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TECHNOLOGICAL ENTREPRENEURSHIP AND SMALL BUSINESS INNOVATION RESEARCH PROGRAMS

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EXECUTIVE SUMMARY

The development and commercialization of new technologies are important to the global economy. New product technologies can revitalize old industries or create entirely new industries. New process technologies can streamline production and increase efficiency. High-tech start-ups and technology development firms, also known as technological entrepreneurs, play an important role in developing and commercializing the technologies, especially in artificial intelligence, biotechnology, software, and the telecommunications industry (Zahra 1996a). As technology adopters, they use new technologies for product and process innovation; as technology developers, they initiate the commercialization of new technologies (Clarysse and Moray 2004).

Though they may be *idea rich*, technological entrepreneurs are typically are *resource poor*, often lacking the operating capital to intensively research an interesting idea, to develop the idea into a prototype, and/or to commercialize the product. Government involvement in early stages of technological development can provide the boost necessary to launch the technology and to develop an industry. Although there are a number of significant government programs to assist technological development in many countries, including the Commercial Ready program in Australia, Malaysia's Multimedia Super Corridor, and the Vinnova programs in Sweden, our initial focus is on the Small Business and Innovation Research (SBIR) program, in the United States. The SBIR program operates in ten Federal government departments and agencies and typically funds over $1 billion in technology development programs annually. A better understanding of its role in the process of assisting technology entrepreneurs in developing and commercializing technology could help governments in other countries develop programs that will assist technological entrepreneurship.

Using a model developed by Lumpkin and Dess (1996), this paper explores the conceptual role that government technology programs can play in facilitating the process of technological entrepreneurship. It examines the relationships between the components of a firm's entrepreneurial orientation and the firm's willingness to participate in the SBIR program. It also explores some of the ways SBIR funding can impact the environmental factors in which the firm operates. Finally it explores some of the ways participation in the SBIR program can impact a firm's organizational structure, and, ultimately, the firm's performance.

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Entrepreneurial Orientation refers to the organizational processes, methods, styles, practices, and decision-making activities employed by entrepreneurs that lead to new entry (Lumpkin and Dess 1996, 2001; Stevenson and Jarillo 1990). Lumpkin and Dess (1996) identify five components of an entrepreneurial orientation: autonomy, innovativeness, risk-taking, proactiveness, and competitive aggressiveness. Environmental factors include dynamism, munificence, complexity, and industry characteristics. Organizational factors include size, structure, strategy, strategy-making processes, culture, and top management team characteristics. We extend organizational factors to also include the effect of firm resources. We expand the performance measures mentioned by Lumpkin and Dess (1996) - sales growth, market share, profitability, overall performance, and stakeholder satisfaction - to explicitly include commercialization, technology transfer, and survival.

A series of propositions is developed for entrepreneurial orientation and the willingness to participate in a program like SBIR, albeit, in the United States or in other countries. There are direct positive relationships between willingness to participate in SBIR and innovativeness, proactiveness, and competitive aggressiveness. As participation in a government program can be seen to offer easier access to venture capital in exchange for compliance with regulations, we posit inverse relationships between willingness to participate and the autonomy and risk-taking components of an entrepreneurial orientation.

A series of propositions is developed for the relationship between SBIR and environmental factors: SBIR can have positive effects on dynamism if the innovations funded are radical in nature; can positively affect munificence if the industry is tightly defined, and can enhance industry competitiveness. In turn, these changes in environment will make it more likely that a technology entrepreneur will develop and commercialize a technology.

Although participation in a program like SBIR can impact many of the organizational factors, we posit that the biggest direct impact of SBIR is to enhance firm resources. The impact of SBIR on other components of the organizational factors will be indirect, through firm resources. Survival rates, rates of commercialization, and rates of technology transfer are posited to be higher for technology firms that participate in programs such as SBIR than for comparable firms which do not participate in the programs.

Future research directions are discussed. This article is propositional in nature. It is also the basis for on-going empirical work, designed to test the conceptual model presented. The focus on this paper has been to examine the role that SBIR might play in assisting technological development, specifically in researching new technologies, developing prototypes, and commercializing the sponsored innovations. In addition it is intended to provide a foundation for researchers to explore other technology development programs, both in the United States and in other countries.

An analysis and implementation of programs like the SBIR program in the United States, Malaysia's Multimedia Super Corridor, the Vinnova programs, in Sweden, and the Commercial Ready program in Australia, offer the potential to help entrepreneurs commercialize new technology in other countries. It might be particularly interesting to learn how informal programs or social initiatives may play a similar role in countries where government programs of this magnitude are not available. For example, it would be interesting to explore the role that quasi-government programs, such as technology parks, might play in helping commercialize technology. It would also be interesting to explore the role government programs play in more directed economies.

Keywords: entrepreneurship, technology entrepreneurs, entrepreneurial orientation, technology development and commercialization, Small Business Innovation Research, SBIR, government support of start-up technology firms..

TECHNOLOGICAL ENTREPRENEURSHIP AND SMALL BUSINESS INNOVATION RESEARCH PROGRAMS

Entrepreneurs contribute toward economic development by introducing new product offerings into the market or through new production methods (Schumpeter 1954, 1976). Market pioneering, where a firm is first to market, is often considered an expression of an entrepreneurial orientation (Covin et al. 1999). Whether it is through product, process, or management innovation, entrepreneurial business ventures are the drivers of modern economies globally (Timmons and Spinelli 2004). The development and commercialization of new can revitalize old industries or create entirely new industries. Entrepreneurial business ventures are the change agents that move society forward (McClelland 1976) and bring forth innovation through continuous improvement, creative destruction, and creative transformation (Terziovski 2002; Venkantaraman 2004).

High-tech start-ups and technology development firms, also known as technological entrepreneurs, play an important role in developing and commercializing technologies worldwide. These firms are integral to many industries including artificial intelligence, biotechnology, software, and the telecommunications (Zahra 1996a). As technology adopters, they use new technologies for product and process innovation; as technology developers, they initiate the commercialization of new technologies (Clarysse and Moray 2004). These firms rely on technology as a key strategic resource that can be used to develop a competitive advantage through innovation (Kelley and Rice 2002). Decisions made by a firm on which technologies to develop and exploit can impact probabilities of success or failure (Zahra and Chandler 1999). A coherent technological strategy is one of the key components for success and superior financial performance (Zahra 1996b). The technology strategy is, in turn, shaped by the firm's scientific, technological, and inherent managerial capabilities (Deeds et al. 1999).

Though they may be *idea rich*, technological entrepreneurs are typically are *resource poor*, often lacking the operating capital to intensively research an interesting idea, to develop the idea into a prototype, and/or to commercialize the product. Government involvement in early stages of technological development can provide the boost necessary to launch the technology. Some examples of programs designed to help small and medium-sized businesses develop and commercialize technology are the Small Business and Innovation Research (SBIR) program in the United States, the Commercial Ready program in Australia, Malaysia's Multimedia Super Corridor, and the Vinnova programs in Sweden. SBIR is a major player in technological development and innovation and typically funds over $1 billion in technology development programs annually. Commercial Ready is run by AusIndustry, the program delivery division of the Australian Government Department of Industry, Tourism and Resources. Commerce Ready typically funds about AUS $200 million annually (approximately US$150 million). Vinnova, the Swedish Agency for Innovation Systems, modeled after the SBIR, has a mission is to promote sustainable growth by financing technology development and developing effective innovation systems.

Although there are government programs to assist technological development in many countries, our initial focus is on the Small Business and Innovation Research (SBIR) program in the United States. We selected the SBIR program as our initial focus as it was one of the first programs of its kind and has been a model for other programs. SBIR was established to help entrepreneurs and to promote innovation and assist in the commercialization of technology. In fiscal year 2003, SBIR programs in the Department of Defense, alone, provided grants of $894.95 million in support of 3,193 projects (DoD SBIR website 2004). A better understanding of its role in the process of assisting technology entrepreneurs in developing and commercializing technology could help governments in other countries develop programs that will assist technological entrepreneurship.

This research is occurring at three levels: the individual level, which focuses on the individuals who drive technological innovation; the organizational level which focuses on the linkages within the organization; and the systems level which "is about the resources exchange among different players in the ecology of value creation, which includes the governing factors such as government technology and competition policy" (Phan and Foo 2004: 2). Although the development of technology is consistent with many government programmatic goals, the inherent culture of government agencies is administrative rather than entrepreneurial. Arguably, governments tend to be

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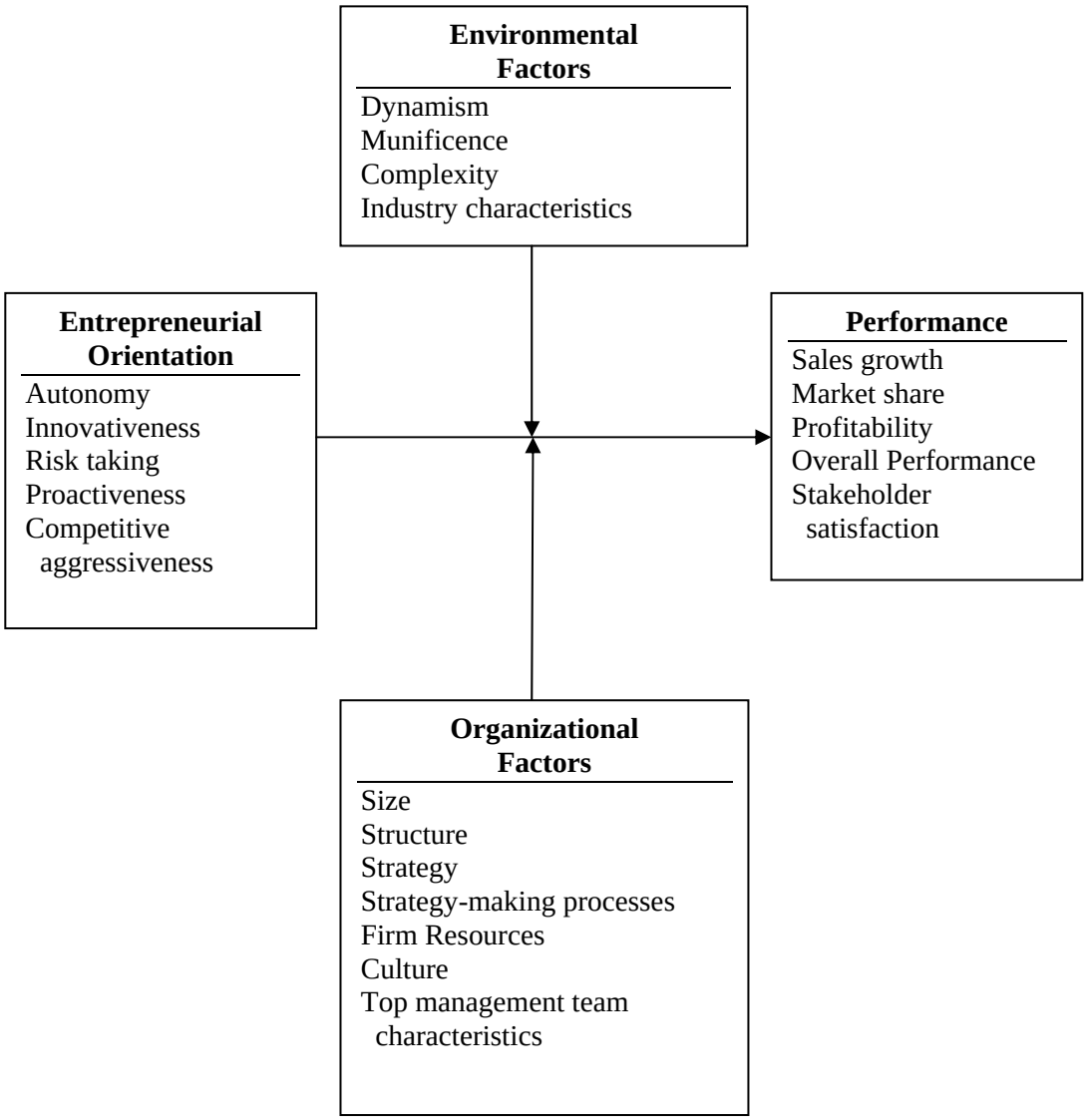
risk averse where entrepreneurial firms are risk-takers. A better understanding of its role in the process of assisting technology entrepreneurs in commercializing technology can assist the government in facilitating the process.

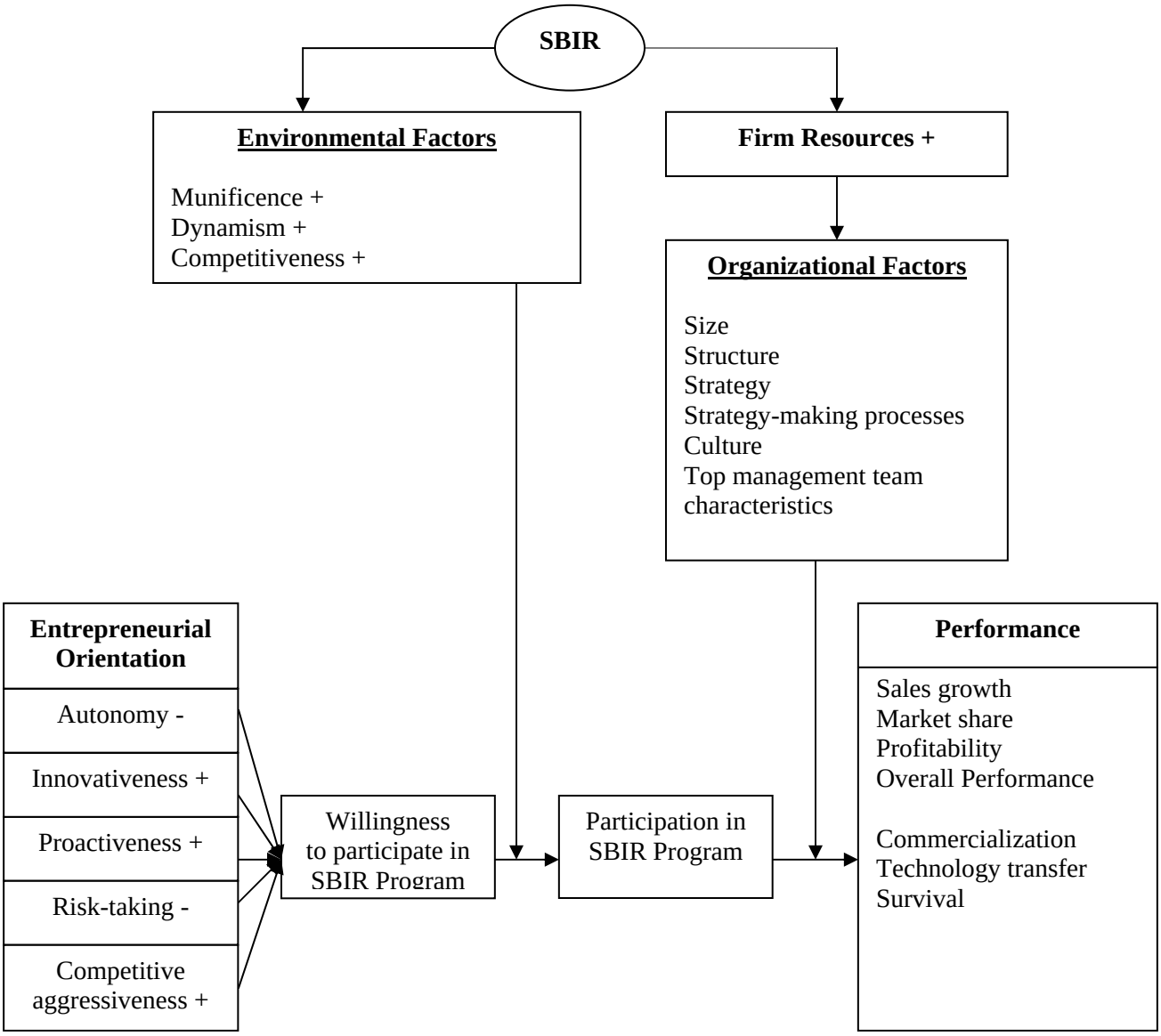
This article explores the conceptual role that government technology programs can play in facilitating the entrepreneurial process in high-tech start-ups. A major focus of this paper is an exploration of the relationships between a firm's entrepreneurial orientation and willingness to participate in a program like the SBIR program. Using the structure posited by Lumpkin and Dess (1996; please see Figure 1), we develop propositions for each of the components of an entrepreneurial orientation - autonomy, innovativeness, risk taking, proactiveness, and competitive aggressiveness - and the firm's willingness to participate in the program. We explore some of the ways government support can impact the environment in which the firm operates, thereby enhancing the likelihood that a firm will research and develop a new technology. Finally we explore some of the ways participation in the SBIR program can impact a firm's organizational structure and, ultimately, the firm's performance.

FIGURE 1
Conceptual Framework of Entrepreneurial Orientation (Lumpkin and Dess, 1996)



We first discuss the framework of the SBIR program. Next, we discuss relations between an entrepreneurial orientation at the firm level and willingness to participate in the SBIR program. Next, we discuss possible impacts the SBIR program can have on environmental factors. We then discuss ways in which participation in the SBIR can impact organizational factors and, ultimately, performance. Finally, we set forth a research plan to examine the conceptual relationships. The enhanced conceptual model, which will be discussed in subsequent sections, is shown in Figure 2.

FIGURE 2
Theoretical Model Predicting the Effects of Entrepreneurial Orientation on Willingness to Participate in Technology Development Programs



SMALL BUSINESS INNOVATION RESEARCH PROGRAM (SBIR)

Founded in 1982, SBIR was formed to assist in the development and commercialization of technology, and to promote small businesses, create new jobs, and develop alternative sources of supply. Additionally the program is designed to help promote minority and disadvantaged businesses. SBIR offices can be found in ten federal agencies or departments: the Departments of Agriculture, Commerce, Defense, Education, Energy, Health and Human Services, and Transportation, as well as, the Environmental Protection Agency, the National Aeronautics and Space Administration, and the National Science Foundation. In addition, there may be multiple SBIR offices within federal departments. For example, the Army, Navy, and Air Force each have SBIR offices within the Department of Defense. There also may be multiple SBIR offices within an organization, e.g., the Navy has an SBIR office devoted to sea defenses and another devoted to air defenses.

The SBIR program is a multi-staged program that provides up to $850,000 in early-stage R&D funding directly to US for-profit technology companies with 500 or fewer employees. The first phase of the project, Phase I, is a feasibility study designed to further explore a technology. It is capped at a $70,000 to $100,000 grant, depending upon the agency or department, and can take up to six months for completion. Although other statements of work can be issued, a Phase II grant is usually considered the stage where a prototype is developed. Phase II awards are capped at $1 million and can last up to two years duration. Phase III of the SBIR program is considered the commercialization stage. No SBIR funds are awarded for Phase III projects, though other government funding programs, such as the Transition Assistance Program, may be used to facilitate the commercialization of the technology.

Requests for proposals are made through topic calls, which specify a technology or problem that needs to be explored. Less than 10% of the Phase I proposals submitted in response to the topic calls are funded. Approximately 40% of successfully completed Phase I projects that apply for Phase II funding are funded. The percentage of successfully completed Phase II projects that make it to Phase III are unknown since Phase III projects cannot be funded by SBIR and there is no financial incentive for the firms to report Phase III projects. In addition, some of the firms that develop a technology under Phase I or Phase II of the SBIR program are acquired by larger firms and are no longer eligible for the program.

There are multiple stakeholders involved with the SBIR program, including small businesses, the government agency or department interested in exploring the technology, and the SBIR program office. The small businesses can be technology development firms that specialize in developing and commercializing new technologies or newly formed entrepreneurial business ventures organized to develop and commercialize a specific technology. On the micro-level, the program manager of the program office that originates the topic call for the new technology is a direct stakeholder. On the macro-level, the public is a major stakeholder and is represented by the Congress which funds and overseas the program.

The difference in perception of success of an SBIR project is determined by the objectives of each of the stakeholders in the process. The project manager is goal-oriented and wants a solution to a problem which usually involves a technology that will solve the problem. The SBIR's goal is to facilitate the technological development and subsequent commercialization and, at the same time, promote small businesses, create new jobs, and develop alternative sources of supply.

The firm strives to achieve any one of a multitude of possible objectives ranging from meeting short-term objectives, such as implementing a component of its technological strategy or survival, to long-term technological or production superiority through innovation and profitability. Another possible goal, which is often a function of a small business technology development firm or a more-oriented R&D firm, is to develop a new technology in order to license, sell or spin-off the technology. The relationship between the SBIR and the technological entrepreneur is developed in subsequent sections of this paper.

ENTREPRENEURIAL ORIENTATION

Entrepreneurial Orientation refers to the organizational processes, methods, styles, practices, and decision-making activities employed by entrepreneurs that lead to new entry (Lumpkin and Dess 1996, 2001; Stevenson and Jarillo 1990). Entrepreneurial orientation can be distinguished from entrepreneurship and is an essential feature of high performing firms (Lumpkin and Dess 1996). Entrepreneurship is the content of entrepreneurial decisions taken and addresses *what is undertaken.* Entrepreneurial orientation is the process, methods or style of what the firm does.

As indicated earlier, Lumpkin and Dess (1996) identify five components to an entrepreneurial orientation: autonomy, innovativeness, risk-taking, proactiveness, and competitive aggressiveness. We discuss each of the components and its conceptual relationships with a willingness to participate in a program like SBIR. These relationships are summarized in Figure 2.

Autonomy

Lumpkin and Dess (2001: 431) define autonomy as "independent action by an individual or team aimed at bringing forth a business concept or vision and carrying it through to completion." On an individual level it implies a relative freedom from organizational constraints. On the firm level, it implies an empowerment to act without a cumbersome process. Shrivastava and Grant (1985) use the term *managerial autocracy* which means that a single key manager could act as the primary decision maker. Burgelman (1983) identified the importance of a product champion as the link between project definition and impetus processes.

Though arguments can be made that participation in a program such as the SBIR program may, in the longer term promote autonomy, participation in government programs can potentially place limitations on a firm's independence in the short-term and medium-term. Therefore, in balance, highly autonomous entrepreneurial firms would be less likely to become involved with a government program.

> P1: There is an inverse relationship between autonomy and participation in government programs that support technology development.

Innovativeness

The concept of innovativeness comes from Schumpeter (1954) and "reflects a firm's tendency to engage in and support new ideas, novelty, experimentation, and creative processes that may result in new products, services, or technological processes" (Lumpkin and Dess 1996: 142). Innovativeness includes fostering a spirit of creativity, supporting R&D and experimentation, developing new processes, introducing new products/services, and technological leadership (Lumpkin 2002; Lumpkin and Dess 2001). Innovative entrepreneurial organizations often are first-to-market with new product offerings (Covin and Slevin 2001). Innovativeness can span a continuum from a willingness to make a marginal improvement to a major commitment to be a technological leader (Lumpkin and Dess 1996). Creativity and innovation are linked; in some ways, in the business context, innovation can be thought of as applied creativity. Technology strategy involves a firm's commitment to acquire, develop, and deploy technology (Lumpkin and Dess 1996).

The posited relationship between innovativeness and participation in government programs developed to support technology, such as the SBIR program, is bidirectional. The SBIR program was developed specifically to promote innovation. In order to promote innovation, innovative entrepreneurial organizations will be more likely to take advantage of available resources. Therefore

> P2: There is a positive relationship between the innovation component of entrepreneurial orientation and willingness to participate in a government program that supports technology development.

Proactiveness

Proactiveness is the opportunity-seeking, forward-looking perspective that involves introducing new products/services and acting in anticipation of future demand. Lumpkin and Dess (2001) describe proactiveness as a response to opportunities and competitive aggressiveness as responsive to threats. Proactiveness involves a wide variety of activities including identifying opportunities and market trends, assessing the strengths and weaknesses of opportunities, and forming teams capable of exploiting them (Kropp, Lindsay, and Shoham 2004). It implies a willingness to participate in emerging markets, acting opportunistically. Although entrepreneurs are predisposed to the formation of business ventures to pursue specific objectives (Kouriloff 2000), they still need to be proactive in seeking out an attractive niche and creating the necessary resources to facilitate new entry (Lumpkin and Dess 2001). Entrepreneurs need to develop a vision and determine ways to combine previously unidentified components to capitalize on the perceived business opportunity (Bird 1989; Schumpeter 1954). Lumpkin and Dess (2001) found that proactiveness was more important to firms in the early stages of industry development than in more mature industries. This is of particular interest to technological entrepreneurs who are often operating in early stages of an industry.

As proactive firms are forward-looking and willing to embrace assistance in bringing forth their innovations,

> P3: There is a positive relationship between the proactiveness component of entrepreneurial orientation and willingness to participate in a government program that supports technology development.

Risk-taking

Although there are many ways of conceptualizing risk, Folani and Mullins (2000: 304) examine entrepreneurs' perception of risk as the "uncertainty and potential losses associated with the outcomes which may follow from a given set of behaviors." Specifically, aspects of strategic risk may include venturing into new and unknown territory, committing a relatively large share of assets and significant borrowing (Baird and Thomas 1985: 231-232, cited in Lumpkin and Dess 1996).

Entrepreneurs generally accept that entrepreneurship involves risk-taking and are willing to take risks in return for potential rewards. Arguably, when possible, entrepreneurs would prefer to lower the risk aspect of the risk-return equation. As the SBIR program provides funds to explore technologies and develop prototypes, by its very nature, the SBIR program helps lower exposure to financial risks. Therefore,

> P4: There is an inverse relationship between the risk component of entrepreneurial orientation and willingness to participate in a government program that supports technology development.

Competitive Aggressiveness

Competitive aggressiveness relates to a firm's willingness to challenge its market rivals directly in order to gain market share (Lumpkin and Dess 1996). Lumpkin and Dess (2001) found that competitive aggressiveness was more helpful to firms in later stages of industry development than in earlier stages. As technology entrepreneurs that would participate in SBIR programs tend to be earlier-stage ventures, it is difficult to formulate a proposition for the relationships between competitive aggressiveness and participation in government programs that support technology development for start-up ventures. However, for more mature technology development firms, it is possible that there may be a direct relationship between their competitive aggressiveness component of their entrepreneurial orientation and willingness to participate in programs that support technology development as their programs may provide a competitive advantage. Therefore,

> P5A: There is no significant relationship between the competitive aggressiveness component of entrepreneurial orientation for a start-up technology entrepreneur and willingness to participate in a government program that supports technology development.

P5B: There is a positive relationship between the competitive aggressiveness component of entrepreneurial orientation for a mature technology entrepreneur and willingness to participate in a government program that supports technology development.

ENVIRONMENTAL FACTORS

Lumpkin and Dess (1996) identified four key environmental characteristics or groups of characteristics in their model: munificence, dynamism, complexity, and industry characteristics. The first three items, dynamism, munificence, and complexity, were identified by Dess and Beard (1984) as a refinement of Aldrich's (1979) six environmental dimensions. These dimensions have been used extensively in the management literature to describe the environment within which firms must operate, and have been validated many times (c.f., Rasheed and Prescott 1992). The fourth group, industry characteristics, appears to be a catch-all category for the other environmental characteristics. Perhaps, the most important of these, is competitiveness. Lumpkin and Dess (1996) posit that environmental factors such as munificence, dynamism, and complexity can moderate business performance (see figure 1).

Munificence

As the availability of resources can affect the potential success or failure of a firm, the scarcity or abundance of critical resources is important to the firm. Munificence or environmental munificence relates to the availability of the critical resources (see Castrogiovanni 1991 for a review on environmental munificence) and the capacity of the environment to permit organizational growth (Aldrich 1979; Wiersema and Bantel 1993). When an environment is munificent, the critical resources are abundant or bountiful. When the environment is not munificent, there is a scarcity of critical resources that can cause organizational stress and which can threaten survival (Wiersema and Bantel 1993).

Although programs such as the SBIR program are designed to help individual firms develop and commercialize technologies, the impact of these programs tends to be on the firm's resources rather than on the industry as a whole. There are, however, situations where, if the industry or industry sector is defined narrowly enough, government technology development programs could have positive impacts on the environment itself. This is especially true in the defense sector. As an example, an SBIR office in one of the branches of the armed forces could issue topic calls for a specific weapons system technology. While this might have an impact on the specific technology, in general, it would not have a significant impact on the military industrial complex in the larger context. If the technology is considered in a narrower context, e.g., a specific weapons technology, the topic calls may actually create a market that might not have otherwise existed. The developmental funding for the technology and the associated support of the sponsoring agency could diminish the scarcity of critical resources, making the environment more munificent. In turn, this would increase the probability that a firm would participate in the SBIR program and start or continue R&D efforts on a new technology. Therefore,

P6A: There is a positive relationship between a government program that supports technology development and munificence if the industry is tightly defined.

P6B: There is a positive relationship between R&D efforts for a new technology if the environment is munificent.

P6C: There is no significant relationship between a government program that supports technology development and munificence if the industry is broadly defined.

P6D: A technology entrepreneur is more likely to develop a technology if the environment is perceived to be munificent.

Dynamism

Dynamism refers to the rate of change or the unpredictable nature of environmental change inherent to the industry within which a firm operates (Duncan 1972; Miller and Friesen 1983). Technological entrepreneurs operate in a very dynamic environment. It is conceptually possible that the development and commercialization of a new technology, especially a more radical innovation that might change the architecture of an industry, could increase the dynamism of a particular industry. It is also possible that, if the innovation is a continuous rather than a radical innovation, one that makes smaller improvements but does not change the architecture, it could have little or no impact on the industry. Therefore,

P7A: There is a positive relationship between a government program that supports technology development and environmental dynamism if the innovation is radical in nature.

P7B: There is no significant relationship between a government program that supports technology development and environmental dynamism if the innovation is continuous in nature.

P7C: A technology entrepreneur is more likely to pursue the development of a radical innovation if the environment is perceived to be dynamic.

Complexity

Environmental complexity relates to the range, variety, and heterogeneity of environmental factors involved in strategic decision-making (Aldrich 1979; Child 1972; Palmer and Wiseman 1999; Wiesema and Bantel 1993). In essence, it involves the complex knowledge and understanding required to succeed in business. Sharman and Dean (1991) reconceptualize and expand environmental complexity to include other factors such as technical intricacy, product diversity, and product complexity. Although complexity is a key environmental factor, we do not see the conceptual linkage between participation in government technology programs and environmental complexity. Therefore, we do not develop propositions for complexity.

Industry Characteristics: Competitiveness

As mentioned earlier, this is a global category, containing many possible aspects of the industry including industry type, industry location, industry structure, and the competitive nature of the industry. Contingency theory would suggest that the interaction between these industry characteristics and a program such as SBIR will be contingent upon congruence and fit of the characteristics. There is a reciprocal causality where structure affects strategy and strategy affects structure (see Miller 1988).

One of the industry characteristics, competition, may be related to a technology development program, such as SBIR. One of the explicit goals of the SBIR program is to develop alternative sources of supply in order to enhance competition, therefore, we postulate:

P8A: There is a positive relationship a government program that supports technology development and competition in an industry if the industry is tightly defined.

P8B: A technology entrepreneur is more likely to develop a technology if the competitive environment is perceived to be open.

ORGANIZATIONAL FACTORS

The resource-based-view of the firm holds that differing firm resources give rise to varying strategies and, subsequently, to performance differences (Barney 1991; Porter 1991; Wernerfelt 1984). Technological entrepreneurs are often resource poor, limiting degrees of freedom in organizational structure and strategy formation. Government programs such as the SBIR in the United States, such as the Commercial Ready program in Australia, or Malaysia's Multimedia Super Corridor can provide critical resources to technological entrepreneurs. In turn, the enhanced resources can potentially impact the firm's size, structure, strategic capabilities, and culture.

Continuing with the SBIR program as an exemplar, though many firms may apply for an SBIR grant, a large percentage of the firms that answer a topic call are not successful. In addition, some of the firms that are awarded a grant may elect not to participate in the programs. For example, the focus of the firm may have changed since it applied for the grant, the firm may have gone out of business, or the opportunity costs may be perceived to be too high. Actual participation in the SBIR program, however, potentially can influence the firm's resources and other organizational factors such as size and structure of the organization, its strategies and strategy-making processes, and organizational culture. An in-depth analysis of each of the organizational factors is outside of the scope of this paper. Although it is conceptually possible that participation in the SBIR program could directly impact size, structure, strategy, strategy-making processes, culture, and top management team characteristics, we posit that it is an indirect effect (see figure 2). In essence, the additional financial resources will have a mediating effect on other organizational characteristics. By providing technology entrepreneurs with addition financial resources to explore and develop technology, especially through larger Phase II grants of up to $1 million, it potentially allows the firm to acquire other resources, including hiring new people. Therefore,

P9A: There is a positive direct relationship between participation in a government program that supports technology development and firm resources.

P9B: There is a positive indirect relationship between participation in a government program that supports technology development and firm size.

In addition to providing resources, success in applying for technology development grants and participating in the application process could interact with the firm's strategy making processes, organizational structure, culture and top management team. In order to be successful in the grant process, a firm may need to make a significant investment in proposal writing, i.e., hiring people who have the necessary skills and creating a separate functional unit. In some cases, this may change the firm's strategy and positioning so it becomes a research firm that generates most of its revenue from research grants rather than a research firm focused on commercialization of technology. In other words, research firms are more likely to participate in a technology development program and participating firms might gradually learn to specialize in winning research grants as opposed to commercializing the technology they develop. The firm's structure, culture and organizational identity could remain firmly rooted in the sphere of research as opposed to commercialization.

P9C: There is a positive relationship between participation in a government program that supports technology development and specialization in research.

P9D: There is a positive relationship between participation in a government program that supports technology development and holding an organizational identity as a research firm.

Earning revenue from research grants means that the firm's employees are likely to be mainly scientists or engineers with little marketing experience. The top management team may not expand to include individuals with expertise in functions associated with commercialization, such as manufacturing, marketing and distribution.

P9E: There is a positive relationship between participation in a government program that supports technology development and having research as opposed to commercialization functions and expertise.

This reciprocal relationship between research specialization and participation in the technology development program creates the necessity for programs like the SBIR to identify their top priority: development of new technology or commercialization of that technology. Currently SBIR may have chosen commercialization as their top priority since the SBIR now requires firms applying for a Phase 1 award to submit a Commercialization Report describing their previous awards and track record for commercialization. This implies that the SBIR might be less likely to grant a Phase 1 award to a firm who has received awards in the past but has not commercialized the technology. This could screen out some of their most productive research firms.

In contrast, if SBIR's top objective were development of new technology, other commercialization strategies could be encouraged, such as licensing the technology to a large firm with strengths in commercialization or spinning off a separate company to commercialize the technology. These strategies could be more successful than relying upon the small firm to commercialize, since gathering the resources needed for commercialization could be beyond the capabilities and interests of the top management of these small research-orientated firms. Therefore programs like the SBIR might better achieve both objectives of technology development and commercialization by allowing small firms to become serial award winners, as long as the firms make other arrangements for commercialization.

PERFORMANCE

The Lumpkin and Dess (1996) model identifies several performance measures including sales growth, market share, profitability, overall performance, and stakeholder satisfaction. While traditional measures of success, e.g., ROI, ROE, ROA, or market share, can be used for older established firms, they may not be appropriate or adequate for entrepreneurial firms. Emerging businesses are fundamentally different from established firms: many emerging businesses are private and not required to disclose financial information; some measures, such as growth rates on a small base are misleading and erratic; and new firms may not yet have reached break-even (see Chandler and Hanks 1993, for a more complete discussion of entrepreneurial performance measures).

Failure rates for technology entrepreneurs are high (Timmons and Spinelli 2004). Given this high mortality of emerging businesses, survival is a key measure. We believe that survival is a key performance metric for technology entrepreneurs and explicitly add it as a performance measure of the revised model (see figure 2). We also believe that participation in technology development programs will enhance the probability of survival for start-up technology entrepreneurs. Therefore,

> P10: The survival rate for start-up technology entrepreneurs that participate in a government program that supports technology development will be higher than for start-up technology firms that do not participate in the program.

Commercialization of technology, whether it is directly by the firm or through licensing, is extremely important for a technology entrepreneur. Commercialization creates the revenue stream technology firms need to survive and prosper. Technology transfer, the use of the technology for a different application or user, also has the potential to create revenue. For these reasons, commercialization and technology transfer are explicitly added as performance measures in the revised model. Therefore,

> P11: The rate of commercialization for start-up technology entrepreneurs that participate in a government program that supports technology development will be higher than for start-up technology firms that do not participate in the program.

> P12: The rate of technology transfer for start-up technology entrepreneurs that participate in a government program that supports technology development will be higher than for start-up technology firms that do not participate in the program.

These dynamic small entrepreneurial firms merge and change with amazing speed. The SBIR program also does not provide any award for achieving the final Phase 3, which is commercialization of the technology through sales to military or commercial customers. It is quite likely that some firms successfully commercialize their technology, but fail to report this to the SBIR because there is no reward for doing so. Also, since the SBIR is focused upon small business success, commercialization of the technology by a larger firm may not be considered success by the small firm or the SBIR. Therefore, measuring firm performance in a program like SBIR will be very difficult.

FUTURE RESEARCH DIRECTIONS

This article is propositional in nature. It is also the basis for on-going empirical work, designed to test the conceptual model presented. In addition it is intended to provide a foundation for researchers to explore other technology development programs, both in the United States and in other countries. The focus on this paper has been to examine the role that SBIR might play in assisting technological development, specifically in researching new technologies, developing prototypes, and commercializing the sponsored innovations. It would be interesting to explore the role that technology transfer programs might have in commercializing products. In particular, it would be interesting to explore ways in which these technology transfer programs might facilitate commercialization of technologies developed for military uses to nonmilitary commercial applications.

The area leaves significant room for exploration. For example, it might be particularly interesting to learn how informal programs or social initiatives may play a similar role in countries where government programs of this magnitude are not available. For example, it would be interesting to explore the role that quasi-government programs, such as technology parks, might play in helping commercialize technology. It would also be interesting to explore the role government programs play in more directed economies.

The authors anticipate that testing such a theoretical model will require several studies to address the various variables that range from the personal to the organizational and even industry levels of analysis. In addition to a cross-sectional approach, such a research program might require a longitudinal approach to tease out the entrepreneurial processes involved.

CONCLUSIONS

Technology entrepreneurs are often idea rich but resource poor. Government programs such as SBIR can provide resources, which will help technology entrepreneurs develop and commercialize technology. Using a model developed by Lumpkin and Dess (1996), this paper explores relationships between SBIR and entrepreneurial orientation, environmental factors, organizational factors, and firm performance. A series of propositions are developed which shows the direct relationships between SBIR and entrepreneurial orientations. Programs like the SBIR may play a role in shaping the environment. The relationship between SBIR and most organizational factors are indirect, with firm resources operating as a mediating variable. In addition, we explicitly add survival, commercialization, and technology transfer to the performance metrics of the model.

Finally, government programs in other countries can learn from the experience of the SBIR program. Technology development programs should take the capabilities and interests of the small firms into account when deciding whether their top priority is technology development or commercialization. Such programs could take a broader view of what constitutes commercialization success and encourage alternative forms of commercialization, such as licensing by large companies or facilitating the creation of spin-off commercialization companies. All such programs will have difficulties identifying and quantifying the benefits they provide to society, but they could provide incentives, such as free public relations, to reward firms that achieve the extremely difficult goal of commercialization and increase the number of firms reporting their success.

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