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Full Length Research Paper

The influence of entrepreneurial orientation on technology commercialization: The moderating roles of technological turbulence and integration

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Commercialization of new technologies within the new product development process helps firms streamline production, increase efficiency and revitalize industries. Technological entrepreneurs, as technology adopters and developers, play an important role in initiating, developing and commercializing the technologies in several fields. Accordingly, cultivating entrepreneurial orientation to enable such a technology commercialization process has become a key for firms. This study examined the effects of entrepreneurial orientation, technology integration and technological turbulence on technology commercialization from resource-based view and dynamic capability view. The findings suggested that entrepreneurial orientation is a mediator between learning capability, entrepreneurial resources and technology commercialization. Furthermore, the empirical evidence indicated that technological turbulence and technology integration moderate the influence of entrepreneurial orientation on technology commercialization. The results would be useful for academics and practitioners in understanding and guiding entrepreneurial firms in the new product development process.

Key words: Entrepreneurial orientation, learning capability, entrepreneurial resources, technological turbulence, technology integration, technology commercialization.

INTRODUCTION

With the ever intensive competition across industries, new product development has been increasingly viewed as a strategic weapon for businesses to maintain a long-term competitive edge. Commercialization of new technologies within the new product development process helps firms streamline production, increase efficiency and revitalize the industry life cycle (Zeng et al., 2010). Successful technology commercialization is important for survival in light of the quick changes in today's competitive markets (Zahra and Nielsen, 2002). As proposed by Kropp and Zolin (2005), technological entrepreneurs, as technology adopters and developers, play an important role in initiating, developing and commercializing the technologies in several fields such as biotechnology, technology, and the telecommunications industry. Accordingly, cultivating an entrepreneurial orientation to enable such a technology commercialization process has become a key for firms (Hindle and Yencken, 2004; Omar et al., 2010).

From a resource-based perspective, organizations are heterogeneous in relation to their resources and capabilities (Barney, 1991; Teece et al., 1997). The resources and capabilities determine its performance. Technology commercialization can be regarded as a performance outcome, because it improve new product development performance by moving technological advances into commercial products, processes, and services (Li et al., 2008; Wonglimpiyarat, 2009). The resource-based

Abbreviations: ITRI, Industrial Technology Research Institute; **SEM,** structural equation model; **R and D,** research and development.

perspective can provide a theoretical foundation for this study that differences in technology commercialization performance exist between firms possessing different entrepreneurial resources and learning capabilities.

Compared with resource-based theory with its emphasis on selecting appropriate resources, dynamic capabilities shed light on resource development and renewal (Teece et al., 1997). The concept of dynamic capabilities takes into account surrounding resources and thus complements the shortcomings of resource-based theory, which assumes that they simply exist (Teece, 2003). Valuable resources may not turn into performance spontaneously, but it needs factors which can drive resources to convert into performance (Hult et al., 2004). Dynamic capabilities consist of the structures and processes that constitute firm's abilities to reconfigure resources to match the requirements of the changing environment (Teece et al., 1997; Wang and Hsu, 2010). As suggested by Griffith et al. (2006), the reconfiguration of resources can be determined by a firm's entrepreneurial orientation. Entrepreneurial orientation encapsulates the firm-level processes, practices, and decision-making style to combine and convert resources into higher relative performance (Lumpkin and Dess, 1996).

Entrepreneurial firms have to recognize changes and to reconfigure firm-specific asset bases continuously to decrease the possibility of loses caused by risks. Dynamic capabilities denote the firm's ability to sense and seize opportunities, and hence reflect the entrepreneurial facet of management (Jantunen et al., 2005). Griffith et al. (2006) further argue that entrepreneurial orientation can be a catalyst to convert and reconfigure existing resources into performance. This logic implies that entrepreneurial orientation may play as a mediator in the relationship between resource, capabilities and performance. However, literature examining this mediating issue is scarce (Day and Reynolds, 2006). Accordingly, this study attempts to examine the research issue by adopting both resource-based view and dynamic capabilities view to investigate the relationships among learning capability, entrepreneurial resource, entrepreneurial orientation and technology commercialization.

The linkage between entrepreneurial orientation and performance is likely to hold across a variety of contexts (Hult et al., 2004). For example, Jeong et al. (2006) empirically state that internal and external variables can either facilitate or impede the effective implementation of a product development strategy. However, the connection between specific technological knowledge and commercial opportunity requires a fit between skills and circumstances (Vyakarnam and Handelberg, 2005). Firms have to deal with various types of organizational contingencies that can affect the effectiveness of product development efforts (Ward and Zhou, 2006). However, these previous studies failed to emphasize industry and competitive conditions; they also did not analyze how companies integrate their internal and external sources to enhance innovation and technology commercialization (Liu et al., 2010; Zahra and Nielsen, 2002). An environment perceived as highly technological turbulence or without technology integration presents a great challenge (Frishammar and Hörte, 2007; Zahra and Nielsen, 2002). If these contingency effects are ignored by entrepreneurial firm managers, firm performance will be substantially discounted. Therefore, this study attempts to address these gaps and proposes that technological turbulence and integration should work together with entrepreneurial orientation to impact technology commercialization.

This study aims to integrate the relevant constructs associated with technology commercialization into a comprehensive research model. The purpose of this study is to identify the antecedents of entrepreneurial orientation, including innovation capability and entrepreneurial resources, and identify the influence of entrepreneurial orientation on technology commercialization. In addition, the moderating roles of technological turbulence and technology integration on the relationship between entrepreneurial orientation and technology commercialization are also explored. Through a series of expert interviews and questionnaire surveys, the results provide solid theoretical platforms for academics to further their investigations regarding the issues surrounding technology commercialization. Practitioners will also find the results useful in terms of applying them to real world situations.

Theoretical background and hypothesis development

Technology commercialization

The increasing technological content of products accompanied by shorter life cycles and more intense competition has encouraged technology commercialization activities (Lichtenthaler and Ernst, 2007; Lin et al., 2006; Parker and Mainelli, 2001). Successful technology commercialization helps a firm cross the chasm that appears during the life cycle of technological implementtation and to solve problems induced by resource configuration difficulties associated with the transfer of sustained innovation to disruptive innovation (Li et al., 2008). The success of technology commercialization process is necessary to improve new product development performance by moving technological advances into commercial products, processes and services (Wonglimpiyarat, 2009). This process includes the commercialization of internally generated technology within the company and technology procured from external sources such as other companies, federal laboratories and academic institutions.

The willingness of firms to engage in the process of invention commercialization is influenced by expectations

about the returns that they will capture from commercialization if they are successful (Nerkar and Shane, 2007). Technology commercialization is defined as the competence to use technologies in improving existing products, getting products to market in a timely manner, and incorporating a greater breadth of technologies in products (Lee, 2009; Wonglimpiyarat, 2007; Wonglimpiyarat, 2009). Technology commercialization includes process of acquiring ideas, augmenting them with complementary knowledge, developing and manufacturing saleable goods, and selling the goods in a market (Lockett and Wright, 2005).

Commercialization of product technology increases the likelihood of delays in the completion of new product development projects (Chryssochoidis and Wong, 2000). Consequently, development and commercialization of new technologies has become a focal activity and a force to be reckoned with (Kumar and Jain, 2003). Furthermore, Li et al. (2008) further propose that technology commercialization is the technology transfer and value creation process based on technological innovation. When the source of technological knowledge is external, technology commercialization can be realized by means of contracts, agreements, technology licensing, or strategic alliances. In order to investigate the influence of entrepreneurial orientation in the new product development process, this study follows Wonglimpiyarat's (2007,2009) concept and defines technology commercialization as a firm's competence to commercialize technological knowledge in terms of bringing internal and external technological capabilities and research and development (R and D) results to the marketplace.

Entrepreneurial orientation

Entrepreneurial orientation has long been recognized as the key for innovative activities, since a dynamic environment necessitates that entrepreneurs integrate resources as well as cope with discontinuities. Entrepreneurial orientation is defined as a firm's processes, practices and decision-making activities, by which the firm embarks on proactive and aggressive initiatives to alter the competitive scene to its advantage (Atuahene-Gima and Ko, 2001; Zhou et al., 2005). Entrepreneurial orientation represents a series of processes, methods, styles, practices and decision making activities that support entrepreneurial opportunities (Kropp and Zolin, 2005; Lumpkin and Dess, 1996; Lumpkin and Dess, 2001). A firm with entrepreneurial value would not only help a stagnant firm that requires transformation, but also facilitate the renewal or creation of a new business. Entrepreneurial orientation is composed of three elements: risk taking, innovativeness and proactiveness (Miller, 1983). Innovativeness is defined as the tendency for a firm to support the staff to create new ideas, experiment with new procedures, renew technological processes, improve existing products and develop new methods (Covin and Miles, 1999; Lumpkin and Dess, 1996). Innovativeness resembles culture, climate or orientation and may occur along a continuum rather than as an outcome (Frishammar and Hörte, 2007).

Proactiveness refers to seeking new opportunities, which may or may not be related to the current operation (Venkatraman, 1989). A proactive firm is always forward-looking, and thus takes advantage of being the first mover in a competitive environment. Risk-taking refers to firms that make large and risky commitments, and to those that accept risk as a potential outcome for costly failure (Coulthard, 2007). These risks occur along a continuum ranging from relatively easy to calculate and manage to very difficult. Lumpkin and Dess (1996) further extend the concept of entrepreneurial orientation by adding autonomy and competitive aggressiveness. Autonomy is concerned with granting freedom to individuals to exercise their creativity in bringing about an idea (Coulthard, 2007). Competitive aggressiveness refers to a firm's efforts to take every opportunity to outperform competitors (Lumpkin and Dess, 1997). In order to provide a comprehensive view of entrepreneurial orientation, this study integrates five components of entrepreneurial orientation into research framework, including innovativeness, risk taking, proactiveness, competitive aggressiveness and autonomy.

An entrepreneurial firm has to develop and commercialize a technology to survive in competitive environments (Kropp and Zolin, 2005). Even though technology commercialization creates the revenue stream for firms, it is characterized by higher-risk processes and extremely uncertain outcomes (Li et al., 2008; Liu, 1998). Through technology commercialization, entrepreneurial firms undertake greater risks by means of using technologies in products across a wider range of markets and getting products to market faster (Wonglimpiyarat, 2010). Entrepreneurial orientation serves as key mechanism while recognizing the opportunity for technology commercialization since it represents a firm's creative experimentation, proactive discoveries, change anticipation and tolerance of the unknown. According to Lumpkin and Dess (1996), entrepreneurial orientation emphasizes the spirit of creating new things out of traditional rules and rejuvenating stagnant companies. Frishammar and Hörte (2007) indicate that an entrepreneurial firm is often the one to come up with new products, and to introduce new products ahead of the competition. Furthermore, Li et al. (2008) argue that firms with greater entrepreneurial orientation will place more emphases on technology commercialization. As proposed by Lumpkin and Dess (1996), firms adhering to an entrepreneurial orientation focus on grasping new market opportunities and proactively competing with their rivals, thus undertaking greater risks. Accordingly, this study proposes that, entrepreneurial orientation cultivates a firm's culture,

which allows the firm to generate tacit and intangible skills for technology commercialization within the new product development process. Based on the above discussion, the following hypothesis is proposed.

H_1: Higher levels of entrepreneurial orientation will result in higher levels of technology commercialization.

The antecedents of entrepreneurial orientation

Organizational resources include human, tangible, and intangible resources (Grant, 1998). The human resource is usually composed of knowledge, expertise and skills of a firm's personnel. The tangible resources are something physical including assets and equipments, while intangible resources are non-physical entities, such as management capabilities and the intellectual properties. Human resource focuses on developing human capital, such as how a firm select, recruit, and train people. According to resource-based theory, a firm's competitive advantage comes from the possession and development of valuable resources. The characteristics of the resource, including valuable, rare, inimitable, or non-substitutable, determine the firm's ability to survive. Entrepreneurial resources is valuable resources, since those resources help a manager lay out possible paths as well as choose one (Mosakowski, 1998). Based on this vein, the entrepreneurial process is one in which the entrepreneurs acquire and develop resources, and where the outcome is to a large extent determined by the nature of the resources the entrepreneurs are able to acquire (Aspelund et al., 2005). Entrepreneurial activities revolve around sanctions and resource commitments for the purpose of innovative results (Zahra and Covin, 2000). Since this study endorses the resource-based view on entrepreneur firms, this study adopts Grant's (1998) concept and includes human, tangible, and intangible resources as entrepreneur firm's resources.

However, this study adopts learning capability instead of human resource. The reasons are as follows. On one hand, this study sheds light on how an entrepreneurial firm transforms resources into competencies in the new product development process rather than organization's operational routine. Learning capability provides a more dynamic view of entrepreneurial process than human resource with a more static status. On the other hand, learning from positive as well as negative experiences is essential for successful entrepreneurial behavior (Krauss et al., 2005). A firm's learning capability which comes from personnel plays an important role for an entrepreneur firm (Jerez-Gómez et al., 2005). Thus, this study adopts learning capability and entrepreneurial resources as two critical antecedents of entrepreneurial orientation to represents the capabilities and resources that entrepreneur firms possess. Entrepreneurial resources are limited to the tangible and intangible resource that entrepreneur firms provide, while learning capability comes from the accumulation of firms' experience and ability.

Learning capability and entrepreneurial orientation

Kloot (1997) states that, organizational learning is the process by which firms can detect problems and provide solutions. A firm's learning capability can be defined as the capability of an organizational to process knowledge, which includes the creation, acquisition, transfer, and integration of knowledge to modify its behavior and improve its performance (Jerez-Gómez et al., 2005). Learning capability has been broadly viewed as the development of new knowledge or insights that have the potential to influence behavior through the values and beliefs that exist within the culture of the organization (Huber, 1991; Nonaka and Takeishi, 1995). This learning capability helps firms develop more adequate mental models and make more successful decisions (Krauss et al., 2005), since firms with learning capabilities tend to acquire diverse information and generating new knowledge or organizational insights. Furthermore, Kropp and Zolin (2005) propose that learning enables the firm to target and enter new markets, since it plays a major role in opportunity recognition by creating, acquiring and transferring knowledge. Morris et al. (2007) state that, learning capable firms associated with fulfilling unmet customer needs and getting ahead of competitors in terms of emphasizing opportunity identification, proactive behavior and innovativeness. It is suggested that a firm with higher levels of learning capability tends to be entrepreneurial-oriented. Therefore, based on the above discussion, the following hypothesis is suggested.

H_2: Higher levels of learning capability will result in higher levels of entrepreneurial orientation.

Entrepreneurial resources and entrepreneurial orientation

The resourcefulness of the entrepreneurial firm facilitates the acquisition and access to customers in turn facilitates smoother implementation of the business idea (Ramachandran and Ray, 2006). Resources are stocks of assets controlled by the firm and can be tangible or intangible (Davis and Sun, 2006). Entrepreneur resources include an entrepreneur firms' resources and abilities (Wu, 2007). Entrepreneurial resources are defined as stocks of production factors or assets controlled by the firm to behave creatively, act with foresight, use intuition, and be alert to new opportunities (Mosakowski, 1998). Firms with entrepreneurial resources employ resources for particular problems, activities, and ideas. Zhou (2007) maintains that

entrepreneurial firms leverage their resources to achieve superior performance in international markets. Entrepreneurial resources reflect the tendency of an entrepreneur to engage the environment in a given way (Mosakowski, 1998). Because entrepreneurial resources act as production factors for creativity, foresight and intuition, they are likely to dictate the most efficient ways that entrepreneurial orientation can be promoted (Mosakowski, 1998). Furthermore, the commercialization of technologies requires firms to provide new infrastructure and resources (Powell, 2010). When entrepreneur firms have sufficient resources to realign and reconfigure their strategy, they are more capable to take risk, compete aggressively and move swiftly from one domain to another based on the demands of the changing product markets. Therefore, an entrepreneur firm with rich resources is likely to use the abundance of the entrepreneur's resources to assess the likelihood of future reciprocity. Following the rational evaluation, they should have more willingness to take risks and anticipate changes. Based on the above discussion, the following hypothesis is proposed.

H_3: Richer entrepreneurial resources will lead to higher levels of entrepreneurial orientation.

Technological turbulence, entrepreneurial orientation and technology commercialization

Contingency theory asserts that a firm's strategy or structure will not be equally effective under different environmental or firm-specific conditions. In other words, there is no "best" strategy or structure for all firms. According to contingency theory, the environment is a key contingent variable that affects how entrepreneurial orientation functions in terms of driving a firm's technology commercialization (Li et al., 2008; Lumpkin and Dess, 1996). From a contingency perspective, the utility of an entrepreneurial orientation remains questionable if the firm and its management do not understand the key technological contingencies that can significantly influence the effective implementation of new product development strategies. Gans and Stern (2003) propose that effective technology commercialization strategy entrepreneurs implement results based on interaction with environments. The context-specific changes not only affect an entrepreneur's respective competitive positions, but also reshape the competitive landscape, and accompanying new opportunities and threats (Calantone et al., 2003; Frishammar and Hörte, 2007; Li et al., 2009b; Lumpkin and Dess, 1996; Wang, 2008).

A firm's performance is not only determined by its strategic planning, but also by the environment it is faced with (Zaheer et al., 2010). Accordingly, the technological environment impacts a firm's strategy regarding how to cope with uncertainties for survival (Jeong et al., 2006). Technological turbulence is defined as the rate of technological advances as experienced by firms within an industry (Frishammar and Hörte, 2007; Zhou et al., 2005). An environment with a high level of technological turbulence has shorter product life cycles. On the one hand, a firm with technological advances can remain competitive and make profits by taking advantage of altered components of the existing value chain. On the other hand, however, intense competition also erodes the competitive advantage of even well-entrenched firms, once they cannot adapt new strategies any faster. Several previous studies have identified the components of technological turbulence (Jeong et al., 2006; Song et al., 2008; Zhou, 2007). Among others, demand uncertainty, competitive intensity and product newness are critical, and thus selected for this study to investigate the moderating role of technological turbulence. Demand uncertainty refers to the instability of consumer preferences and expectations (Jeong et al., 2006; Zhou et al., 2005). Competitive intensity is defined as the degree of competition that a firm faces within its industry (Frishammar and Hörte, 2007; Li et al., 2009a; Zhou et al., 2005). Product newness for customers is defined as the extent to which new products produced by a firm are compatible with the experiences and consumption patterns of potential customers (Atuahene-Gima, 1995).

Kropp et al. (2006) propose that environmental factors may influence the relationship between entrepreneurial dimensions and performance. Technological turbulence refers to the rapid change of technological advances within an industry (Zhou et al., 2005). According to Lumpkin and Dess (1996), the influence of entrepreneurial orientation on performance relationship is contingent upon environmental factors, such as demand uncertainty, competitive intensity, and product newness. Due to changing customers or changing preferences among customers, a firm has to predict and follow what customers want by creating buying incentives. Demand uncertainty implies that firms had to predict customers' needs. Hostile environments are characterized by intense competition.

A low level of competitive intensity is characterized by a consumer's loyalty to a focal product, while a high level of competitive intensity is characterized by a consumer with many options that satisfy their needs. In an environment with intense competition, a firm has to add more services for customers and increase its advertising budget. If technology turbulence is high, in terms of demand uncertainty and competitive intensely, environment is unstable and identification of consumers' changing needs becomes increasingly difficult, and incremental innovations are unlikely to satisfy them (Zhou et al., 2005). An entrepreneurial orientation suggests that organizations are more risk-taking, innovative, proactive, autonomous, and aggressive, so that the firm is more willing to exploit the dynamics of their macro and task environments (Calantone et al., 2003; Frishammar and

Hörte, 2007). Accordingly, a firm with higher levels of entrepreneurial orientation decreases the negative influence of demand uncertainty and competitive intensity on technology commercialization.

Jeong et al. (2006) argue that turbulent environmental settings force a firm to facilitate the gathering and processing of information for superior responsiveness. Since launching new products is inevitably accompanied by uncertainty and precariousness, a firm has to learn from experience or change its behavior (Frishammar and Hörte, 2007). Product newness reveals a firm's need to both understand the preferences of existing customers and find out the consumption patterns of potential customers. An entrepreneur firm producing new products that are compatible with customers' experiences and consumption patterns tends to control the turbulences in the changing environment. Therefore, if firms can provide newly product which satisfy customers' needs with higher levels of entrepreneurial orientation, technology commercialization can be realized. Based on the above, the following hypothesis is suggested:

H_4: Technological turbulence will serve as a moderating variable on the relationship between entrepreneurial orientation and technology commercialization. Demand uncertainty and competitive intensity tend to attenuate the influence of entrepreneurial orientation on technology commercialization, while product newness tends to accentuate the influence of entrepreneurial orientation on technology commercialization.

Technology integration, entrepreneurial orientation and technology commercialization

Integration is the process by which the firm coordinates and deploys its resources among different functional departments (Grant, 1991). Technology integration refers to the process of managing the acquisition and incorporation of technology (Stock and Tatikonda, 2008). Technology integration improves coordination among the various groups involved in the new product development process, because it increases interaction between members and encourages them to solve problems jointly (Zahra and Nielsen, 2002). Technology integration also helps firms to combine internal and external technology through communication and systems integration. Integration improves coordination among the various groups involved in the technology commercialization process (Zahra and Nielsen, 2002).

When the integration of technology is high, a firm can properly align different internal and external resources (Kahn, 1996). According to Iansiti (1995), technology integration also can improve learning and makes the overlapping of the different internal and external resources within technology commercialization possible. When an entrepreneurial firm has high levels of technology integration, group interaction, joint problem solving activities, and cross-learning will be encouraged. Furthermore, employees are allowed and given authority to aggressively and proactively develop ideas for new products using existing and untapped capabilities for technology commercialization. Therefore, it is suggested that when the firm has high levels of technology integration; its employees will be more capable of new product development in ways that differentiate its strategies from those of the competition. Based on the above discussion, the following hypothesis is suggested:

H_5: Technology integration will serve as a moderating variable on the relationship between entrepreneurial orientation and technology commercialization. Accordingly, technology integration tends to accentuate the influence of entrepreneurial orientation on technology commercialization.

RESEARCH DESIGN AND METHODOLOGY

Key factors affecting the technology commercialization as derived from previous studies as well as the hypotheses developed previously constitute the foundation of the research model for this study. Figure 1 illustrates how these factors and hypotheses are integrated to form the base for further empirical validations.

Questionnaire design

As illustrated above, six major constructs are included in this study: learning capability, entrepreneurial orientation, entrepreneurial resources, technological turbulence, technology integration, and technology commercialization. A preliminary version of the questionnaire was designed by the author. Principally, questionnaire items developed by previous studies were adopted in this study, following a process of content validity confirmation. Two panel discussions were conducted to identify the content validity of the research questionnaire items. The first panel discussion consisted of three professors from National Cheng Kung University and two experts, who are senior project managers of new product development projects. The second panel discussion consisted of one professor and 8 Ph.D. students. The questionnaire was pre-tested through a pilot study. Questionnaire items were modified based upon the results of the pilot study before being put into the final form. Eventually, a 42-item survey questionnaire was developed. Detailed questionnaire items are shown in the appendix.

Sampling plan and data collection

Data were collected via a questionnaire survey. Since this study explores the influence of entrepreneurial orientation on technology commercialization within the new product development process, a sampling plan was developed to ensure that relevant firms were included. Due to the risks followed with entrepreneurial process, many governments establish incubators centers to help firms exploit and commercialize the technological opportunities. Incubators centers assistance firms by providing its tenants with a nurturing environment and a range of administrative, consulting, and networking services (Wonglimpiyarat, 2010). This study utilized survey data from technology commercialization projects in the new product development process conducted by the Technology Transfer and Service Center of the Industrial Technology Research Institute (ITRI), the Small and Medium Enterprise Incubation Center

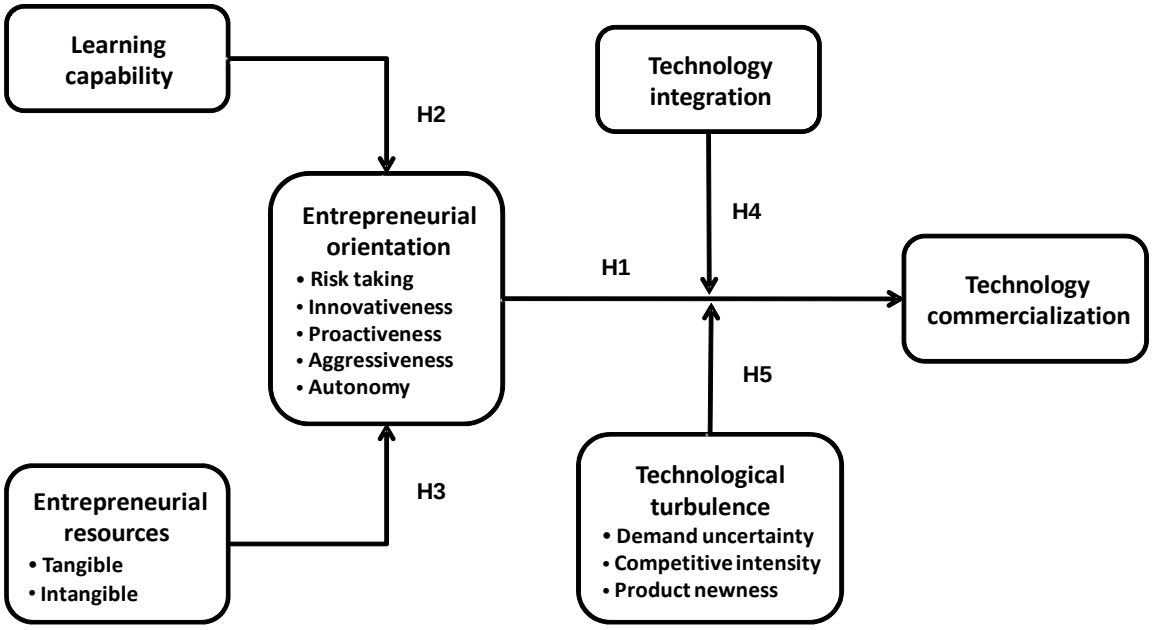

Figure 1. The research framework of this study.

and 12 other Incubation Centers related to universities in Taiwan.

In the beginning stage of selecting samples from the population, personal interviews were conducted with the Director of the Technology and Service Center of the ITRI to gain permission to interview or distribute questionnaire surveys to the project managers of new product development and technology incubation projects. Personal interviews were then conducted to obtain responses about the research constructs from new product development project managers. Similar processes were followed at the Small and Medium Enterprise Incubation Center and the 12 other university Incubation Centers to get responses from new product development managers.

Data were collected over a three month period from the beginning of April, 2008 to the end of June, 2008. A quota sampling method was adopted to select survey samples. Based on the population, 300 project managers were selected as the sample for this study. The respondents were asked to indicate their perceptions regarding a specific new product development project and commercialization case implemented between 1997 and 2007. Due to the limitation of time, parts of the questionnaires were sent through the mail. However, telephone contact was made before sending the questionnaires to specific managers. After two waves of telephone follow ups (double confirmed with sampled firms for the assigned participants), 120 questionnaires were returned, with nine incomplete questionnaires. Thus, 111 questionnaires were usable, resulting in a response rate of 37%. Those 111 usable questionnaires include information of 52 projects, where opinions of 37 projects are obtained from personal interviews conducted by the author and opinions of 15 projects are obtained from the mailed survey.

A detailed list is shown in Table 1. Responses indicated that approximately 49% of the respondents were between 36 and 45 years of age. When examining educational background, it is of interest to note that about 68% of the respondents had graduate degrees. Finally, more than 52% of the respondents had more than 10 years of working experience. Approximately 98% of the companies are with less than five years of history and 81% of the companies belonged to high technology industry. Nearly 87% of the firms had less than 50 employees. More than 61% of the firms operated on a comparatively small scale, with revenues of less than 6 million ($6, 000000).

Since this study collected data from a single respondent within each responding firm, two tests were conducted to check the validity of the survey data. First, according to Harman's one-factor test (1967), if common method bias exists, (1) a single factor will emerge from a factor analysis of all surveyed items, or (2) one general factor accounting for most of the common variance that exists will emerge (Podsakoff and Organ, 1986; Podsakoff et al., 2003). The test yielded 13 factors with eigenvalues greater than 1, and no single factor was dominant, indicating that common method variance was not a significant problem. Secondly, as suggested by Armstrong and Overton (1977), we compared early and late respondents to assess non-response bias. A series of *t*-tests were run to test for differences in terms of the construct measures and various demographic variables. No significant factor score differences were found between the early respondents and later respondents in our preliminary analysis.

RESEARCH ANALYSIS AND RESULTS

Reliability and validity

To ensure the reliability and validity of the measurement system, multi-item scales are designed for each research construct in this model. Validated seven-point Likert-type scales ranging from “1 = very little extent” to “7 = very large extent” are employed. A principal component factor analysis with varimax rotation method is used to extract relevant factors with an eigenvalue of greater than 1. Two essential criteria when examining factor loadings are that each loading must be greater than 0.7, and the differences in item loadings between factors must be greater than 0.3 to ensure convergent and divergent

Table 1. Sampling plan of this study.

Incubation center	Sampling frame	Sampling firms
Industrial technology research institute of Taiwan (ITRI)	581	155
Small and medium enterprise incubation center	277	45
National Cheng Kung University licensing and business incubation center	20	6
National Taiwan University innovation and incubation center	74	24
National Chiao Tung University innovation and incubation center	24	8
National Tsing Hua University innovation and incubation center	55	13
Yuan Ze University innovation and incubation center	28	4
Chinese Culture University innovation and incubation center	21	6
National Yang-Ming University innovation and incubation center	39	8
National Kaohsiung First University of Science and Technology incubation center	50	14
National Kaohsiung University of Applied Science incubation center	24	5
Fu Jen Catholic University college of management innovation and incubation center	27	3
National Taiwan University of Science and Technology incubation center	28	7
National Chengchi University innovation and incubation center	20	2
Total	1280	300

Table 2. Factor analysis for each construct in this study.

Research construct	Research item	Number of Items	Eigenvalues	Factor loadings	Cronbach's α
Learning capability	Learning capability	5	3.136	0.70-0.85	0.85
Entrepreneurial resources	Tangible resources	3	2.724	0.86-0.92	0.95
	Intangible resources	4	2.510	0.68-0.84	0.81
Entrepreneurial orientation	Risk taking	3	2.103	0.81-0.89	0.79
	Innovativeness	2	1.625	0.901	0.77
	Proactiveness	3	2.145	0.83-0.87	0.81
	Aggressiveness	3	2.020	0.78-0.84	0.76
	Autonomy	2	1.641	0.906	0.78
Technology integration	Technology integration	4	2.833	0.77-0.89	0.85
Technological turbulence	Demand uncertainty	2	1.609	0.897	0.76
	Competitive intensity	2	1.535	0.876	0.70
	Product newness	2	1.470	0.857	0.64
Technology commercialization	Technology commercialization	3	2.216	0.81-0.92	0.82

validity (Hair et al., 2010). In terms of the reliability analysis, the item-to-total correlation must be larger than 0.5 and Cronbach's coefficient alpha (α) must be larger than 0.6 (Hair et al., 2010). Table 2 presents the results of the factor analysis for each construct involved in this study. As all constructs in Table 2 meet the above criteria, the dimensionality, reliability and validity of the measures in the study are deemed acceptable. We feel confident stating that the factors for all constructs in this study are reliable and valid. In order to simplify the calculations, factor scores listed are the average scores of all useful items within each factor or construct.

Hypothesis testing

This study conducts multiple regression technique to examine the influence of learning capability,

Table 3. The influence of learning capability on entrepreneurial orientation.

Dependent variable \ Independent variable	Entrepreneurial orientation									
	Risk taking		Innovativeness		Proactiveness		Aggressiveness		Autonomy	
	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10
Control variable										
Type	0.057	0.039	0.120	0.107	0.192	0.179	-0.065	-0.078	0.041	0.039
History	-0.132	-0.195	0.091	0.045	0.196	0.147	0.065	0.015	-0.057	-0.068
Employees	0.020	0.068	-0.018	0.017	-0.174	-0.137	0.023	0.062	-0.074	0.066
Sales	-0.218	-0.226	-0.063	-0.069	0.086	0.080	-0.169	-0.175	0.127	0.126
Learning capability		0.461***		0.336***		0.360***		0.366***		0.078
R^2	0.057	0.267	0.025	0.137	0.038	0.165	0.037	0.169	0.021	0.027
Adj R^2	0.022	0.232	-0.012	0.095	0.001	0.126	0.001	0.130	-0.016	-0.019
F	1.611	7.635	0.676	3.321	1.040	4.165	1.023	4.284	0.580	0.593
p	0.177	0.000	0.610	0.000	0.390	0.002	0.399	0.001	0.678	0.705

***, The regression weights (standardized beta coefficients) are significant at the p<0.001 level; **, the regression weights (standardized beta coefficients) are significant at the p<0.01 level; *, the regression weights (standardized beta coefficients) are significant at the p<0.05 level.

entrepreneurial orientation on entrepreneurial orientation and the influence of entrepreneurial orientation. In addition, this study would like to investigate moderating roles of technology integration and technological turbulence on the relationship between entrepreneurial orientations on technology commercialization. Since entrepreneurial orientation is composed of five sub-dimensions, including risk-taking, innovativeness, proactivenss, competitive aggressiveness and autonomy, the research model is complex and it is hard to test the single relationship between the sub-dimensions by using structural equation model (SEM), that is, the relationship between tangible resources (sub-dimension of entrepreneurial resources) and risk taking (sub-dimension of entrepreneurial orientation). In addition, hierarchical regression analysis can be used to conduct moderating effects step by step (Cohen et al., 2003). Thus, this study uses hierarchical regression analysis rather than SEM. All regressions met the major model assumptions; that is, no serious violations were found in the plots of standardized residuals as compared to the predicted values, in the normal probability plots of standardized residuals, or with regard to the independence of error terms.

Table 3 indicates the influence of learning capability on entrepreneurial orientation. As shown in M2, M4, M8 and M10 of Table 4, learning capability has a significant effect on risk taking (β = 0.461, Adj-R^2 = 0.232, *F* = 7.635, *p*<0.000), innovativeness (β = 0.336, Adj-R^2 = 0.095, *F* = 3.321, *p*<0.000), proactiveness (β = 0.360, Adj-R^2 = 0.126, *F* = 4.165, *p*<0.002) and competitive aggressiveness (β = 0.366, Adj-R^2 = 0.130, *F* = 4.284, *p*<0.000). These results indicate that when firms have higher levels of learning capability, they tend to have higher levels of entrepreneurial orientation, including risk taking, innovativeness, proactiveness and competitive aggressiveness. However, learning capability does not have a significant influence on autonomy (β = 0.078, Adj-R^2 = -0.019, *F* = 0.593, *p*>0.705). The insignificance of autonomy may result from the following reasons. First, autonomy is concerned with granting individuals the freedom to exercise their creativity in bringing about an idea (Coulthard, 2007). However, autonomy may be limited by firm policies or the situations they face. Even though learning capability refers to the development of new knowledge or insights that potentially influence behavior through values and beliefs within the culture of the organization (Huber, 1991; Nonaka and Takeishi, 1995), employees may not have the autonomy to realize their ideas. The conversion from insights to granting freedoms depends not only on employees, but also on manager and firm policies. To sum up, the relationship between learning capability and autonomy is not proved in this study. Thus, hypothesis 2 is partially supported.

As shown in models M11, M13, M15, M17 and M19 of Table 4, tangible resources have significant effects on entrepreneurial orientation, including risk taking, innovativeness, proactiveness, competitive aggressiveness and autonomy (β= 0.429~ 0.587, Adj-R^2 = 0.171~0.336, *F* = 5.5553~12.136, *p*<0.000). The results indicate that the tangible resources to implement technology commercialization are associated with the levels of entrepreneurial orientation. In addition, as shown in models M12 M14, M16, M18, and M20 of Table 4, intangible resources have significant influences on entrepreneurial orientation, including risk taking, innovativeness, proactiveness, and competitive aggressiveness (β =0.562~ 0.696, Adj-R^2 = 0.302~0.455, *F* = 10.538~ 19.631, *p*<0.000), but not autonomy (β = 0.255, Adj-R^2 = 0.039, *F* = 1.882, *p*= 0.104). The results suggest that when entrepreneurial firms have more intangible resources, they are more

Table 4. The influence of entrepreneurial resources on entrepreneurial orientation.

Dependent variable \ Independent variable	Entrepreneurial orientation									
	Risk taking		Innovativeness		Proactiveness		Aggressiveness		Autonomy	
	M11	M12	M13	M14	M15	M16	M17	M18	M19	M20
Control variable										
Type	-0.027	-0.076	0.033	-0.034	0.114	0.069	-0.128	-0.198	-0.024	-0.015
History	-0.110	-0.112	0.114	0.113	0.216	0.214	0.082	0.084	-0.040	-0.049
Employees	-0.036	0.028	-0.075	-0.008	-0.226	-0.168	-0.019	0.032	-0.118	-0.071
Sales	-0.174	-0.149	-0.017	0.017	0.127	0.150	-0.136	-0.100	0.162	0.056
Entrepreneurial resources										
Tangible	0.567***		0.587***		0.527***		0.429***		0.442***	
Intangible		0.603***		0.696***		0.562***		0.604***		0.255*
R^2	0.366	0.398	0.356	0.480	0.304	0.334	0.214	0.380	0.209	0.082
Adj R^2	0.336	0.369	0.325	0.455	0.271	0.302	0.177	0.350	0.171	0.039
F	12.136	13.883	11.605	19.631	9.194	10.538	5.732	12.865	5.553	1.882
p	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.104

***, The regression weights (standardized beta coefficients) are significant at the p<0.001 level; **, the regression weights (standardized beta coefficients) are significant at the p<0.01 level; *, the regression weights (standardized beta coefficients) are significant at the p<0.05 level.

willing to take risks and be pioneers in new markets, leading to higher levels of entrepreneurial orientation. However, greater intangible resources do not have a significant effect on autonomy. Thus, hypothesis 3 is partially supported. According to Coulthard (2007), autonomy comes from the granted freedom for individuals to exercise their creativity. However, based on different organizational structures, not every entrepreneurial firm has the same authority to be autonomous. For example, a firm with many hierarchical levels may be controlled by the top managers or directors, giving rise to a lack of autonomy.

Table 5 illustrates the moderating roles of technological turbulence and technology integration on the relationship between entrepreneurial orientation and technology commercialization. As shown in model M22 on Table 5, entrepreneurial orientation has a significant and positive influence on technology commercialization (β =0.654, Adj-R^2 = 0.423, F = 16.279, p<0.000). The result suggests that, if firms have higher levels of entrepreneurial orientation, their performance on technology commercialization is also better. Accordingly, firms with entrepreneurial orientation are more willing to seize every entrepreneurial opportunity and transform pure technology into a new commercialized product. Therefore, it is important for firms to become entrepreneurially oriented to create products ahead of their competitors. Thus, hypothesis 1 is supported.

Table 5 also indicates the moderating effects of technological turbulence on the relationship between entrepreneurial orientation and technology commercialization. As shown in M23, M24, and M25 of the regression models, the moderating effects of technological turbulence, including demand uncertainty (A*B= -0.433, p<0.001), competitive intensity (A*C= -0.572, p<0.001), and product newness (A*D= 0.293, p<0.001), significantly impact the relationship between entrepreneurial orientation and technology commercialization. Thus, hypothesis 4 is supported. Since demand uncertainty and competitive intensity attenuate the influence of entrepreneurial orientation on technology commercialization, the interaction items have negative signs rather than positive ones. In order to clarify the moderating effects of technological turbulence, which influence the relationship between entrepreneurial orientation and technology commercialization, this study divides technology commercialization into four groups based on two levels of entrepreneurial orientation and two levels of technological turbulence using a K-means cluster analysis. These four groups are labeled: high entrepreneurial orientation with high technological turbulence, high entrepreneurial orientation with low technological turbulence, low entrepreneurial orientation with high technological turbulence, and low entrepreneurial orientation with low technological turbulence. The results are shown in Figure 2.

As shown in Figure 2a and b, if firms have higher levels of entrepreneurial orientation when their environment is in low demand due to uncertainty and competitive intensity, they tend to achieve a higher level of technology commercialization. This is consistent with the regression results, which exhibit interaction items with negative signs rather than positive ones. However, firms that have lower levels of entrepreneurial orientation while in a high demand environment due to uncertainty and competitive intensity tend to achieve a lower level of technology commercialization. As shown in Figure 2c, firms have

Table 5. The moderating role of technological turbulence and technology integration on technology commercialization.

Dependent variable \ Independent variable	Technology commercialization					
	M21	**M22**	**M23**	**M24**	**M25**	**M26**
Control variable						
Type	-0.042	-0.103	-0.015	0.030	-0.010	0.010
History	-0.061	-0.091	-0.055	-0.116	-0.085	-0.060
Employees	-0.012	0.032	0.015	0.052	0.042	0.002
Sales	-0.089	-0.061	-0.087	-0.109	-0.068	-0.055
Main effect						
Entrepreneurial orientation (A)		0.654***	0.526	0.391***	0.365***	0.371**
Technological turbulence						
Demand uncertainty (B)			-0.283***			
Competitive intensity (C)				-0.261***		
Product newness (D)					0.355***	
Technology integration (E)						0.266
Moderating effects						
A*B			-0.433***			
A*C				-0.572***		
A*D					0.293***	
A*E						0.389***
R^2	0.014	0.437	0.654	0.765	0.653	0.672
Adj R^2	-0.023	0.410	0.631	0.749	0.629	0.649
$\triangle R^2$	0.014	0.423***	0.218***	0.328***	0.216***	0.235***
F	0.380	16.279	27.870	47.780	27.657	30.105
p	0.822	0.000	0.000	0.000	0.000	0.000

***, The regression weights (standardized beta coefficients) are significant at the p<0.001 level; **, the regression weights (standardized beta coefficients) are significant at the p<0.01 level; *, the regression weights (standardized beta coefficients) are significant at the p<0.05 level.

higher levels of entrepreneurial orientation with higher levels of product newness tend to achieve higher technology commercialization. Firms having lower levels of entrepreneurial orientation with lower levels of product newness tend to achieve lower technology commercialization. In addition, the interaction between product newness and entrepreneurial orientation also leads to catalytic effects on technology commercialization.

Furthermore, Table 5 shows the moderating effects of technology integration on the relationship between entrepreneurial orientation and technology commercialization. As shown in M26, technology integration (A*E= 0.389, p<0.001) has a positive and significant influence on the relationship between entrepreneurial orientation and technology commercialization. Thus, hypothesis 5 is supported. Similar method with technological turbulence is used to show the moderating effects of technology integration on the influence between entrepreneurial orientation and technology commercialization. As shown in Figure 2d, firms with higher entrepreneurial orientation and higher levels of technology integration tend to achieve higher technology commercialization. Firms with lower levels of entrepreneurial orientation and lower levels of technology integration tend to achieve lower technology commercialization. The above results suggest that entrepreneurial firms are likely to be more risk-taking, innovative, proactive, autonomous and aggressive, and simultaneously put emphasis on the integration of technology through different approaches, systems, and processes management uses to achieve higher levels of technology commercialization.

CONCLUSIONS AND SUGGESTIONS

Given the potential theoretical and practical importance of understanding the effects of entrepreneurial orientation on technology commercialization, and the importance of this topic to entrepreneurial l firms, this study aims to

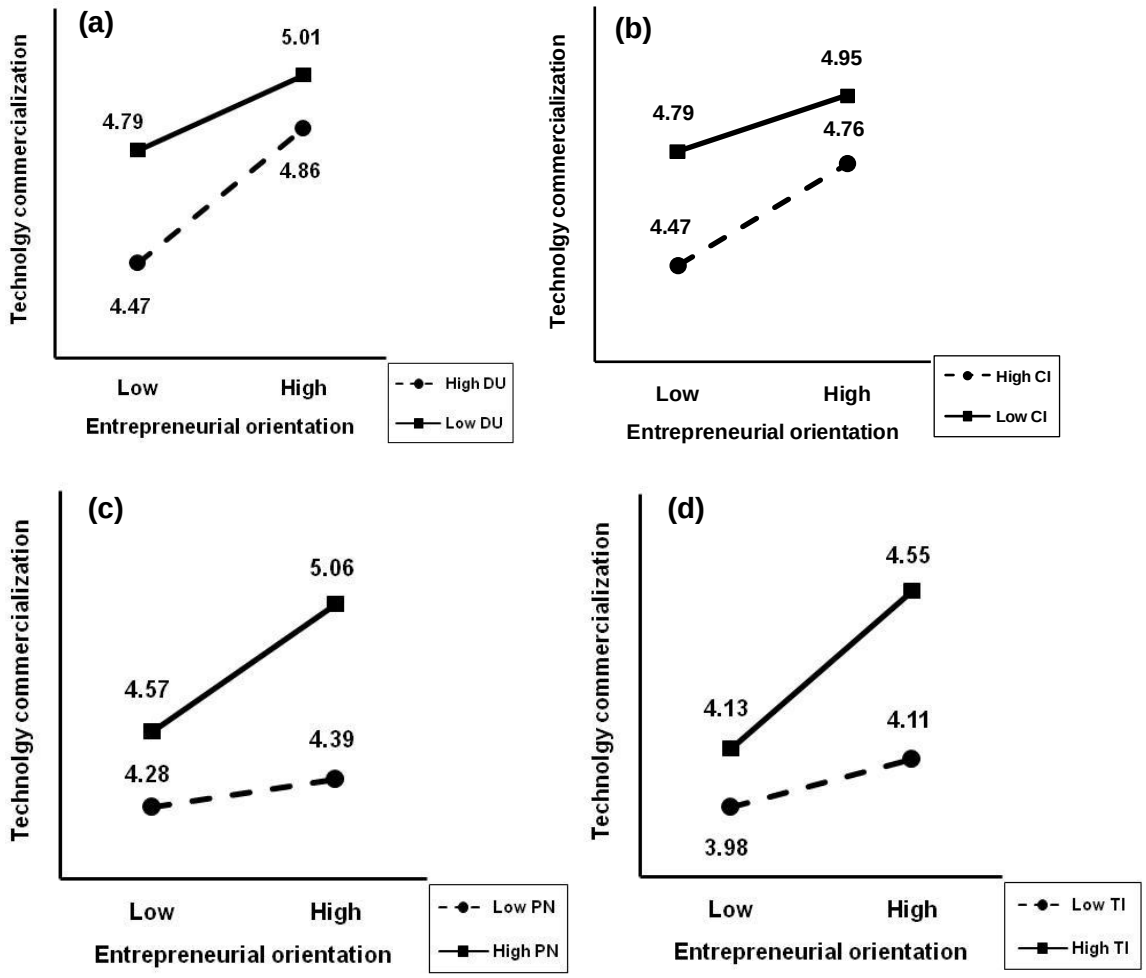

Figure 2. The moderating role of technological turbulence and technology integration on technology commercialization. Note: DU, demand uncertainty; CI, competitive intensity; PN, product newness; IT, technology integration.

contribute to this area by investigating entrepreneurial orientation and technology commercialization from resource-based view and dynamic capability view. In addition, since many academics and practitioners have recognized the importance of contextual factors in the technology commercialization process, formal conceptualizations and empirical validations are scarce. Thus, a contingency framework is developed in this study to elaborate on how the relationship between different levels of influence of entrepreneurial orientation on technology commercialization is moderated by technological turbulence and technology integration.

The results of this study are as follows. First, learning capability has a direct effect on entrepreneurial orientation, including risk taking, innovativeness, proactiveness, and competitive aggressiveness. As stated by Morris et al. (2007), a firm with the learning capability to fulfill unmet customer needs and to remain ahead of competitors emphasizes opportunity identification, proactive behaviors and innovativeness. Therefore, when firms have higher levels of learning capability, they are more inclined to innovate, to take risks, and to be proactively and aggressive. However, it is interesting to note that learning capability does not have any impact on the autonomy of firm entrepreneurial orientation. This result may be due to the fact that autonomy is concerned with granting individuals the freedom to exercise their creativity to bring about an idea (Coulthard, 2007). When the organizational structure is hierarchical or the new product development environment is quite stable, a conservative manager may not give individuals the authority to realize their ideas. Even though autonomy is a very important component of entrepreneurial orientation, its relationship with learning capability is not verified in this study.

Second, both tangible and intangible resources have significant and positive influences on entrepreneurial orientation, including risk taking, innovativeness,

proactiveness and competitive aggressiveness. These results correspond with previous results. As stated by Wu (2007), entrepreneurial resources will often influence the decision making process, which in turn produces unique variations for an entrepreneur's successes. Since the entrepreneurial process is accompanied by a series of challenges, supportive resources facilitate both decision making and problem-solving activities. Therefore, the greater the entrepreneurial resources possessed by the firm, the more willing the firm should be to take risks, anticipate changes, innovation, and be proactive and aggressive in terms of new opportunities.

Third, entrepreneurial orientation has a positive effect on technology commercialization. An entrepreneurial firm that represents a series of processes, methods, styles, practices and decision making activities that support entrepreneurial opportunities is often more willing to adopt new and advanced technologies, create new customer values, and introduce a large number of new product or process technologies. These results are consistent with Zhou et al. (2005) and Li et al. (2008). These studies suggest that entrepreneurial orientation reveals boldness and tolerance for risk; thus, an entrepreneurial firm may tend to be innovative in terms of new opportunities and the commercialization of technologies. Therefore, firms with greater levels of entrepreneurial orientation should acquire greater levels of technology commercialization.

Fourth, context-specific changes do not only affect an entrepreneur's respective competitive positions, but also reshape the competitive landscape in terms of new opportunities and threats (Calantone et al., 2003). Technological turbulence issues, including demand uncertainty, competitive intensity, and product newness, serve as moderating variables that suppress the influence of entrepreneurial orientation on technology commercialization. Since demand uncertainty implies that a firm has to predict and follow through on what customers want by creating buying incentives, it is a very important contextual variable that influences a firm's technology commercialization within the new product development process. It is interesting to note that, under a high demand uncertainty situation, firms with lower levels of entrepreneurial orientation tend to have lower levels of technology commercialization; while under a low demand uncertainty situation, firms with higher levels of entrepreneurial orientation tend to have higher levels of technology commercialization.

In addition, competitive intensity serves a similar function in terms of the influence of entrepreneurial orientation on technology commercialization. These results are consistent with Zhou et al. (2005) and Frishammar and Hörte (2007). On the one hand, if technological turbulence is high, the environment is unstable, identification of consumers' changing needs becomes increasingly difficult, and incremental innovations are unlikely to satisfy them. On the other hand, a firm with greater entrepreneurial orientation has is more likely to be able to decrease the uncertainties resulting from the turbulence created by the fast technological changes. Furthermore, product newness serves as a moderating variable for the relationships between entrepreneurial orientation and technology commercialization. Our results also advance the explanation of Atuahene-Gima (1995), who suggests that the greater a firm's ability to both understand preferences of existing customers and find out consumption patterns of potential customers, the greater the possibility for that firm to be successful in terms of the new product development process.

Finally, the levels of technology integration can serve as amplifiers for the link between entrepreneurial orientation and technology commercialization. These results are in line with Zahra and Nielsen (2002), who state that technology integration improves coordination among the various groups involved in the new product development process, because it increases interaction between employees and encourages them to solve problems jointly. Therefore, technology integration is an important element in the relationship between entrepreneurial orientation and technology commercialization.

MANAGERIAL IMPLICATIONS

The growing literature on new product development has paid great attention to commercializing products through cutting-edge technologies in order to create greater profits (Gans and Stern, 2003; Li et al., 2008; Zahra and Nielsen, 2002). The current study moves forward in this important direction by incorporating the beneficial role of entrepreneurial orientation for technology commercialization into the new product development process. Several managerial implications follow from the above discussion. First, as many scholars have noted, entrepreneurial orientation plays a critical role in terms of firm performance. One of the significant contributions of this study is the identification of the antecedents of entrepreneurial orientation. As stated by Davidson (2005), much of the attention paid to entrepreneurial orientation has emphasized either the unsatisfactory trait approach or the superior behavioral approach. As such, this study advocates that learning capability and entrepreneurial resources can be enablers for entrepreneurial orientation. According to Kloot (1997), organizational learning capability is the process by which firms can detect problems and provide solutions. When a firm has a high learning capability, they tend to share learned knowledge, encourage teamwork, and be good at resolving conflicts. Therefore, through the use of reward systems or knowledge management systems, managers should develop a learning environment which encourages employees to attend training programs and exchange ideas. Furthermore, from a resource-based view, a firm's

competitive advantage stems from its unique assets and distinctive capabilities (Barney, 1991). It is not surprising that entrepreneurial resources can support a firm in terms of being highly aggressive, anticipative toward change, proactive toward market opportunities, tolerant of risk, and receptive to innovations. Nevertheless, the acquisition of entrepreneurial resources is not always without cost. Managers need to be aware of the possibility that the costs will outweigh the benefits. Consequently, managers must understand how to employ tangible and intangible resources to create competitive advantages.

Second, the biggest issue is not how important the role of entrepreneurial orientation is for firms, or what the components of entrepreneurial orientation are, but rather how entrepreneurial orientation contributes to firm performance. Accordingly, the role of an entrepreneurial orientation on technology commercialization is verified in this study. The results suggest that as firms enhance their entrepreneurial orientation though risk taking, innovativeness, proactiveness, competitive aggressiveness and autonomy, they become more likely to take up technology commercialization. This finding affords insights for firms in terms of promoting entrepreneurial activities. It highlights the importance of cultivating a culture where employees are encouraged to express their new thoughts and realize their crazy ideas. Although, entrepreneurial orientation can help firms by increasing innovation, it remains difficult to achieve technology commercialization due to possibility of failure or loss. However, in the advance of dynamic environments, if firms do not search for change, respond to it, and exploit the opportunity, they may not be capable of dealing with discontinuities or fierce competition. Consequently, managers need to be aware of the possibility that increased levels of entrepreneurial orientation which will be associated with the outperformance of rivals and superior profits through the technology commercialization process.

Finally, several moderators shed additional light on the relationship between entrepreneurial orientation and technology commercialization. As noted by the contingency theory, a firm's strategy or structure will not be equally effective under different environmental or firm-specific conditions. The results of this study certify that technology commercialization is influenced not only directly through entrepreneurial orientation, but also as moderated by these contextual factors. Frishammar and Hörte (2007) and Jeong et al. (2006) propose that technological turbulence is the rate of technological advances as experienced by firms within an industry, and thus it may impact a firm's strategy on how to cope with uncertainties for survival.

Demand uncertainty and competitive intensity may be dampers in terms of the influence of entrepreneurial orientation on a firm's technology commercialization. It is conceivable that firms associated with higher levels of demand uncertainty and high competitive intensity will find it difficult to estimate consumer expectations or satisfy their needs for novelty, and thereby differentiate their products from those of competitors. Although, if the firms cannot control or change their external environments firms can attenuate the negative influences of demand uncertainty and competitive intensity by strengthening their entrepreneurial orientation. It is worth noting that when firms have higher levels of entrepreneurial orientation, the impact resulting from demand uncertainty and competitive intensity will be diminished. Managers in entrepreneurial firms should be aware that in dynamic environments, entrepreneurial orientation is necessary to strengthen a firm's capability, and also to deter the negative impact of turbulence such that performance can be improved.

Product newness also plays an important role. According to Atuahene-Gima (1995), product newness for customers extends beyond the new products produced by a firm to the degree that the product newness is compatible with the experiences and consumption patterns of potential customers. The results of this study show that product newness moderates the influence of entrepreneurial orientation on technology commercialization. Importantly, managers seeking superior new product development performance should reconcile their product development strategies and introduce products that match consumer requirements, to enlarge the positive impact of entrepreneurial orientation.

Technology integration is the other important moderator employed in this study in terms of the influence of entrepreneurial orientation on technology commercialization. According to Zahra and Nielsen (2002), technology integration improves coordination among the various groups through increased interaction among employees. In other words, as employees tightly coordinate their activities across different functional units and stress informal relationships set up to get things done, higher levels of technology commercialization can be achieved. In order to perform well within the technology commercialization process, an entrepreneurial firm manager can establish informal communication channels for cross-functional cooperation and encourage employees to freely exchange technological knowledge or relevant information. Therefore, managers should maintain high levels of integration among different teams or units. Consequently, capable managers should continuously inspect every entrepreneurial firm's operations, and establish formal channels to coordinate and cooperate with other members.

FUTURE RESEARCH DIRECTIONS

Although the research results are compelling, several limitations deserve comment. These limitations suggest areas and directions for further research. The cross-sectional research design, the composition of the sample,

and the response rates all serve to temper the results of this study. A few extensions of this study would be beneficial. First, since this study adopts a cross-sectional research design, the respondents are asked to recall a specific technology commercialization case and relevant information regarding their entrepreneurial firms at one point in time. However, the development of technology commercialization may last longer than one period, such that the direction of the relationships listed in the results should be evaluated with caution. Future researchers are recommended to conduct longitudinal studies to reconfirm the findings of this study. Second, this study emphasizes the role of technology commercialization within the new product development process. However, due to time and resource constrains, this study measures technology commercialization based on respondents' perceptions rather than hard data, such as the number of patents or the frequency of new patents issued over one period. Therefore, future research should take those important indicators into consideration.

REFERENCES

Armstrong JS, Overton TS (1977). Estimating nonresponse bias in mail surveys. J. Mark. Res., 14:396-402.

Aspelund A, Berg-Utby T, Skjevdal R (2005). Initial resources' influence on new venture survival: a longitudinal study of new technology-based firms. Technovation, 25: 1337-1347.

Atuahene-Gima K (1995). An exploratory analysis of the impact of market orientation on new product performance—a contingency approach. J. Prod. Innov. Manage., 12(4): 275-293.

Atuahene-Gima K, Ko A (2001). An empirical investigation of the effect of market orientation and entrepreneurship orientation alignment on product innovation. Organ. Sci., 12(1):54-74.

Barney JB (1991). Firm resources and sustained competitive advantage. J. Manage., 17(1):99-120.

Calantone R, Garcia R, Droge C (2003). The effects of environmental turbulence on new product development strategy planning. J. Prod. Innov. Manage., 20(2): 90-103.

Chryssochoidis GM, Wong V (2000). Customization of product technology and international new product success: mediating effects of new product development and rollout timeliness. J. Prod. Innov. Manage., 17(4): 268-285.

Cohen J, Cohen P, West S, Aiken L (2003). Applied multiple regression/correlation analysis for the behavioral sciences Erlbaum, Hillsdale, NJ.

Coulthard M (2007). The role of entrepreneurial orientation on firm performance and the potential influence of relational dynamism. J. Global Bus. Technol., 3(1): 29-39.

Covin JG, Miles MP (1999). Corporate entrepreneurship and the pursuit of competitive advantage. Entrep. Theo. Pract., 23(3): 47-63.

Davidsson P (2005). Researching Entrepreneurship Springer, Berlin.

Davis CH, Sun E (2006). Business development capabilities in Information Technology SMEs in a regional economy: An exploratory study. J. Technol. Trans., 31:145-161.

Day J, Reynolds P (2006). Entrepreneurship and the small to medium-sized enterprise: A divergent/convergent paradox in thinking patterns between advisers and SME owner-managers. Manage. Decis., 44(5): 581-597.

Frishammar J, Hörte SÅ (2007). The role of market orientation and entrepreneurial orientation for new product development performance in manufacturing firms. Technol. Anal. Strateg. Manage., 19(6): 765-788.

Gans JS, Stern S (2003). The product market and the market for "ideas": commercialization strategies for technology entrepreneurs. Res. Pol., 32:333-350.

Grant RM (1991). The resource based theory of competitive advantage: implications for strategy formulation. California Manage. Rev., 33(3): 114-135.

Grant RM (1998). Contemporary strategic analysis: concepts, techniques, applications. 3rd ed. Blackwell, Malden, MA.

Griffith DA, Noble SM, Chen Q (2006). The performance implications of entrepreneurial proclivity: A dynamic capabilties approach. J. Retail., 82: 51-62.

Harman HH (1967). Modern factor analysis University of Chicago Press, Chicago.

Hindle K, Yencken J (2004). Public research commercialisation, entrepreneurship and new technology based firms: an integrated model. Technovation, 24(10): 793-803

Huber GP (1991). Organizational learning: The contributing processes and the literatures. Organ. Sci., 2: 88-115.

Hult GTM, Hurley RF, Knight GA (2004). Innovativeness: Its antecedents and impact on business performance. Ind. Mark. Manage., 33: 429-438.

Iansiti M (1995). Technology integration: Managing technological evolution in a complex enviroment. Res. Pol., 24:521-542.

Jantunen A, Puumalainen K, Saarenketo S, Kylaheiko K (2005). Entrepreneurial orientation, dynamic capabilities and international performance. J. Int. Entrep., 3: 223-243.

Jeong I, Pae JH, Zhou D (2006). Antecedents and consequences of the strategic orientations in new product development: The case of Chinese manufacturers. Ind. Mark. Manage., 35: 348-358.

Jerez-Gómez P, Lorente JJC, Cabrera RV (2005). Organizational learning capability: a proposal of measurement. J. Bus. Res., 58: 715-725.

Kahn KB (1996). Interdepartmental integration: a definition with implications for product development performance. J. Prod. Innov. Manage. 13: 137-151.

Kloot L (1997). Organisational learning and management control systems: Responding to environmental change. Manage. Account. Res., 8(1): 47-74.

Krauss S, Frese M, Friedrich C, Unger J (2005). Entrepreneurial orientation: A psychological model of success among southern African small business owners. Eur. J. Work Organ. Psychol., 14(3): 315-344.

Kropp F, Zolin R (2005). Technological entrepreneurship and small business Innovation research programs. Acad. Mark. Sci. Rev., 7: 1-14.

Kropp F, Lindsay NJ, Shoham A (2006). Entrepreneurial, market, and learning orientations and international entrepreneurial business venture performance in South African firms. Int. Mark. Rev., 23(5): 504-523.

Kumar V, Jain PK (2003). Commercialization of new technologies in India: an empirical study of perceptions of technology institutions. Technovation, 23(2): 113-120.

Lee GK (2009). Understanding the timing of 'fast-second' entry and the relevance of capabilities in invention vs. commercialization. Res. Pol., 38(1): 86-95.

Li Y, Huang J, Tsai M (2009a). Entrepreneurial orientation and firm performance: The role of knowledge creation process. Ind. Mark. Manage., 38(4): 440.

Li Y, Guo H, Liu Y, Li M (2008). Incentive mechanisms, entrepreneurial orientation, and technology commercialization: Evidence from China's transitional economy. J. Prod. Innov. Manage., 25: 63-78.

Li Y, Liu X, Wang L, Li M, Guo H (2009b). How entrepreneurial orientation moderates the effects of knowledge management on innovation. Sys. Res. Behav. Sci. 26: 645-660.

Lichtenthaler U, Ernst H (2007). External technology commercialization in large firms: results of a quantitative benchmarking study. RD Manage., 37(5): 383-397.

Lin BW, Lee Y, Hung SC (2006). RD intensity and commercialization orientation effects on financial performance. J. Bus. Res., 49: 679-685.

Liu CC, Chuang LM, Huang CM, Tsai WC (2010). Construction of index weight for organizational innovation in Taiwanese high-tech enterprises. Afr. J. Bus. Manage., 4(5): 594 - 598.

Liu SJ (1998). Industrial development and structural adaptation in Taiwan: Some issues of learned entrepreneurship. IEEE Trans. Eng.

Manage., 45(4): 338-348.
Lockett A, Wright M (2005). Resources, capabilities, risk capital and the creation of university spin-out companies. Res. Pol., 34(7): 1043-1057.
Lumpkin GT, Dess GG (1996). Clarifying the entrepreneurial orientation construct and linking it to performance. Acad. Manage. Rev., 21(1): 135-172.
Lumpkin GT, Dess GG (1997). Proactiveness versus competitive aggressiveness: Testing apart key dimensions of an entrepreneurial orientation, in: P. Reynolds, et al. (Eds.), Frontiers of Entrepreneurship Res., Babson College, Babson Park, MA., pp. 47-58.
Lumpkin GT, Dess GG (2001). Linking two dimensions of entrepreneurial orientation to firm performance: The moderating role of environment and industry life cycle. J. Bus. Ventur., 16: 429-451.
Markman G, Siegel D, Wright M (2008). Research and Technology Commercialization. J. Manage. Stud., 45(8): 1401-1423.
Miller D (1983). The correlates of entrepreneurship in three types of firms. Manage. Sci., 29: 770-791.
Morris MH, Coombes S, Schindehutte M, Allen J (2007). Antecedents and outcomes of entrepreneurial and market orientations in non-profit context: Theoretical and empirical insights. J. Leadership organ. Stud., 13(4): 12-39.
Mosakowski E (1998). Entrepreneurial resources, organizational choices, and competitive outcomes. Organ. Sci., 9(6): 625-643.
Nerkar A, Shane S (2007). Determinants of invention commercialization: an empirical examination of academically sourced inventions. Strateg. Manage. J., 28: 1155-1166.
Nonaka I, Takeishi H (1995). The knowledge-creating company: how Japanese companies create the dynamics of innovation Oxford University Press, Oxford.
Omar ARC, Ishak S, Rahid MR (2010). Consultation-based entrepreneurial/business learning: Malaysia experience. Afr. J. Bus. Manage., 4(12): 2508 - 2513.
Parker K, Mainelli M (2001). Great mistakes in technology commercialization. Strateg. Change, 10: 383-390.
Podsakoff P, Organ D (1986). Self-reports in organizational research: problems and prospects. J. Manage., 12(4): 531-544.
Podsakoff PM., MacKenzie SB, Lee JY, Podsakoff NP (2003). Common method biases in behavior research: A critical review of the literature and recommended remedies. J. Appl. Psychol., 88(5): 879-903.
Powell B (2010). Equity carve-outs as a technology commercialization strategy: An exploratory case study of Thermo Electron's strategy. Technovation, 30(1): 37-47.
Ramachandran K, Ray S (2006). Networking and new venture resource strategies: a study of information technology start-ups. J. Entrepreneurship, 15(2): 145-168.
Song M, Podoynitsyna K, Bij H, Halman JIM (2008). Success factors in new ventures: A meta-analysis. J. Prod. Innov. Manage., 25: 7-27.
Stock GN, Tatikonda MV (2008). The joint influence of technology uncertainty and interorganizational interaction on external technology integration success. J. Oper. Manage., 26:65-80.
Teece DJ (2003). Explicating dynamic capabilities: Asset selection, coordination, and entrepreneurship in strategic management theory, University of California, Berkeley Business and Public Policy.
Teece DJ, Pisano G, Shuen A (1997). Dynamic capabilities and strategic management. Strateg. Manage. J., 18(7): 509-533.
Venkatraman N (1989). Strategic orientation of business enterprises: The construct, dimensionality and measurement. Manage. Sci., 35: 942-962.
Vyakarnam S, Handelberg J (2005). Four themes of the impact of management teams on organizational performance. Int. Small Bus. J., 23(3): 236-256.
Wang CH, Hsu LC (2010). The influence of dynamic capability on performance in the high technology industry: The moderating roles of governance and competitive posture. Afr. J. Bus. Manage., 4(5): 562-577.
Wang CL (2008). Entrepreneurial orientation, learning orientation, and firm performance. Entrep. Theo. Pract., 32(4):635-657.
Ward P, Zhou H (2006). Impact of information technology integration and lean/just-in-time practices on lead-time performance. Decis. Sci., 37(2): 177-203.
Wonglimpiyarat J (2007). Manage. of government research and development towards commercialisation. Int. J. Manage. Pract., 2(3): 214-225.
Wonglimpiyarat J (2009). Commercialization strategies of technology: Lessons from Silicon Valley. J. Technol. Transfer. DOI: 10.1007/s10961-009-9117-3.
Wonglimpiyarat J (2010). Commercialization strategies of technology: lessons from Silicon Valley. J. Technol. Trans., 35(2): 225-236.
Zaheer A, Rehman KU, Khan MA (2010). Development and testing of a business process orientation model to improve employee and organizational performance. Afr. J. Bus. Manage., 4(2): 149-161.
Zahra SA, Garvis DM (2000). International corporate entrepreneurship and firm performance: the moderating effect of international environmental hostility. J. Bus. Vent., 15: 469-492.
Zahra SA, Nielsen AP (2002). Sources of capabilities, integration and technology commercialization. Strateg. Manage. J., 22: 377-398.
Zeng SX, Tam CM, Tong TKL, Sun PM (2010). Creating synergy for cross-cultural teams in international R&D projects. Afr. J. Bus. Manage., 4(13): 2625 - 2633.
Zhou KZ, Yim CK, Tse DK (2005). The effects of strategic orientations on technology and market-based breakthrough innovations. J. Mark., 69: 42-60.
Zhou L (2007). The effects of entrepreneurial proclivity and foreign market knowledge on early internationalization. J. World Bus., 42: 281-293.

APPENDIX

Questionnaire items of this study

S/N	Learning capability [adopted from Ingelgard et al. (2002) and measured on a seven-point Likert scale]
1	My firm has created a policy that positions it well for the future
2	The staffs of my firm are composed of highly trained and talented personnel
3	My firm always develops new ways of looking
4	Success and failures are shared within my firm
5	A learning agenda has been clearly defined and communicated for all personnel involved
	Entrepreneurial resources [adopted from Wu (2007) and Song et al. (2008) and measured on a seven-point Likert scale]
	Tangible
1	My firm has committed a lot of physical, financial, and logistical resources to support the seeking, diffusion and sharing of information
2	Financial resources my firm owns are abundant
3*	Capital my firm owns is abundant
4	R and D investment my firm owns is abundant
	Intangible
1	Managerial capabilities my firm has are excellent
2	Intellectual property my firm owns is abundant
3	Relationships between my firm and supply chain partners are tight
	Entrepreneurial orientation [adopted from Lumpkin and Dess (1997) and measured on a seven-point Likert scale]
	Risk taking
1	My firm has a strong proclivity for high-risk projects (with chances of very high returns)
2	People in my firm are encouraged to take calculated risks with new ideas
3	My firm emphasizes both exploration and experimentation for opportunities
	Innovativeness
1	On my firm, there exists a very strong emphasis on R and D, technological leadership and innovation
2	My firm is creative in its methods of operation
3*	My firm actively introduces improvements and innovations in our business
	Proactiveness
1	More new products as compared with our main competitors
2	There exists a very strong emphasis on the development of new and innovative products
3	My firm excels at identifying opportunities
	Competitive aggressiveness
1	In dealing with its competitors, my firm typically initiates actions that competitors then respond to
2	In dealing with its competitors, my firm is very often the first business to introduce new products/services, operating technologies, etc.
3	In dealing with its competitors, my firm typically adopts a very competitive, ‘undo the competitors’ posture
	Autonomy
1	My firm stresses the freedom for individuals to develop new ideas
2	My firm stresses a fully delegated policy for employees
	Technology commercialization [adopted from Li et al. (2008) and measured by on a seven-point Likert scale]
1	Our firm possesses the competence to initiate the product idea in a timely manner

Appendix. Contd.

2	Our firm possesses the competence to develop the product in a timely manner
3	Our firm is very competent at improving existing products
4*	Our firm is very competent at creating new products
	Technology integration [adopted from Zahra and Nielsen (2002) and measured on a seven-point Likert scale]
1	1. My firm encourages the free exchange of operating and technical information
2	2. My firm encourages bypassing of formal communication channels
3*	3*. My firm stresses informal relationships for getting things done
4	4. My firm maintains open communication channels in its operation
5	5. My firm tightly coordinates the activities of different functional units
	Technological turbulence [adopted from Zhou et al. (2005) and Frishammar and Hörte (2007) and measured on a seven-point Likert scale]
	Demand uncertainty
1	1. It is difficult to understand consumers' expectations of a brand
2	2. Consumers always look for novelty; they are never loyal to a single brand
	Competitive intensity
1	There are too many similar products in the market; it is very difficult to differentiate our brand
2	Competition in our industry is cut-throat
3*	There are many 'promotion wars' in our industry
	Product newness
1	Products we launch nowadays are usually more complex than products previously launched into the same market by our firm
2	Over the last 5 years, we have seen that in the industry where our brand operates, the diversity in production technology has dramatically increased