The Complementary Assets and Appropriability Affect Patent Commercialization on The Moderate Effect of Marketing Sensing Capability: The Case of Bio-Patents in Taiwan

Jie-Heng Lin¹, Ming-Yeu Wang², Hsien-Chen Lo³
1Institute of Technology and Innovation Management, National Taiwan University, Taipei, Taiwan
2Department of Bio-industry and Agribusiness Administration, National Chiayi University, Chiayi, Taiwan
3Institute of Technology Management, National Tsing Hua University, Hsinchu, Taiwan

Abstract—The issues of technology commercialization is continued to be concerned when Teece demonstrated the Profit From Innovation model (PFI model). From invention to commercialization, it's a complex process that is high-costs and uncertainties. There are many factors affect the patent commercialization, including appropriability, complementary assets, technical quality and lead time of new technology, etc. However, previous studies have often overlooked that sensing capability of firm strengthens the effect of patent commercialization on complementary assets and appropriability. Therefore, this study takes the PFI model to be the principal theory to construct the research framework to know the impacts about patent of biotech commercialization. Through reviewing literatures, this study, which on the condition of PFI model, not only proposes the effect of patent commercialization on complementary assets and appropriability but also consider the moderating influence of sensing capability. This study collected samples from firms who hold patent of biotech in the United States Patent and Trademark Office (USPTO) or Taiwan Intellectual Property Office (TIPO). Of the 354 questionnaires sent to firms, 22 valid questionnaires were returned. The result of the study, the complementary assets and appropriability are significant positively affect patent commercialization, also the sensing capability moderate this positively influence.

I. INTRODUCTION

Patent commercialization has a high level of uncertainty. Many studies have attempted to find the factors affecting patent commercialization and solve the problems. The definition of patent commercialization made by previous studies is the same as that of technical products [47, 49, 50], which is to sell, transfer or give authorization of patent technologies to existing companies, the establishment of a new company through patent technologies, or the transfer of a patent to a product or process. From the perspective of invention, patent commercialization is considered as an important stage of improving organizational performance. Thus, rapid commercialization of innovative technologies can speed up the fulfillment of organization innovation performance requirements. Thus, patent commercialization is regarded as a kind of innovation performance [5, 7].

In discussing the factors affecting commercialization, most past studies have focused on the influence of patent and technology features on patent commercialization in areas such as patent strength and category, trade secrets, patent age and citation statistics, technology lead time or scientific linkage [13, 22, 30, 41, 47, 57].

Past studies have seldom mentioned the effect of organization capabilities on patent commercialization, and few studies have discussed organization capabilities and patent commercialization. However, these studies paid little attention to analysis of whether organization capabilities can promote technology commercialization success [6, 7, 38, 53, 54, 55]. Thus, this study continues to utilize these arguments and discuss how organization capabilities affect patent commercialization.

PFI architecture (Profiting from Innovation) as suggested by Teece [50] explains how organizations use their own capabilities to capture profits from invention commercialization. The PFI discusses why inventors cannot make more profits during access to markets with appropriability and complementary assets, from the viewpoint of inventor failure. Some scholars have stated that enterprises can get channels by protecting complementary assets in order to strategically weaken the technology appropriability of competitors [43]. Helfat and Lieberman [23] further found that the complementary assets for new enterprises are increasingly more important than core resources. Evidently, the importance of complementary assets increases with industry development. Jacobides, Knudsen and Augier [25] discussed the cospecialization of complementary assets through the three dimensions of value creation, appropriability and industry structure. Most previous literature has discussed PFI concepts and paid attention to value creation, however, there are few empirical studies that measure patent commercialization.

In addition to appropriable and complementary assets, Teece [53] considered that invention profits will be affected if the organization has better strategy for timing access to the market. Day [12] considered that top management's sensitivity to the market will affect technical innovation decisions during the management of emerging technologies, especially in high-tech and high-risk industries. Past studies have found that technology commercialization information has a significantly positive effect on patent commercialization performance [4, 27]. Lindblom, Olkkonen, Mitronen and Kajalo [35] suggested market sensing capacity either does not have a positive relationship with organization performance or that it has only a minor positive effect, and that the sensing capability can disturb but not directly affect organizational performance. This study intended used PFI to analyze the effect of complementary assets and appropriability on patent commercialization with market sensing capability. This study
empirically analyzed Taiwanese medical & biotech enterprises that obtained patents granted by the USA Patent and Trademark Office and TIPO in 2000 to 2009. This study used the structural equation model to discuss the influencing factors of organization on patent commercialization with market sensing capability. This study hoped to understand the influence of organizations with complementary assets and appropriability on patent commercialization with market sensing capability.

II. PATENT COMMERCIALIZATION

Most of the previous studies on patent commercialization have been aimed at patent commercialization. The main purposes can be divided into five types: increasing revenue and market share [9, 13, 50], maintaining corporate growth and competitive power [9, 10, 50], technological entrepreneurship [2], the creation of new opportunities [2,42], and obtaining core technology and complementary assets [50, 21, 53].

Cooper and Lybrand [9] stated that patent commercialization can increase income and market share. Patent commercialization can increase company revenues to recover research costs and subsequent technical development costs or future corporate development expenditures. Technology commercialization and continuous improvement can reinforce corporate market position and further increase market share through the protection of intellectual property rights and technical appropriability [50; 13]. Patent commercialization aims to obtain key technologies, and then protect these technologies through the application of patents. In this mechanism, more and more organizations can obtain key technical patents. The results of Glick [21] showed that medical and biotech companies can have more advantages in technology trade with strong appropriability when the organizations have more technical patents. Thus, companies can obtain key technologies through cross licensing. On the other side, Cooper and Lybrand [9], and Cooper [10] indicated that patent commercialization can maintain corporate growth and competitive power. During technology commercialization, interactions between technology push and market pull are needed. A successful patent commercialization will not only bring profits to companies but also promote the accumulation of commercialization experience and the reinforcement of technical strength and staff training. It is a source of corporate growth and competitive strength [50]. Teece [50, 53] proposed that complementary assets can be obtained through patent commercialization and stated that successful commercialization requires complementary assets.

Past studies have also discussed the influencing factors of patent commercialization. Complete innovation as suggested by Kirihata [29] refers to a process of applying invention to both product and process. Shane [46] suggested that past studies on high-tech companies focused on industry level or personal level. For newly established companies, technical innovation, importance and category have a significant positive effect. This shows that patent importance affects technology commercialization and economic growth, as well as company decisions. Due to patent protection, technical development is broad, and technologies are not imitated. Regarding organizations and patent commercialization, Chang, Yang and Chen [6] stated that complete organization ambidexterity should have structural ambidexterity to solve conflicts. Nerkar and Shane [41] stated that the longer the age of an invention is, the greater the possibility of elimination will be. In order to understand the impact of appropriability on commercialization, Dechenaux, Goldfarb, Shane and Thursby [13] suggested that the lead time and the learning curve are the factors affecting patent commercialization or termination, finding that the patent category and strength, trade secrets and the learning curve have a significantly positive effect on patent commercialization. The patent strength and trade secrets have a significant adverse impact on the probability of patent grant termination, and the lead time is negatively related to patent commercialization.

With the above considerations, the need for technology commercialization information for organization performance. External technology commercialization is not perfect in the technology market, and technology licensing is an important channel of technology commercialization. The study results showed that technology commercialization information had a positive effect on organization performance.

III. PFI MODEL AND MARKET SENSING CAPABILITY

A. PFI Model

In the last two decades, how to obtain value from innovation has been widely discussed. However, the economic value of innovation must be obtained through commercialization [50]. Based on the study of Teece [50], subsequent studies changed the problem to that of understanding the key factors affecting commercialization success, and further discussed the time of access to the market and the patent commercialization time instead of the invention [53]. Teece [50] proposed several basic components of PFI, stating that appropriable and complementary assets are closely related to patent commercialization [13, 32, 50, 52, 55]. The two basic components affect patent commercialization strategy and play important roles in patent commercialization.

1. Appropriability

Dechenaux, Goldfarb, Shane and Thursby [13] suggested that appropriability increases market share and has an influence on patent commercialization. Dixit and Pindyck [15] stated that licensing can stop the uncertainty faced by a company in decision making. The uncertainty is resulted from basic studies and some market protection mechanisms [46]. Teece [50] stated that strong appropriability (technology that is easily protected) or weak (technology that may not be
protected) appropriability will affect patent commercialization strategy. Previous studies used patent appropriability (including patent strength, category and trade secrets), technical lead time, patent age, scientific linkage and previous patent citation statistics as analysis factors affecting commercialization. Cooper and Lybrand [9] stated that technology commercialization can increase corporate revenues to recover research costs, subsequent technical development expenses, or future corporate development expenditures. Continuous improvement and commercialization of technology can stabilize company market position and allow a company to enjoy appropriability through the protection of intellectual property rights, which can enhance market share [13, 50]. Najib [40] suggested that strong appropriability can increase corporate technology innovation performance and achieve technology commercialization.

During patent commercialization, a company may face decision uncertainty and competitor imitation, as well as market protection mechanisms. As appropriability can exclude competitors and reduce the uncertainty of patent commercialization, patent organizations may have more advantages in coordination or judgment. When corporate key knowledge is integrated with enterprise equipment and machines, personnel skills, management systems and enterprise organizations, and when it cannot be transferred or separated, patent commercialization will be easier for the company. Thus, appropriability may positively affect patent commercialization. Based on the above, the following hypothesis was proposed:

**H1: When the company patent appropriability is strong, it will have a positive effect on patent commercialization.**

2. Complementary Assets

Complementary assets refer to other capabilities (different from technology) that are required for manufacturers to commercialize technology, such as manufacturing, sales, distribution channels, service, reputation, trademark and complementary technology [50]. An established company will have specific assets to prevent the invasion of newcomers. Regarding PFI architecture, Teece [53] suggested that profits may flow to companies, suppliers, agencies and clients due to a lack of needed complementary assets in manufacturing and marketing, as well as an inadequate spread of technical know-how and the protection of intellectual property in different industry development stages. Helfat and Lieberman [23] verified that for new entrepreneurs complementary resources are increasingly more important than the key resources. Thus, the importance of complementary assets increases with industry development.

The intensification of complementary assets is an important factor of technology commercialization [49, 50], and the replenishment of complementary assets (capability) can make it easier for technology commercialization to occur. In the whole commercialization process, not all the necessary capability can be found, especially in middle and small enterprises. For commercialization, a large amount of time and capital must be input. Small enterprises do not have such huge capital, and they need to use external funds in commercialization [28 : 49]. Gambardella, Giuri and Luzzi [18] regarded company size as a proxy variable of complementary assets. The results showed that the larger the company size is, the lower the number of licensed patents and the lower the willingness to pursue patents will be. With reference to the above studies, this study considered that the measurement of complementary assets depends on their importance for companies in technology commercialization. Tripsas [58] indicated that existing companies survive due to radical innovation with their own complementary assets; Gans and Stern [19] stated that companies can improve their judgment power through the importance of complementary assets. Rothaermel [44] proposed that existing pharmacy companies can obtain important complementary assets through alliances with newly established biotech companies, thus making the existing pharmacy companies obtain new profits. McGahan and Silverman [37] found that complementary assets are important in the industry, and demonstrated that increased cooperation with external inventors has a positive effect on corporate market value.

In order to obtain profits, companies must conduct patent commercialization. During commercialization, not all the organizations will have the capability of introducing it to the market. Complementary assets can make technology commercialization success easier to achieve. During commercialization, not all the necessary capabilities can be found, especially in mid-sized and small enterprises. In technology commercialization, if manufacturing capability is not adequate, the complementary technology of other organizations may be needed. In addition, even when the complementary technology may is a process patent of another organization, companies with the capability of introducing technology to a new product or service might not have a market channel. When companies have more complementary assets, these complementary assets will facilitate patent commercialization. This study believed that complementary assets would have a positive effect on patent commercialization. Based on the above, the following hypothesis was proposed:

**H2: When companies have strong complementary assets, these complementary assets will positively affect patent commercialization effect.**

B. Market sensing capability

Day [11] considered market sensing as a view on decision making. It is a series of market information behaviors and activities, and it is customer-oriented [14]. In addition, some scholars have stated that market orientation is closely related to organization learning [48]. Teece [50] proposed the concept of dynamic capability and discussed rapid responses to environment besides organization integration, as well as the establishment and proper use of internal and external
capabilities and assets. For different change degrees of a market environment, organizations need to properly use their knowledge integration capability [31], create flexible market strategies [3], conduct capability allocation for market changes [36], and deeply understand the product life cycle, so as to make relevant strategy planning [24]. The dynamic management capability [1] of the resource reallocation, and the relationships with management organization and enterprise network capability [39] are necessary in a transient market environment. From the above, the first component of dynamic capability is a market-oriented sensing capability. The market sensing capability is an enterprise capability of sensing environment change and understanding customer market demand. Sensing capability is often used in the successful management of internal technology development and new product development [16, 50].

There are few relevant studies on sensing capability. Most studies have inferred the proposition, and there is a lack of quantitative studies. Teece [54] further discussed the relationship between sensing capability and entrepreneurial performance, and considered that entrepreneurial performance benefits from the sensing capability of the market and technology, including external (science and technology development, customer demand and market segmentation) and internal (research and development programs, suppliers and complementary innovation activities, and the selection of new technologies) resources. Based on the studies by Teece [54] suggested that sensing capability is useful for entrepreneurship environment cognition and the identification of entrepreneurship opportunities, as well as surveys and innovation. In view of the PFI model, market sensing capability is more important for successors. When the successors pursue mainstream technology, the failure to seek new technology will cause the loss of development opportunities [33].

In discussing organizational innovation performance, if organizations can know market changes early, the internal technology will have opportunities, and the time from the conception of the technology’s market value to the market display of the feasibility of the product and process can be reduced. As a result, organizations can reduce the patent commercialization time. Market sensing capability is an important factor [33]. Lindblom, Olkkonen, Mitronen and Kajalo [35] found that individual entrepreneurs are positively related to corporate growth, but that they are not related to profit making capability. In the PFI architecture, [53] discussed why innovative technology manufacturers cannot obtain profits from single technologies based on market access time, appropriability, and complementary assets. Organizations shift from research models with patent protection appropriability to hybrid models, through which cooperation with external organization technology can enter the market more rapidly. By relying on the sensitivity to the market, organizations can obtain complementary assets [26, 50] through different market units. Thus, market sensing is valuable for enterprises. It makes enterprises focus on the continuous collection of the target customers’ demands and the competitors’ capabilities, and then allows the companies to use this collected information to create value.

From the above, market sensing capability is the response capability of an enterprise sensing environment changes and understanding customer demand market. Previous studies have found either minor positive effects or no positive relationships between market sensing capability and patent commercialization [35]. If companies do not have better complementary assets or strong appropriability, a high sensitivity to the market will not have a significant impact on commercialization, and a strong market sensing capability will not give direct assistance to commercialization. When companies have better market sensing capabilities, these capabilities can help the enterprises obtain suitable complementary assets or increase their appropriability. This study considered sensing capability as having no direct impact on decisions about patent commercialization, meaning that sensing capability is a moderator for complementary assets to affect patent commercialization probability. Based on the above, the following hypotheses were proposed:

H3a: Corporate market sensing capability has a moderating effect on the relationship between appropriability and patent commercialization.
H3b: Corporate market sensing capability has a moderating effect on the relationship between complementary assets and patent commercialization.

IV. RESEARCH METHOD

A. Research architecture and Variable operation definition

The key factors of invention commercialization success include factors other than technology superiority. The research architecture for the influencing factors of patent commercialization is illustrated in Fig. 1. By understanding the market sensing capability interference, organization complementary assets and appropriability can affect patent commercialization.

Appropriability refers to the technology protection resulting from intellectual property rights that can prevent technology imitation, allows inventors to charge royalties from the invention, and prevent imitation with authorized technologies [32, 51, 52, 55]. Complementary assets refer to other capabilities (different from a technology basis) that are required for manufacturers in patent commercialization, such as manufacturing, sales and distribution channels, services, business reputation, brands and complementary technologies [50]. Market sensing capability can seek potential demand, analyze competitor actions and investigate markets to coordinate organizations, in order to predict opportunities and threats, as well as to make filtrations and corrections. It can correctly predict how a market will respond to the organization strategies. The organizations will frequently explore new knowledge, and they will have stronger capabilities of predicting future technology development [8, 12, 54].
B. Research objects and data collection

As per the IPC and Technology Concordance Table by [45], this study collected biotech patents granted by the USA Patent and Trademark Office and TIPO in 2000 to 2009, including analyses of biological materials, medical technology, organic fine chemistry, biotechnology, pharmaceuticals, and food chemistry. Next, enterprises as patentees were found. A total of 506 corporate biomedical patents were found, which were owned by 229 enterprises. This study referred to the directories, official websites, and business registration search system of the Industrial Development Bureau, Ministry of Economic Affairs to find responsible persons and address of the 229 enterprises. The questionnaires were sent between late May and mid-June of 2011 and the respondents were prompted by phone to return the completed surveys. A total of 33 questionnaires were collected, and one invalid questionnaire was deducted due to numerous blank items. The number of effective samples was 32, showing a return rate of 14%. The 32 enterprises had a total of 102 patents, accounting for 7% of the 506 patents.

The funds of five manufacturers were provided by the government. The funds of the rest of the enterprises were sourced from Taiwanese investment companies (eight enterprises), Taiwanese enterprises (17 enterprises) and individual Taiwanese shareholders (seven individuals). This reflected that individual shareholders and enterprises were more interested in the investment and management of biotech companies than were investment companies. Of the collected sample companies, six companies had an actual turnover not exceeding TWD 40 million, four companies had a turnover of TWD 40 million-100 million, 11 companies had a turnover of TWD 100 million-1 billion, and 11 companies had a turnover of more than TWD 1 billion. The average number of employees was 983. Most biotech companies belonged to the medical equipment industry. No regenerative medicine was found. The other categories had from one to six companies in them. In most of the collected samples, the number of R&D employees was lower than 25% of the total number. The target product markets of the manufacturers were not concentrated in one specific area but were distributed all over the world. In this study, the defined patent commercialization included licensing or transfer to overseas manufacturers, as well as licensing or transfer to Taiwan manufacturers and the transformation of patents to processes and products. Based on the statistics on patent commercialization of the manufacturers holding biotech patents, these manufacturers independently applied patents to processes or products, and they authorized or transferred patents to more overseas manufacturers and fewer Taiwan manufacturers.

C. Data analysis method

This study used SmartPLS 2.0 to analyze the path between constructs in the research model and verify whether the hypotheses were true. PLS (Partial Least Squares) is a very common tool in social science research, even when the number of question items or samples are few. It can verify cause and effect based on theory and provide hypothesis tests for the relations between constructs, which can be used as a reference for future theory or the establishment of research models [20]. However, PLS does not provide fitness of the model. Thus, this study used the R-square to test the predictive capability of the structural path. The R-square is the ratio of one variable to the total number of variables. The larger the R-square is, the higher the explanatory power of the model will be. This study used a two-tailed test (t-value>1.645, p<0.05) to verify the hypotheses [56]. The parameters were estimated using bootstrapping, which is a non-parametric method. The statistical magnitude was distributed through resampling of the sample data. According to the suggestions by Gefen [20], the resampling frequency was assumed to be 500, which served as a significance test of the estimated value of each structural path.

V. RESULTS

The factors affecting the PFI model are shown in Table 3. The average score of the complementary assets was 3.727-4.318. The grand average score of the complementary assets was 3.973. This indicated that the respondents generally acknowledged the influence of complementary assets on patent commercialization. The grand average score of appropriability was 3.576. This indicated that the respondents generally acknowledged the influence of appropriability on patent commercialization. For the effect of
market sensing capability, the answers of most respondents ranged from “neither agree nor disagree” to “strongly agree”. For patent commercialization, most respondents answered between “neither agree nor disagree” and “agree”. This study measured dimension validity by using convergent validity and discriminant validity. In terms of the standardized factor loading, the values were between 0.590 and 0.969 and were greater than 0.5. For the composite reliability, the values were between 0.782 and 0.950 and were greater than 0.7. The average variance extracted was between 0.549 and 0.863 and was greater than 0.5 for all dimensions. According to Fornell and Larcker [17], a better discriminant validity means the AVE of the current dimension is greater than the average correlation coefficient of the other dimensions. Namely, the AVE square root of the current dimension is greater than the correlation coefficient of the other dimensions. As shown in Table 4, each diagonal value is greater than the left and lower values, indicating that the AVE square root of all dimensions was greater than the correlation coefficient between dimensions. Thus, the study dimensions had discriminant validity.

This study used SEM PLS to verify the structural coefficient between dimensions and the covariance, as well as to measure whether the loading had any difference. If the results reached significance, there would be a difference, as well as a moderating effect. This study used the potential variable moderating effect analysis method, as proposed by Kenny and Judd [28]. If B3 in the model was significant, there would be a difference, and the moderating effect would exist. This study verified the effect of market sensing capability, complementary assets and appropriability on commercialization. The value of P of marketing sensing capability moderating effect path B3 on complementary assets and commercialization was 0.024. The value of P of market sensing capability moderating effect path B3 on appropriability and commercialization was 0.232 (Table 5).

### TABLE 3 QUESTION ITEM SEQUENCE ANALYSIS

<table>
<thead>
<tr>
<th>Major dimension</th>
<th>Minor dimension</th>
<th>Question</th>
<th>Average</th>
<th>Grand average</th>
<th>Root-mean-square</th>
</tr>
</thead>
<tbody>
<tr>
<td>PFI model</td>
<td>Complementary assets</td>
<td>C1 The company integrates relevant industry information, and applies it to new product development.</td>
<td>3.727</td>
<td>3.973</td>
<td>0.703</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C2 The company has better HR scheduling and can flexibly mobilize staff.</td>
<td>3.727</td>
<td>0.767</td>
<td>0.767</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C3 The company can independently produce products besides technology development.</td>
<td>4.318</td>
<td>0.477</td>
<td>3.973</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C4 The company can provide supporting services and products for technology.</td>
<td>4.046</td>
<td>0.722</td>
<td>0.477</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C5 The company has promotion channels.</td>
<td>4.046</td>
<td>0.785</td>
<td>0.722</td>
</tr>
<tr>
<td>Appropriability</td>
<td>A1 The company can prevent patent imitation.</td>
<td>3.636</td>
<td>3.576</td>
<td>0.902</td>
<td></td>
</tr>
<tr>
<td></td>
<td>A2 The company discloses its patents but can still protect technical secrets.</td>
<td>3.682</td>
<td>3.780</td>
<td>3.576</td>
<td></td>
</tr>
<tr>
<td></td>
<td>A3 There are learning difficulties when other companies implement the patent technology.</td>
<td>3.409</td>
<td>0.908</td>
<td>3.780</td>
<td></td>
</tr>
<tr>
<td>Market sensing capability</td>
<td>S1 The company can rapidly obtain and effectively use market information.</td>
<td>3.318</td>
<td>0.894</td>
<td>0.908</td>
<td></td>
</tr>
<tr>
<td></td>
<td>S2 The company can predict competitor strategic actions.</td>
<td>3.364</td>
<td>0.848</td>
<td>3.318</td>
<td></td>
</tr>
<tr>
<td></td>
<td>S3 The company can predict consumer demand and preferences.</td>
<td>3.409</td>
<td>0.959</td>
<td>3.364</td>
<td></td>
</tr>
<tr>
<td></td>
<td>S4 The company establishes customer databases as per customer answers.</td>
<td>3.500</td>
<td>0.964</td>
<td>3.409</td>
<td></td>
</tr>
<tr>
<td>Patent commercialization</td>
<td>CP1 The company commercialized patent faster than the main competitors.</td>
<td>3.318</td>
<td>0.894</td>
<td>3.500</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CP2 The company commercialized patent more successful than the main competitors.</td>
<td>3.364</td>
<td>0.848</td>
<td>3.318</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CP3 The company's patent commercialization activities bring more profits than the main competitors.</td>
<td>3.409</td>
<td>0.959</td>
<td>3.364</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CP4 The company's patent commercialization activities make the strategic goals be achieved.</td>
<td>3.500</td>
<td>0.964</td>
<td>3.409</td>
<td></td>
</tr>
</tbody>
</table>

### TABLE 4 CORRELATION MATRIX OF ALL THE DIMENSIONS AFTER CORRECTION

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Complementary Assets</th>
<th>Appropriability</th>
<th>Market Sensing Capability</th>
<th>Patent commercialization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complementary Assets</td>
<td>0.741</td>
<td>0.929</td>
<td>0.814</td>
<td>0.756</td>
</tr>
<tr>
<td>Appropriability</td>
<td>0.123</td>
<td>0.209</td>
<td>0.566</td>
<td>0.756</td>
</tr>
<tr>
<td>Sensing Capability</td>
<td>0.407</td>
<td>0.429</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patent commercialization</td>
<td>0.572</td>
<td>0.429</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: the diagonal value is the AVE square root
This study used the structural equation model to verify the research model. In H1, from the viewpoint of the PFI model, appropriability and the patent commercialization of companies had a positive correlation. The $T$ value was $3.619 > 3.29$. In view of this, appropriability and patent commercialization were found to have a significant effect. In H2, from the viewpoint of PFI, complementary assets and the patent commercialization of companies were found to have a positive correlation. The $T$ value was $3.984 > 3.29$. In view of this, complementary assets and patent commercialization were found to have a significant effect. In H3, the interaction effect of corporate market sensing capability and appropriability on patent commercialization, the $T$ value was $<1.96$. From this, the interaction effect of market sensing capability and appropriability on patent commercialization was found to be insignificant. In H4, the interaction effect of market sensing capability and complementary assets on patent commercialization, the $T$ value was $>3.29$. From this, the interaction effect of market sensing capability and complementary assets on patent commercialization was found to be significant.

VI. CONCLUSIONS

No perfect theory framework has been used in past studies regarding the effect of market sensing capability on technology or patent commercialization. Thus, this study summarized a perfect theory framework, and analyzed the complementary assets and appropriability affecting profits proposed by innovation profit theory. This study considered marketing sensing capability and the two factors of complementary assets and appropriability in the innovation profit theory. There were a number of findings, as shown below.

In Effect of appropriability and complementary assets on patent commercialization view, past commercialization studies have paid attention to the commercialization time, the patent and technology characteristics. After Teece [50] suggested that complementary assets and corporate appropriability can help obtain profits, scholars began to study the effect of complementary assets and appropriability on profits. From a company’s viewpoint, the two factors are important for innovation profits. Thus, this study used the important complementary assets of organizations and appropriability in analysis and innovation performance analysis. The empirical results showed that appropriability and complementary assets have a significant positive effect on biotech patent commercialization. This study demonstrated the impact of generic complementary assets proposed by Teece [50] on patent commercialization, finding that corporate appropriability was enough to protect corporate technology and intellectual property, and that it had a better effect on corporate patent commercialization. Past studies have seldom mentioned the impact of capabilities on patent commercialization, and few studies discussing organizational capabilities and patent commercialization have focused on analyses of whether organizational capability can promote successful technology commercialization; not all organization capabilities can directly affect patent commercialization. Thus, this study discussed the moderating effect of market sensing capability and the two factors of complementary assets and appropriability in the innovation profit theory.
sensing capability on patent commercialization. After the empirical study, it was found that the sensing capability could moderate the effect of complementary assets on patent commercialization. If the corporate appropriability is enough to protect the technology or prevent imitations with unauthorized technology, the moderating effect of market sensing capability will be small and can be neglected.

PFI is a mature model. However, after Teece, Pisano, and Shuen [55] proposed dynamic capabilities, the effect of organization capabilities on innovation profits has been further discussed. In addition to the learning, reorganization and integration of the dynamic capabilities, the market sensing capability should not be neglected. The dependence between assets and path can be combined with relevant PEI. This study only roughly regarded market sensing capability as a moderator to discuss the relationship between PFI and the patent commercialization of Taiwanese biotech formations. Also, the specialized and cospecialized complementary assets in the biotech industry can be used to discuss the relationship between complementary assets and innovation performance. Future research can test the effect of new management modes of biotech manufacturers on organization innovation when the industry boundaries are not clear. It is expected that open management modes instead of traditional closed management modes can promote the evolution of current learning organization.

REFERENCES


