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Modes of Appropriability in Taiwanese Innovating Service Firms: Reconsidering the Early Study of Thoma & Bizer (2013)

Min-Nan Chen
National Chiayi University
Department of BioBusiness Management
mnchen@mail.ncyu.edu.tw

Chia-Hung Wu
Yuan Ze University
College of Management
megchwu@saturn.yzu.edu.tw

Ching-Hsing Chang
National Chiayi University
Department of Biobusiness Management
chc@mail.ncyu.edu.tw

Abstract

This study aims to extend Thoma and Bizer's appropriability taxonomy and provides empirical evidence to deepen the understanding of appropriability modes adopted by all innovating service firms. By redeveloping a new taxonomic appropriability as the synthesis view, the drawback of Thoma & Bizer (2013) exercise can be overcome. Based on clustering techniques analysis, 311 out of 1,103 Taiwanese service firms are conducted by using a wide respect of factors including input, process and output. We identify four distinctive groups to extend Thoma and Bizer's finding: (1) complementary-based appropriability mode, (2) formal-based appropriability mode, (3) informal-based appropriability mode, and (4) low-profile appropriability mode. These four groups following the firm-specific assumption depend on such factors as R&D investment, innovation sourcing, and appropriability depth and breadth, indicating that service firms form varied appropriability modes in response to their specific business contexts. Furthermore, we also reveal evidence to show that the complementary-based appropriability mode offers the competitive protection strategies to prove in achieving better firm's innovation outputs. Finally, some managerial implications to enhance innovation protection are also provided.

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Abstract

This study aims to extend Thoma and Bizer's appropriability taxonomy and provides empirical evidence to deepen the understanding of appropriability modes adopted by all innovating service firms. By redeveloping a new taxonomic appropriability as the synthesis view, the drawback of Thoma & Bizer (2013) exercise can be overcome. Based on clustering techniques analysis, 311 out of 1,103 Taiwanese service firms are conducted by using a wide respect of factors including input, process and output. We identify four distinctive groups to extend Thoma and Bizer's finding: (1) complementary-based appropriability mode, (2) formal-based appropriability mode, (3) informal-based appropriability mode, and (4) low-profile appropriability mode. These four groups following the firm-specific assumption depend on such factors as R&D investment, innovation sourcing, and appropriability depth and breadth, indicating that service firms form varied appropriability modes in response to their specific business contexts. Furthermore, we also reveal evidence to show that the complementary-based appropriability mode offers the competitive protection strategies to prove in achieving better firm's innovation outputs. Finally, some managerial implications to enhance innovation protection are also provided.

Keywords: Appropriability, Service firms, Appropriability taxonomy

1. Introduction

Protecting returns from their innovative activities as "appropriability" has been identified as one of the key incentive for innovation by firms and sectors (Levin, Klevorick, Nelson, & Winter, 1987). Intellectual property rights (IPRs) play a major role for solving the appropriability problem if the certain knowledge is associated with the codification or explicitness. Cohen, Nelson, & Walsh (2000) revealed that firms improve conditions for appropriation the returns via different methods. These are not only including patents as formal forms but also covering lead time advantages as informal ways over competitors (Harabi, 1995). Patents are easily applicable used to protect physical artifacts in manufacturing sectors. Lead time advantages provide methods to move quickly down the learning curve over rivals. As pointed out by Blind et al. (2003), nature of attributes in service industries makes it difficult to use formal appropriability due to heterogeneous contents, diverse knowledge of service transactions, and intangible outputs. Instead, informal appropriability may play a substitutive mechanism to protect innovations (Miles, Andersen, Boden, & Howells, 2000; Teece, 1986).

However, the informal appropriability may not play a dominate method in innovation protection because it is usually considered as a service strategy that lacks the legal legitimacy (Bader, 2007). In such a context of loose appropriability situation in service industries, many empirical evidence show that using joint appropriability combining formal and informal forms may provide a competitive protection strategy rather than mutual exclusive appropriable mechanism usage (Amara, Landry, & Traore, 2008; Chang, Linton, & Chen, 2012; de Faria & Sofka, 2010; Gallie & Legros, 2012; Howells, Blind, Elder, & Evangelista, 2003). Thoma & Bizer (2013) pioneered the study of appropriability mode in service industries. They conduct cluster techniques to analyze appropriability strategies applied in small service firms and particular sectors. Unfortunately, their results have been

criticized and three major limitations have been deserved further investigation. Firstly, the measure scale of the formal and informal appropriability is firmly underestimated. This may affect a major bias of appropriability strategy modes. The measure applied 4-point Likert scale in their study is merely capable of investigating the "relevance" of appropriability activities but it is not sufficient for capturing the "depth" of appropriability. Its scale somehow only reflects the degree of the importance of appropriability use rather than actual appropriable behavior conducted inside firm. Coombs & Miles (2000) argued that a new proxy to capture appropriability depth should be further replaced with consideration of "number of times for appropriability adoption" repeatedly used by firms in a period time. Secondly, firm-size issues exceedingly do matters on appropriability applied and decide on appropriability modes selection. Harabi (1995) suggested that national innovative activities along with firm-size matter influence firm's choices of how to protect intellectual property. Large firms usually apply formal appropriable mechanisms as inferior to other informal methods in intellectual property rights protection (Arundel, 2001), because they often have sufficient resources to legally defend their intellectual property rights and own supportive enforcement costs while they rarely benefit from cross-licensing arrangements (Arundel & Kabla, 1998; Cohen et al., 2000). This indicates that large-size firms perceive formal appropriability more efficient than informal ones in innovation protection. In contrast, other studies argued that small firms refrain from using registered appropriability strategies because firm-size matter may disadvantage enforcements of intellectual property rights (Cohen et al., 2000; Thoma & Bizer, 2013). Only highly R&D-oriented small firms viewed the formal appropriability as the most critical protection instruments. Indeed, small firms prefer informal protection practices to intellectual property rights (Kitching & Blackburn, 1998; Leiponen & Byma, 2009). Third, many scholars have acknowledged that service

innovation processes are becoming open, diversified, distributed and democratic (Chang et al., 2012; Chesbrough, 2003; von Hippel, 1988, 2005). This suggests that service firms need to focus on maturity appropriability strategies to protect their innovations when they engage in diversity sourcing, implying that service firms approach ideas and knowledge not available within the boundaries of their organization (Cassiman & Veugelers, 2002). In the current study, we focus on two aspects of firm's appropriability- breadth and depth of appropriability (Katila & Ahuja, 2002; Laursen & Salter, 2006) by looking at the number of protection forms a firm replies on such as patent, copyright, trademark, lead time advantage and etc., and the number of times it repeatedly uses. Therefore, the study aims to extend appropriability taxonomies about how service firms are categorized by linking to their protection strategies in order to understand the firm's innovative behaviors and suggest a framework for policy implications.

By redeveloping a new taxonomic appropriability as the synthesis view, the drawback of Thoma & Bizer (2013) exercise can be overcome. Using a large-scale of samples, this paper adopts the synthesis perspective to reconsider Thoma and Bizer's appropriability taxonomy and significantly provides empirical evidence to deepen the understanding of appropriability modes adopted by all innovating service firms. The synthesis view integrates both assimilation and demarcation approaches to offer a complete perspective to measure appropriability activities (Drejer, 2004; Gallouj & Savona, 2009; Gallouj & Weinstein, 1997). The study has major potential theoretical contributions as follows. First, the current taxonomy provides particularly contribution given that the extant literature recognizes the importance of the taxonomic modes of appropriability that focus on using a large scale sample consideration of all innovative firms in service sectors. This exercise describes a comprehensive method to account for heterogeneity at firm level in Taiwan and suggests specific firm patters of behaviors of innovating firms that

are labeled in a group to predict their actions (Archibugi, 2001). In such situation, policymakers will be in a better position to meet the specific needs and provide the scaffold helps to certain firms since they have understood the taxonomy of appropriability modes. Second, the results consider a wide respect of factors of input, process and output to characterize four different modes of appropriability in all innovative firms. A particular measure of appropriability depth and breadth is mainly conducted to examine the strength of individual appropriation modes. These determinants offer special insights that can be derived into which kinds of appropriability modes are made decision by which the strength of protection and firm's innovative features. From the policymakers' perspective, it provides crucial clues to take into account the general appropriability conditions of firms before considering their abilities to utilize appropriability strategies.

This study is organized as follows. Section 2 reviews the literature related to the appropriability strategies including formal, informal and complementary. In Section 3, methodological issues are considered to address the data collection, analytical techniques and clustering variables. Section 4 presents the empirical taxonomy and taxonomic features. Section 5 offers some remarkable conclusions and discusses the implications for policy and future implementation.

2. Literature Review

2.1 Various Appropriability Mechanisms

Technological and service innovations contribute intellectual property and valuable knowledge that have to be protection by using various appropriability mechanisms to stop imitations and capture monopolistic profits (Harabi, 1995). These appropriability mechanisms need to be attention on protection forms and strategies while firms adopt methods and they distinguish formal, informal and complementary.

2.2 Formal Appropriability

Appropriability mechanisms include patent, trademark, copyright and trade secret are the most important formal forms to protect knowledge. Specifically, a patent offers the strongest form of appropriable protection. It provides the inventors monopolistic right to exclude others from economically exploiting, using and selling the innovation. Patenting is usually applicable for physical artifacts but service firms adopt the certain mechanisms against imitation (Bader, 2007, 2008). For instance, service insurance firms often use patents to prohibit insurance analytical model rights that stop rivals to copy (Bader, 2008). Software firms utilize patents as effective protection strategies to strengthen intellectual assets such as functions or technical services from competitors expropriation (de Laat, 2005), since they publish software products made information that are easily to be copied (Chabchoub & Niosi, 2005).

A trademark is a symbol, sign or image that offers a distinction of goods or services for one firm to others. It provides owners exclusive rights to use for identifying goods or licensing it to another in returns of payment. Trademarks are viewed as complementary index to capture aspects of innovation phenomena (Mendonca, Pereira, & Godinho, 2004), suggesting that trademarks are critical instruments in helping to position products and market segments. Trademarks in knowledge-intensive and technological-intensive firms are proved to enable to construct intellectual protections because these chosen symbols convey meaning and associations that serve professional offerings and resonate with a diversity of stakeholder audiences (Schmoch, 2003).

A copyright protects the writing of creators against imitation. Literary, music and artistic works are included within covering of protection that offers owners exclusive rights to distribute and publish their works with literal forms. The concept or idea of efforts is not subject to copyright protection. Only when these

are expressed in fixed media may protection arise. Software products utilize protection under the copyright since they comprise aspects such as components, algorithms and commands (de Laat, 2005). These software products worthy to be protected by using adoption of both copyrights and patents if they cover as different aspects of literary and process performed (Samuelson, 1993). Software producers use copyright appropriability that are stronger protection for their products as intellectual property (Maurer & Zugelder, 2000).

A trade secret includes any forms such as secret formula, patterns, programs, and techniques that are useful for owner's business and offer better advantages over competitors. Unlike other formal mechanisms (i.e., patent or copyright), the trade secret keeps the protection under continually conducting administration. This cause that the trade secret becomes a significant method that is jointly used together with other appropriable instruments (West, 2003) and plays a strategic alternative to other formal mechanisms with its involved disclosure requirement (Nieto & Perez-Cano, 2004). Software firms use joint appropriability methods to protect intellectual property including patents, copyrights and trade secrets (Hanel, 2006). This special combination reinforces a protection strategy because the trade secret is often seen as the mutually exclusive alternative to other forms of protection (Arundel, 2001).

2.3 Informal Appropriability

Compared to formal appropriability, service firms frequently adopt informal forms to attain their business advantages (Bader, 2007). These informal methods usually include lead time advantage, design complexity and lock-in tactic. Lead time advantages refer to firms creating shorter innovation cycles and updating new versions of products quickly to reduce the risk of copying by rivals (Lopez & Roberts, 2002). Such strategy imposes considerable innovation costs for firms due to short product cycles over small periods and offers potential tactics to

prevent competitors who increase imitation cost (Andersen, Howells, Miles, & Roberts, 2003; Harabi, 1995). Lead time advantages allow firms to gain better technological edge over the competition for a period time (Delerue & Lejeune, 2010).

A design complexity addresses a method to increase difficulties in keeping up with the pace of progress imposed and failing to achieve required throughput by rivals (Dibiaggio, 2007). Complexity of products and processes often relies on the integration of a wide range of technologies, components, and systems. This certain integration required thorough knowledge of technologies and abilities to specify and connect interface between different sub-systems (Brusoni, Prencipe, & Pavitt, 2001) that consist in building an entry barrier more complexity than one's rivals. For example, software products often bundle packages with software algorithms and hardware components together to prevent rival's imitation (Miles et al., 2000). IC (integrated circuit) design encompasses the particular specialized techniques required and professional capabilities that create a huge entry barrier for rivals who would like to replicate (Andersen & Howells, 2000).

A lock-in tactic offers the use of specific standards and protocols to increase user switch time and allow easy interoperability of products (Miles et al., 2000). This suggests that lock-in strategy uses a set of software operation and IT services support for relevant products of interoperability and increasing the learning time to retain client's loyalty (Andersen et al., 2003). Lock-in tactics provide codified products in a package that combine with marketing service and after-sales support to make complete total solutions that are difficult to imitate. This informal form is in line with PFI (profit form innovation) model offering the complementary assets to lock user loyalty in (Teece, 1986).

2.4 Complementary Appropriability

However, as no single appropriability provides firms with perfect protection

for their innovations. Using joint appropriability strategies offers a competitive protection than a single one tool. A joint use of appropriability combining formal and informal forms provides a better protection strategy rather than mutual exclusive mechanism use (Amara et al., 2008; Chang et al., 2012; Thoma & Bizer, 2013). Firm simultaneously use different appropriability as sets of formal and informal ways because the innovation delivery such varies in terms of codified knowledge and tangible output that suitable protection strategies vary (Amara et al., 2008; Howells et al., 2003). Moreover, a few studies have empirically explored on how different protection methods are jointly used in complementary to prevent intellectual imitation. Amara et al. (2008) focused on how to protect in knowledge-intensive business services and revealed that formal and informal appropriability constitute joint including patents, registration of design patterns, trademarks, trade secrets, and lead-time advantage. Leiponen & Byma (2009) examined that small firms' strategies for capturing returns on innovation investment and identified that IP strategies for small firms differ from large ones. Particularly, small firms prefer using informal means of protection such as lead time advantages as well as trade secret than patents, and adopt these two as join use. Chang et al. (2012) empirically tested the Miozzo and Soete's taxonomy. The study reveals that service firms often use joint appropriation mechanisms to protect innovations with formal and informal methods. Trade secrets, lead time, and lock-in tactics are complementary forms that are mutually reinforced by heterogeneity in service sectors. In addition, Gallie & Legros (2012) revealed that how French firms' use of intellectual property mechanisms with focusing on types of innovation, market sector and HR strategies. They draw on choices of appropriability forms are particular complex strategies but general appropriable methods of protection are commonly complementary inside firms.

3. Methodology

3.1 Data Collection

To carry out the empirical evidence, this study uses the firsthand data drawn from the large-scale survey of Taiwanese innovating service firms. A structured questionnaire is a primary instrument referred on basis of academic and practice literature. Following literature suggested by extant studies (Howells et al., 2003; Miles et al., 2000; OECD, 2005), the study modifies and extends the existing scale of the survey. In order to enhance the readability of the scale, the in-depth pilot interviews are also conducted with six academic researchers and five industrial experts who extensively engaged in service innovation studies and practices. After a preliminary scale is temporarily considered, a pretest is continuously conducted to test the validity and reliability of the scale. The final copy of the scale was used to collect wider activities such as formal and informal appropriability, innovation activities, process, and innovation outputs.

The survey population of Taiwanese innovating service firms is drawn from two sources: Top 1,000 innovating firms from China Credit Information Service 2009 and Top 500 innovating service firms from Global View Monthly 2009. I adopt these two lists to exclude the overlap samples and manufacturing firms and obtain 1,103 top innovating service firms ranked by annual revenue in 2009. Following prior literature suggestions (Bonner & Walker, 2004; Olson, Walker, & Ruekert, 1995), the survey is conducted to use postal mail distribution, and asks a firm's general manager participation and accepts multiple responses for other participants who engage in service innovation practices. To avoid bias, each valid survey has three respondents to confirm the scale items. These efforts elicit 311 samples that imply a final response rate as 28.2%. Following the procedures by (Armstrong & Overton, 1977; Miller & Smith, 1983; Radhakrishna & Doamekpor, 2008), Table 1 indicates the non-respondent bias test to compare population by sector (χ^2=16.67, p=0.34), location (χ^2 = 0.17, p=0.92) and size (χ^2= 6.21, p=0.52).

These results imply that non-respondent bias does not exist and 311 samples can significantly generalize the population of 1,103 top Taiwanese innovating service firms. The study conducts a Harmon's single-factor test to examine the common method bias because the survey items are primarily covering self-reported data. A result of the Harmon's single-factor indicates that no-single factor accounts for majority the variance (the first factor accounts for 14% of 55% total variance), while I conduct all variables into a single exploratory factor analysis (Podsakoff, MacKenzie, Podsakoff, & Lee, 2003).

There are 311 samples in a variety of sectors including 73 wholesale firms (23.47%), 29 financial firms (9.32%), 25 IC design firms (8.04%), 25 electronic engineering service firms (8.04%), 23 construction firms (7.40%), 23 other specialized service firms (7.40%), 19 transport and retaining firms (6.11%), 18 computer and software firms (5.79%), 15 system integration firms (4.82%), 12 insurance firms (3.86%), 11 utility service firms (3.54%), 10 real estate firms (3.22%), 8 hotel and restaurant firms (2.57%), 8 health service firms (2.57%), 8 technical service firms (2.57%), and 4 telecommunication firms (1.29%).

<<INSERT Table 1>>

3.2 Clustering Analyses

Following procedures suggested by prior studies (de Jong & Marsili, 2006; Evangelista, 2000; Hollenstein, 2003; Peneder, 2010; Thoma & Bizer, 2013), this study conducts a clustering analysis technique to develop appropriability modes. The clustering methodology is a primary analysis technique to classify similar firm's appropriability behaviors into homogeneous groups. The study performs the two-stage cluster analysis combining with hierarchical and non-hierarchical procedures to analyze the appropriability mechanisms. The two-stage clustering offers robust recover characteristics suggested by extensive literature (Ketchen & Shook, 1997; Milligan & Sokol, 1980).

Such a two-stage clustering analytical procedure initiates the first step of hierarchical analysis that considers a self-starting process to discover the best recovery of cluster structure (Milligan, 1980). A popular agglomerative algorithm of hierarchical analysis is a centroid method that builds a tree-like structure to provide a comparison of the centroid of each cluster (Punj & Stewart, 1983). A non-hierarchical technique of K-means algorithm proceeds to utilize the second step of clustering analysis. The K-means technique would automatically assign each observation to clusters with the closest centroid after initiative centroids of hierarchy process are produced. As each new observation is allocated, the cluster centroids are recomputed. This computing process continues until the nearest cluster centroid is determined for every observation. To arrive at optical clusters, the computing stops until no observation changes clusters.

To validate the robustness of each solution (two up to six clusters), the study conducts the Kappa technique, the chance correction coefficient between initial and final solution (Singh, 1990). The four-cluster solution is the most favorable and it shows the highest value of Kappa analysis ($k=0.75$, while $k<0.72$ for other solution) that compares with other solutions of cluster analysis. Lastly, the study performs four clusters as a final solution.

3.3 Clustering Variables

3.3.1 Innovation Performance

Following prior studies (Atuahene-Gima, Slater, & Olson, 2005; Hsieh, Tsai, & Hultink, 2006; Mansury & Love, 2008; OECD, 2005), we conduct survey measures to assess the innovation output as objective and subjective performance. We use four-item to capture the subjective degree of which a firm has achieved its goal of increasing efficiency, market share, service quality, and profitability. These four were measured on a seven-point scale with scale poles ranging from strongly disagree to strongly agree. Moreover, we also consider three objective measures

to assess the innovation performance that indicate the reality of which a firm has achieved its goal of number of new product development, share of new product development in total, and share of new product development sales in total sales (Cainelli, Evangelista, & Savona, 2006; OECD, 2005). These three items were used on measuring quantity or percentage a firm has conducted for a period of past three years (2007-2009).

3.3.2 Formal Appropriability

Formal appropriability reflects the extent of valuable skills and knowledge contributed by technological and service innovations that needs to be protected by using legal methods to barrier imitations (Gallouj & Weinstein, 1997; Harabi, 1995). We adopt and modify four-item scale (OECD, 2005) to assess the degree of which a firm utilizes legal protection mechanisms of patent, trademark, copyright and trade secret. These four were measured on a seven-point scale with scale poles ranging from strongly disagree to strongly agree for a period of past three years (2007-2009).

3.3.2 Informal Appropriability

Informal appropriability reflects the extent to manage service innovations to attain firm's business advantages and protect its market position (Bader, 2007; Milesi, Petelski, & Verre, 2013). We use and modify a three-item scale, developed by Bader (2008); Blind et al. (2003); OECD (2005) to access the degree of which a firm utilize non-legal protection mechanisms of lead time advantage, complexity design and lock-in tactic. These three items were scored on a 7-point scale with scale poles ranging from strongly disagree to strongly agree for a period of past three years (2007-2009).

3.3.3 Appropriability Breadth & Depth

Following a prior study (Laursen & Salter, 2006), we develop the concepts of breadth and depth as two components of the appropriability strategies. The first

concept refers to *appropriability breadth* that is defined as the number of formal and informal forms that a firm relies upon in their innovative activities (Katila & Ahuja, 2002). We use a dichotomy measure to access the idea of which a firm adopts formal and informal protection mechanisms for a period of past three years (2007-2009). The second concept refers to *appropriability depth* that is defined as the number of times a firm repeatedly uses different forms of formal and informal protection (Katila & Ahuja, 2002). We adopt a continuous measure to access the idea of which a firm repeatedly uses in terms of formal and informal appropriability for a period of past three years (2007-2009).

3.3.4 Innovation Input

Innovation input refers extent of a firm's innovative investment that enables to develop new products or improve the existing ones (Cainelli, Evangelista, & Savona, 2004; Djellal, Francoz, Gallouj, Gallouj, & Jacquin, 2003; Miles, 2007). We measure innovation input by capturing expenses of sets of innovation investment of which a firm achieves its goal of internal R&D, external consulting, marketing introduction and training activities (Leiponen, 2005; Miles, 2007; OECD, 2005). These four were measured on a continuous scale to capture innovative expenses in 2009.

3.3.5 Innovation Activity

R&D investment based on either internal or external sources enhances a firm's performance and its absorptive capacities (Cohen & Levinthal, 1990). The better internal R&D positions a firm to explore opportunities involving external R&D (Cohen & Levinthal, 1989, 1990). External sources of R&D offer innovation opportunities for a firm to develop or improve innovation performance (Amara & Landry, 2005; Chang, 2003). We use and modify a seven-item scale, developed by Amara & Landry (2005); Frenz & letto-Gillies (2009); Magnusson, Matthing, & Kristensson (2003); OECD (2005) to capture the degree of which a firm utilizes

innovation activities by adopting internal or external sources of in-house R&D, supplier, customer, research institute, consultant, responsive as well as proactive involvement. These seven items were scored on a 7-point scale with scale poles ranging from strongly disagree to strongly agree for a period of past three years (2007-2009).

3.3.6 Innovation Process

Innovation trajectories represent the movement along a path based on past accumulation of knowledge, competences, capabilities and strategies (Dosi, 1982; Nelson & Winter, 1977, 1982). Following prior studies (Amit & Zott, 2012; Barras, 1986; Damanpour, 1991; OECD, 2005), we conduct survey measures to assess the innovation process as four types of innovation: product, process, organizational and business model. We use eight-item to assess the subjective degree of which a firm achieves its innovative types. These eight were measured with seven-point scale, ranging from strongly disagree to strongly agree.

4. Result

This study performs two-stage cluster analysis to identify different modes of appropriability (Table 2). Based on cluster results, we implement variables that pertain to innovation input, process and output factors determining innovative intensity, innovation structural characteristics of firms and selected performance to characterize four clusters (Table 3). As shown in Table 2, four specific modes of appropriability are prevalent in the Taiwanese innovating service firms. These four are labeled as: (1) cluster 1: complementary-based appropriability mode, (2) cluster 2: formal-based appropriability mode, (3) cluster 3: informal-based appropriability mode, and (4) cluster 4: low-profile appropriability mode. Now each cluster is specifically described.

<<INSERT Table 2>>

<<INSERT Table 3>>

4.1 Cluster1: complement-based appropriability mode

This cluster consists of 29 innovative firms (9% of the total firms), which are endowed with the strongest intellectual property rights protection to present in the highest mean values in all formal and informal mechanisms except the patent, and perform the highest mean values in appropriability breadth (5.79 channels) and appropriability depth (12.50 intensity), and are engaged intensively in R&D input within a highly favorable environment in terms of internal R&D investment, external consulting, marketing introduction, and training expenses on employee. Innovative activities are supported by intensive adoption of internal sources of knowledge, as well as diversity external sources including supplier, customer, co-operative R&D projects with universities and research institutes, and other consultants. Co-opting innovation value is also created with customers by using both responsive and proactive type involvement simultaneous. These two market value co-creation mechanisms collect customer knowledge throughout satisfying their expressed and latent needs. Innovation processes in the cluster involve both of products and processes consider the degree of new to market and new to firm, and devote organizational innovations and business models creation. Innovation output consists in many outperformed objective and subjective instances that include numbers of NPD (11.45), share of NPD in total (18.10%), and share of NPD sale in total sales (17.76%) as objective outputs, and efficiency increased, market share increased, service quality improvement and profitability increased as subjective outputs. The cluster also contains an above-average proportion of large-sized firms. Specialized services, IC design and system integration are main sectors to be composed in the cluster (see Table 4).

4.2 Cluster2: formal-based appropriability mode

This cluster contains 74 innovative firms (24% of the total firms), which are made efforts by adoption of formal intellectual property rights especially patents

for protection innovation. Trade secrets are relevant for this cluster that confirms the special role of trade secrets protection. Apart from technical mechanisms, the cluster also attributes higher mean values of informal appropriable ways of lead time advantages and complexity design so it reflects on higher characteristics of appropriability breadth (4.66 channels) and depth (10.15 intensity). Firms in the cluster mainly consider the highest input of R&D investment with internal R&D, marketing introduction, training activities on qualified employee. These firms are intensive users of manifold sources of internal knowledge specialized in in-house R&D and conduct responsive type of involvement to understand users' expressed needs. Innovation processes in the cluster focus on developing new products and adopting new business models so that it achieves outperformance on numbers of NPD (11.24), share of NPD in total (21.22%), and share of NPD sale in total sales (20%) as objective outputs. Due to intensive internal R&D investment, the cluster involves an above-average proportion of large-sized firms and sectors composed across the cluster include IC design, electronic engineering and wholesale firms.

4.3 Cluster3: informal-based appropriability mode

This cluster of 122 innovative firms is by far the largest group (39% of the total firms), which is characterized by higher using informal intellectual property rights of other than formal IPRs. Lock-in tactics and trade secrets mechanisms in particular serve as important protection for this cluster. Compared with the other groups, the cluster performs the firmly characteristics of appropriability breadth (2.94 channels) and depth (7.71 intensity), and conducts moderately low level of R&D innovation inputs (all input investment ranking third highest). Firms within the cluster drive innovative activities from sources of suppliers and consultants and employ responsive involvement to collect users' expressed needs. Innovation processes occur in the cluster that draws attention on process and organizational innovations, indicating that implementation of a new or significantly improved

production and delivery methods by adopting machinery and software as well as equipment and application plays an important role. This performs better process improvement in terms of efficiency (4.82) and service quality (5.64) rather than product development on numbers of NPD (8.37), share of NPD in total (14.18%), and share of NPD sale in total sales (14.51%). These firms occupy above average proportion of large-sized firms in the cluster and majorly compose sectors in the wholesale, transport and retailing, finance, construction, and specialized services firms.

4.4 Cluster4: low-profile appropriability mode

This cluster includes 86 firms (28% of the total firms), which are shown by making weak conscious efforts to protect their innovations. Compared with other three groups, the cluster seems to face a lower risk of imitation and displays that the IPRs protection plays a minor role in determining innovations. Firms within the cluster consider relatively weak in all characteristics of poor appropriability breadth (1.72 channels) and depth (2.96 intensity), less innovation investment (all inputs ranking lowest), unfavorable innovation activities in term of internal as well as external sources and innovation processes, and employ lower outcome of performance. The cluster conducts main proportion of small and medium sized firms (firm's size under 200) that occupies than more 50% of compositions and mainly compose construction, utility services and a few of wholesale firms.

<<INSERT Table 4>>

5. Discussion and Conclusion

The study extends appropriability taxonomies about how service firms are categorized by linking to their protection strategies in order to understand the firm's appropriability behaviors. Using a starting point of the study from Thoma and Bizer (2013), we focus on firm's appropriability breadth and depth to derive into four distinct groups of firms. Based on clustering techniques analysis, 311

out of 1,103 Taiwanese service firms are conducted to analyze. There are four groups following firm-specific assumption that depend on such factors as R&D investment, innovation sourcing, appropriability depth and breadth, indicating that service firms form varied appropriability modes in response to their specific business contexts. These four are identified as follows: (1) complementary-based appropriability mode, (2) formal-based appropriability mode, (3) informal-based appropriability mode, and (4) low-profile appropriability mode. Moreover, we significantly provide empirical evidence to reveal that the complementary-based appropriability mode offers the competitive protection strategies to prove in achieving better firm's innovation outputs.

Based on our findings, the firm-specific assumption offers a rationale why industry compositions across these four clusters have distribution of protection patterns and firm within sectors follow multiple appropriability strategies. This firm specificity suggests that firm's innovations and heterogeneities differ across industries and within an industry that have formed varied patterns of knowledge accumulation and development strategies to face their idiosyncratic situations (Ahuja & Katila, 2004; Helfat, 1994; Leiponen & Drejer, 2007). Such firm-specific assumption is characterized by firm's prior strategic differentiation and initial resources in terms of internal knowledge search and application to firm-specific setting (Leiponen & Drejer, 2007; Wang & Chen, 2010). The two original theories form why the firm specificity is built. First, from the loosely coupled innovation system theory, service firms show a lack of coherence and less of series of relationships between different innovative trajectories through which knowledge and ideas are diffused (Chang et al., 2012; Sundbo & Gallouj, 2000). This loose chain linking is a cause of ambiguity to result in which service firms within an industry differ from the norms of the sector (Orton & Weick, 1990) and decide whether innovation patterns in service firms are less sector-dependent (Hipp &

Grupp, 2005). Second, from the path-dependence of the evolutionary theory, service firms intend to search for and develop new innovation knowledge in area that enables them to build on their established knowledge base (Dosi, 1982, 1988; Nelson & Winter, 1982). This path dependent nature suggests knowledge learning is cumulative process to draw on applying past innovative knowledge to new innovations and reinforce the firm-specific application on firm's innovative knowledge. The path-dependence facilitates a specific form of firm observed in reality that differ significantly across firms because it reflects different individual learning process and development environment (Malerba & Orsenigo, 1993).

The study confirms that the complement-based appropriability mode offers competitive protection strategies to achieve the better innovation performance. This finding corresponds with previous literature that joint use of appropriability provides better protection strategies rather than mutual exclusive mechanism use that perform the competitive outputs (Amara et al., 2008; Chang et al., 2012; Gallie & Legros, 2012; Leiponen & Byma, 2009; Thoma & Bizer, 2013). Moreover, the study also reveals that the informal-based appropriability mode occupies the largest group that is majority proportion of total firms (39% of total service firms in the sample). This finding extends previous empirical evidence that informal appropriability are prevalent strategies than formal ones to manage protection innovation in service firms (Bader, 2007; Miles et al., 2000). Such informal ways are often used frequently because these are an integral part of daily routines and are characterized by simple, easy to control and economical to use (Paallysaho & Kuusisto, 2011). Another explanation is that informal appropriability provides an effective strategy to capture its benefits promptly but formal ones have a time lag limitation between publication and market launch. Particularly, an informal way of lead time advantages is capable of updating new versions of products quickly to reduce risks of imitation and processes monopolistic profits because of short

product life cycles, but a formal method of patents often have the time lag effect on the firm's profitability. Such distinction between these two methods may be a critical characteristic to decide the protection strategies applied for service firms.

The study also verifies that firm-size issue does a matter on appropriability model selection. Our findings indicate that large-size firm compositions occupy beyond 50% in the two clusters including complement-based and formal-based modes (for which these two involve formal appropriability), suggesting that the large firms are more likely than small-medium sized firms (<200 employee) to conduct registered IPRs. This may be caused by that SMEs are disadvantaged by their firm size when it comes to the acquisition and enforcement of IPRs (Cohen et al., 2000; Thoma & Bizer, 2013). Oppositely, the large firms often have more sufficient resources to legally defend their registered IPRs and their enforcement costs while they rarely benefit from cross-licensing arrangements (Arundel & Kabla, 1998; Cohen et al., 2000).

Table 1 Non-respondents bias test by sector, location and size

Items	Population (%)	Respondents (%)	GFT test
Sector			
Hotel and restaurant	33 (2.99)	8 (2.57)	χ^2 = 16.67
Health services	31 (2.81)	8 (2.57)	p= 0.339
Utility services	28 (2.54)	11 (3.54)	
Transport and retailing	82 (7.43)	19 (6.11)	
Wholesale	287 (26.02)	73 (23.47)	
Finance	116 (10.52)	29 (9.32)	
Insurance	51 (4.62)	12 (3.86)	
Telecommunications	17 (1.54)	4 (1.29)	
Technical service	28 (2.54)	8 (2.57)	
Real estate	41 (3.72)	10 (3.22)	
Electronic engineering	96 (8.70)	25 (8.04)	
Computer and software	62 (5.62)	18 (5.79)	
System integration	28 (2.54)	15 (4.82)	
IC design	61 (5.53)	25 (8.04)	
Construction	65 (5.89)	23 (7.40)	
Specialized services	77 (6.98)	23 (7.40)	
Total	1103 (100)	311 (100)	
Location			
Northern	900 (81.60)	257 (82.64)	χ^2 = 0.17
Middle	67 (6.07)	17 (5.47)	p= 0.920
Southern	136 (12.33)	37 (11.90)	
Total	1103 (100)	311 (100)	
Size			
Low than 200	423 (38.35)	141 (45.34)	χ^2 = 6.21
201-400	212 (19.22)	53 (17.04)	p= 0.515
401-800	172 (15.59)	43 (13.83)	
High than 801	296 (26.84)	74 (23.79)	
Total	1103 (100)	311 (100)	

Table 2 Cluster results and significant difference of cluster

	Clusters of all innovative firms					
	1 (N=29)	2 (N=74)	3 (N=122)	4 (N=86)	d.f.	F test
Patent	3.83	5.11	1.16	1.02	3	152.20***
Trademark	4.62	4.14	1.07	1.23	3	93.09***
Copyright	5.90	1.03	1.00	1.01	3	1244.42***
Trade secret	5.66	5.54	5.89	1.27	3	245.28***
Lead time	5.52	4.97	3.72	3.27	3	11.04***
Complexity design	4.83	4.20	3.09	2.65	3	9.98***
Lock-in tactic	6.00	5.42	4.82	3.53	3	17.09***
Label	Complementary-based mode	Formal-based mode	Informal-based mode	Low-profile mode		
Share of sample	9.3%	23.8%	39.2%	27.7%		

Table 3 Innovation determinants by cluster results

	Clusters of all innovative firms				
	1 (N=29)	2 (N=74)	3 (N=122)	4 (N=86)	F test
Appropriability breadth	5.79	4.66	2.94	1.72	166.13***
Appropriability depth	12.50	10.15	7.71	2.96	2.59*
Innovation input (NT$ Million)					
In-house R&D	71.16	86.02	25.20	3.76	2.96*
External consultant	1.96	0.57	0.40	0.41	3.55*
Marketing introduction	17.09	24.23	6.26	6.00	3.45*
Training activity	6.24	6.39	3.71	1.33	3.42*
Innovation activity					
Internal R&D	6.03	6.05	5.25	5.27	6.04***
Supplier	4.07	3.69	4.07	3.24	2.84*
Customer	4.28	4.43	4.04	3.73	1.34
Research institute	3.41	2.49	2.84	1.98	4.80***
Consultant	2.66	1.74	2.67	2.19	3.98***
Responsive involvement	4.90	4.14	3.99	3.59	4.61***
Proactive involvement	4.60	3.15	2.81	2.53	15.74***
Innovation process					
New to market product	5.69	5.24	4.51	3.41	11.21***
New to firm product	5.90	5.69	5.31	5.02	3.30*
Machinery and software	5.69	4.54	4.98	4.08	5.76***
Equipment and application	5.45	4.57	4.90	4.29	2.96*
Administrative innovation	4.86	4.95	4.98	4.23	2.85*
Cross-function integration	5.52	5.11	5.02	4.44	3.09*
Business model creation	5.45	4.85	4.20	3.80	5.21***
Cross-sector collaboration	4.14	3.03	3.12	2.79	2.84*
Innovation output					
No. of NPD	11.45	11.24	8.37	6.31	5.67***
Share of NPD in total	18.10	21.22	14.18	13.49	6.43***
Share of NPD sales in total	17.76	20.00	14.51	13.14	4.51***
Efficiency	5.45	4.92	4.82	4.17	6.03***
Market share	6.03	5.45	5.24	4.78	8.27***
Service quality	5.90	5.70	5.64	5.21	4.51***
Profitability	5.93	5.68	5.32	4.70	10.50***
Firm size (%)					
<50	6.90	5.41	9.84	13.95	3.25*
51-100	6.90	10.81	16.39	22.09	
101-200	10.34	22.97	22.13	17.44	
201-800	55.17	29.73	27.87	27.92	
>800	20.69	31.08	23.77	18.60	
Firm age (%)					
<5	0.00	1.35	1.64	2.33	2.07
6-10	6.90	16.22	14.75	4.65	
11-15	22.69	25.68	11.48	19.77	
16-20	22.69	12.16	15.57	11.63	
21-25	6.90	13.51	12.30	16.28	
>25	44.83	31.08	44.26	45.35	

Table 4 Distribution firms in clusters

Variables	N	Clusters								Chi-square Test
		1		2		3		4		
			%		%		%		%	
Hotel and restaurant	8	0	0.0	3	37.5	1	12.4	4	50.0	χ^2 = 120.12***
Health services	8	3	37.5	1	12.5	2	25.0	2	25.0	p= 0.000
Utility services	11	1	9.1	0	0.0	5	45.5	5	45.5	
Transport and retailing	19	0	0.0	1	5.3	13	68.4	5	26.3	
Wholesale	73	5	6.8	21	28.8	24	32.9	23	31.5	
Finance	29	0	0.0	4	13.8	11	37.9	14	48.3	
Insurance	12	0	0.0	1	8.3	8	67.7	3	25.0	
Telecommunications	4	0	0.0	1	25.0	2	50.0	1	25.0	
Technical service	8	1	12.5	0	0.0	5	62.5	2	25.0	
Real estate	10	1	10.0	1	10.0	4	40.0	4	40.0	
Electronic engineering	25	2	8.0	8	32.0	13	52.0	2	8.0	
Computer and software	18	3	16.7	6	33.3	4	22.2	5	27.8	
System integration	15	4	26.7	4	26.7	7	46.7	0	0.0	
IC design	25	4	16.0	19	76.0	2	8.0	0	0.0	
Construction	23	0	0.0	2	8.7	10	43.5	11	47.8	
Specialized services	23	5	9.3	2	8.7	11	47.8	5	21.7	
Total	311	29	9.3	74	23.8	122	39.2	86	27.7	

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