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A taxonomy of patent strategies in Taiwan's small and medium innovative enterprises

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ABSTRACT

An empirical taxonomy of patent strategies for SMEs is proposed in this paper based on a study of 238 innovative SMEs in Taiwan. The taxonomy identifies five categories of patent strategy — comprehensive, exploitative, defensive, reactive, and marginal — by using cluster analysis. This study demonstrates effective use of taxonomies to map the differences in patent strategies among SMEs by industry, firm size, R&D expenditure, and firm innovation. The results show that the larger the SMEs that developed radical innovations were, and the more they spent on R&D, the more likely they were to adopt comprehensive patent strategies. The R&D expenditure of most of the reactive and marginal strategy adopters is lower than that of adopters of the other three strategies. Among SMEs, firms' patent strategies are also correlated with firm size and R&D expenditure, which supports the findings of the existing literature. The taxonomy adds considerable value to our existing knowledge of management patents in SMEs by making our descriptions of patent strategic groups more clear and concise.

1. Introduction

In the new economy, patents are valued assets for firms (Prahalad and Hamel, 1990; Granstrand, 1999). Protecting promising technology with patents has become a necessary condition for attracting venture capital and increasing firms' value and profitability (Miele, 2001; Reitzig, 2004). Small and medium-sized enterprises (SMEs) also need to protect innovation with patents or other intellectual property rights to increase their chances of survival and growth (Sathirakul, 2006). SMEs typically represent 95 to 99% of a country's total enterprises. The types of SMEs vary substantially (e.g., high-tech oriented, service oriented, and manufacturing oriented).

No matter what the type of SMEs, when they achieve technical innovation, product renewal or process innovation, they decide whether to use patents to protect their innovation or how to manage patents to capture returns from innovation (Olsson and Mcqueen, 2000). Given the skewed size distribution of enterprises toward SMEs and their importance in the economy, it is necessary to understand how SMEs realize adequate patent management strategies and implementation.

From literature review, some studies gathered information on patent exploitation and management in Japanese SMEs by interviewing successful patent-active SMEs or large firms (Sathirakul, 2006; Eppinger and Vladova, 2013). Some studies have focused on investigating the relationship between patent management and performance, filing, patenting patterns and the factors that influence patenting (Ernst, 1995; Macdonald, 2004; Blind et al., 2009; Pitkethly, 2001). Such studies place relatively little emphasis on identifying strategic configurations and taxonomies, and have mainly focused on large firms (Granstrand, 1999; Rivette and Kline, 2000a, 2000b; Hanel, 2006). Granstrand (1999) identified seven strategic clusters of patent portfolio strategies: ad hoc blocking, inventing around,

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strategic patents, blanketing and flooding, fencing, surrounding, and portfolios. Rivette and Kline (2000a, 2000b) proposed a three-pronged patent strategy for large research and development (R&D) projects — grow, fix, and sell — which provides examples of value that can be extracted from management and exploitation of patents for large scale high-tech firms. Although these studies focused on identifying patent strategic configurations and taxonomies, their patent management modes and patent strategies are derived by using interviews in large firms, and very few attempts have been made to examine such patent management in SMEs. Those studies lack clarity on the actual process of building the framework from cases, especially regarding the central inductive process and the role of the literature. Most empirical studies indicate that SMEs do not use patents in the same way as larger firms (Eppinger and Vladova, 2013; Himmelberg and Petersen, 1994; Cohen et al., 2000; Audretsch, 2002; Blind et al., 2006; Cohen, 2010).

In addition, from 111 articles focusing on intellectual property (IP) issue studies published in the seven leading management journals during the years 1970–2009, Candelin-Palmqvist et al. (2012) indicated that although IP issue studies are a fast-growing research field in innovation management, most of the studies emphasizing patents relied on patent data and focused on North American and European contexts. There is a need to develop coherent constructs, conceptual frameworks and management patterns in patent management that would strengthen the theoretical basis of the research, and to pay more attention to firm-level analysis, as this may provide more feasible implications for innovation-management practitioners working on the organizational level (Candelin-Palmqvist et al., 2012). Though organizations such as the Japan Patent Office (JPO), European Patent Office (EPO), World Intellectual Property Organization (WIPO) and Taiwan Intellectual Property Office (TIPO) have made efforts to promote patent management for SMEs, the knowledge field in patent management also remains little known in the SME community.

The purpose of this research is to review the current state of empirical research into patent management in SMEs, and to investigate how innovative SMEs manage patents to protect innovation, and what are the patent strategy patterns among innovative SMEs by firm size, firm characteristics or industries. This study focuses on patent management of innovative SMEs. Innovative SMEs are here defined as SMEs that base their businesses on new or improved technologies, processes and products (Holgersson, 2013). The paper begins with a theoretical discussion of dimensions and types of patent strategy, addressing both empirical and theoretical aspects, and develops a classification system to examine patent strategy patterns based on innovative SMEs. The patent value chain perspective is used to elucidate the structure of the patent management activities of firms to better grasp their strategies. In Section 3, the methodological issues arising in the development of a classification system using cluster analysis are discussed. Section 4 describes the results of the analysis, including the taxonomy of firms' patent strategies from cluster analysis and their relationships with the characteristics of the respective firms. Limitations, managerial implications, and suggestions for future research are presented at the end of the paper.

2. Framework of firms' patent strategies

A review of related patent management or patent strategy literature demonstrates no general consensus on a definition of patent strategy. Strategies can be viewed as being composed of process and content concerns (Ansoff, 1965); scope and resource deployments (Hofer and Schendel, 1978); or corporate, business, and functional-level issues (Andrews, 1971). Motohashi (2008) defined patent strategy as a firm's management of its technology pool or capacity, based on in-house R&D or acquired technology from external sources, which is used for innovation outputs such as new products and processes. Patent strategies are traditionally characterized by filing strategies according to subject matter (quality vs. quantity), regional filing decisions (e.g. national, multinational, global), and general filing and enforcement practices (defensive vs. aggressive) (Gassmann and Bader, 2007). Some studies focus on identifying patent strategy types through case studies. For example, Granstrand (1999) offered a detailed discussion of patenting strategies, completed with flow charts and operational details based on interviews. He proposed seven patent portfolio strategies: ad hoc blocking, inventing around, strategic patents, blanketing and flooding, fencing, surrounding, and portfolios. Rivette and Kline (2000a, 2000b) proposed a three-pronged patent strategy — grow, fix, and sell — taking examples from large high-tech firms in information technology industries. Davis and Harrison (2001) developed the IP value hierarchy with a focus on patent value from studies of worldwide companies, which included five types of patent value: defensive, cost center, profit center, integrated, and visionary. At each patent value level, firms establish different patent management mechanisms to extract value. The five patent value types could also be viewed as five patent-value-extraction strategies.

From discussing the process and content of patent strategy, Sathirakul (2006) derived a best-practices model of patent exploitation and management for Japanese SMEs and venture companies based on the best practices of large companies and successful patent-active SMEs. The model involved patent strategic planning, patent creation, protection, and exploitation, known as the "patent cycle" or "patent creation cycle." The vision of top management for patents, IP's function in the organization, and patent reward mechanisms are three key management mechanisms that need to support the patent creation cycle. Reitzig (2007) proposed an IP strategy framework that theoretically encompassed the entire IP value chain — from generating intangible assets in R&D departments to the protection of IP in patent and legal departments through 34 questionnaire data points and in-depth interviews with leaders of two companies. He defined the dimension of IP strategy as one that includes IP acquisition and generation, IP protection, and IP exploitation and enforcement, and that involves corporate, business, and functional levels of the organization.

The aforementioned studies (Sathirakul, 2006; Davis and Harrison, 2001; Reitzig, 2007) state that patent management activities include patent pool management and extraction of patent value. Thus, to better understand the activities in which a firm develops a patent competitive advantage, it is useful to categorize the patent management system into a series of value-generating activities, referred to as the "value chain," as proposed by Porter (1985). In this study, the value chain perspective is employed to define patent strategy taxonomy.

According to Porter's definition, a “value chain” is a chain of activities, including primary activities and support activities, of a firm operating in a specific industry and providing more value to products than the sum of the independent activities' values (Porter, 1985). In the research of Sathirakul (2006) and Reitzig (2007), patent generation, patent portfolio maintenance decisions, and patent exploitation are the three key value-extracting activities. Thus, the primary patent activities in the patent value chain include patent creation, patent renewal and patent exploitation, which are primarily linked to support activities such as technology development, human resource management, and infrastructure, which help to improve their effectiveness or efficiency (Porter, 1985). Sathirakul (2006) proposed that the vision of top management for patents, patent function in the organization structure and patent reward mechanisms need to support patent value-creating activities. In addition, research has shown that there is a positive correlation between a company's success and the strength of its patent portfolio (Ernst, 1995; Parchomovsky and Wagner, 2005). SMEs with lower number of patents are less active in patent exploitation and management than ones with higher numbers of patents. In Parchomovsky and Wagner's (2005) study, a larger patent pool was shown to increase the value of a patent portfolio. Moreover, SMEs can manage their patent pools to extract value and benefit from the wealth of technological information in patent databases (Hall et al., 2000). Patent pool construction activities and patent information search behaviors are “patent energy” activities. Support activities include patent management institutionalization and patent energy in the patent value chain. Thus, the patent strategy of a firm in this paper contains five dimensions: (1) patent energy, (2) patent management institutionalization, (3) patent creation, (4) patent renewal, and (5) patent exploitation as determinants of patent strategy.

3. Research methodology

3.1. Sample and data collection

The research data in this study were collected as part of a survey performed by the SME IP Consulting Center (IPCC), supported by the Small and Medium Enterprise Administration, and the Ministry of Economic Affairs of Taiwan in 2011. The IPCC used the original survey to gain a better understanding of and better diagnose how SMEs use legal IP rights to protect innovation so as to formulate further measures to assist SMEs in building IP value. 95 to 99% of all firms in Taiwan are SMEs that have less than 200 employees, and the number of SMEs that employ legal IP for IP protection varies by the sector in which they operate and the size of the company, although it remains very small in general. This presented us with difficulty in obtaining data from all of Taiwan's industries. The source of patent application protections depends on whether SMEs are engaged in knowledge-intensive innovative activities. Thus, the original survey conducted by the IPCC used purposive sampling to select specific predefined SMEs that are innovation-oriented and have cooperated with the Industrial Technology Research Institute (ITRI) in technology development innovation in 2010. ITRI is a non-profit R&D organization that engages in applied research and technical services, which has played a vital role in transforming Taiwan's economy from a labor-intensive one to a high-tech one, and provides SMEs with consultation on the development of new technologies or new business models. Thus, cooperation with ITRI is an ideal sampling criterion for our study due to the innovative behavior implicit in such cooperation.

The open-ended questionnaire used in this study was structured in three sections. The first section includes general contact information about the firm and respondents. The second section used to measure the patent strategy: four dimensions — patent management institutionalization, patent creation, patent renewal, and patent exploitation — were measured using 5-point Likert scales with a range from “strongly disagree” to “strongly agree,” and the patent energy dimension was measured by multiple choice responses. The third section focuses on the characteristics of the firms, including industry sectors, total assets, number of employees, total sales on R&D expenditure and firm innovation categories, which were measured by multiple choice responses. Due to the varying perspectives for degree of innovativeness, detailed explanations of innovation categories are given. In this study innovation is defined as the creation of a new idea, product, or process. In this context, “new” could imply the entry of a novel item to firms, markets, or industries. Previous studies state that innovation typologies could be modeled as the degree of newness in marketing and/or technologies (Garcia and Calantone, 2002; Georghiou et al., 2004). Accordingly, innovation is classified into four types — off-the-shelf, incremental, next generation, and radical (Georghiou et al., 2004). The detailed definition of the demographic characteristics is shown in Appendix Table 1.

The 640 SMEs that cooperated with ITRI in 2010 were used as the sample for this study. Because the SMEs that cooperated with ITRI had signed non-disclosure agreements, their participation was first confirmed by email and telephone by ITRI. 238 firms accepted the survey, a response rate of 37.19%. The respondents were divided into two groups based on their response timing: 138 (57.98%) respondents in the first month comprised the first group; 100 (42.02%) respondents in the second month comprised the second group. Because we could not collect firm characteristic data from the non-responding SMEs among those that cooperated with the ITRI, we employed a common approach described by Armstrong and Overton (1977) and Lambert and Harrington (1990) to analyze the non-response bias by comparing the responses of early and late respondents. They recommend assuming that the response of late respondents is similar to that of non-respondents. Demographic variables, such as industry sector, total assets, number of employees, R&D expenditure, and firm innovation category, were used to characterize differences in response bias between the 138 respondents in the first group and the 100 respondents in the second. The p-values of test results by industry sector, total assets, number of employees, R&D expenditure, and firm innovation category were .589, .484, .930, .989, .929 and .684 respectively, using a cross-table χ^2 test. The results suggest that the demographic structures of the respondents in the first group and those in the second are not statistically or significantly different.

Appendix Table 1 shows a detailed definition and descriptive statistics of the demographic characteristics of the 238 respondent firms. The respondents came from a variety of industries. The largest number of respondents (82, 34.5%) came from the biotechnology and pharmacy industry, which includes biotechnology, pharmacy and medical devices. Innovation and patent protection are at the core of their business for the biotechnology and pharmacy industry, and therefore firms need strong patents to protect their technological innovations because, in principle, many biotechnology inventions, once published, are easily copied. About 36% of the responding companies had total assets of more than NT$80 million. Some 52% had fewer than 50 employees and about 18% had 150 or more employees. 35% of the firms spent more than 10% of their total sales on R&D. In terms of innovation typology, some 66% of innovations by responding companies were improvements to existing technology in the current market (of-the-shelf and incremental innovation). The data shown in Appendix Table 1 illustrate that the SMEs may have devoted insufficient expenditures to capital investments and innovation to compete in their industries.

3.2. Research methods

The purpose of this research is to present taxonomy of patent strategy for innovative Taiwanese SMEs using cluster analysis. Cluster analysis has been criticized for its extensive reliance on researchers' judgment, with four critical issues involved (Ketchen and Shook, 1996): (1) selection of variables; (2) selection of appropriate clustering algorithms; (3) determination of the number of clusters; and (4) validation of clusters. In this study we employed the cluster analysis procedure offered by Ketchen and Shook (1996) that is used to construct and validate the taxonomy, with major steps including the selection of variables, determination of the number of clusters, and the validation of the cluster solution as follows (see Fig. 1).

3.2.1. Selection of variables

The first key in cluster analysis process is a clear rationale for the selection of variables (Ketchen and Shook, 1996; Punj and Stewart, 1983; Everitt et al., 2001). Patent strategy variables were developed from an extensive review of the literature regarding patent management issues. Variables were selected or constructed as candidate indicators of five dimensions based on the patent value chain: patent energy, patent management institutionalization, patent creation, patent renewal, and patent exploitation. Table 1 shows the dimensions and variables that formed the basis of our taxonomy.

3.2.1.1. Patent energy. Patent energy includes the patents a firm owns (Blind et al., 2009) and its patent information usage (Sathirakul, 2006; Hall et al., 2000). Parchomovsky and Wagner (2005) thought that a larger patent pool size, measured by number of patents filed and granted, would increase the value of patents. Eppinger and Vladova (2013) also found that the more patents companies file, and the more countries they file the same patents in, the more they engage in IP management activities. In addition, SMEs can manage their patent pools to extract value, benefit from the wealth of technological information in patent databases, examine recent technological breakthroughs, identify future partners, and study the innovative activities of competitors for the purpose of extracting IP value (Hall et al., 2000). The more frequently patent information databases are searched, the more business intelligence the firms have (Gassmann et al., 2012). Thus patent energy is measured by the number of patent applications, the number of patent grants, the number of countries in which the same patent is filed, and the frequency of patent searches (Sathirakul, 2006; Motohashi, 2008; Gassmann et al., 2012).

3.2.1.2. Patent management institutionalization. The institutionalization of patent management plays an important role in realizing IP benefits (Eppinger and Vladova, 2013). Based on interviews with large companies and 21 successful patent-active Japanese SMEs, Sathirakul (2006) proposed that the key issues of patent management are the establishment of their patent functions from the vision of senior management, reserving an annual budget for patent activities, and

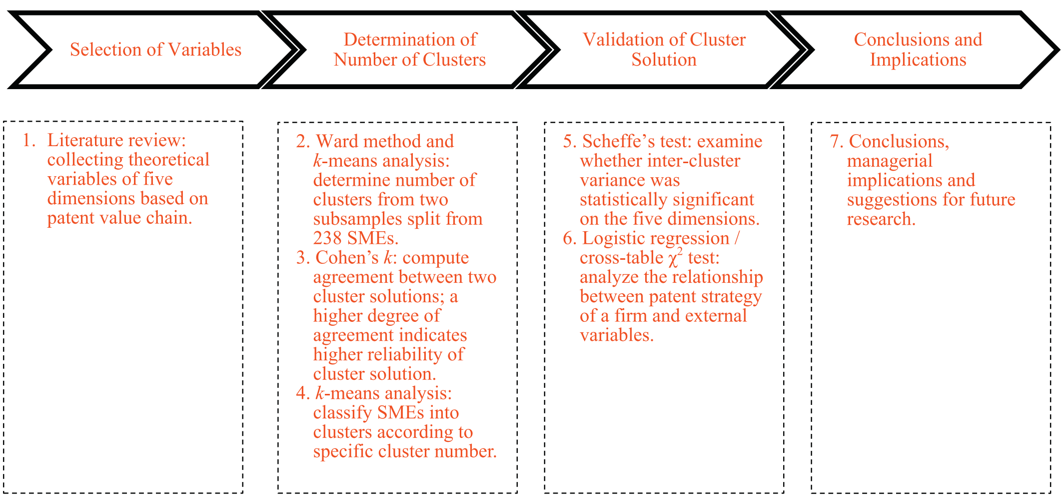

Fig. 1. Research process of this study.

Table 1
Variables used to develop the taxonomy of patent strategy.

Constructs and variables	Description of items	Reference source
Patent energy		
Patent application	1. Number of patent applications[a]	Sathirakul (2006), Eppinger and Vladova (2013), Blind et al. (2009), Parchomovsky and Wagner (2005)
Patent issued	2. Number of patent grants[a]	Sathirakul (2006), Eppinger and Vladova (2013), Blind et al. (2009), Parchomovsky and Wagner (2005)
Patent family	3. Average number of countries in which the same patent is filed[b]	Eppinger and Vladova (2013)
Patent information search	4. Frequency of patent information database search[c]	Sathirakul (2006), Hall et al. (2000), Gassmann et al. (2012)
Patent management institutionalization		
Annual budget for patent activities	5. Firm reserved an annual budget for patent activities.	Sathirakul (2006), Bader (2008)
Top management commitment	6. Top managers had strong intention to patent management.	Sathirakul (2006), Bader (2008)
Training courses	7. Firm emphasized education and training for managers, engineers, and researchers to improve their knowledge and skills in patent management.	Sathirakul (2006), Bader (2008), Eppinger and Vladova (2013)
Patent ownership law	8. Firm established rules and principles about ownership of inventions.	Sathirakul (2006), Eppinger and Vladova (2013)
Financial incentive mechanisms	9. Firm had incentive mechanisms to encourage employees to generate new ideas, file a patent application or obtain the grant of a patent.	Sathirakul (2006), Eppinger and Vladova (2013), Bader (2008)
Confidentiality mechanisms	10. Firm had a confidentiality program to make sure that new inventions and ideas are kept secret before a patent application is filed.	Hemphill (2004)
Research notebook mechanisms	11. Firm emphasized that employees need to write research notebooks during the innovation process.	Sathirakul (2006)
Patent creation		
Patent application examination	12. Firm emphasized patent application examination before filing a patent application.	Sathirakul (2006), Eppinger and Vladova (2013), Reitzig (2007), Knight (2001), Jun et al. (2013), Kay et al. (2014)
Patent prior art search	13. Firm emphasized prior art search before filing a patent application.	Sathirakul (2006), Eppinger and Vladova (2013), Reitzig (2007), Gassmann et al. (2012)
Patent family examination	14. Firm determined whether or not to file a patent application in foreign countries.	Sathirakul (2006), Gassmann et al. (2012), Knight (2001)
Commercialization evaluation	15. Firm evaluated the commercialization potential for each invention.	Sathirakul (2006), Gassmann et al. (2012), Knight (2001)
Claim patentability examination	16. Firm determined the patentability of each claim.	Sathirakul (2006), Gassmann et al. (2012), Knight (2001)
Patent renewal		
Patent portfolio examination	17. Firm regularly reviewed patent portfolio to see if all company technologies that are crucial for current and future business are well protected.	Sathirakul (2006), Reitzig (2007), Bader (2008)
Patent maintenance examination	18. Firm regularly reviewed patent portfolio to consider which patents to maintain.	Sathirakul (2006), Reitzig (2007), Bader (2008)
Patent exploitation		
Patent exploitation planning	19. Firm periodically examined patent exploitation planning.	Sathirakul (2006), Eppinger and Vladova (2013), Rivette and Kline (2000a, 2000b), Hsieh (2013)
Patented technology application	20. Firm applied its patented technologies into products.	Sathirakul (2006), Eppinger and Vladova (2013), Holgersson, 2013
Patent licensing revenue	21. Firm had revenue from patent licensing.	Rivette and Kline, 2000a, 2000b, Holgersson (2013), Reitzig (2007), Bader (2008)

[a] These two variables are measured for 0, 1–5, 6–10, 11–20, and >21.
[b] The variable is measured for 0, 1, 2, 3, and >4.
[c] The variable is measured for never, every season, every month, every week, and every day.

establishing patent reward mechanisms and confidentiality mechanisms to support the patent value-creating activities. Eppinger and Vladova (2013) found that the human capital of a company plays an essential role in improving the patent management practices of SMEs. SMEs employ new personnel with relevant experience and knowledge, or emphasize education and training for managers, engineers, and researchers to improve their patent-related skills, consequently raising the patent awareness of employees. Based on an in-depth case study of a Swiss company, Bader (2008) concluded that success factors for managing patents include support from upper and middle management, awareness programs, incentive systems for inventions, and sufficient budgetary allocation. Thus, patent management institutionalization includes internal patent management functions, allocating appropriate resources for the execution of patent management, commitment from senior management, patent ownership law, and the available knowledge and management skills of employees (Sathirakul, 2006; Eppinger and Vladova, 2013; Hemphill, 2004).

3.2.1.3. Patent creation. Patent creation activities are the actions whereby firms make decisions on whether or not to pursue legal protection for innovations, and are crucial initial steps in patent management (Reitzig, 2007; Knight, 2001). Knight (2001) and Jun et al. (2013) suggested that before filing patents for innovations, firms should undertake a formal patent examination process including technology value analysis, patentability analysis and evaluation of potential for commercialization. Prior art searches and full assessments of patentability can be costly for SMEs, and they rarely possess the necessary expertise in-house to conduct substantive patent searches and correctly judge the gaps in the patent landscape (Knight, 2001). However, through examining pharmaceutical companies, Eppinger and Vladova (2013) study showed that SMEs still carry out most patent screening, monitoring and enforcement activities with their own staff because SMEs depend on external advisors and patent attorneys, who are expensive and therefore only used for short periods when absolutely necessary. Parchomovsky and Wagner (2005) also proposed that SMEs have to patent more carefully through prior art searches as they are unable to acquire broad patent portfolios. Thus, patent creation activities in SMEs are measured by patent application examinations, prior art searches, evaluation of patentability, patent family and commercialization (Sathirakul, 2006; Eppinger and Vladova, 2013; Gassmann et al., 2012; Kay et al., 2014).

3.2.1.4. Patent renewal. Patent creation is a crucial initial step, but effective patent renewal management actually means more than just protecting the patents of an enterprise (Sathirakul, 2006; Reitzig, 2007; Bader, 2008). Reitzig (2007) suggested that firms need to evaluate their patent portfolios to see if all their technologies are crucial for current and future business and are well protected in order to decide on whether to renew their patents or dispose of them. The items that we use to describe such patent renewal activities are drawn from Reitzig (2007), namely patent portfolio examination and patent maintenance examination.

3.2.1.5. Patent exploitation. Regarding patent commercialization practices, firms need to fully assess their patent pools to consider which patents have significant impact on the business and which patents offer no further profitability for the firm itself, but could be a source of revenue through licensing or sale (Eppinger and Vladova, 2013; Rivette and Kline, 2000a, 2000b; Holgersson, 2013; Hsieh, 2013). From Sathirakul (2006) study, patent-active SMEs could generate returns on R&D investments by licensing their patents to third parties. In order to maximize the benefit from their patent portfolios, the management of companies needs to periodically examine patent exploitation planning to consider which patents to license out or sell, which to turn into products, and which to dispose of (Sathirakul, 2006; Eppinger and Vladova, 2013; Rivette and Kline, 2000a, 2000b). Bader (2008) also concluded that a company that successfully manages its patents must investigate possible infringement, and that licensing opportunities with other parties should be sought periodically, as long as they fulfill a need or such parties have a use for company products. Thus, patent exploitation activities should include patent exploitation planning, patented technology application and licensing out of patents.

Exploratory factor analysis was performed on candidate indicators for each dimension using principal component analysis (PCA) with varimax rotation. The advantage of PCA is that the obtained factors are uncorrelated, which reduce the risk of any single indicator dominating the outcome of cluster analysis, and no variable is implicitly weighted heavier than others in the cluster (Hair et al., 1998).

3.2.2. Determining number of clusters

Cluster analysis was performed to classify patent strategy in five dimensions, each measured as the average of rescaled indicators. Many clustering techniques are available, and can generally be divided into hierarchical and nonhierarchical (or iterative) algorithms. Each category of algorithms has its own strengths and weaknesses (Ketchen and Shook, 1996). Complementary clustering methods from both groups (Ward's and the *k*-means algorithms) were used to determine the optimal cluster structure.

Ward's partitioning and squared Euclidean distance were used in the hierarchical stage to maximize within-cluster homogeneity and between-cluster heterogeneity and to recover known cluster structure. The *k*-means algorithm follows an entirely different concept than the hierarchical methods as discussed before. The clustering process of *k*-means is not based on distance measures such as Euclidean distance, but uses within-cluster variation as a measure to form homogeneous clusters. Generally, *k*-means is superior to hierarchical methods as less influenced by outliers and the presence of irrelevant clustering variables. One problem associated with the application of *k*-means relates to the fact that the researcher has to pre-specify the number of clusters to retain from the data. Thus, a two stage procedure was employed to take advantage of the strengths of both the Ward method and *k*-means clustering approaches (Ketchen and Shook, 1996; Hair et al., 1998). The Ward method was employed first to define the number of clusters and cluster centroids, which then served as the starting points for subsequent *k*-means analysis to classify SMEs into clusters according to the specific cluster number.

To validate an appropriate number of clusters, we split the sample into two subsamples to compare the results from cluster analysis according to Lee et al. (2006). The analysis first divides the sample randomly into halves. To implement cluster analysis on the first subsample, the Ward method is used to identify the appropriate number of clusters. Then, we perform a *k*-means cluster analysis, in which the firms are iteratively classified into cluster until the assignments no longer change. The *k*-means analysis assists in classifying the second subsample into clusters according to the initial starting center generated from the first subsample using Ward's method. Then we compute the agreement between two cluster solutions for the second subsample using Cohen's *k* measures of rater agreement. A greater degree of agreement between the two solutions indicates a higher reliability of the cluster solution. Finally, we again use the Ward method and *k*-means analysis to classify the entire sample and obtain finalized resulting clusters. Note that unusual or outlier observations may skew the cluster analysis validity (Ketchen and Shook, 1996). In this research, however, the data were from similar scales with no outliers, therefore standardization was not necessary.

3.2.3. Validation of the cluster solution

Three analyses were performed to validate the resulting clusters. The multivariate comparison of Scheffe's test was employed to examine whether the inter-cluster variance was statistically significant on the five dimensions. A logistic regression and cross-table χ^2 test was used to analyze the relationship between patent strategy of a firm and external variables other than used to generate the solution (i.e. criterion-related validity) (Kerlinger, 1973).

4. Results of empirical analyses

4.1. Factor analysis

To perform the PCA, this study used 21 items to measure the content of patent strategy. The principal components and varimax rotation analysis with eigenvalue of more than one were used to extract underlying factors. To test if the data are suitable for PCA analysis, measures of sampling adequacy (MSA) were calculated for the individual variables (Hair et al., 1998). All the variables obtained satisfactory MSA values (>0.60), indicating their suitability as candidates for a PCA. In addition, All KMO and the Bartlett test of sphericity met common standards (KMO = 0.80 and p(Bartlett) < 0.001) (Hair et al., 1998). For patent energy, four items were used to derive the dimensions related to patent pool and patent information search behavior. Factor analysis revealed only one underlying factor with an eigenvalue of 2.836. This factor explained 70.91% of the total variation, and the factor loadings were greater than 0.57. Seven items were used to evaluate patent management institutionalization, with factor analysis revealing one factor, with a cumulative variance of 65.71%. The other three factor analyses also revealed only one factor with cumulative variances of 75.28%, 86.91% and 70.16%. Table 2 summarizes the patent strategy variables for factor analysis. The Cronbach's alpha scores for the items range from a low of 0.78 to a high of 0.92, all greater than 0.70, indicating that the Cronbach's alpha scores have a sufficiently high degree of inter-item reliability (Flynn et al., 1990). To evaluate the items, corrected item-total scale correlations and pairwise correlations between the items were calculated. An item was deleted if any of the following was true: (1) its item-total scale correlation coefficient was below 0.30 (Ferketich, 1991); and (2) the correlation between two items within a dimension did not exceed 0.30 (Robinson et al., 1991). The results of item-total scale correlations range from 0.423 to 0.808 and all pairwise correlations between two items within a dimension range from 0.359 to 0.776, all greater than 0.30, so 21 items were retained from the above analysis.

The next step was to analyze the content and convergent validity of the measurement scales used. Content validity indicated that the items included in the survey correlated represent the concept to be analyzed. Since the scales built on the basis of the previous literature (Table 1) had already been validated for measuring similar concepts and the questionnaire was pre-examined by four SMEs' patent managers, it was considered that each item had the necessary content validity. Convergent validity was assessed by evaluating the factor loadings. EFA was used to validate the convergent validity of the research. Table 2 shows that the engine-values of all the factors were exceeding 1.0 and that all the factor loadings exceeded 0.57. Thus, the research construct had a valuable convergent validity.

4.2. Determining number of clusters

Results of the cluster analysis in both split-half subsamples indicate a five-cluster solution. Assessment of the agreement between the subsamples using the Cohen's k statistic suggests

Table 2
Factors and corresponding items of patent strategy.

Constructs	Measurement	Factor loadings	Communality	Eigenvalue/cumulative variance (%)	Cronbach's alpha	Corrected item-total correlation
Patent energy	Patent application	0.935	0.875	2.836/70.91%	0.86	0.535
	Patent issued	0.921	0.849			0.492
	Patent family	0.888	0.788			0.558
	Patent information search	0.570	0.325			0.422
Patent management institutionalization	Annual budget for patent activities	0.800	0.639	4.600/65.71%	0.91	0.769
	Top management commitment	0.848	0.718			0.729
	Training courses	0.880	0.774			0.752
	Patent ownership law	0.820	0.672			0.722
	Financial incentives mechanisms	0.781	0.609			0.649
	Confidentiality mechanisms	0.767	0.588			0.634
	Research notebook mechanisms	0.774	0.598			0.623
Patent creation	Patent application examination	0.825	0.680	3.764/75.28%	0.92	0.784
	Patent prior art search	0.905	0.818			0.779
	Patent family examination	0.880	0.774			0.808
	Commercialization evaluation	0.835	0.696			0.690
	Claim patentability examination	0.891	0.795			0.789
Patent renewal	Patent portfolio examination	0.932	0.869	1.738/86.91%	0.85	0.762
	Patent maintenance examination	0.932	0.869			0.758
Patent exploitation	Patent exploitation planning	0.821	0.822	2.105/70.16%	0.78	0.723
	Patented technology application	0.634	0.688			0.731
	Patent licensing revenue	0.875	0.595			0.486

that the cluster solution has high internal reliability ($k = 0.742$; $p < 0.000$). We then use the Ward method to identify the number of clusters, which shows that when the number of groups is reduced from five to four, the agglomeration coefficient suddenly rises sharply (from 341.92 to 385.87). The agglomeration coefficient represents the square Euclidean distance between the two clusters joined. As such, small coefficients indicate that fairly homogeneous clusters are joined, whereas larger values indicate that dissimilar clusters are joined. Therefore, the most suitable number of groups is defined as five.

After deciding on the number of groups, we used *k*-means cluster analysis to divide the 238 SMEs into five clusters. Scheffe's multivariate comparison was used to identify the differences among groups, which shows that each of the five clustering variables is significant at $p < 0.05$ respectively. To enhance the interpretation and validation of the clusters, we also used Scheffe's multivariate comparison to test the four items of patent energy to compare among five clusters. Table 3 records the average scores and the results of the Scheffe's multivariate comparison of the five patent strategy dimensions in the five groups.

4.3. Interpretation of clusters

Returning to Table 3, the five patent strategies were identified based on the level of the emphasized activity in the patent value chain across the five clusters, and the relative emphasis of the activity within each cluster. The interpretation of clusters is described below.

4.3.1. Cluster 1: comprehensive patent strategy

Statistically, cluster 1 ($n = 45$) reported the strongest emphasis on the entire patent management dimension among the five clusters. Firms in cluster 1 perform the most active patent management activities to assess commercial value and competitive use of patents for their businesses. The patent strategy of firms in cluster 1 spans the patent value chain from generation through protection to exploitation. These firms employ patent management as part of a business strategy aimed at accumulating large patent portfolios, which are used as bargaining chips in cross-licensing to protect innovative firms against infringement suits, to generate royalty revenues from licensing, and to apply technology in products. The firms in this cluster believe that patent management is the comprehensive collection of ongoing activities and processes that organizations use to systematically coordinate and align resources into a business strategy to extract value from patents. Thus cluster 1 is named the “comprehensive” patent strategy.

4.3.2. Cluster 2: exploitative patent strategy

Cluster 2 ($n = 57$) has the second highest scores for patent management institution mechanism, patent creation, patent renewal, and patent exploitation, but lower scores for patent energy than cluster 3. The firms from cluster 2 focus on how to reduce the costs of filing and maintaining their patent portfolios through patent creation and patent renewal management using better patent management mechanisms, and maximization of profits from patent exploitation. We identified this cluster as “exploitative” to reflect the firm's aim to improve the quality of patents through management and extracting more economic value from them rather than increasing their quantity.

4.3.3. Cluster 3: defensive patent strategy

In cluster 3 ($n = 64$), the mean score of the patent energy indicator is 2.95 and the four items — patent application, patent issued, patent family and patent information search indicators — have significantly higher mean scores, while the other four dimensions of patent strategy have lower mean scores than those in cluster 2. However, the firms in cluster 3 generally agree that patent application and patent management are important, and that more attention should be paid on accumulating the patent pool. Davis and Harrison (2001) mentioned that firms that applied for and filed a significant number of patents for the initiation of a basic patent strategy that facilitates patent generation and maintenance have their core businesses or technologies adequately protected. Defense is the most fundamental patent function, providing a patent shield to protect the firm from litigation (Davis and Harrison, 2001). Thus, defense of patent is a necessary and desirable activity. Cluster 3 is hence labeled the “defensive” pattern.

4.3.4. Cluster 4: reactive patent strategy

Firms in cluster 4 ($n = 54$) display lower scores in most variables when compared to the aforementioned three clusters, with mean scales all lower than 3 except for patent management institutionalization and patent creation. The mean score for the patent energy dimension is not significantly different from the firms with an exploitative patent strategy (cluster 2). The results show that firms in cluster 4 focus on filing and granting patents and accumulating patent energy, but are not good at patent management or extracting value from patents. These firms lack a set of consistent patent management

Table 3
Profile of clusters of firms and analysis of variance test.

Factors	Comprehensive (1) (n = 45)	Exploitation (2) (n = 57)	Defensive (3) (n = 64)	Reactive (4) (n = 54)	Marginal (5) (n = 18)	F-value	Scheffe's test
Patent management institutionalization	4.39	4.10	3.65	3.03	2.34	113.224***	1 > 2 > 3 > 4 > 5
Patent creation	4.53	4.21	3.85	3.10	2.00	188.372***	1 > 2 > 3 > 4 > 5
Patent renewal	4.50	4.07	3.57	2.96	1.86	139.236***	1 > 2 > 3 > 4 > 5
Patent exploitation	4.28	4.04	3.32	2.93	2.11	111.086***	1,2 > 3 > 4 > 5
Patent energy	3.82	1.90	2.95	1.65	1.47	103.528***	1,3 > 2,4,5
Patent application	3.98	1.86	3.09	1.69	1.39	68.001***	1,3 > 2,4,5
Patent issued	3.67	1.74	2.73	1.56	1.44	54.115***	1,3 > 2,4,5
Patent family	4.58	2.16	3.63	1.87	1.50	67.260***	1,3 > 2,4,5
Patent information search	3.04	1.86	2.34	1.50	1.56	20.048***	1,3 > 2,4,5

***: $p < .01$.

mechanisms. They may be granted patents, but they do not employ them when needed. Miles and Snow (1978) call this kind of strategy the "reactor" type, with a pattern of adjustment to the environment that is both inconsistent and unstable. Miles and Snow (1978) also mentioned that the inconsistency of their management mechanisms means that these firms fail to articulate a viable organizational strategy, or articulate ones without adequate structural and process coordination. Thus, lacking patent management mechanisms, the firms granted patent pools face difficulties in protecting their technologies, ensuring their defensive ability against potential competitors, and extracting value through licensing or infringement. Cluster 4 is categorized as the "reactive" pattern.

4.3.5. Cluster 5: marginal patent strategy

In cluster 5 ($n = 18$), the means of the five patent strategy constructs are all lower than 2.5, with the mean value of patent energy being 1.47. Firms in this cluster do not pay attention to patent management and have the fewest patent applications. Since these firms may have used other appropriable mechanisms aside from patents (i.e. complementary capabilities, lead times, and secrecy) to protect their innovations, they do not use patent rights for that purpose. We could say that firms in this cluster have marginal patent management activities. Therefore, cluster 5 is named the "marginal" pattern.

4.4. Patent strategies with external variables

As mentioned above, the five patent strategy clusters were determined by cluster analysis. Firms with a comprehensive patent strategy pay attention to the whole patent value chain; those with an exploitative strategy spend more energy on patent exploitation activities; firms with a defensive pattern concentrate on current patent applications and grants to ensure their core technologies are adequately protected. In contrast, firms with a reactive patent strategy accumulate several patents but do not know how to extract value from them, and lack a set of consistent patent management mechanisms when faced with changing environments. Lastly, marginal pattern firms are those that are not concerned with patent management activities.

In order to seek more in-depth information and to provide a measure of criterion-related validity, a number of external variables that were theoretically related to the cluster were used to examine the relationship with the patent strategy patterns for a measure of criterion-related validity using the Chi-square test and logistic regression. Previous references (Cohen et al., 2002; Jensen and Webster, 2006) have shown that firms that use patents to protect innovations differ in terms of industry, firm size, R&D expenditure, and firm innovation category. The results of these tests are discussed below and summarized in Appendix Tables 2–5 by using a Chi-square test. All organizational attributes and industries are significantly correlated with each patent strategy identified (at $p < 0.1$).

Appendix Table 2 shows that different strategic clusters were found across different industries. At the same time, different strategic clusters were also present within the same industry, implying that SMEs could compete effectively in the same industry using different combinations of patent management activities. For example, there are 16 firms with comprehensive strategies, 23 exploitative, 24 defensive, 15 reactive and 4 marginal patent strategies in the BIOTECH industry. Patent strategies are hence not industry-specific, but depend more upon firm-specific or environmental factors. This finding is consistent with that of Cohen et al. (2002) and Hanel (2006). The finding also supports Porter's (1980) view that players can use wide range of strategies within the same industry.

Appendix Table 3 shows the crosstab analysis for patent strategy patterns and the firm size measured by total assets and number of employee categories. The results show that the patent strategy patterns among different firm sizes are significantly different. 66.7% of firms with comprehensive patent strategy have more than NT$3 billion in total assets, and 44.5% of the firms with comprehensive patent strategy have more than 100 employees. The firms labeled as comprehensive tend to be relatively larger in size than other types of firms. These results reveal that larger SMEs with sufficient resources are more likely to systematically manage and extract patent value throughout the whole organization.

The patent strategy patterns of the firms in the four R&D expenditure categories presented diverse results and the statistical result is significantly different ($\chi^2(12) = 42.762$, $p = 0.000$) in Appendix Table 4. 82.2% of the comprehensive strategy adopters, 49.1% of the exploitative strategy adopters, and 53.1% of the defensive strategy adopters had more than 6% of total sales on R&D expenditures. Additionally, 62.2% of the comprehensive patent strategy pattern adopters spent more than 10% of total sales on R&D expenditures annually. However, the R&D expenditure of most of the reactive and marginal strategy adopters is lower than that of adopters of the other three strategies — 50.0% of marginal patent strategy adopters spent less than 3% on R&D. This finding shows that firm size or R&D expenditure of firms influences resource allocation regarding patent management in the application stage as well as in the monitoring and enforcement stages. These results are the same as those of previous research (Hanel, 2006; Cohen, 2010; Cohen et al., 2002; Jensen and Webster, 2006).

The relationship between firm innovation categories and patent strategy patterns using Chi-square test shows a significant result ($\chi^2(12) = 2.137$, $p = 0.027$) (in Appendix Table 5). 40.0% of firms with comprehensive patent strategies adopted radical innovation that first used technologies new to their industries, while more than 64% of firms adopting the other four patent strategies were of the off-the-shelf and incremental innovation types, where firms work to improve existing products or processes.

Furthermore, the estimated regression coefficient of five logistic models predicts the probability that a firm uses a particular patent strategy with the dependent variable in binary form, regressed on external variables (dummy variables for industries, Size, R&D/Sales and the innovation strategy). The signs of regression coefficients show whether they answer "yes" to a particular external variable (the variable takes value one), increasing (+) or decreasing (−) the probability that a firm uses the particular patent strategy.

Table 4 shows the result of logistic regression analysis. Except model 3 (the adopting of defensive patent strategy), the overall model evaluation results of the other four patent strategies are significant. Besides, the Hosmer–Lemeshow test showed that the p-value of five logistic models was insignificant ($p > 0.05$), suggesting that the five models were fit to the data well. In other words, the null hypothesis of a good model that fit to data was tenable. The statistical significance of individual regression coefficients in each model was tested using the Wald chi-square statistic. Regarding the type of patent strategy used, there seems to be a difference between the main factors determining the choice of patent strategy.

Regarding the factors determining the use of comprehensive patent strategies, the main explanatory factors are asset size, size of R&D expenditure and firm innovation categories. The larger SMEs that developed radical innovations were, the more they spent on R&D expenditures to adopt comprehensive patent strategies. This result is similar to that of previous research, which indicated that larger SMEs with sufficient resources are more likely to systematically manage and extract patent value throughout the whole organization (Cohen et al., 2000; Blind et al., 2006). Organizations that engage in basic research have sufficient R&D resources and tend to devote their resources proactively to the identification, development and subsequent exploitation of patents (Siegel et al., 2003; Lockett and Wright, 2005; Younga et al., 2008).

Additionally, the firms are not more likely to use exploitation patent strategy in the electrical, office and communication industry and when they are larger SMEs, as indicated by the negative effect of electric industry and total asset size. The firms have 3%–6% R&D expenditure on sales that tend to adopt the exploitation patent strategy, as indicated by the positive effect of R&D expenditure. These results indicate that firms need to evaluate the risk and profit in the patent value chain to determine filing patents based on limited R&D resource and generally spend more energy on patent exploitation (Parchomovsky and Wagner, 2005; Lanjouw and Schankerman, 2004).

Finally, the use of reactive and marginal patent strategy is negatively influenced by the size of R&D expenditure. Reactive and marginal patent adopters have insufficient R&D resources, and did not pay attention to patent management and accumulate patent energy and may have used other appropriable mechanisms (i.e. complementary capabilities, and lead times) to protect their innovation.

5. Conclusions and implications

5.1. Theoretical implications

How do SMEs strategically manage their patents to reflect the multiple pressures emanating from competition and costs? In addressing this question, we provide a list of variables, conceptual definitions, and operational measures of patent strategy through literature review. Five patent management dimensions were used to indicate the types of patent strategy employed by SMEs. Through exploratory factor analysis, candidate indicators for each of the five dimensions — patent energy, patent management institutionalization, patent

Table 4
Use of patent strategy — results of logistic regressions.

Determinants	Dependent variable				
	Comprehensive (M1)	Exploitation (M2)	Defensive (M3)	Reactive (M4)	Marginal (M5)
Intercept	−6.333(1.492)***	−0.275(0.687)	−2.056(0.749)***	0.190(0.662)	−1.683(1.264)
INDUSTRY					
CHEMIC	0.502(0.853)	−0.504(0.627)	0.617(0.684)	−1.051(0.698)	1.378(1.204)
ELECTRIC	1.461(0.887)	−2.508(1.137)**	0.694(0.739)	0.104(0.686)	−0.112(1.549)
MACHINE	0.111(0.848)	−0.673(0.578)	0.481(0.661)	0.100(0.583)	0.515(1.220)
BIOTECH	0.542(0.771)	−0.410(0.526)	0.722(0.616)	−0.571(0.566)	−0.193(1.213)
ENERGY	1.282(0.932)	−0.849(0.741)	0.747(0.734)	−0.674(0.758)	−1.522(1.999)
INTERNET	Ref.	Ref.	Ref.	Ref.	Ref.
ASSET SIZE					
<5	Ref.	Ref.	Ref.	Ref.	Ref.
5–10	1.595(0.991)	−0.447(0.561)	−0.347(0.610)	−0.045(0.555)	0.347(0.936)
10–30	2.012(0.844)***	−0.541(0.463)	−0.148(0.481)	−0.330(0.477)	−0.100(0.857)
30–80	2.365(0.905)***	−1.778(0.831)**	0.597(0.575)	−0.910(0.729)	0.152(1.244)
≧80	2.259(0.793)***	−0.970(0.427)**	0.357(0.417)	−0.664(0.450)	−0.288(0.820)
R&D					
<3%	Ref.	Ref.	Ref.	Ref.	Ref.
3%–6%	1.702(1.124)	1.046(0.514)**	0.363(0.468)	−0.964(0.461)**	−1.139(0.640)**
6%–10%	2.637(1.119)***	0.371(0.589)	0.202(0.522)	−0.532(0.497)	−1.793(0.864)**
≧10%	2.788(1.090)***	0.552(0.530)	0.279(0.474)	−1.201(0.476)***	−2.004(0.864)**
INNOVATION					
SHELF	Ref.	Ref.	Ref.	Ref.	Ref.
INCRE	−0.392(0.540)	−0.220(0.387)	0.113(0.385)	0.109(0.405)	0.353(0.629)
NEXT	0.156(0.643)	−0.664(0.591)	0.510(0.469)	0.130(0.515)	−0.396(0.933)
RADICAL	1.014(0.500)**	−0.563(0.498)	−0.147(0.465)	−0.163(0.543)	−0.845(1.185)
Observations	238	238	238	238	238
Chi-square(15)	53.611	25.260	8.10	20.478	24.149
Prob > chi^2	0.000	0.047	0.920	0.100	0.063
Hosmer–Lemeshow test					
Chi-square(8)	7.495	3.588	11.700	4.788	4.021
Prob > chi^2	0.484	0.892	0.165	0.780	0.855

Standard errors are in brackets.
**: p < .05, ***: p < .01.

creation, patent renewal, and patent exploitation — were explored independently. This study contributes to the literature by exploring different factors of patent strategy and demonstrating empirical evidence for taxonomy of SME patent strategy.

Then, using Ketchen and Shook (1996) cluster analysis procedure, we validated the five types of strategies employed in these five dimensions, labeling the resulting patent strategy types "comprehensive", "exploitative", "defensive", "reactive", and "marginal", each with its own strategy for responding to the environment and its own particular configuration. Firms with a comprehensive patent strategy pay attention to the whole patent value chain. Firms with an exploitative pattern emphasize cost-effective analysis that evaluates the risk and profit in the patent value chain to determine filing of patents, and generally spend more energy on patent management institutionalization and patent exploitation. Firms with a defensive pattern focus on current patent applications and grants to ensure their core businesses or technologies are adequately protected. Firms with reactive patent strategies lack a set of consistent patent management mechanisms and are not able to extract value from patents in changing environments. Firms that do not pay attention to patent management and have the lowest patent energy show features of the marginal pattern.

Previous patent management research that focused on identifying patent strategic configurations and taxonomies used large firms as samples, and therefore lacks a series of procedures to analyze qualitative data and clear theoretical frameworks, especially regarding the central inductive process and the role of literature (Granstrand, 1999; Rivette and Kline, 2000a; Rivette and Kline, 2000b; Davis and Harrison, 2001; Reitzig, 2007). Compared with these studies, the main contribution of this study is the provision of a new description of patent strategies for SMEs and a discussion of the analytical assessment of the actual practice of patent management and respective patent strategies.

Finally, the patent strategy types show positive correlation with firm size, R&D expenditure categories, and firm innovation categories. This analysis offers a number of useful insights regarding the relationship between organization characterization and patent strategy patterns, which adds to validation of the clusters in terms of criterion validity. The results show that the larger SMEs that developed radical innovations with more R&D expenditures adopted comprehensive patent strategies. This result indicates that larger SMEs with sufficient resources are more likely to systematically manage and extract patent value throughout the whole organization (Cohen et al., 2000; Blind et al., 2006). However, most of the reactive and marginal strategy adopters have lower R&D expenditure than the other three strategy adopters — comprehensive, exploitation and defensive. Additionally, some SMEs of smaller size or with lower R&D expenditure on sales adopted the exploitation patent strategy. SMEs that adopted the exploitation patent strategy generally filed fewer patent applications but spent more energy on patent exploitation. Firms need to evaluate risk and profit in the patent value chain to determine whether to file patents based on limited R&D resources (Parchomovsky and Wagner, 2005; Lanjouw and Schankerman, 2004). The results are similar to those of some studies (Cohen, 2010; Cohen et al., 2002; Jensen and Webster, 2006) that found that patent strategies of firms are correlated with firm size and R&D expenditure.

5.2. Practical implications

Most SMEs are well aware of the importance of innovation and patent management, and how these enable them to develop new product fields and markets and give them a competitive edge in existing markets through differentiation or cost advantages. However, most SMEs do not utilize patent management and strategies. IP government organizations in many countries, such as the JPO, EPO, and WIPO, have promoted the importance of patent management and formulated related policies to aid SMEs in building patent value. Taiwanese policy-makers also need to formulate related policies to aid SMEs in patent management. Policy-makers can utilize the reference picture of patent management of SMEs provided by the results of this research and provide adequate assistance to firms with diverse organizational characteristics. The five patent strategy constructs showcase the overall patent awareness within the SME sector.

5.3. Limitations and future research suggestions

The results are influenced by several limitations. First, this paper provides a conceptual framework and taxonomy of patent strategy based on 238 Taiwanese innovative SMEs cooperated with the ITRI. In Taiwan there are a large number of SMEs, covering a broad spectrum of industries, technical fields and innovative level. Very few SMEs are considered innovative and some SMEs are involved in less or no innovation but still could generate innovation protected by design patent and instead survive by operating in specific geographic or market niches. The small sample size used in this study limit possibilities for generalizations. However, the result of this study has enabled a contrast to previous results by providing richer contexts in understanding the implementation of patent management in innovative SMEs. To gain a more comprehensive understanding of the taxonomy of patent strategy in SMEs, future studies may consider using a larger sample representative of innovative and non-innovative firms to compare the differences in patent strategy taxonomy among different innovative levels and across more industry or technical field types.

Besides, we are unable to track the innovation or financial performance of the patent strategies, and therefore this research cannot verify the performance of each patent strategy. Furthermore, firms may change patent strategy in unstable business environments. All participants responded within a particular time frame and were only given a single opportunity to respond. As such, the results cannot reliably assert that such data will hold true over time, especially in an unstable business environment. Changes of strategy are not within our research scope, but may make a good issue for future research. Based on the Davis and Harrison (2001) patent value hierarchy system, another interesting topic is suggested for future studies: the prospective and defensive patent strategies are at opposite ends of a continuum of adjustment strategies; do firms with exploitative patent strategies create better patent management institution mechanisms and patent exploitation audit mechanisms than those with defensive strategies focused on patent application but not patent management? Firms employing exploitative patent strategies may minimize patent application cost while maximizing their opportunity to profit from patent exploitation. Davis and Harrison (2001) thought that if the defensive strategy is the foundation of patent value, then firms should establish different patent management mechanisms to extract different patent values. Firms with exploitative patent strategies attempt to move from an era in which companies have sought to overwhelm their competition with the number of patent applications filed (defensive patent strategy), to a new era in which companies have attempted to file patents to protect core technologies and have effectively used their patent portfolios (comprehensive patent strategy). Between these two extremes, is there a patent strategy called the exploitative?

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Appendix A

Appendix Table 1
Profile of respondents.

Variables	Descriptions	Number of firms
INDUSTRY	Type of industry	
CHEMIC	Chemical, rubber, and plastic industry	36(15.1%)
ELECTRIC	Electrical, office, and communication industry,	23(9.7%)
MACHINE	Machinery, motor vehicle, and transport equipment industry	51(21.4%)
BIOTECH	Biotechnology, pharmacy, medical instrument industry	82(34.5%)
ENERGY	Energy and environment-friendly industry	22(9.2%)
INTERNET	Internet and E-business industry.	24(10.1%)
ASSET SIZE	Total asset size (NT$ millions)	
<5	<5	51(21.4%)
5–10	5 to <10	26(10.9%)
10–30	10 to <30	54(22.7%)
30–80	30 to <80	21(8.8%)
≧80	≧80	86(36.1%)
EMPLOYEE	Employment size	
≦10	≦10 employees	48(20.2%)
11–50	11–50 employees	77(32.4%)
51–100	51–100 employees	44(18.5%)
101–150	101–150 employees	26(10.9%)
151–200	151–200 employees	43(18.1%)
R&D	Total sales on R&D expenditure	
<3%	<3%	44(18.5%)
3%–6%	3% to <6%	67(28.2%)
6%–10%	6% to <10%	42(17.6%)
≧10%	≧10%	85(35.7%)
INNOVATION	Firm innovation category	
SHELF	Of-the-shelf: exploits current standard technology without extending the operating window	73(30.7%)
INCRE	Incremental: extends existing technologies beyond the normal operating window	85(35.7%)
NEXT	Next generation: pushes existing technologies into a completely different operating window	34(14.3%)
RADICAL	Radical: first uses technology that is new to the industry	46(19.3%)

Appendix Table 2
Crosstab analysis for patent strategy and industry.

		Industry						
		CHEMIC	ELECTRIC	MACHINE	BIOTECH	ENERGY	INTERNET	Total
Comprehensive	Count	6(13.3%)	7(15.6%)	6(13.3%)	16(35.6%)	7(15.6%)	3(6.7%)	45
	Expected count	6.8	4.3	9.6	15.5	4.2	4.5	45.0
	Standard residual	−.3	1.3	−1.2	.1	1.4	−.7	
Exploitation	Count	8(14.0%)	1(1.8%)	12(21.1%)	23(40.4%)	4(7.0%)	9(15.8%)	57
	Expected count	8.6	5.5	12.2	19.6	5.3	5.7	57.0
	Standard residual	−.2	−1.9	−.1	.8	−.6	1.4	
Defensive	Count	10(15.6%)	7(10.9%)	12(18.8%)	24(37.5%)	7(10.9%)	4(6.3%)	64
	Expected count	9.7	6.2	13.7	22.1	5.9	6.5	64.0
	Standard residual	.1	.3	−.5	.4	.4	−1.0	
Reactive	Count	5(9.3%)	7(13.0%)	16(29.6%)	15(27.8%)	4(7.4%)	7(13.0%)	54
	Expected count	8.2	5.2	11.6	18.6	5.0	5.4	54.0
	Standard residual	−1.1	.8	1.3	−.8	−.4	.7	

(continued on next page)

Appendix Table 2 (*continued*)

		Industry						
		CHEMIC	ELECTRIC	MACHINE	BIOTECH	ENERGY	INTERNET	Total
Marginal	Count	7(38.9%)	1(5.6%)	5(27.8%)	4(22.2%)	0(.0%)	1(5.6%)	18
	Expected count	2.7	1.7	3.9	6.2	1.7	1.8	18.0
	Standard residual	2.6	−.6	.6	−.9	−1.3	−.6	
	Total	36	23	51	82	22	24	238

Appendix Table 3
Crosstab analysis for patent strategy and firm size.

		Total assets (NT$ millions)					Total
		<5	5–10	10–30	30–80	≧80	
Comprehensive	Count	2(4.4%)	3(6.7%)	10(22.2%)	7(15.6%)	23(51.1%)	45
	Expected count	9.6	4.9	10.2	4.0	16.3	45.0
	Standard residual	−2.5	−.9	−.1	1.5	1.7	
Exploitation	Count	19(33.3%)	7(12.3%)	13(22.8%)	2(3.5%)	16(28.1%)	57
	Expected count	12.2	6.2	12.9	5.0	20.6	57.0
	Standard residual	1.9	.3	.0	−1.4	−1.0	
Defensive	Count	12(18.8%)	5(7.8%)	12(18.8%)	8(12.5%)	27(42.2%)	64
	Expected count	13.7	7.0	14.5	5.6	23.1	64.0
	Standard residual	−.5	−.8	−.7	1.0	.8	
Reactive	Count	15(27.8%)	8(14.8%)	14(25.9%)	3(5.6%)	14(25.9%)	54
	Expected count	11.6	5.9	12.3	4.8	19.5	54.0
	Standard residual	1.0	.9	.5	−.8	−1.2	
Marginal	Count	3(16.7%)	3(16.7%)	5(27.8%)	1(5.6%)	6(33.3%)	18
	Expected count	3.9	2.0	4.1	1.6	6.5	18.0
	Standard residual	−.4	.7	.5	−.5	−.2	
	Total	51	26	54	21	86	238
	$\chi^2 = 26.899$; DF = 16, p = .043						
		Number of employees					Total
		≦10	11–50	51–100	101–150	151–200	
Comprehensive	Count	4(8.9%)	15(33.3%)	6(13.3%)	7(15.6%)	13(28.9%)	45
	Expected count	9.1	14.6	8.3	4.9	8.1	45.0
	Standard residual	−1.7	.1	−.8	.9	1.7	
Exploitation	Count	17(29.8%)	18(31.6%)	10(17.5%)	5(8.8%)	7(12.3%)	57
	Expected count	11.5	18.4	10.5	6.2	10.3	57.0
	Standard residual	1.6	−.1	−.2	−.5	−1.0	
Defensive	Count	9(14.1%)	15(23.4%)	15(23.4%)	9(14.1%)	16(25.0%)	64
	Expected count	12.9	20.7	11.8	7.0	11.6	64.0
	Standard residual	−1.1	−1.3	.9	.8	1.3	
Reactive	Count	15(27.8%)	21(38.9%)	10(18.5%)	2(3.7%)	6(11.1%)	54
	Expected count	10.9	17.5	10.0	5.9	9.8	54.0
	Standard residual	1.2	.8	.0	−1.6	−1.2	
Marginal	Count	3(16.7%)	8(44.4%)	3(16.7%)	3(16.7%)	1(5.6%)	18
	Expected count	3.6	5.8	3.3	2.0	3.3	18.0
	Standard residual	−.3	.9	−.2	.7	−1.2	
	Total	48	77	44	26	43	238
	$\chi^2 = 26.899$; DF = 16, p = .047						

Appendix Table 4
Crosstab analysis for patent strategy and total sales on R&D expenditure.

		Total sales on R&D expenditure				Total
		<3%	3%–6%	6%–9%	≧10%	
Comprehensive	Count	1(2.2%)	7(15.6%)	9(20.0%)	28(62.2%)	45
	Expected count	8.3	12.7	7.9	16.1	45.0
	Standard residual	−2.5	−1.6	.4	3.0	
Exploitation	Count	7(12.3%)	22(38.6%)	9(15.8%)	19(33.3%)	57
	Expected count	10.5	16.0	10.1	20.4	57.0
	Standard residual	−1.1	1.5	−.3	−.3	
Defensive	Count	10(15.6%)	20(31.3%)	11(17.2%)	23(35.9%)	64
	Expected count	11.8	18.0	11.3	22.9	64.0
	Standard residual	−.5	.5	−.1	.0	

Appendix Table 4 (*continued*)

		Total sales on R&D expenditure				Total
		<3%	3%–6%	6%–9%	≧10%	
Reactive	Count	17(31.5%)	13(24.1%)	11(20.4%)	13(24.1%)	54
	Expected count	10.0	15.2	9.5	19.3	54.0
	Standard residual	2.2	−.6	.5	−1.4	
Marginal	Count	9(50.0%)	5(27.8%)	2(11.1%)	2(11.1%)	18
	Expected count	3.3	5.1	3.2	6.4	18.0
	Standard residual	3.1	.0	−.7	−1.7	
	Total	44	67	42	85	238
	$\chi^2 = 42.762$; DF = 12, p = .000					

Appendix Table 5
Crosstab analysis for patent strategy and firm innovation categories.

		Firm innovation category				Total
		Of-the-shelf	Incremental	Next generation	Radical	
Comprehensive	Count	13(28.9%)	8(17.8%)	6(13.3%)	18(40.0%)	45
	Expected count	13.8	16.1	6.4	8.7	45.0
	Standard residual	−.2	−2.0	−.2	3.2	
Exploitation	Count	20(35.1%)	23(40.4%)	5(8.8%)	9(15.8%)	57
	Expected count	17.5	20.4	8.1	11.0	57.0
	Standard residual	.6	.6	−1.1	−.6	
Defensive	Count	19(29.7%)	22(34.4%)	12(18.8%)	11(17.2%)	64
	Expected count	19.6	22.9	9.1	12.4	64.0
	Standard residual	−.1	−.2	.9	−.4	
Reactive	Count	16(29.6%)	22(40.7%)	9(16.7%)	7(13.0%)	54
	Expected count	16.6	19.3	7.7	10.4	54.0
	Standard residual	−.1	.6	.5	−1.1	
Marginal	Count	5(27.8%)	10(55.6%)	2(11.1%)	1(5.6%)	18
	Expected count	5.5	6.4	2.6	3.5	18.0
	Standard residual	−.2	1.4	−.4	−1.3	
	Total	73	85	34	46	238
	$\chi^2 = 23.137$; DF = 12, p = .027					

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