The Influence Prism in SMEs: The Power of CEOs' Perceptions on Technology Policy and Its Organizational Impacts

Louis A. Lefebvre • Robert Mason • Élisabeth Lefebvre
Department of Industrial Engineering, École Polytechnique, Montreal, Quebec, Canada H3T 1J7
Weatherhead School of Management, Case Western Reserve University, Cleveland, Ohio, 44106
Department of Industrial Engineering, École Polytechnique, Montreal, Quebec, Canada H3T 1J7

The research proposes a model, which relates the following variables: (a) the CEO's perceptions of the environment, (b) the strategic business orientation, scanning, and structural characteristics, (c) technology policy, (d) realized innovative efforts of the firm, and (e) measures of firm performance. The empirical data from small manufacturing enterprises (SMEs) that share a common economic and industrial environment show that CEOs' perceptions of external environment—and not objective measures—are key significant issues with respect to technology policy formulation and enactment in SMEs and its subsequent organizational impacts. In particular, perceived environmental hostility and dynamism are shown to have specific and differing moderating roles on the form and strength of the relationships between technology policy and its determinants and between technology policy and realized innovative efforts. Furthermore, a more aggressive technology policy leads to greater realized innovative efforts, which in turn are positively related to export performance and, to a lesser extent, to financial performance.
(*Strategic Management of Technology; Small Firms; Strategy Enactment; Perceptions of the External Environment*)

1. Introduction

Technology is considered to be one of the most powerful factors shaping the rules of competition. As a result, the strategic management of technology is a crucial concern for an increasing number of firms and also generates considerable academic interest (NRC 1991). This paper investigates one central theme in the area of strategic management of technology, focusing on the determinants and outcomes of technology policy at the firm level. More specifically, the study presented here is conducted in the context of small manufacturing enterprises (SMEs), where the CEO is known to play a crucial role (Harrison 1992). This paper makes a substantial contribution to understanding technology and strategy in SMEs because heretofore little empirical evidence has been available on the formulation or effects of technology policy in small firms (Zahra and Covin 1993).

The study also builds extensively on previous work realized in contingency theory where environmental characteristics are known to be important moderating variables (Prescott 1986). However, it departs from past research by simultaneously pursuing two objectives:

(i) to analyze the specific moderating role of environmental variables not on the classical link between strategy and performance (S → P) but rather on the relationships defined in the sequence S&D → TP → RIE → P (i.e., strategy and other determinants of technology policy, technology policy itself, actions in the form of realized innovative efforts, and performance);

0025-1909/97/4306/0856$05.00

(ii) to investigate whether perceived (not factual) characteristics of the external environment moderate the form and the strength of specified relationships.

The intent of this article is to demonstrate the power of the CEO's perceptions of the firm's environment in moulding an SME's technological policy and to present evidence of its related specific moderating effects. A CEO's personal view of the world acts as a prism through which data from the environment passes and is differentially weighted to form patterns that make sense to the CEO. In other words, different CEOs interpret the same external environment differently, and these different interpretations lead to the formulation and enactment of distinctive technology policies and to different innovative actions. These differences affect ultimately organizational performance.

The paper is organized as follows. The next section gives a summary of the foundations for the research, presents the proposed model and variables as well as the specific hypotheses to be tested. Section 3 of the paper describes the data collection procedures and research variables. Section 4 presents the results of the analyses and discusses the degree to which they support the model and the hypotheses. Section 5 identifies the study's strengths and limitations and presents a summary of the results.

2. Research Framework

Trying to establish a direct relationship between overall strategic behavior and firm performance may bypass some important intermediate stages a firm engages in in its pursuit of performance. In a hierarchical perspective, strategy has traditionally been categorized at three levels—corporate, business, and functional (Grant and King 1982). In small independent firms, corporate and business unit levels are indissociable and merge into a single dimension, which leaves us with two levels, namely overall firm strategy and functional strategies, the latter being derived from the former (Hofer and Schendel 1978). In this particular case, because the focus is on the strategic management of technology, rather than concentrating on the numerous functional strategies, we decided to investigate the firm's technology policy. Technology policy is strongly connected to the overall firm strategy (Maidique and Patch 1988), and is, by definition, cross-functional because it encompasses products, processes, and support technologies (Adler 1989). The enactment of technology policy is observed through specific realized innovative efforts in the form of R&D investments, adoption of computer-based administrative or production applications and technological monitoring, all of which are aimed at improving the firm's products or processes. In turn, these efforts contribute to the organization's performance.

It is therefore proposed to investigate here the sequence (S & D → TP → RIE → P) shown on the right side of Figure 1, which also includes other known determinants of technology policy. These relationships and the corresponding hypotheses identified next to the vertical arrows are clarified and supported in §§2.1, 2.2, and 2.3.

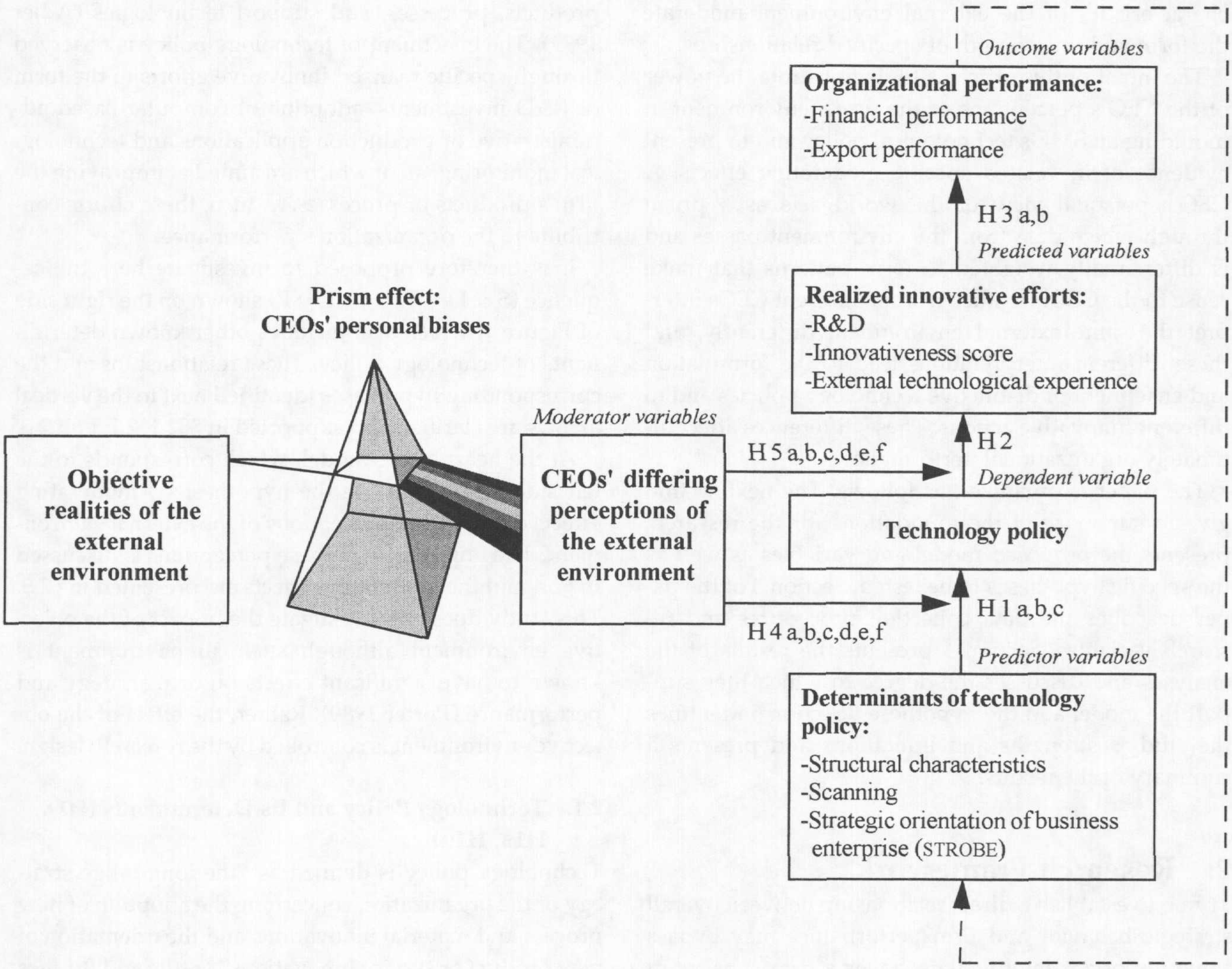
At the heart of the model, which corresponds to the left side of Figure 1, lie the hypothesized moderating effects of the CEOs' perceptions of the external environment. The importance of these perceptions is discussed in §2.4 and the moderating effects are presented in §2.5. This study does not investigate the impact of the objective environment although such an environment is known to have significant effects on firm strategy and performance (Porter 1980). Rather, the effect of the objective environment is controlled by the research design.

2.1. Technology Policy and Its Determinants (H1A, H1B, H1C)

Technology policy is defined as "the long-range strategy of the organization concerning the adoption of new process and material innovations and the orientation of new product or service innovations" (Ettlie and Bridges 1987: 118). Technology policy thus refers to the degree to which a firm aggressively pursues technological changes in terms of process innovation (i.e., up-to-date production technologies and equipment), product innovation, technological forecasting activities, and recruitment of qualified human resources. Administrative innovations are not included, yet it is becoming increasingly apparent that these forms of innovation are intricately intertwined with the new process innovations, that is, computer-based administrative or production applications.

As shown in Figure 1, the determinants of technology policy that act as predictor variables comprise the structural characteristics of the firm, scanning, and strategic

Figure 1 **Research Framework**



orientation (STROBE). Each of these factors is discussed briefly in the following paragraphs.

Structural Characteristics. The actual organizational structure provides the appropriate context for strategic choices (Burgelman 1986) and for an aggressive technology policy (Ettlie and Bridges 1987), although structure can also be viewed as the result of strategic choices (Chandler 1962). In particular, a concentration of technical and scientific knowledge, also termed technocratization, has been shown to be a crucial determinant of innovativeness (Collins et al. 1988) and a significant predictor of organizational technology policy (Ettlie and Bridges 1987). On the other hand, a greater degree of centralization and formalization appears to hamper innovativeness (Cohn and Turyn 1984).

Scanning. Strategic awareness of the competitive actions undertaken by direct competitors and of prevailing market conditions appears to be a crucial organizational function that promotes within the firm activities aimed at defining clients' opinions, conducting market studies, following competitors' strategies, and predicting sales behavior and customer needs. The systematic use of scanning mechanisms directed at the identification of opportunities and threats from competitors or from emergent technologies is crucial (Weiss and Birnbaum 1989) and should be viewed as a powerful determinant of technology policy. Furthermore, Hambrick (1981) has indicated that scanning is an important source of influence over the strategic decision-making process.

Strategic Orientation of Business Enterprise (STROBE). Strategic orientation of the business enterprise or STROBE (Venkatraman 1989) reflects the actual strategies pursued by a firm with respect to its competitors and involves a host of organizational activities, whether they be product-related, price-related, process-related, or financially related. The STROBE measure characterizes a firm along six dimensions that correspond to traditional strategic orientations: aggressiveness, analysis, defensiveness, futurity, proactiveness, and riskiness. The *aggressiveness* dimension reflects a firm's market share seeking behavior, and *analysis* captures the presence of formal planning and evaluation activities with respect to strategic alternatives. *Defensiveness* relates to the emphasis a firm places on performance monitoring and enhancement of core manufacturing competencies. The *futurity* dimension denotes the presence of a long-term view, supported by ongoing evaluation of significant trends, and of activities such as R&D, that are designed to provide longer-term benefits for the firm. *Proactiveness* emphasizes an opportunity seeking behavior, "first-to-market" innovativeness, and strategic acquisitions that support the preceding elements. Finally, the *riskiness* dimension relates to risk management in terms of resource allocation decisions, operations, and choice of projects.

Given that policy can be defined as "the operationalized substance of strategy" (Adler 1989: 54), specific corporate strategic orientations (Venkatraman 1989) can determine a firm's technology policy. In this respect, higher values along the STROBE dimensions should promote an aggressive technology policy because clear and strong strategy statements should also translate into a strong technology policy. In fact, the need for a closer link between strategy and technology has been suggested by a number of authors (Zahra et al. 1994) and explored empirically in manufacturing firms (Zahra and Covin 1993) and within the specific context of SMEs (Lefebvre et al. 1992).

This discussion of the determinants of technology policy leads to the following hypotheses:

H1A. *Technocratization is positively related to the degree of aggressiveness of technology policy in SMEs whereas centralization and formalization are negatively related to it.*

H1B. *The systematic use of scanning mechanisms is positively related to the degree of aggressiveness of technology policy in SMEs.*

H1C. *All dimensions of STROBE (aggressiveness, analysis, defensiveness, futurity, proactiveness, riskiness) are positively related to the degree of aggressiveness of technology policy in SMEs.*

2.2. Technology Policy and Realized Innovative Efforts (H2)

Realized innovative efforts (or predicted variables) in SMEs are usually of three types. The first is associated with traditional R&D investments mainly aimed at improving or modifying existing products, and, more rarely, developing new ones. The second concentrates on improving existing practices through the adoption of computer-based information and manufacturing technologies (Lefebvre and Lefebvre 1993). Finally, the third represents the extent of external technological experience and know-how with respect to new technological developments, the commercial availability of new technologies and the comparative advantages that may be derived from the new technologies (Weiss and Birnbaum 1989).

An aggressive technology policy should promote organizational innovativeness and success (Maidique and Patch 1978). Empirical evidence provided by Ettlie and Bridges (1982) suggests that firms that have an aggressive and forward-looking technology policy are also more likely to innovate.

Thus:

H2. *A more aggressive technology policy leads to greater realized innovative efforts in SMEs.*

2.3. Realized Innovative Efforts and Organizational Performance (H3A, H3B)

We have seen that a firm's realized innovative efforts are the result of an aggressive technology policy, which is itself determined by several predictors. Obviously, this line of inquiry is of interest if we can ultimately show that realized innovative efforts can enhance a firm's performance.

All three types of innovative efforts should contribute to a firm's performance. R&D activities have been associated with different types of firm performance such as profitability (Morbey and Reithner 1990), productivity growth (Chakrabarti 1990), sales growth, and success on worldwide markets (Franko 1989). However, the link between R&D investment and subsequent performance at the firm level is not always clearly established due in part to the lag effect reported by Brockoff (1986). As for computer-based process innovations, there is general agreement that the adoption of new technologies does improve a firm's competitiveness and is associated with competitive advantages derived from higher-quality products, lower production costs, or increased diversity. Ultimately, this could translate into improved firm performance. Finally, the level of external technological experience is of the utmost importance (Lefebvre et al. 1991) and gives firms a leading edge in terms of new market opportunities and new manufacturing or administrative processes. Again, this should have a positive impact on firm performance.

For SMEs, two types of performance are of critical importance. The first is financial performance, given the lack of financial resources in these firms and the second is export performance. With the opening up of new markets, SMEs are subjected to increased competition from new rivals and therefore must themselves broaden their reach by developing new markets (Baldwin et al. 1994). Thus:

H3A. *Realized innovative efforts are positively associated with financial performance in SMEs.*

H3B. *Realized innovative efforts are positively associated with export performance in SMEs.*

2.4. The Crucial Importance of CEOs' Perceptions of the External Environment

The following argument is both central and fundamental to our research framework: the strategic management of technology is subject to CEOs' perceptions of the external environment, which reflect more or less imperfectly the objective realities of that environment. This is illustrated by the prism effect created by CEOs' personal biases, which translates into differing perceptions of a common external environment. Furthermore, these perceptions have a moderating effect on the relationships between determinants of technology policy and technology policy itself and between technology policy and realized innovative efforts.

This argument rests on three key, and complementary, premises.

FIRST PREMISE. *The external environment is of crucial importance to strategy in general and to the strategic management of technology in particular.*

Firms operate in turbulent environments that can radically alter the bases of competition. Consequently, firms need to make strategic choices that are adapted to their external environments (Harrison 1992). In fact, an impressive tradition of research literature in organizational theory and strategy has recognized the key role of environmental scanning in the strategy making process (Bourgeois 1980, Hambrick 1981). This is also in line with the growing body of literature suggesting that organizations should become what Quinn (1992) has called "intelligent enterprises." In particular, in an open systems perspective, firms are continuously required to adapt to rapid market and technological changes. Accordingly, the understanding a firm develops of its external environment is the starting point for "the determination of a suitable strategy" (Andrews 1971: 59) and of "the process of competition" (Pettigrew and Whipp 1991: 105) and is indeed "a prerequisite for any strategy" (Adler 1989: 31).

Because increasingly technology is considered "the engine that drives competition" (Galbraith and Lawler 1993: 6), strategic management of technology also requires in-depth knowledge and continuous monitoring of changes in the environment.

SECOND PREMISE. *Strategic coalignment or fit with the external environment is essential.*

A wide range of organizational studies have placed considerable emphasis on contingency theories. In such theories, the notion of "fit," also referred to as "coalignment" or "match," is an important concept, although it raises both conceptual and methodological difficulties (Venkatraman 1989). In the literature on strategy, the required coalignment between strategy and its context has traditionally received a vast amount of attention from researchers (Lawrence and Lorsch 1967, Bourgeois 1980, Ginsberg and Venkatraman 1985). The appropriate match between organizational strategies and the external environment ("external fit") has been shown to have a positive impact on performance (Venkatraman and Prescott 1990, Prescott 1986). "Internal fit" can be viewed, for example, in terms of coalignment between strategy and organizational structure leading to increased performance (Chandler 1962), or in terms of coalignment between technology and structure that also leads to greater performance (Hoffman et al. 1992). Achieving both external and internal fit may prove extremely difficult. Miller concludes that firms generally achieve either one or the other, although exceptionally they may attain both, since "internal and external fit are not always incompatible" (Miller 1992: 159).

This study focuses on the issue of external fit, because a concern with SMEs' technology policy and competitiveness presupposes a concern with the overall competitive dynamics of the industrial sector within which SMEs operate. Moreover, because of the inherent characteristics of SMEs (e.g., their organic nature and the limited number of strategic decision-makers), we might presume that such firms would find internal fit easier to achieve than external fit.

THIRD PREMISE. *CEOs' diverging perceptions of the environment override factual characteristics of the environment.*

As Bourgeois (1980: 34) pointed out, there is an explicit distinction between characteristics of the environment and the perception of that environment by human agents. This study adopts the process view, whereby a decision-maker's perceptions of the environment prevail over the objective measurements (Jauch and Kraft 1986). This view has been supported by various authors who have argued quite strongly that managers' perceptions of the environment are more critical to organizational strategy than objective or archival measures of the environment (Hambrick and Snow 1977). In fact, firms react to the environment their top management perceives and "the same ⟨⟨objective⟩⟩ environment may appear differently to different organizations" (Snow 1976: 249). From an empirical standpoint, Boyd et al. (1993) reported large differences in munificence and dynamism scores obtained by firms operating in the semiconductor industry. This preliminary evidence prompted them to hypothesize that managerial perceptions of the environment are indeed significantly different across firms within a single industry.

One of the strong arguments in favor of differing perceptions between CEOs sharing the same external environment comes from the social constructionist perspective (Gergen 1985), which claims that environmental pressures are socially determined (Mason 1991). In Weick's (1979) interpretation of the process of sense-making by an organization, action, knowledge, cognition, and communication are inseparable and thus CEOs' perceptions are largely determined by their respective cognitive maps. Furthermore, every top manager is subject to his or her own bounded rationality (Simon 1957), which, as a consequence, limits the scope and focus of observation, in particular with respect to the external environment. This is also referred to as segmentalism (Kanter 1983).

Sources of variations between objective and perceptual characteristics of the external environment found also some compelling explanations in the notion of "mediating filter"[1] introduced by Downey and Slocum (1975) who focussed on cognitive factors at the individual level. In a thorough literature review, Boyd et al. (1993) suggested that individual perceptions of the environment are influenced not only by individual factors (mainly cognitive factors such as ambiguity tolerance and cognitive complexity as well as one's choice of communication media) but also by workgroup, organizational, and strategic factors.

The above literature demonstrates the importance of perceptions of the external environment and provides explanation for individual perceptual differences. Our objective will be to analyse the effects of these perceptual differences.

2.5. The Moderating Role of Perceived Characteristics of the External Environment (H4A, H4B, H4C, H4D, H4E, H4F, H5A, H5B, H5C, H5D, H5E, H5F)

Environmental perceptions reflect two dimensions previously identified by Miller (1987) and more recently by

[1] Figure 1 retains the notion of prism rather than the notion of filter. A filter implies that some elements of the external environment are captured by CEOs whereas a prism better illustrates the array of CEOs' diverging perceptions.

Gupta and Chin (1993): hostility and dynamism. Environmental hostility captures the perceived threats to the very survival of the firm, namely increasingly harsh competition on product prices, depleting markets, scarcity of qualified and specialized labor, difficulty of access to raw materials, components or parts from suppliers, and government intervention. Obviously, these threats exist for all manufacturing firms but they may be more acute for SMEs, which do not have the financial leverage of larger firms. Hence, perceived hostility is considered as a key characteristic of the external environment in an SME context. Equally important, environmental dynamism, also referred to as uncertainty (Khandwalla 1977), reflects the perceived degree of unpredictability and rate of change of the external environment.

According to Venkatraman (1989), fit may be defined as moderation, when the relationship between a predictor variable and a dependent variable is "contingent" upon a third variable called a moderator. The form and the strength of the moderation are, however, "separate and separable" issues (Arnold 1982) that require distinct conceptual arguments and statistical analyses. If the dependent variable is jointly determined by the predictor and the moderator, the moderator is said to influence the form of the relationship. If the degree of the relationship between the predictor and the dependent variable varies with different levels of the moderator, then the moderator is said to influence the strength of the relationship. This distinct role of moderators is critical in a contingency perspective and has been recognized by several researchers. For example, Prescott (1986) has shown that factual characteristics of the environment, namely market structures, moderate the strength but not the form of the relationship between strategy and performance.

As previously discussed, CEOs' perceptions are decisive and, in spite of their inherent inaccuracies, it is hypothesized here that these perceptions largely influence the form and strength of the relationship between the determinants of technology policy and technology policy itself (H4A, H4B, H4C, H4D, H4E, H4F) and between technology policy and realized innovative efforts (H5A, H5B, H5C, H5D, H5E, H5F).

The Moderating Role of Environmental Perceptions on the Form and Strength of the Relationship between Technology Policy and Its Determinants. In order to deal with the complex issues created by uncertain or dynamic environments, it has been shown that firms tend to decentralize decision-making, to rely to a greater extent on specialists such as engineers, scientists and technicians (Miller 1991), to implement in the case of small firms more formal organizational procedures (Miller 1992) and to intensify scanning activities (Hambrick 1983). Furthermore, uncertain environments require specific attributes (or dimensions) of business strategies such as more proactive and comprehensive strategies (Khandwalla 1977) or strategies that integrate a higher acceptance of risk (Paine and Anderson 1977). Specific generic strategies (Porter 1980) also yield better results depending on the characteristics of the environment: for example, strategies of differentiation (including more aggressive marketing differentiation) are positively related to uncertain environments whereas, in contrast, strategies of cost leadership are more suitable in stable and predictable environments (Miller 1988).

If dynamic environments tend to be sources of opportunities for small firms, especially those driven by entrepreneurial and venturesome CEOs (Miller and Friesen 1982), hostile environments, also known as "risky, stressful, and dominating" environments (Khandwalla 1977: 335), constitute serious threats to the survival of these firms. In the context of SMEs, hostility generally represents a more fearsome characteristic of the environment, and it is expected that CEOs would react more drastically to hostility than to dynamism. Following this line of reasoning, hostility should play a more important moderating role than dynamism. Furthermore, hostility might even change the direction of the relationships of some determinants of technology policy. For example, in hostile environments, CEOs may well choose less-risky strategies. Although CEOs of small firms, and more particularly entrepreneurs, are usually viewed as risk takers, constantly on the look out for new opportunities, in reality they expend a great deal of their efforts on reducing risk. It is therefore assumed that, in a more hostile environment they choose to protect their firms' long-term survival and to act prudently with respect to technology policy.

Accordingly, the relationship of any given determinant and technology policy may vary across different subenvironments and environmental perceptions would then be said to have an effect on the *strength* of the relationship between the determinants of technology policy and technology policy itself. Yet the joint influence of technology policy determinants and environmental perceptions should provide some explanatory power with respect to technology policy, in which case environmental perceptions would affect the *form* of the relationship between the determinants and technology policy. Finally, the set of determinants of technology policy would display a stronger predictive validity in more hostile and more dynamic environments.

The following hypotheses will therefore be tested:

H4A. *Perceived hostility moderates the form of the relationship between technology policy and its determinants.*

H4B. *Perceived dynamism moderates the form of the relationship between technology policy and its determinants.*

H4C. *The predictive validity of the set of determinants of technology policy varies with the level of perceived hostility.*

H4D. *The predictive validity of the set of determinants of technology policy varies with the level of perceived dynamism.*

H4E. *Perceived hostility moderates the strength of the relationship between technology policy and its determinants.*

H4F. *Perceived dynamism moderates the strength of the relationship between technology policy and its determinants.*

The Moderating Role of the Perceived Environment on the Form and Strength of the Relationship between Technology Policy and Realized Innovative Efforts. All three types of realized innovative efforts require substantial financial and nonfinancial investments, which may be delayed or accelerated depending on CEOs' perceptions of the external environment. In more dynamic and hostile environments, strategies of innovation seem more appropriate (Hambrick 1983, Miller 1988) and realized innovative efforts should, as a consequence, be greater, thus suggesting that the strength of the relationship between technology policy and innovative efforts is greater in these subenvironments.

This general proposition has, however, been challenged. Miller and Friesen (1982) found a positive correlation with environmental characteristics (in particular, dynamism and hostility) for both entrepreneurial and conservative firms, whereas Khan and Manopichetwattana (1989) observe a negative relationship between product innovation and environmental hostility. Both these results suggest an important conflicting role for hostility with respect to product innovation. It is argued here that, in highly hostile environments, small firms may have a tendency to take more precautions, to limit any high-risk investments with long payoff periods, such as engaging in R&D activities, and to avoid less hasty commitment of resources (Bourgeois 1985). This leads us to hypothesize that the predictive validity of technology policy would be higher with respect to all three types of innovative efforts in highly dynamic environments, but is expected to be lower especially with respect to R&D investments in highly hostile environments.

The combination of both favourable environmental conditions and a clear and strong technology policy would lead to greater innovative efforts. However, perceived environmental hostility, even with the presence of a very aggressive technology policy, would tend to divert resources away from the longer term and the more uncertain innovative efforts. This does not imply that innovation is an inappropriate answer to environmental hostility as empirical evidence shows that hostility and innovation are positively related in the case of successful firms (Hall 1980), and also in the case of small high-performing firms (Covin and Slevin 1989). Rather, it suggests that the emphasis placed on the three types of innovative efforts is different depending on CEOs' perceptions of hostility. R&D investments in small firms entail a fairly high level of uncertainty with respect to their potential return especially in highly hostile environments. The same argument prevails when computer-based applications are considered: the adoption and implementation of these technologies, in particular advanced manufacturing technologies generate numerous difficulties (Schroeder et al. 1989) that are often overlooked or underestimated by the CEOs of small manufacturing firms. The role of perceived environmental hostility on the form of the relationship between technology policy and realized innovative efforts certainly merits further investigation.

From the above discussion, the following hypotheses are proposed:

H5A. *Perceived hostility moderates the form of the relationship between technology policy and realized innovative efforts.*

H5B. *Perceived dynamism moderates the form of the relationship between technology policy and realized innovative efforts.*

H5C. *The predictive validity of technology policy with respect to realized innovative efforts varies with the level of perceived hostility.*

H5D. *The predictive validity of technology policy with respect to realized innovative efforts varies with the level of perceived dynamism.*

H5E. *Perceived hostility moderates the strength of the relationship between technology policy and realized innovative efforts.*

H5F. *Perceived dynamism moderates the strength of the relationship between technology policy and realized innovative efforts.*

3. Methodology

Relationships indicated in Figure 1 are tested in the specific context of SMEs for the following reasons. First, in these smaller firms, strategy tends to be intuitively derived (Mintzberg 1988), essentially driven by CEOs and difficult to detach from the characteristics of its founders (Adler 1989). Since, the CEO is the "principal architect of corporate strategy" (Harrison 1992), his/her perceptions of the environment, no matter how biased they may appear, are therefore predominant in determining the strategic direction of the firm. Second, with respect to technology policy, the prism effect resulting from CEOs' biases cannot be ignored, as technological choices and investments are greatly influenced by managerial attitudes (Ginsberg and Venkatraman 1992) and personal characteristics and personality traits of CEOs (Lefebvre and Lefebvre 1992). Third, SMEs may be more vulnerable than larger firms to hostile environmental changes because they lack the resources that could be used as buffers (Carter 1990). Fourth, SMEs constitute not only an important proportion of all operating firms in industrialized economies, but also contribute significantly to new job creations.

The emphasis on environmental perceptions requires a tight research design. It is necessary to control for intersectorial variations of the objective characteristics of the external environment. Retaining a single industrial sector is a relatively easy and straight forward way to control for industry effects (Dess et al. 1990). Furthermore, perceptions also vary among members of a same organization depending on their hierarchical position and their functional expertise (Boyd et al. 1993) and, as consequence, it is proposed to control for these two factors by selecting CEOs as single respondents.

3.1. Population and Data Collection

In order to ensure that the CEOs share an environment as homogeneous as possible, the following criteria were retained: all firms were independent, active in the same industrial sector (metal), located in the same geographical region (province of Quebec) and belonged to the same size group (fewer than 200 employees). Furthermore, all had adopted at least one advanced manufacturing technology, which automatically excluded smaller artisanal firms and low-level "job shops." From the list published by the Canadian Association of Manufacturers, 151 firms met all of the above criteria.

The CEOs of all these firms were contacted by phone: 86 CEOs agreed to schedule an interview. The principal reason CEOs of nonparticipating firms gave for not taking part in the study was lack of time. Two CEOs could not be reached in person during the four-month data collection period. Semistructured interviews were conducted with the CEOs on the company sites and lasted between two and three hours. Two of the principal investigators and two graduate students conducted the interviews using identical protocols. In the case of two firms, the CEO was not available at the time of the scheduled interview and close associates participated in the study: these two firms were discarded from the sample. The actual number of respondents in this study is therefore 84 CEOs, for a final response rate of 56%.

Analysis of nonrespondents (goodness of fit tests) indicated that they did not differ from respondents with respect to firm size. However, the response rate was

Figure 2 Research Variables, Operational Measures, and Descriptive Statistics

			In This Study		
Variables	Operational Measures	Construct Reliability in Previous Studies	Construct Reliability	Mean	S.D.
DEPENDENT VARIABLE		(Ettlie and Bridges 1987)[1]			
Technology policy[3]	nine items	0.79	0.85	4.02	1.39
PREDICTOR VARIABLES					
• Structural characteristics:					
Technocratization[3]	% of scientists, engineers, programmers and technicians	(Collins et al. 1988) N/A	N/A	5.97%	11.74%
Formalization[3]	three items	(Lefebvre & Lefebvre 1992) 0.89	0.51	4.05	1.53
Centralization[3]	six items	(Miller & Friesen 1982) 0.79	0.70	6.56	0.46
• Scanning:					
Scanning mechanisms[3]	four items	(Miller & Friesen 1982) 0.74	0.72	3.91	1.36
• Strategic orientation (STROBE):		(Venkatraman 1989)[2]			
Aggressiveness[3]	four items	0.68	0.71	2.79	1.27
Analysis[3]	six items	0.67	0.67	5.56	0.85
Defensiveness[3]	four items	0.53	0.71	5.50	1.09
Futurity[3]	five items	0.61	0.68	4.68	1.43
Proactiveness[3]	five items	0.64	0.51	3.30	1.63
Riskiness[3]	five items	0.53	0.52	3.40	1.27
MODERATOR VARIABLES					
• Perceived environmental uncertainty:					
Hostility[3]	six items	(Miller & Friesen 1982) 0.55	0.50	3.96	1.43
Dynamism[3]	five items	0.74	0.58	3.06	1.24
PREDICTED VARIABLES					
• R&D	investments in R&D as a % of annual sales	N/A	N/A	1.83%	3.79%
• Degree of process innovativeness:					
Computer-based administrative technologies	see Appendix 2 (composite measures)	N/A	N/A	56.02	36.43
Computer-based manufacturing technologies			N/A	53.40	39.60
• External technological experience[3]	three items	N/A, derived from Weiss and Birnbaum (1989)	0.68	5.28	1.29
OUTCOME VARIABLES					
• Financial performance[3]	three items	(Collins et al. 1988)	0.73	4.59	0.89
• Export performance	export sales as a % of annual sales	N/A	N/A	17.17%	28.01%

[1] The 9-item construct is adapted from Ettlie et al.'s (1984) 7-item construct; one of the items was split into two separate items, and an additional item was added.

[2] Venkatraman used a composite measure of reliability developed by Werts et al. (1974); all other authors used the typical Cronbach α coefficient.

[3] Measured on 7-point Likert scales; the remaining variables are based on factual measures.

slightly higher outside the metropolitan Montreal area (response rate = 62%).

3.2. Research Variables

The variables are presented in Figure 2 along with their theoretical justification, Cronbach alpha coefficients, when applicable, and descriptive statistics. All of the perceptual variables retained in this study were measured using previously tested multiscale constructs. As operational measures for some variables were developed for larger firms, the Cronbach alpha coefficients from previous studies are shown, when available. The reliability of these constructs seems to hold up for the small firms involved in this study. The Cronbach alpha coefficients are within the guidelines set by Van de Ven and Ferry (1980), ranging from 0.50 to 0.85. The operational measures used in the structured interview guide are presented in Appendix 1. The exact wording and scale reference anchor phrases appearing in the original interview guide can be obtained from the lead author.

The measure of the degree of process innovativeness is a composite measure of the level of process innovativeness using data on computer-based administrative and manufacturing applications (see Appendix 2). This measure, inspired by the well-known Khandwalla Score (1977) is defined by using both the number of applications adopted by a firm and the weight attributed to each by a panel of experts who ranked each application on 7-point Likert scales according to its degree of radicalness (Lefebvre and Lefebvre 1992, Dewar and Dutton, 1986) thus providing for each firm a total weighted score of process innovativeness. No distinction is made here between computer-based administrative and manufacturing applications because they are becoming more and more integrated in the manufacturing sector and are increasingly difficult to dissociate (Goldhar and Jelinek 1985).

One last comment pertains to the measure of performance. Financial performance is assessed by perceptual measures that have been used extensively by other researchers (Robinson and Pearce 1988) and have been shown to correlate highly with objective measures such as return on assets (ROA). Subjective measures were also used because CEOs of small firms are often reluctant to provide hard financial data (Sapienza et al. 1988). For export performance, factual measures were used because the CEOs surveyed did not consider these measures to be sensitive information.

4. Results and Discussion

4.1. Structural Characteristics, Process, and STROBE as Predictors of Technology Policy

The first three hypotheses (H1A, H1B, H1C) were tested using hierarchical regression analysis. No serious problems of multicollinearity exist between the independent variables[2] since the strongest correlation coefficient occurs between defensiveness and analysis ($r = 0.49$). The results of the hierarchical regression analysis, in which the three blocks of variables (structural characteristics, scanning and strategic orientation) are entered one by one, are presented in Table 1. It can be observed in model 1 that the variance explained by the effect of structural characteristics on technology policy accounts for slightly more than 6%. When entering the second block (scanning), we witness a significant change in the explained variance ($\Delta R^2 = 6.39\%$). Therefore, scanning mechanisms account for as much explained variance as do structural characteristics. A significant and sharp increase in the variance is noted as a result of the inclusion of the STROBE variables (model 3): the explained variance jumps to 48.93%, an increase of more than 36%. It therefore seems that organizational structure and scanning mechanisms have far less explanatory power than strategic orientation. The rather informal and ill-defined organizational structure found in SMEs as well as the apparent lack of formal scanning mechanisms largely explain this result.

The values of standardized betas in model 3 reveal some interesting results. First, H1A is only partially supported: technocratization is significantly and positively related to technology policy as predicted, but both centralization and formalization show significant but opposite relationships to the ones predicted. With regard to *technocratization*, it comes as no surprise that the relative proportion of technically oriented personnel in a firm is related to a greater emphasis on technology pol-

[2] The full Pearson correlation matrix is available on request from the lead author.

Table 1 Results of Hierarchical Regression Analysis: Technology Policy as a Function of Structural Characteristics, Scanning, and Strategic Orientation ($n = 84$)

Independent Variables	Model 1 $\beta^{(1)}$	Model 2 $\beta^{(1)}$	Model 3 $\beta^{(1)}$
Structural Characteristics			
Formalization	0.23***	0.19***	0.17**
Technocratization	0.08	0.11*	0.09*
Centralization	0.07	0.09*	0.09*
Scanning			
Scanning mechanisms		0.26***	0.04
Strategic Orientations			
Aggressiveness			0.21***
Analysis			−0.08
Defensiveness			0.31***
Futurity(4)			0.33***
Proactiveness			0.39****
Riskiness			0.01
$R^{(2)}$	6.24%(2) **	12.63%(2) ***	48.93%(2) ****
$\Delta R^{(2)}$		6.39%(3) **	36.30%(3) ***

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

(1) Standardized betas reported.

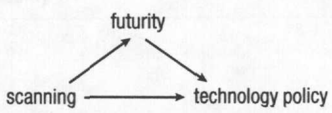
(2) Adjusted $R^{(2)}$.

(3) Change in $R^{(2)}$ after each step of the hierarchical regression. F test is performed using the following formula:

$$F = \frac{\Delta R^{(2)}/M}{(1 - R^{(2)})/(n - k - 1)}$$

where M is the number of independent variables added from model 1 to model 2, n is the number of respondents and k is the number of variables in model 2. This is repeated for each subsequent model.

(4) Scanning for futurity are related ($r = 0.45$, $p < 0.001$ in appendix 3) although this does not pose any serious multicollinearity problem for regression analysis. The mediating effect of scanning on the relationship between futurity and technology policy can be represented as below:



The above mediational model is simply tested with the following regression functions:

futurity = f(scanning); $R^{(2)} = 30.51\%$, $p = 0.0000$; $\beta = 0.55$, $p = 0.0000$.

technology policy = f(scanning): $R^{(2)} = 7.19\%$, $p = 0.0137$; $\beta = 0.27$, $p = 0.0035$.

technology policy = f(scanning, futurity): $R^{(2)} = 26.43\%$, $p = 0.0000$; $\beta_1 = -0.02$, $p = 0.8436$ and $\beta_2 = 0.53$, $p = 0.0000$ respectively for scanning and futurity).

icy, which is a natural extension of the degree of concern with technical issues in the firm. One surprising finding that contradicts the results of previous empirical studies on innovation (Cohn and Turyn 1984) is the positive relationship between *formalization* and technology policy. This could be explained by the fact that the firms in this sample were all actively engaged in the new manufacturing technologies and were all "producers" of hard goods. These smaller firms require some structured procedures and guidelines in order to get things done and take advantage of the full benefits the new technologies provide; in any case, formalization does not equate to "bureaucratization," as our on-site observations enabled us to note. The unexpected positive impact of *centralization* could be explained by the fact that limiting the number of people involved in policy-making decisions may facilitate and accelerate the decision-making process.

Second, *scanning* is a strong determinant of technology policy in model 2 ($\beta = 0.26$, $p < 0.01$ as stipulated in H1B) but becomes a nonsignificant predictor when the dimensions of STROBE are added (model 3). This indicates that certain dimensions of STROBE have a mediating effect on the relationship between scanning and the independent variable (technology policy). Additional analysis presented in Note 4 to Table 1 sheds some light on this last remark: scanning significantly affects futurity ($\beta = 0.55$; $p = 0.0000$) which in turn significantly affects technology policy ($\beta = 0.27$; $p = 0.0035$) but, when one regresses technology policy on both scanning and futurity, scanning has no effect on technology policy ($\beta = -0.02$, $p = 0.8436$). Futurity therefore acts as a perfect mediator (Baron and Kenny 1986, p. 1177) or as a key prime intervening variable in the relationship between scanning and technology policy. The interpretation of this mediating role is appealing on both practical and theoretical grounds: the presence of a strongly futuristic strategic orientation is necessary for more intense scanning mechanisms to translate into a more aggressive technology policy.

Third, as we turn to the contribution of the STROBE dimensions, *proactiveness*, *futurity*, *defensiveness*, and *aggressiveness* are strong predictors of a more progressive technology policy which, overall, allows us to confirm H1C. This again appears quite reasonable because the first three strategic orientations reveal an innovative and opportunistic market seeking behavior oriented towards the long term, while the fourth, aggressiveness, reflects a strong preoccupation with performance monitoring and the enhancement of core manufacturing competencies. Finally, the negative beta coefficient for *analysis* is more intriguing. Although not significant, it raises the possibility that decision-making behavior in SMEs differs from that observed in larger organizations because it may rely as much on intuition as it does on formal analysis.

4.2. Environmental Characteristics as Moderators between Technology Policy and Its Determinants

This section tests the specific moderating effects of environmental characteristics on the relationship between technology policy and its determinants.

On the Form of the Relationship. Table 2 summarizes the results obtained from the moderated regression analyses conducted between technology policy and its determinants. Model 4 represents the addition of the two presumed moderators to model 3 (shown in Table 1). This addition only accounts for a small increase in the explained variance ($\Delta R^2 = 2.18\%$, N.S.) which indicates that dynamism and hostility cannot be considered as predictors. Our next step is therefore to investigate the interaction effects between environment and structural characteristics, process, and strategic orientation. The interaction between environmental hostility and the main effects (model 5) accounts for a significant increase of more than 18% whereas the interaction with environmental dynamism (model 6) results in a far less important and nonsignificant increase of 8%. Model 7, which incorporates both hostility and dynamism, shows a cumulative R^2 of more than 73% and a significant interaction effect with the two environmental variables ($\Delta R^2 = 22.14\%, p < 0.05$).

Conceptually, the presence of a significant interaction demonstrates that a moderator basically modifies the form of the relationship between the predictor and the dependent (or criterion) variable (Sharma et al. 1981). With ten predictor variables and two moderators, results are not as clearcut. A closer look at model 5 (as reported in Note 4 to Table 2) reveals that hostility moderates the form of the relationship between technology policy and half of its de-

Table 2 Testing the Form of the Relationship between Technology Policy and Its Determinants: Results of Moderated Regression Analysis ($n = 84$)

	Cumulative $R^{2(1)}$	$\Delta R^{2(1)}$
Independent Variables		
Model 4: Main effects (structural characteristics, decision-making process, strategic orientation and perceived environmental hostility and dynamism)	51.11%****	2.18% (model 4 vs. model 3)
Model 5: Main effects and interaction effects with perceived environmental hostility(3)	69.56***	18.45%***(4) (model 5 vs. model 4)
Model 6: Main effects and interaction effects with perceived environmental dynamism(3)	59.07***	7.96%(4) (model 6 vs. model 4)
Model 7: Main effects and interaction effects with both perceived environmental hostility and dynamism(5)	73.25%**	22.14%** (model 7 vs. model 4)

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

(1) Adjusted R^2.

(2) ΔR^2 = change in R^2; the F test is performed as in Table 1.

(3) Although multicollinearity problems arise from the introduction of cross-product terms (interaction effects) for models 5, 6, and 7, moderated regression analysis is a valid tool when variables measured by Likert scales are used (Venkatraman 1989). Further, stepwise regressions are performed in order to reduce the number of terms in the regressions for models 5, 6, and 7. Finally, ridge procedures used as remedial measures for multicollinearity (Neter et al. 1990: 412–418) show that interaction terms (both in terms of sign and relative importance) are stable although the resulting R^2 somewhat lower.

(4) The following interaction terms are positively and significantly related to technology policy: technocratization × hostility, proactiveness × hostility, defensiveness × dynamism, analysis × dynamism. The following interaction terms are negatively and significantly related to technology policy: riskiness × hostility, scanning × hostility, futurity × hostility, formalization × dynamism.

(5) Results from model 7 are not interpreted here and are only shown for indicative purposes, because problems of multicollinearity are more serious than those observed in models 5 and 6.

terminants (namely, technocratization, scanning, proactiveness, riskiness and futurity). The presence of these five significant interaction terms is consistent with the significant increase in the explained variance mentioned earlier. Based on the results of model 6, dynamism moderates the form of the relationship between technology policy and only three of the determinants—formalization, defensiveness, and analysis (Note 4 to Table 2). Hence, hypothesis H4A is generally supported, whereas H4B receives only minimal support.

In order to further investigate the specific moderating effects of the two environmental variables,[3] the sample is divided according to perceived low versus high hostility and perceived low versus high dynamism. The median value is used to split the sample. The regression analysis is then performed in each of the four subgroups or subenvironments (Table 3). The analysis carried out in Table 3 is identical to that performed in Table 2 but does provide additional information. In fact, testing the significance of the difference between the βs of two subgroups is identical to testing the significance of the partial of the βs associated with the interaction terms (Arnold 1982), the difference being that, in the first case, moderators are continuous variables and, in the second case, they are dichotomic. In both cases, the form of the relationship is being tested. The significant differences in βs in the subgroup analyses corresponds to the significant interaction terms identified in Table 2 with the exception of scanning in the first two subenvironments and formalization and defensiveness in the last two subenvironments. These three exceptions are borderline cases (scanning, $p = 0.1105$; formalization, $p = 0.1032$; defensiveness, $p = 0.1108$) that can be explained by the way the sample is split into subgroups.[4]

What is gained from the analyses presented in Table 3 is twofold: first, an indication of the direction of the changes and of the values of the βs across subenvironments and second, an assessment of the predictive validity of the set of determinants also across subenvironments.

Overall results reveal some important observations. First, technology policy is best explained by the predictor variables in highly hostile environments ($R^2 = 79.54\%$) and least explained in less dynamic environments ($R^2 = 43.71\%$). Second, proactiveness emerges as a significant positive predictor across all subenvironments, indicating that it plays a significant role in the formulation of technology policy in SMEs. Third, all predictor variables that relate significantly to technology policy are positive except for riskiness in the highly hostile subenvironment. This sheds some light on the non-significant standardized beta reported in Table 1 for riskiness. CEOs of manufacturing SMEs do not invest in high-risk innovative projects when they perceive their environment to be highly hostile.

A comparison of the different sub-environments also yields significant findings. The significantly different ($p = 0.005$) regression functions in the first two subenvironments allow us to support H4C and reinforce the role of hostility as a strong moderator. Partial F tests demonstrate that some specific standardized betas are significantly different in low- and high-hostility environments. The role of technocratization and proactiveness as predictors of technology policy is much higher in hostile environments and the direction of the relationship between riskiness and technology policy changes as expected between the first two environments. The significantly lower beta for futurity in hostile environments is intriguing: a long-term strategic orientation is the most important determinant of technology policy in less hostile environments but does not play a significant

[3] To ensure that the above moderating effects are not subject to a priori correlations, correlation coefficients between each of the two presumed moderator variables and the dependent and predictor variables are examined (the specific correlation coefficients are available on request from the lead author). On one hand, environmental hostility has no significant relationships with technology policy and the majority of predictor variables (7 out of the 10). As a result, hostility is considered as a pure moderator defined by Cohen and Cohen (1983) as a variable that enters into interaction with predictor variables, while having a negligible correlation with the criterion. On the other hand, perceived environmental dynamism is significantly related to technology policy (the dependent variable) and to 6 out of 10 predictor variables. This strongly suggests that environmental dynamism is not a pure moderator.

[4] For example, rather than using the median to split their subgroups, some authors have chosen to remove the grey zone in order to obtain unambiguously distinct groups (see Miller and Friesen 1982 or Covin and Covin 1990).

Table 3 Testing the Predictive Validity of Technology Policy's Determinants across Subenvironments: Results of Regression Analyses

	Independent Variables	Low Hostility	High Hostility	p[1]	Low Dynamism	High Dynamism	p[1]
Structural Characteristics							
V1	Formalization	0.13	0.27***	NS	0.28**	0.01	NS
V2	Technocratization	−0.04	0.38***	0.0021	−0.07	0.02	NS
V3	Centralization	0.20*	0.27***	NS	0.00	0.29**	NS
Scanning							
V4	Scanning mechanisms	0.10	−0.12	NS	0.05	−0.14	NS
Strategic Orientations							
V5	Aggressiveness	0.14	0.28***	NS	0.15	0.14	NS
V6	Analysis	−0.14	−0.11	NS	−0.18	0.22*	0.0874
V7	Defensiveness	0.15	0.36***	NS	0.19	0.47***	NS
V8	Futurity	0.62****	0.06	0.0050	0.36**	0.01	NS
V9	Proactiveness	0.29***	0.72****	0.0064	0.39***	0.34***	NS
V10	Riskiness	0.36***	−0.17*	0.0011	0.02	−0.02	NS
R^2		60.09%****	79.54%****	0.0005	43.71%***	62.17****	NS

Low Hostility, High Hostility, Low Dynamism and High Dynamism are Subenvironments.

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

[1] Comparisons between the first two regression functions and between the last two regression functions were performed using indicator variables (i.e., hostility = 0 if less than median and = 1 otherwise, dynamism = 0 if less than median and 0 otherwise) as suggested in Neter et al. (1990: 364–370). In order to assess whether a particular regression coefficient β is different across subenvironments, a partial F test is performed following Neter et al. (1990: 369). The Chow test of the differences in the overall regressions between the subenvironments gives similar results: $F = 3.99$, $p < 0.01$ and $F = 1.34$, $p > 0.10$ respectively for the first two and last two subenvironments.

role in highly hostile environments where short-term considerations seem to prevail.

No significant differences are found between the regression functions in low- versus high-dynamism subenvironments and H4D is, therefore, not supported. In highly dynamic environments, analysis acts as a significant predictor of technology policy while, in less dynamic environments, it becomes nonsignificant and negative. Thus, the relationship between analysis and technology policy is subject to the level of perceived "predictability" of the environment. The best determinant in highly dynamic environments is defensiveness, indicating that, in small firms operating in a mature industry such as the metal sector, an emphasis on the efficiency of operations and product quality becomes an important ingredient of technology policy when the environment is perceived as highly unpredictable. Efforts to improve what one already does well with respect to existing products, markets, and technologies seems to be the focus of technology policy in highly dynamic environments.

On the Strength of the Relationship. The results of the correlation analyses conducted between technology policy and each of its determinants reveals that correlation coefficients do not vary significantly across the different subenvironments except in the cases of centralization and riskiness in the first two subenvironments and analysis and defensiveness in the last two (Table 4). This suggests that only minimal support is provided for hypotheses H4E and H4F because differential validity is found in only 4 of the 20 cases. Thus, perceived environmental characteristics are not likely to

Table 4 Testing the Strength of the Relationship between Technology Policy and Each of Its Determinants Individually across Subenvironments: Correlation Analyses

		Subenvironments					
Independent Variables		Hostility	Low Hostility	High p^1	Dynamism	Low Dynamism	High p^1
Structural Characteristics							
V1	Formalization	0.26**	0.19	NS	0.32**	−0.03	NS
V2	Technocratization	0.03	0.26*	NS	−0.07	0.02	NS
V3	Centralization	−0.08	0.24*	0.0757	−0.04	0.22*	NS
Scanning							
V4	Scanning mechanisms	0.26**	0.27**	NS	0.34***	0.10	NS
Strategic Orientations							
V5	Aggressiveness	0.05	−0.06	NS	0.06	−0.04	NS
V6	Analysis	0.26**	0.30**	NS	0.15	0.51****	0.0346
V7	Defensiveness	0.36***	0.50****	NS	0.26**	0.64****	0.0149
V8	Futurity	0.60****	0.41***	NS	0.47****	0.50****	NS
V9	Proactiveness	0.32***	0.54****	NS	0.34***	0.48****	NS
V10	Riskiness	0.23*	−0.43****	0.0011	−0.08	0.00	NS

* $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$; **** $p < 0.001$.
(1) Using the Fisher Z transformation of correlation coefficients to test the differences between correlation coefficients in the first two subenvironments and in the last two subenvironments (unilateral test).

moderate the strength of the relationship between technology policy and most of its predictors.

4.3. Technology Policy, Realized Innovative Efforts and the Moderating Effect of Perceived Environmental Characteristics

Table 5 shows that technology policy is a strong determinant of all three types of realized innovative efforts (model 1) and is positively and significantly related to technology policy ($\beta = 0.34, 0.40$, and 0.37, respectively, and $p < 0.001$ for all βs) thus supporting H2. Using a similar methodology to the one followed in the previous analysis, the specific moderating effects of CEOs' perceptions of the external environment on the relationship between technology policy and realized innovative efforts are investigated.

On the Form of the Relationship. Further analysis reported in Table 5 indicates that adding the two presumed moderators and interaction terms (models 2, 3, and 5) increases significantly the explained variance only in the case of R&D. Yet, all interaction terms for all three dependent variables are significant (Note 1 to Table 5). Therefore, both environmental variables moderate the form of the relationship between technology policy and realized innovative efforts, fully supporting hypotheses H5A and H5B.[5] The positive effect of an aggressive technology policy on all three types of realized innovative efforts (denoted by the three positive interaction terms in Table 5) is increased when combined with higher perceived environmental dynamism. The

[5] Both perceived hostility and dynamism are significantly related to two out of three dependent variables (R&D and innovativeness score) and therefore can be termed quasi-moderators on the relationship between technology policy and R&D and innovativeness score. However, the two environmental variables are not related to external experience and, as such, are considered to be pure moderators on the relationship between technology policy and external technological experience. Specific correlation coefficients are available on request from the lead author.

Table 5 Testing the Form of Moderating Effects of Perceived Environmental Characteristics on the Form of the Relationship between Realized Innovative Efforts and Technology Policy (Moderated Regression Analysis)

	Dependent Variables		
Independent Variables	R&D	Innovativeness Core	External Technological Experience
Model 1: Technology policy	$R^2 = 11.71\%$***	$R^2 = 16.00\%$****	$R^2 = 13.84\%$***
Model 2: Technology policy, hostility, and dynamism	$R^2 = 19.59\%$**** $\Delta R^2 = 7.87\%$** (model 2 vs. model 1)	$R^2 = 18.89\%$*** $\Delta R^2 = 2.89\%$ (model 2 vs. model 1)	$R^2 = 14.60\%$*** $\Delta R^2 = 0.76\%$ (model 2 vs. model 1)
Model 3: Technology policy, hostility, dynamism, and technology policy × hostility(1)	$R^2 = 28.83\%$**** $\Delta R^2 = 3.25\%$* (model 3 vs. model 2)	$R^2 = 19.39\%$*** $\Delta R^2 = 0.50\%$ (model 3 vs. model 2)	$R^2 = 15.89\%$*** $\Delta R^2 = 1.29\%$ (model 3 vs. model 2)
Model 4: Technology policy, hostility, dynamism, and technology policy × dynamism(1)	$R^2 = 20.78\%$**** $\Delta R^2 = 1.20\%$ (model 4 vs. model 2)	$R^2 = 20.56\%$*** $\Delta R^2 = 1.67\%$ (model 4 vs. model 2)	$R^2 = 16.73\%$*** $\Delta R^2 = 2.13\%$ (model 4 vs. model 2)
Model 5: Technology policy, hostility, dynamism, technology policy × hostility, and technology policy × dynamism(1)	$R^2 = 26.12\%$**** $\Delta R^2 = 6.54\%$** (model 5 vs. model 2)	$R^2 = 22.26\%$*** $\Delta R^2 = 3.37\%$ (model 5 vs. model 2)	$R^2 = 17.19\%$** $\Delta R^2 = 2.59\%$ (model 5 vs. model 2)

* $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$; **** $p < 0.001$.
• Adjusted R^2 are reported.
• ΔR^2 = change in R^2.
• Significant interaction terms are as follows. When R&D is the dependent variable: technology policy × hostility (negative term); technology policy × dynamism (positive term). When innovativeness score is the dependent variable: techhnology policy × hostility (negative term); technology policy × dynamism (positive term). When external technological experience is the dependent variable: technology policy × hostility (positive term); technology policy × dynamism (positive term).

joint influence of technology policy and perceived hostility is positively related to external technological experience (positive interaction term) but negatively related to both R&D investments and innovativeness score. Perceived hostility, therefore, has a dampening effect on investments with relatively long payoff periods such as R&D and the adoption of computer-based applications while at the same time appears to stimulate the need for a better understanding of the external environment.

Results in Table 5 are consistent with those presented in Table 6, where the regression equations are significantly different across subenvironments for all three types of efforts. Predictive validity also varies across subenvironments: technology policy is a consistently better predictor of each type of realized innovative effort in highly dynamic rather than less dynamic environments. In the less hostile environments, technology policy is a significantly better predictor of R&D whereas in the more hostile environments it is a better predictor of external technological experience. In 4 out of the 6 cases, the regression lines are significantly different across subenvironments. Hence, H5C and H5D are mostly supported.

On the Strength of the Relationship. Since regression coefficients (βs) and correlation coefficients "share an identical test in simple bivariate regressions" (Arnold 1982: 146), correlation coefficients corresponding to the βs in Table 6 are obviously similar and are not presented here. However, testing the difference of the correlation coefficients between subgroups does not necessarily correspond to testing the difference of βs between subgroups because the ratio of standard deviations is not necessarily the same for each subgroup.[6]

[6] Arnold (1982) provides the classical example of the area of a rectangle to demonstrate the phenomenon and also gives examples of two data sets where, in the first data set, the degree of the relationship between two variables (given by the correlation coefficients) is significantly different for two subgroups, while the form of the relationship

Table 6 Testing the Predictive Validity of Technology Policy across Subenvironments: Results of Regression Analysis

	Subenvironments					
Dependent Variables	Low Hostility	High Hostility	p^1	Low Dynamism	High Dynamism	p^1
R&D = *f* (technology policy)	$\beta = 0.47^{***}$ $R^2 = 22.14\%^{***}$	$\beta = 0.25^{*}$ $R^2 = 6.28\%^{*}$	0.0079	$\beta = 0.20^{*}$ $R^2 = 3.90\%^{*}$	$\beta = 0.38^{***}$ $R^2 = 14.17\%^{***}$	0.0806
Score of innovativeness for computer-based applications = *f* (technology policy)	$\beta = 0.42^{***}$ $R^2 = 17.39\%^{***}$	$\beta = 0.39^{***}$ $R^2 = 15.27\%^{***}$	NS	$\beta = 0.21^{*}$ $R^2 = 4.44\%^{*}$	$\beta = 0.61^{****}$ $R^2 = 37.09\%^{****}$	0.0277
External technological experience = *f* (technology policy)	$\beta = 0.25^{**}$ $R^2 = 6.43\%^{**}$	$\beta = 0.50^{***}$ $R^2 = 25.19\%^{***}$	0.0825	$\beta = 0.30^{***}$ $R^2 = 9.10\%^{***}$	$\beta = 0.47^{***}$ $R^2 = 21.65\%^{***}$	NS

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

Indeed, we observe only two significant differences between correlation coefficients across the different subenvironments. These differences occur with respect to external technological experience for the first two subenvironments ($p < 0.10$) and innovativeness score in the last two environments ($p < 0.02$). This indicates that environmental characteristics moderate the strength of the relationship between technology policy and one type of innovative effort. Thus minimal support is provided for hypotheses H5E and H5F.

4.4. Realized Innovative Efforts and Performance

Table 7 reveals a link between financial performance and one form of innovative effort (score for process innovativeness) and thus H3A is only partially supported. Hard economic times for North American manufacturing firms at the time of this survey (early 1990s) may provide some explanation for the lack for significant findings. The negative coefficient observed for R&D could be sector-specific: in the metal industry, R&D activities are generally somewhat lower than in high technology sectors such as biotechnology and, surprisingly, additional analysis reveals that, in our sample, R&D investments are not correlated with the degree of process innovativeness ($r = 0.01$, $p = 0.91$). In fact, it has been shown that unfavourable economic conditions translate quickly into poor performance in small firms due in part to their lack of liquidity. During the course of interviews, number of CEOs reported that the general slowdown in the industry was forcing them to rely on past profits to maintain ongoing operations.

Support for hypothesis H3B is more evident as the link between export-generated sales and innovation efforts appears to be stronger: all correlation coefficients are positive and the scores for innovativeness and external technological experience are significantly related to export performance ($r = 0.21$, $p < 0.05$, and $r = 0.18$, $p < 0.05$).

The minimal support for H3A and the somewhat stronger support for H3B may also be explained by the fact that small firms sacrifice short-term benefits for the longer-term benefits that may accrue from the opening-up of new markets. This is confirmed by the positive yet nonsignificant correlation coefficient between financial performance and export performance ($r = 0.11$) and supports results from previous studies suggesting that the market share-profitability relationship is not necessarily positive and in fact is context specific (Prescott et al. 1986).

(given by the βs) is not and where, in the second data set, the reverse phenomenon is observed.

Table 7 Intercorrelations between Realized Innovative Efforts and Performance ($n = 84$)

Realized Innovative Efforts	Financial Performance ($n = 84$)	Export Performance
R&D	−0.05	0.09
Innovativeness score for computer-based applications	0.14*	0.21**
External technological experience	0.11	0.18**

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

5. Summary of Results and Research Limitations

The majority of hypotheses (10 out of the 18) are either mostly or fully supported and the empirical results unveil the presence of complex relationships. Support for the hypotheses is not as clearcut as it would have been if we had adopted a much more reductionist approach by limiting the analysis to a smaller number of variables. The rather large set of variables involved in this study allows a broader conceptualization of the implications of coalignment. As such, perceived hostility and dynamism are considered distinct characteristics shown to play differing moderating roles on the specified relationships. Furthermore, these relationships are investigated taking into account the different constituent dimensions of strategy, structure, innovative efforts, and performance (6, 3, 3, and 2 dimensions, respectively).

This study yields some important findings that are significant for understanding technology management in small firms. These findings are as follows:

1. Structural characteristics and scanning mechanisms are less important determinants of technology policy than the strategic orientation of the enterprise.

2. Perceived environmental hostility plays a more important moderating role on the relationship between technology policy and its determinants than perceived environmental dynamism.

3. Hostility and dynamism are shown to have specific and differing moderating effects on the form and strength of the relationship between technology policy and some of its determinants.

4. Similarly, hostility and dynamism also play moderating roles, mostly with respect to the form of the relationship between technology policy and realized innovative efforts.

5. A more aggressive technology policy leads to greater realized innovative efforts, which in turn are positively related to export performance and, to a lesser extent, to financial performance.

Study findings should thus be interpreted in the light of certain limitations. Any research design is faced with tradeoffs (Weick 1979) since trying to achieve simultaneously generalizability, simplicity, and accuracy or dealing with what Thorngate (1976) called the postulate of commensurate complexity is indeed an impossible task. First, the sample is rather small ($n = 84$) and homogeneous. This may preclude our making comprehensive generalizations: the results may be context-specific, because both industrial sector and organizational size have a definite impact. Second, caution must be exercised, as reciprocal causality may exist among certain variables. Third, each firm's results are based on data given by a single informant (the CEO) at a given point in time.

On the other hand, some of these limitations can also be viewed as providing benefits. Considerable efforts were made to identify a rather homogeneous and tight sample within a well-defined geographical area where firms share a common political, social, and fiscal environment and where the availability and cost of production factors are largely similar. Furthermore, concentrating on firms of a similar size within a single industry allows one to examine contingency perspectives within a similar context which, according to Ginsberg and Venkatraman (1985), constitutes a first step before making generalizations. Yet this does not imply that no difference exists, because variations could be attributed to the specificity of a firm's activity within the overall metal sector. The small sample size also allows one to conduct two-to-three-hour-long structured interviews on site: the data collected is probably more accurate and richer than it would be otherwise. Researchers also noticed that the timing of this survey influenced the results. All the CEOs we talked to were deeply concerned with the recession. This suggests that the results of this study, or of other studies, for that matter, should be considered in the light of the economic context. The fact that only CEOs were interviewed, no matter how difficult it might have been to reach them, is also a strength in any research on strategic orientations and activities in SMEs and becomes an essential condition when studying the impact of environmental perceptions on strategic activities and organizational outcomes.

6. Conclusion

Two major contributions emerge from the study. First, the focus on the strategic management of technology helps to better understand an understudied but crucial dimension of small firm competitiveness. Second, while environment has long been considered an important contingency variable by researchers, this study departs from past research efforts in demonstrating empirically the power of environmental perceptions on the formulation and enactment of technology policy in SMEs and its subsequent organizational impacts in terms of realized innovative efforts and firm performance.

Theoretical implications are far-reaching. The sequence S + D → TP → REI → P sheds some light on a complex phenomenon which offers several research avenues. The model presented in Figure 1 is essentially static but could be extended to include the dynamic nature that is assumed in the framework. Future research should concentrate on the feedback loop from the outcome variables to the predictor variables concentrating on the impact of performance on the determinants of technology policy. Furthermore, if environmental perceptions override reality, how are perceptions formed? And how can we determine the prism effect of CEOs' personal biases? Answering such questions requires that considerable emphasis be placed on the cognitive schemas of CEOs and their relationships with strategy formulation in general and technology policy in particular.

The practical implications are also obvious, as misread and/or misinterpreted environments will result in inadequate technology policy. This in turn will probably translate into suboptimal allocation of resources, which could be detrimental to the overall performance or survival of a firm. This is indeed a critical issue for all firms, especially for SMEs, which face scarce human and financial resources. In our industrial economies, these firms are increasingly important because they are known to provide a significant number of new job creation opportunities as well as being an important structural mechanism for innovation, and as a result warrant more attention on the part of researchers and policy makers.[7]

[7] The authors are grateful to the Departmental Editor and three anonymous referees. Their detailed comments and direction improved considerably the content and final orientation of the paper. This work was supported in part by research grants from SSHRC and FCAR.

Appendix 1. Structured Interview Guide

I. Dependent Variable

Technology policy: (measured on 7-point scales ranging from "strongly disagree" to "strongly agree"); the degree to which respondents agree that they (1) have always tried to explore the most up-to-date production-operations technology; (2) move ahead with plans to evaluate new processing equipment; (3) have a long tradition and reputation in the industry for attempting to be first in trying out new methods and equipment; (4) plan to increase R&D spending over the next five years; (5) spend more than most firms in the industry on new product development; (6) are actively engaged in a campaign to recruit the best qualified technical personnel available; (7) are actively engaged in a campaign to recruit the best qualified marketing personnel available; (8) are one of the few firms in the industry that does technological forecasting for products; (9) are one of the few firms in the industry that does technological forecasting for production processes.

II. Predictor Variables

Technocratization: number of scientists, engineers, programmers, and technicians divided by the total number of employees.

Formalisation: (measured on 7-point scales using opposite anchor phrases); the degree to which (1) there are complete job descriptions for all jobs; (2) employees must strictly abide by company rules; (3) there are no arguments about job overlap among managers.

Centralisation: (measured on 7-point scales corresponding to managerial levels); the level of management responsible for making decisions of the following types (1) capital budgeting; (2) introduction of new products; (3) acquisition of other companies; (4) pricing of major product lines; (5) entry into major new markets; (6) hiring and firing senior personnel.

Scanning: (measured on 7-point scales ranging from "never used" to "used extremely frequently"); the extent to which the firm uses the following scanning methods to gather information about its environment (1) routine gathering of opinions from clients; (2) explicit tracking of policies and tactics of competitors; (3) sales forecasting and customer preferences; (4) special market research studies.

STROBE: (measured on 7-point scales ranging from "strongly disagree" to "strongly agree")

- **Aggressiveness dimension:** the extent to which (1) profitability is sacrificed to gain market share; (2) prices are cut to gain market share; (3) prices are set below competition; (4) a market share position is sought at the expense of cash flow and profitability.
- **Analysis dimension:** the extent to which (1) effective coordination is emphasized among different functional areas; (2) it is believed that information systems provide support for decision making; (3) thorough analysis is developed when confronted with a major decision; (4) the use of planning techniques is encouraged; (5) the use of the output of management information and control systems is encouraged; (6) manpower planning and performance appraisal of senior managers is encouraged.
- **Defensiveness dimension:** the extent to which (1) significant modifications to the manufacturing technology were brought; (2) the use of cost control systems for monitoring performance is encouraged; (3) the use of production management techniques is encouraged; (4) product quality is emphasized.
- **Futurity dimension:** the extent to which (1) the criteria for resource allocation generally reflect short term considerations; (2) basic

research is emphasized to provide a future competitive edge; (3) key indicators of operations are forecasted; (4) a formal tracking of general trends is available; (5) critical issues are analysed.

• **Proactiveness dimension:** the extent to which respondents agree that (1) new opportunities related to present operations are constantly sought; (2) they are the first to introduce new brands or products in the market; (3) they are constantly on the lookout for businesses that can be acquired; (4) competitors generally pre-empt them by expanding capacity; (5) operations in the later stages of life cycle are strategically eliminated.

• **Riskiness dimension:** the extent to which (1) activities can generally be characterized as high-risk; (2) a rather conservative review is adopted when making major decisions; (3) new projects are approved on a "stage by stage" basis; (4) operations have generally followed the "tried and true" paths; (5) projects where the expected returns are certain tend to be supported.

III. Moderator Variables

Environmental hostility: (measured on 7-point scales ranging from "not a substantial threat" to a "a very substantial threat"); • the extent to which the external environment is considered as a threat to the survival of the firm; • the extent to which the following challenges are considered as threatening (1) tough price competition; (2) competition in product quality or novelty; (3) dwindling markets for products; (4) scarce supply of labour and / or material; (5) government interference.

Environmental dynamism: (measured on 7-point scales using opposite anchor phrases); the degree to which respondents agree that (1) changes in marketing practices are required to keep up with the markets and the competitors; (2) the rate at which products and services in this industry become obsolete is very slow; (3) actions of competitors are easy to predict; (4) demand and customer tastes are easy to forecast; (5) production / service technology is well established and not subject to significant change.

IV. Predicted Variables

Research and Development: R&D as a % of sales.

Degree of Process Innovativeness: see Appendix 2.

External technological experience: (measured on 7-point scales ranging from "very minimal" to "very maximal") The extent of (1) awareness of the most recent technological developments; (2) knowledge on the availability of the most recent technological developments in the market; (3) awareness of the comparative advantages that can be derived from these most recent developments.

V. Outcome Variables

Financial performance compared to industry: (measured on 7-point scales ranging from "below industry average" to "above industry average"); respondents' performance evaluation compared to industry average with respect to (1) annual rate of growth measured in percentage of total assets in the last five years; (2) annual rate of growth of sales in the last five years; (3) average rate of return in the last five years.

Export performance: export sales divided by total sales.

Appendix 2 Measuring the Degree of Process Innovativeness of a Manufacturing Firm

Degree of process innovativeness for computer-based administrative applications $= \Sigma_{i=1}^{21} i_j \times r_j$ where $i_j = 0$ or 1 depending on the adoption of innovation j, and $r_j =$ degree of radicalness of innovation j as established by a panel of experts who ranked each innovation on 7-point Likert scales.

Computer-based administration applications: $i_1 =$ Accounts payable/accounts receivable; $i_2 =$ Inventory management; $i_3 =$ Sales analysis; $i_4 =$ Payroll; $i_5 =$ Billing; $i_6 =$ Cost accounting; $i_7 =$ Operations management; $i_8 =$ Word processing; $i_9 =$ Electronic mail/electronic filing.

Computer-based production applications: Production Technology $i_{10} =$ Computer-assisted design (CAD) and/or Computer-assisted engineering (CAE); $i_{11} =$ CAD output used to control manufacturing machines (CAD/CAM); Fabrication and Assembly: $i_{12} =$ Flexible manufacturing cells (FMC) or systems (FMS); $i_{13} =$ Numerical control machines (NC); $i_{14} =$ Pick and place robots; $i_{15} =$ Other robots. Automated Material Handling: $i_{16} =$ Automated storage and retrieval system (AS/RS); $i_{17} =$ Automated guided vehicle system (AGVS). Automated Sensor-Based Inspection and/or Test Equipment: $i_{18} =$ Performed on incoming or in-process materials; $i_{19} =$ Performed on final product. Communications and Control: $i_{20} =$ Inter-company computer network linking plant to subcontractors; Manufacturing Information Systems: $i_{21} =$ MRPI or MRPII.

* Adapted from a typology produced by Statistics Canada (1989).

References

Adler, P. S., "Technology Strategy: A Guide to the Literatures," in R. S. Rosenbloom and R. A. Burgelman (Eds.), *Research on Technological Innovation, Management and Policy*, vol. 4, JAI Press, London, 1989.

Andrews, K. R., "*The Concept of Corporate Strategy*," Dow Jones-Irwin, Homewood, IL, 1971.

Arnold, H. J., "Moderator Variables: A Clarification of Conceptual, Analytic and Psychometric Issues," *Organizational Behavior and Human Performance*, 29 (1982), 143–174.

Baldwin, J., W. Chandler, C. Le, and T. Papailiadis, *Strategies for Success*, Statistics Canada, Catalogue No. 61-523E, Government of Canada, Ottawa, Canada, 1994.

Baron, R. M. and D. A. Kenny, "The Moderator-Mediator Variable Distinction in Social Psychological Research: Conceptual, Strategic and Statistical Considerations," *J. Personality and Social Psychology*, 51 (1986), 1173–1182.

Bourgeois, L. J., "Strategy and Environment: A Conceptual Integration," *Acad. Management Rev.*, 5 (1980), 25–39.

Bourgeois, L. J., "Strategic Goals, Perceived Uncertainty, and Economic Performance in Volatile Environments," *Acad. Management J.*, 28 (1985), 548–573.

Boyd, B. K., G. G. Dess, and A. M. A. Rasheed, "Divergence between Archival and Perceptual Measures of the Environment: Causes and Consequences," *Acad. Management Rev.*, 18 (1993), 204–226.

Brockhoff, K., "Die Produktivität der Forschung und Entwicklung eines Industrieunternehmens," *Zeitschrift für Betriebswirtschaft*, 56 (1986), 525–537.

Carter, N. M., "Small Firm Adaptation: Responses of Physicians' Organizations to Regulatory and Competitive Uncertainty," *Acad. Management J.*, 33 (1990), 307–333.

Chakrabarti, A. K., "Innovation and Productivity: An Analysis of the Chemical, Textiles and Machine Tool Industries in the U.S.," *Res. Policy*, 19 (1990), 257–269.

Chandler, A. D., *Strategy and Structure*, MIT Press, Cambridge, MA, 1962.

Cohen, J. and P. Cohen, *Applied Multiple Regression/Correlation Analysis for the Behavioral Sciences*, Lawrence Erlbaum Associates, Hillsdale, NJ, 1983.

Cohn, S. F. and R. M. Turyn, "Organizational Structure, Decision-Making Procedures and the Adoption of Innovations," *IEEE Trans. on Engineering Management*, EM-31 (1984), 154–161.

Collins, P. D., J. Hage, and F. M. Hull, "Organizational and Technological Predictors of Change in Automaticy," *Acad. Management J.*, 31 (1988), 512–543.

Covin, J. G. and T. J. Covin, "Competitive Aggressiveness, Environmental Context and Small Firm Performance," *Entrepreneurship Theory and Practice*, Summer (1990), 35–50.

—— and D. P. Slevin, "Strategic Management of Small Firms in Hostile and Benign Environments," *Strategic Management J.*, 10 (1989), 75–87.

Dess, G. G., R. D. Ireland, and M. A. Hitt, "Industry Effects and Strategic Management Research," *J. Management*, 16, 1 (1990), 7–27.

Dewar, R. D. and J. E. Dutton, "The Adoption of Radical and Incremental Innovations: An Empirical Analysis," *Management Sci.*, 32 (1986), 1422–1433.

Downey, H. K. and J. W. Slocum, "Uncertainty: Measures, Research, and Sources of Variation," *Acad. Management J.*, 18 (1975), 562–578.

Ettlie, J. E. and W. P. Bridges, "Environmental Uncertainty and Organizational Technology Policy," *IEEE Trans. on Engineering Management*, 29 (1982), 2–10.

—— and ——, "Technology Policy and Innovation in Organizations," in J. M. Pennings and A. Buitendam (Eds.), *New Technology as Innovation*, Ballinger Publishing Company, MA, 1987.

——, ——, and R. D. O'Keefe, "Organization Strategy and Structural Differences for Radical versus Incremental Innovation," *Management Sci.*, 30 (1984), 682–695.

Franko, L. G., "Global Corporate Competition: Who's Winning, Who's Losing, and the R&D Factor as One Reason Why," *Strategic Management J.*, 10 (1989), 449–474.

Galbraith, J. R. and E. E. Lawler III, "Challenges to the Established Order," in J. R. Galbraith, E. E. Lawler III and Associates, *Organizing for the Future—The New Logic for Managing Complex Organizations*, Jossey-Bass Publishers, San Francisco, CA, 1993.

Gergen, K., "The Social Constructionist Movement in Modern Psychology," *American Psychologist*, 40 (1985), 266–275.

Ginsberg, A. and N. Venkatraman, "Contingency Perspectives of Organizational Strategy: A Critical Review of Empirical Research," *Acad. Management Rev.*, 10 (1985), 421–434.

—— and ——, "Investing in New Information Technology: The Role of Competitive Posture and Issue Diagnosis," *Strategic Management J.*, 13 (Special Issue, Summer 1992), 37–53.

Goldhar, J. D. and M. Jelinek, "Computer Integrated Flexible Manufacturing: Organizational, Economic and Strategic Implications," *Interfaces*, 15 (1985), 94–105.

Grant, J. H. and W. R. King, *The Logic of Strategic Planning*, Little Brown and Co., Boston, MA, 1982.

Gupta, Y. P. and D. C. W. Chin, "Strategy Making and the Environment: An Organizational Life Cycle Perspective," *Technovation*, 13 (1993), 27–44.

Hall, W. K., "Survival Strategies in a Hostile Environment," *Harvard Business Rev.*, 58, 5 (1980), 75–85.

Hambrick, D. C., "Environmental Scanning and Organizational Strategy," *Strategic Management J.*, 3 (1983), 159–173.

——, "Strategic Awareness within Top Management Teams," *Strategic Management J.*, 2 (1981), 263–279.

—— and C. C. Snow, "A Contextual Model of Strategic Decision Making in Organizations," *Acad. Management Proceedings*, (1977), 108–112.

Harrison, E., "Perspectives on Uncertainty in Successful Strategic Choice at the CEO Level," *Omega*, 20 (1992), 105–116.

Hofer, C. W. and D. E. Schendel, *Strategy Formulation: Analytical Concepts*, West Publishing Co., New York, 1978.

Jauch, L. R. and K. L. Kraft, "Strategic Management of Uncertainty," *Acad. Management Rev.*, 11 (1986), 777–790.

Kanter, R. M., *The Change Masters*, Simon and Schuster, New York, 1983.

Khan, A. M. and V. Manopichetwattana, "Innovative and Non-Innovative Small Firms: Types and Characteristics," *Management Sci.*, 35 (1989), 597–606.

Khandwalla, P. N., *The Design of Organizations*, Harcourt Bruce Jovanovich Inc., New York, 1977.

Lawrence, P. R. and J. Lorsch, *Organization and Environment*, Harvard University Press, Boston, MA, 1967.

Lefebvre, É. and L. A. Lefebvre, "Firm Innovativeness and CEO Characteristics in Small Manufacturing Firms," *J. Engineering and Technology Management*, 9 (1992), 243–277.

Lefebvre, L. A. and É. Lefebvre, "Competitive Positioning and Innovative Efforts in SMEs," *Small Business Economics*, 5 (1993), 297–305.

——, J. Harvey, and É. Lefebvre, "Technological Experience and the Technology Adoption Decisions in Small Manufacturing Firms," *R&D Management*, 21 (1991), 241–249.

Lefebvre, L. A., A. Langley, J. Harvey, and É. Lefebvre, "Exploring the Strategy—Technology Connection in Small Manufacturing Firms," *Production and Operations Management*, 1 (1992), 269–285.

Maidique, M. A. and P. Patch, *Corporate Strategy and Technology Policy*, The President and Fellows of Harvard College, 1978.

—— and ——, "Corporate Strategy and Technological Policy" in M. L. Tushman and W. L. Moore (Eds.), *Readings in the Management of Innovation*, 2nd ed., Ballinger, Cambridge, MA, 1988, 236–248.

Mason, R. M., "Metaphors for Thinking about Corporate and Technical Strategies," *Engineering Management J.*, 3 (1991), 9–15.

Miller, D., "Strategy Making and Structure: Analysis and Implications for Performance," *Acad. Management J.*, 30 (1987), 7–32.

——, "Relating Porter's Business Strategies to Environment and Structure," *Acad. Management J.*, 31 (1988), 280–308.

——, "Stale in the Saddle: CEO Tenure and the Match between Organization and Environment," *Management Sci.*, 37 (1991), 34–52.

——, "Environmental Fit Versus Internal Fit," *Organization Sci.*, 3 (1992), 159–179.

—— and P. H. Friesen, "Innovation in Conservative and Entrepreneurial Firms: Two Models of Strategic Momentum," *Strategic Management J.*, 3 (1982), 1–25.

Mintzberg, H., "Strategy-Making in Three Modes," in J. B. Quinn, H. Mintzberg, and R. J. James (Eds.), *The Strategy Process*, Prentice-Hall, Englewood Cliffs, New York, 1988.

Morbey, G. K. and R. M. Reithner, "How R&D Affects Sales Growth, Productivity and Profitability," *Res. Technology Management*, May–June (1990), 11–14.

NRC (National Research Council), *Research on the Management of Technology: Unlashing the Hidden Competitive Advantage*, National Science Foundation, National Academy Press, Washington, DC, 1991.

Neter, J., W. Wasserman, and M. H. Kutner, *Applied Linear Statistical Models*, Irwin, Boston, MA, (1990).

Paine, F. T. and C. R. Anderson, "Contingencies Affecting Strategy Formulation and Effectiveness: An Empirical Study," *J. Management Studies*, 41 (1977), 147–158.

Pettigrew, A. and R. Whipp, *Managing Change for Competitive Success*, Blackwell Publishers Ltd., Oxford, England, 1991.

Porter, M. E., *Competitive Strategy*, Free Press, New York, 1980.

Prescott, J. E., "Environments as Moderators of the Relationship Between Strategy and Performance," *Acad. Management J.*, 29 (1986), 329–346.

——, A. J. Kohli, and N. Venkatraman, "The Market-Share Profitability Relationship: An Empirical Assessment of Major Assertions and Contradictions," *Strategic Management J.* 7 (1986), 377–394.

Quinn, J. B., *Intelligent Enterprise*, The Free Press, New York, 1992.

Robinson, R. B. and J. A. Pearce, "Planned Patterns of Strategic Behaviour," *Strategic Management J.*, 9 (1988), 43–60.

Sapienza, H. J., K. G. Smith, and M. J. Gannon, "Using Subjective Evaluations of Organizational Performance in Small Business Research," *American J. Small Business*, 12 (1988), 43–53.

Schroeder, D. M., C. Gopinath, and S. W. Congden, "New Technology and the Small Manufacturer: Panacea or Plague?" *J. Small Business Management*, 27 (1989), 1–10.

Sharma, S., R. M. Durand, and O. Gurarie, "Identification and Analysis of Moderator Variables," *J. Marketing Res.*, 18 (1981), 291–300.

Simon, H. A., *Administrative Behavior*, Macmillan, New York, 1957.

Snow, C., "The Role of Managerial Perceptions in Organizational Adaptation: An Exploratory Study," *Acad. Management Proceedings*, (1976), 249–255.

Statistics Canada, *Survey of Manufacturing Technologies*, Science Technology and Capital Stock Division, Government of Canada, Canada, 1989.

Thorngate, W., " 'In General' vs 'It Depends': Some Comments of the Gergen–Schlenker Debate," *Personality and Social Psychology Bulletin*, 2 (1976), 404–410.

Van de Ven, A. and D. Ferry, *Measuring and Assessing Organizations*, Wiley Interscience, New York, 1980.

Venkatraman, N., "Strategic Orientation of Business Enterprises: The Construct, Dimensionality, and Measurement," *Management Sci.*, 35 (1989), 942–962.

—— and J. E. Prescott, "Environment–Strategy Coalignment: An Empirical Test of Its Performance Implications," *Strategic Management J.*, 11 (1990), 1–23.

Weick, K. E., *The Social Psychology of Organizing*, 2nd ed., Addition-Wesley, Random House, New York, 1979.

Weiss, A. R. and P. H. Birnbaum, "Technological Infrastructure and the Implementation of Technological Strategies," *Management Sci.*, 35 (1989), 1014–1026.

Werts, C. E., R. L. Linn, and K. G. Joreskog, "Interclass Reliability Estimates: Testing Structural Assumptions," *Educational and Psychological Measurement*, 34 (1974), 25–33.

Zahra, S. A. and J. C. Covin, "Business Strategy, Technology Policy and Firm Performance," *Strategic Management J.*, 14 (1993), 451–478.

——, R. S. Sisodia, and S. R. Das, "Technological Choices within Competitive Strategy Types: A Conceptual Integration," *International J. Technology Management*, 9, 2 (1994), 173–195.

Accepted by Ralph Katz; received September 1993. This paper has been with the authors 14 months for 3 revisions.