four subgroups:

i) A scientific and technological culture which often results from the steps taken by a firm to hire and retain engineers, scientists, computer specialists or technicians who are not directly involved in R&D activities but support different aspects of technological innovation. The number and percentage of employees with technical and scientific backgrounds[1] provide an indication of the firm's technological knowledge intensity and R&D-related capability;
ii) R&D being firm-specific (Helfat, 1994), each firm has a diversified allocation of R&D resources which corresponds to a particular R&D strategy. Link and Tassey (1987) propose five broad strategies, namely basic research, applied research, product development, process development and, improvement of existing products. In view of the recent literature on the economics of technological change, which strongly emphasizes the cumulativeness and firm-specificity of technology, efforts to improve existing scientific/technological assets could be viewed as a sixth R&D strategy;
iii) The ability to resort to external collaboration reflects the widespread trend towards the creation of alliances and other forms of co-operation among firms, government agencies and universities. In fact, it has been strongly suggested that collaboration may be an essential ingredient for successful new product development by SMEs (Freeman, 1991). The choice of partners varies substantially, which explains why six categories of partnerships are included, namely with customers, competitors, subcontractors, colleges, universities and government agencies. These six categories reflect the usual forms of collaborative R&D,[2] i.e. business to business (Kleinknecht and Reijnen, 1991), university to business (Acs and Audretsch, 1992) and government agency to business (Roessner and Bean, 1993).
iv) The capability to gather technological knowledge from different sources is also a definite asset. External information support from universities, technical colleges or government agencies is essential (Chrisman and Kalrishen, 1995), especially for SMEs, whereas extensive internal communication among the different functional groups, for example, engineering and production (Kiggs, 1996), is also critical. Some thirteen distinct sources of information firms can draw on in support of their product development; they have been suggested[3] by authors such as Hauschildt (1992) and Bierly and Chakrabarti (1994).

3. Method

3.1. *Sample*

The sample used for this study consisted of firms located in Canada and registered in government files as being firms conducting formal R&D activities. A population of 692 firms that have received R&D tax credits, which corresponds to the total number within one province (Quebec), was considered for the survey. A self-administered questionnaire was mailed to the CEO of each firm after having been extensively pre-tested with 15 persons (10 of whom were CEOs). Considering the strategic nature of all innovation-oriented activities, CEOs are considered to be the best

respondents for this kind of survey as they have a major influence on resource allocation and strategic orientation, especially in the context of small firms.

A total of 236 questionnaires were correctly completed, for a response rate of 34.8%.[4] It should be noted that the sample representation does not differ from that observed in the population of R&D firms operating in Quebec with respect to size and sector of economic activity (goodness of fit test $\chi^2 = 4.67$, $p = 0.197$ and $\chi^2 = 0.005$, $p = 0.968$ respectively). However, firms with formal R&D activities are not representative of all Canadian or Quebec firms. They are more likely to be carrying out export activities (Baldwin et al., 1994). Furthermore, successful SMEs not only invest more in R&D but also "diffuse technology more rapidly and develop more products and services than do other firms" (Industry Canada, 1995, p. ii). The targeted population (692 firms) and the resulting sample (236 firms) are therefore deliberately biased towards highly performing firms. The focus of the study on R&D-related capabilities in itself justifies such bias. Further, the study of high performers constitutes a useful benchmarking exercice.

Three restrictions are imposed on the responding firms in order to reflect the focus of this study. First, the firms retained have fewer than 200 employees. This upper limit corresponds to one of the standard definitions of small firms. Second, they are privately held and independent, thereby excluding firms operating as affiliates of multinational consortiums, which may be exporting as a result of advantages provided by the head office or preferential trade agreements among affiliates. In both these cases, the smaller firms have access to a pool of resources which is not available to independent firms, which is why multinational affiliates are not considered in this study. Third, in order to control for and "take into account the enormous variety between firms in sources of technological opportunities and in the rate and direction of their development" (Pavitt, 1990, p. 19), we decided to concentrate on one technological family identified by Pavitt, whose original typology has already been extensively tested empirically, although with some variants (Pavitt et al., 1989; Archibugi et al., 1991). All firms retained belong to the category labeled "specialized suppliers". These firms derive their technological advantages from their ability to improve the performance of specialized inputs and are characterized by the fact that they thrive on product innovation. A detailed description of such firms is provided in Pavitt (1984). A rigorous and systematic procedure for identifying firms in our sample that fit the profile of specialized suppliers was followed: (i) firms were retained on the basis of their principal sector of activity (four-digit SIC codes); (ii) all firms retained were examined individually in order to ensure that they corresponded to the profile of specialized suppliers with respect to firm size and technological profile. Four persons[5] participated in this second step and firms were selected on the basis of a consensus.

With these three simultaneous restrictions, the final sample on which all statistical analyses are performed totals 101 firms.

3.2. *The dependent variables: groups of exporters and export intensity on different target markets*

Numerous measures of export performance are found in the literature (Cavusgil and Zou, 1994). The relative volume of exports, captured by the ratio of export sales to the firm's total sales, is certainly one of the most frequently used and is retained here. Yet it was felt that a further distinction should be made to take into account the geographical distribution of sales since the final destination of exports may, for small independent firms, constitute an additional obstacle in the case of markets that are geographically and/or psychologically distant. Export performance, assessed here by a dual measure of relative volume and destination of exports allows one to distinguish between *groups of exporters* based on the simple presence of export activities and to assess what we call *export intensity*, i.e. the level of exports realized on different markets.

As indicated in Figure 1, target markets are usually classified in three broad categories, namely domestic or local markets, proximate export markets and world or global export markets (Kleinschmidt and Cooper, 1995). Domestic or local markets refer usually to a region, state or province. Extraregional, interstate or interprovincial "exports" are often viewed by SMEs as a

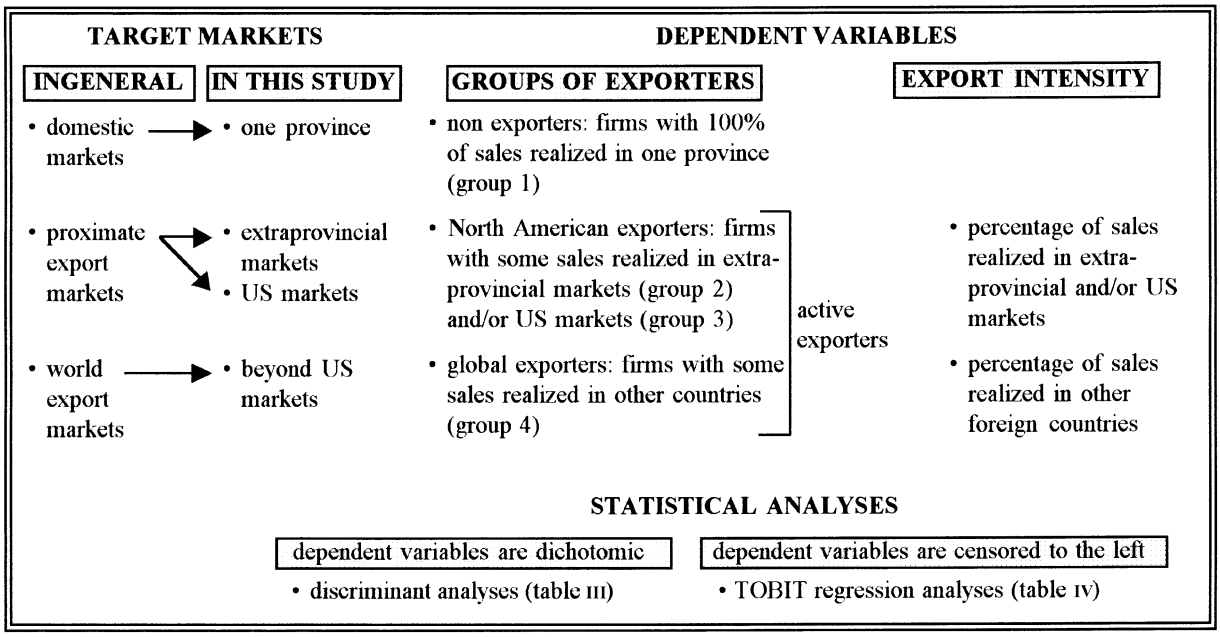

Fig. 1. The dependent variables (groups of exporters and export intensity), definitions and corresponding statistical analyses.

crucial step before engaging in "real" exports (Christensen, 1991, p. 52). Proximate export markets are usually those of neighboring countries while world markets clearly go further than proximate markets.

Groups of exporters

Within the geographical context in which the study was carried out, non-exporters are defined as SMEs with 100% of their sales realized in the province of Quebec (group 1 in Figure 1). Active exporters comprise groups 2, 3 and 4 as defined in Figure 1. We will seek to find differences not only between non-exporters and active exporters but also between the different groups of exporters. Porter (1991), in his analysis of Canada's competitiveness, suggested that exports realized in countries other than the United States, which is by far Canada's most important trading partner, are a better indicator of the performance of Canadian firms and significant differences are therefore expected between exporters to proximate markets (groups 2 and 3) and exporters to world markets (group 4). Some differences, although not as acute, may also exist between interprovincial exporters (group 2) and U.S. exporters (group 3).

Export intensity

The dichotomy implied by the definition of different groups of exporters cannot fully capture the gradual commitment of SMEs to export activities within a target export market. The ratio of export sales to total sales, or export intensity, better assesses the process of internationalization[6] (Cavusgil, 1980) from initiation, with a limited percentage of export sales, to increased experience, with a substantial share of export sales. Once again, export intensity will be measured for both proximate and world export markets (Figure 1).

3.3. *The independent and control variables*

Traditional R&D efforts and R&D-related capabilities as presented in Table I are the independent variables. Size was controlled for ex ante by the sample design but will also be considered ex post as a control variable in all statistical analyses. The same remark also pertains to the industrial sector: the choice of specialized suppliers may be viewed as an a priori, although rather crude, control and therefore the principal sectors of activity (four-digit SIC codes) were also entered as dummy variables in subsequent analyses.

4. Research results

Results will be presented in four consecutive steps. First, we will draw a brief profile of the firms in our sample. Second, since the data collected from each individual firm was quite extensive, factorial analyses will be conducted in order to summarize R&D-related efforts as meaningful underlying dimensions (Tables I and II). Third, we will examine the types of R&D-related efforts which best discriminate between exporters and non-exporters as well as between types of exporters (Table III). Finally, R&D-related efforts as potential determinants of export performance intensity on North American markets and other foreign markets will be analyzed (Table IV).

4.1. *Profile of specialized suppliers*

The firms acting as specialized suppliers in the sample are all independent SMEs which, on average, employ 127 full-time workers and have an annual sales volume in the order of $15 million. Without exception, these firms are all engaged in formal R&D activities with a mean investment representing more than 10% of their annual sales. They are also very dynamic in terms of export performance: more than 83% of these firms export their products on North American markets and 48% are active on other foreign markets. Exports are also rather substantial (on average, 33.46% for North American markets and 10.62% for other foreign markets) but are subject to significant variations (standard deviations are 29.06% and 20.08% respectively).

The dynamism displayed by the vast majority of the 101 R&D-intensive firms in our sample in terms of export performance is not overly surprising: according to official statistics, R&D-intensive firms export more (Baldwin et al., 1994), which suggests that the presence of some positive association between R&D and export activities.

4.2. *Underlying patterns among types of R&D-related efforts*

R&D-related efforts are captured by some 25 variables as they represent complex and multi-dimensional concepts. In order to obtain a smaller, and therefore more manageable, set of new composite dimensions for these innovative efforts, factorial analyses using the component analyses[7] model with varimax rotation are performed.

Factorial analysis conducted on the different types of collaborative R&D efforts produces a clean and easily interpretable factor structure (Table I). The first factor points to the collaborative R&D efforts with public agencies (government, universities and colleges) while the second factor represents the firm's external linkages (upstream and downstream) in the product value chain. Collaboration with competitors is a separate third factor. The three factors together explain 69.5% of the variance.

The second factorial analysis reduces the 13 sources of information used in the product development process to 5 factors which collectively explain 68.9% of the variance (Table II). The first factor reflects the combined importance of customers and functional groups internal to the firm (mainly marketing and production and, to a lesser extent, finance). Surprisingly, the R&D group is not represented in this first factor but constitutes the fifth factor by itself, suggesting that effective cross-functional integration is not yet a reality in small firms or that the R&D group constitutes a separate source of information, probably more technical in nature. The second factor corresponds to sources of information from public agencies (universities, colleges, and governments) while the third factor essentially represents sources from the private sector (consultants and industrial partners). The fourth factor seems to be related directly and indirectly to the competition since trade shows are easily accessible means for small firms to obtain information on their competitors' products.

TABLE I
Factorial analysis performed on the different forms of collaborative R&D*

R&D conducted with:	FA1	FA2	FA3
Customers	–0.04	*0.77*	0.18
Competitors	–0.03	0.05	*0.96*
Subcontractors	0.01	*0.82*	–0.09
Colleges	*0.57*	0.46	–0.31
Universities	*0.85*	–0.18	0.15
Government agencies	*0.73*	–0.07	–0.13
Cumulative percentage of explained variance	29.3%	52.3%	69.5%

* K.M.O. = 0.54 (Sampling adequacy test).

TABLE II
Factorial analysis performed on the different sources of information for the development of products*

Sources of information	FB1	FB2	FB3	FB4	FB5
Trade shows	–0.04	–0.02	0.17	*0.78*	0.09
Suppliers	0.03	–0.09	0.23	0.44	0.36
Customers	*0.77*	–0.04	0.35	0.01	–0.08
Competitors	0.24	0.17	–0.06	*0.64*	–0.17
Consultants	0.12	0.14	*0.75*	0.15	0.02
Industrial partners	–0.05	0.22	*0.82*	0.02	0.07
Government agencies	0.25	*0.67*	0.31	–0.12	0.23
Colleges	–0.05	*0.71*	0.11	0.42	0.01
Universities	–0.14	*0.80*	0.29	–0.02	–0.15
R&D group	0.11	0.11	–0.04	–0.20	*0.79*
Marketing group	*0.83*	–0.16	–0.07	0.02	0.12
Production group	*0.74*	0.35	–0.01	0.18	0.11
Finance group	*0.52*	0.36	–0.21	0.06	0.33
Cumulative percentage of explained variance	25.09%	40.49%	50.9%	60.1%	68.9%

* K.M.O. = 0.69 (Sampling adequacy test).

4.3. *R&D-related efforts as determinants of export activities: discriminating between non-exporters and exporters and between North American and global exporters*

Table III summarizes the results of the two stepwise discriminant analyses where the independent variables (size and industrial sector which act as control variables, R&D efforts,[8] level of knowledge intensity,[9] the six dimensions of R&D strategies and the eight factors representing the different types of R&D collaborations and sources of R&D information) were entered. Table III highlights only the variables which show significant discriminating power.[10] The first analysis presents the most discriminating variables between non-exporters and active exporters while the second analysis displays the most significant predictors between the two groups of exporters labeled North American and global exporters respectively.

The first discriminant function which is highly significant (p = 0.0000) allows us to correctly classify 81.25% of the non-exporters and 91.76% of the active exporters, with an overall classification rate of 90.10%. Larger size, followed by a stronger focus of R&D efforts on fundamental research[11] and improvement of existing products as well as a closer collaboration with competitors, best distinguish the exporters from the non-exporters. A more technically oriented workforce also significantly discriminates the exporters from the non-exporters.

Do exporters differ based on the destination of their exports? Five key discriminating characteristics appear to distinguish between North American exporters and global exporters (Table III, left column): first, global exporters invest proportionately less in R&D but these investments are more directed towards new product development and applied research; second, they collaborate more closely with public agencies; third, their workforce is more technically oriented. Surprisingly, size is not a discriminating variable between these two groups of exporters. The discriminating function based on these five characteristics is again highly significant (p = 0.0000) and classifies the North American exporters better than the global exporters (75.00% vs. 72.97%). The overall classification rate is 74.12%.

The industrial sector (four-digit SIC codes) as well as some R&D-related capabilities such as improvement of existing scientific/technological assets, collaborative R&D with customers/subcontractors and all sources of information for the development of new products are not displayed in Table III as they fail to be significant predictors in either of the two discriminant functions.

No discriminating differences are found between firms operating only on extraprovincial markets and firms exporting to U.S. markets. The

TABLE III
Discriminant analyses between different groups of specialized suppliers based on their level of export performance

	Non-exporters vs. active exporters (n_1 = 16 and n_2 = 85 respectively) Standardized discriminant coefficients	North American exporters vs. global exporters (n_1 = 37 and n_2 = 48 respectively) Standardized discriminant coefficients
Independent variables:		
Size	0.652****	–
R&D intensity	–	–0.368**
Technocratization	0.238***	0.415***
R&D strategies:		
fundamental research	0.439***	–
applied research	–	0.464*
new product development	–	0.714****
improvement of existing products	0.491****	–
Collaborative R&D with:		
public agencies	–	0.452***
competitors	0.495****	–
Level of significance of the discriminant function	0.0000	0.0000
Classification results:		
Total of cases correctly classified	90.10%	76.27%
Cases correctly classified in group 1	81.25%	81.50%
Cases correctly classified in group 2	91.76%	71.90%
Proportional chance criterion	71.68%	50.84%

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; ****$p < 0.0000$.

discriminant function between these last two groups of exporters is not significant ($p = 0.3729$). The presence of provincially imposed barriers to trade inside Canada may only play a small role in explaining the lack of significant differences between U.S. exporters and exporters to other Canadian provinces as these barriers have rather negligible effects. The geographical proximity of markets and the historic flow of goods along a south-north/north-south axis may contribute much more to explaining this phenomenon.[12]

Although there is considerable discriminating power among the variables retained in each of the two discriminant functions, the classification results presented in Table III should be interpreted taking into account the following observation. The rather high classification rate of the first discriminant function is actually misleading as it is partially due to the sample sizes of the two groups of firms (non-exporters vs. exporters): the overall classification rate (90.10%) slightly exceeds the proportional chance criterion[13] by the required 25% (89.60% or 71.68% × 125%) as suggested by Hair et al. (1992, p. 104) and the classification accuracy is therefore not the result of mere chance. The predictive validity of the second discriminant analysis is in fact much higher, as the obtained classification rate of 74.12% exceeds the requisite accuracy of 63.55% (125% × 50.84%) by more than 10 percentage points.

4.4. *R&D and R&D-related efforts as determinants of export intensity on North American and global markets*

The main objective of the TOBIT regression analyses displayed in Table IV is to determine the relative contribution of R&D and R&D-related efforts to export intensity. The percentages of sales realized on North American and global markets are therefore the dependent variables (first and second regressions respectively) and the independent variables are the same 13 variables mentioned previously. TOBIT regression analyses are chosen over the more common least squares because each of the two dependent variables has a left-

TABLE IV
TOBIT results: determinants of export intensity on North American markets and on global markets (n = 101)

	Export intensity on			
	North American markets		Global markets	
Independent variables	Coefficient[a]	Level of significance	Coefficient[a]	Level of significance
• *Size*	6.03 (2.802)	***	1.49 (0.720)	
• *R&D intensity*	–0.36 (–0.753)		–0.19 (–0.338)	
• *Technological knowledge intensity*	1.08 (1.723)	*	1.45 (2.786)	***
• *R&D strategy directed towards:*				
Basic research	8.96 (3.372)	****	0.33 (0.106)	
Applied research	1.27 (0.781)		4.64 (2.877)	***
Product development	1.11 (0.365)		7.57 (3.407)	****
Process improvement	1.55 (0.692)		2.20 (0.805)	
Improvement of existing products	3.87 (1.846)	*	4.21 (2.030)	**
Improvement of existing scientific/ technological assets	2.72 (1.751)	*	1.60 (0.676)	
• *Collaborative R&D with:*				
Public agencies	4.53 (0.919)		7.48 (2.830)	***
Customers/subcontractors	–0.50 (–0.140)		–5.69 (–1.904)	*
Competitors	2.05 (0.543)		7.89 (2.776)	***
• *Sources of information:*				
Internal sources/customers	5.20 (1.815)	*	0.82 (0.174)	
Public agencies	4.97 (1.049)		3.89 (2.808)	***
Private sector	–5.54 (–1.077)		–0.62 (–0.123)	
Competitors/trade shows	4.09 (1.236)		0.66 (0.146)	
Internal R&D	0.85 (1.062)		7.40 (2.765)	***
Pseudo R^2	37.84%		49.07%	

[a] β and β/sβ in parentheses.
* $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$; **** $p < 0.001$.

censored distribution (with either zero or a positive value).

For the two TOBIT models presented in Table IV, the pseudo R^2 (Maddala, 1983) are respectively 37.84% and 49.07%, which can both be considered as a good fit.[14] These rather strong R^2 are largely the result of several specific R&D-related capabilities which are significantly linked to export intensity on either American or global markets. This supports the proposition that R&D investments are not enough to compete on export markets without some complementary R&D-related capabilities. Further support for this proposition is also found by the non-significant and negative coefficient for R&D intensity although this should be interpreted taking into account the context of this research. Firms in this study already carry out a significant amount of R&D and the results may only point to the fact that, beyond a certain point, higher R&D investments are not associated with export performance.

Turning to specific determinants of export intensity on North American markets (first TOBIT model in Table IV), technological knowledge intensity, R&D strategies directed towards basic research (by far the strongest determinant) as well as towards the improvement of existing products and existing scientific/technological assets, and privileged sources of information from internal groups and customers are all related positively and significantly to export performance. By contrast, determinants of export intensity on global markets (second TOBIT model in Table IV) are different: first, R&D strategies directed not towards basic research but rather towards product development (now the strongest determinant), applied research

and improvement of existing products are associated with export performance. Second, technological intensity plays a stronger role. Third, different forms of collaborative R&D mainly with competitors, public agencies and, to a lesser extent, with customers are important determinants, which is not the case in the first model. And finally, sources of information from the R&D group within the firm and from public agencies are definitely more related to export intensity on global markets.

Based on the above results, specialized suppliers which are able to go beyond current and existing activities (and the preservation of these activities) and which are continuously exploring new product opportunities through increased collaborative R&D and stronger links with potential sources of information on new technological developments are also more present on global markets. The general picture which appears to emerge from these results is that an increased presence on global markets requires more proactive, aggressive, and externally oriented R&D-related capabilities. This seems to be in sharp opposition to the greater reliance on existing products and scientific and technological assets, coupled with the internally oriented R&D activities and the long-term view implied by the emphasis on basic research, associated with export intensity on North American markets.

As we enter industrial sectors as dummy variables in the two TOBIT models, we fail to find any support for a sectorial effect on the specialized suppliers' export intensity: there is no increase in the pseudo R^2, the different modalities of the control variable are not related to export intensity and the coefficients for the R&D-related capabilities do not change in either magnitude, direction or corresponding significance levels. This is revealing and provides additional support for the previous findings of the two discriminant analyses since they apply irrespective of the sector of activity of firms belonging to the same technological trajectory.

What is gained from the analyses presented in Table IV compared to those displayed in Table III is two fold: first, a more accurate assessment of the predictive validity of a specific set of determinants with respect to the degree of internationalization (rather than simple presence on export markets) and second, the observation that a wider array of R&D-related capabilities is related to more intense export activities on global markets.

5. Conclusion

The results presented here rest on the empirical evidence gathered from a group of privately held small specialized suppliers which carry out formal R&D activities. These firms, by their very nature, allow for a more comprehensive investigation of the complex links between R&D-related capabilities and export performance. This investigation reveals some interesting results.

First, while size acts as an important control variable, sectorial influences within our particular technological trajectory do not account for significant differences. In fact, size, which can be considered as a proxy for the availability of financial and non-financial resources, seems to be a stumbling block for the penetration of proximate export markets but has no effect on a firm's export generating capacity on global markets. Since almost all specialized suppliers actively involved on global markets are also operating on proximate export markets, the main difficulty may very well reside in the mobilization of resources necessary to undertake the first steps towards the internationalization process (i.e. the penetration of proximate export markets). This difficulty becomes a less important obstacle for the next steps of the internationalization process when these firms start to export on global markets.

Second, R&D is certainly firm-specific not only in terms of the level of investment but also in terms of the type, nature, and direction of the efforts devoted to R&D-related activities. This proposition is more evident in the case of privately held small firms since each firm is free to decide on the extent of such efforts. These decisions, usually made by the CEO and a few key managers, result in distinct R&D-related capabilities. There is a clear indication that some R&D-related capabilities are definitely linked to different dimensions of export performance. In particular, export intensity on global markets is strongly related to a broad and diversified base of R&D-related capabilities: a workforce with strong technological and scientific knowledge, an R&D-strategy aimed at launching new products, an

emphasis on collaborative R&D and an intense use of external sources of information. Operating on global markets therefore requires significant efforts from specialized suppliers which constitutes a departure from the usual practices found in the small firms. The distinctive capabilities of the global exporters to reach out for external information and to collaborate to a significant extent not only with public agencies, customers and subcontractors but also with competitors are particularly at odds with the individualistic practices found in the more traditional small firms.

Third, no evidence is found with respect to the contribution of the level of R&D investments to the export dynamism of our firms on either North American or global markets. The specific context of this empirical investigation may largely explain this finding. As specialized suppliers actively engaged in formal R&D activities, these firms are already convinced of the rich potential investments in this area. However, R&D investments may be necessary but not sufficient; beyond a certain point, it is impossible to stay at the leading edge of progress and knowledge without also engaging in the creation of complementary distinctive R&D-related capabilities.

The implications of the empirical evidence presented here are far-reaching. From a theoretical perspective, R&D spending is an essential indicator of technological innovation. Yet, it has been shown that R&D-related capabilities are also important explanatory factors which will need to be taken into account in subsequent studies. Similarly, export performance is multifaceted and it has been shown that specific target export markets require a unique range of R&D-related capabilities. Hence, the final destination of exports modifies the set of determinants of export performance. As a result, when measuring the export performance of firms, it becomes crucial not only to consider the traditional measure of volume of sales but also and simultaneously the final destination of those sales.

Implications for public policy can also be drawn. The implicit assumption that more R&D is better can be challenged. Numerous countries have adopted R&D tax incentives but the relative impact of these incentives, although positive, remains elusive and in fact has caused a great deal of controversy. The results presented here suggest that the effectiveness of government programs to promote technological innovation in small firms could be improved by focusing as well on R&D-related capabilities, especially by encouraging networking and collaborative R&D and establishing easily accessible sources of technological information. Better understanding of the relationship between R&D-related capabilities and export performance at the firm level may further contribute to the design of more appropriate programs. Small exporters already account for a significant share of exports and, in the case of Canada and the United States, constitute the "fastest growing group of exporters" (Industry Canada, 1995; Axinn et al., 1994, p. 49). Mobilizing small firms' export potential as a mean of improving the national trade balance may deserve increased attention from researchers and public policy makers.

Notes

[1] This is also referred to as "technocratization".

[2] Collaborative R&D refers here to formal cooperative agreements. Special provisions such as the R&D tax incentives existing in the province of Quebec promote such agreements with universities and the public-parapublic sector.

[3] The thirteen distinct sources of information are: trade shows, suppliers, customers, competitors, consultants, industrial partners, government agencies, colleges, universities, R&D group, marketing group, production group, finance group.

[4] The response rate of 34.8% is the ratio of 236 over 687 firms rather than 692. In the case of 14 of the targeted firms, the address had changed or the firm had ceased its activities.

[5] Including the first two authors of this article as well as Marie Lavoie, visiting professor at the École Polytechnique, and Carl St-Pierre, research professional.

[6] The internationalization process as initially proposed by Cavusgil (1980) is a five-stage model (domestic marketing, pre-export stage, experimental involvement, active involvement, committed involvement).

[7] The factorial analysis performed on the six dimensions of R&D strategy is not presented here since these dimensions are based on distinct and opposite theoretical concepts which are clearly illustrated in the literature (i.e. basic vs. applied research, process vs. product). The empirical evidence confirms that these dimensions cannot be combined meaningfully: the factorial solution is weak (K.M.O. < 0.50). This is not surprising since the correlation matrix among the six dimensions of R&D strategy shows non-significant correlation coefficients.

[8] The four measures of R&D efforts are obviously highly correlated. In order to avoid problems of multicollinearity, each of these four measures was entered alternately in each

discriminant analysis to assess its discriminating power. The ratio of R&D investments over annual sales proved to be the most discriminating.

[9] The two measures of technological knowledge are also highly correlated. The ratio of employees with a technical/scientific background over the total number of employees turned out to be the most discriminating variable and is therefore retained here.

[10] The selection of the best predictors is similar to the stepwise multiple regression analysis and is based on the *F*-values. The single best discriminating variable is simply the one with the largest computed *F*-value whereas the next best predictors are chosen based on the *F*-values conditioned by the combined presence of the variables already selected.

[11] The emphasis on fundamental research is generally rather low as the vast majority of R&D investments are directed towards product development. However, the exporters place more efforts on fundamental research than non-exporters.

[12] The largest shares of all exports by Quebec SMEs are 22.5% for Ontario and 11.6% for the U.S.A. whereas the Atlantic provinces and the Western provinces/Northern territories represent only 3.9% and 7.2% respectively.

[13] Proportional chance criterion = $p^2 + (1 - p)^2$ where p = proportion of firms in group 1 and $1 - p$ = proportion of firms in group 2. The more disproportionate the groups are, the larger this criterion is.

[14] Several pseudo R^2 measures exist. A detailed discussion on these measures is offered in Maddala (1983, pp. 38–41).

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