The Valuation Methods and Applications for Academic Technologies in Taiwan

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Abstract--**Many universities in Taiwan have taken action to commercialize and to license out academic technologies. During the processes of technology transfer, the determination of technological value greatly affects the successes of transfer. Although previous studies introduced several valuation methods for technologies, how Taiwanese universities execute the methods remains unknown. Therefore, this study aims at identifying the valuation methods used by Taiwanese universities, the concerns of usage, and the difficulties in implementing the valuation methods. After interviewing managers of Technology Transfer Offices in five universities, this study obtains that the universities typically use cost approach, market approach, income approach and auction to value the academic technologies. Among which, cost approach is the most widely used one. The difficulties suffered by Taiwanese universities include lacking staffs specialized in valuation, expensive valuation service by external consultants, and the restrictions by government regulations. Based on the interview findings and previous studies, this study further designs a technology valuation framework for Taiwan universities and applies the framework to valuing the vaccines of duck viral hepatitis owned by a Taiwan university. At last, this study offers suggestion for valuing academic technologies by integrating the results from interviews and the experiences in empirical applications.**

I. INTRODUCTION

Following the legislative spirit of the Bayh-Dole Act, Taiwan implemented the Fundamental Science and Technology Act at the beginning of 1999 [6]. This act endows Taiwan's research institutions with the source of law on using state-owned research and development outcomes and promotes research institutions to convert research and development findings into actual production and utilization instead of regarding the outcome subsidized by the government budget as a passive state-owned property. The implementation of this act initiated the opportunity for interaction and cooperation between Taiwan's industries and academia. Colleges soon began to pay attention at how to commercialize academic technologies, while manufacturers began to look for the required technologies and partners among academia, so as to reduce research and development costs. However, it is difficult to reach a consensus on industry-academia cooperation or technology transfer, because the value and price of technology are sometimes the key points to any consensus formation. The factors obstructing or enhancing the commercialization of university inventions in previous studies were mostly centered on the organizational design of a university, such as the inducement system, location, or school culture [14], with less attention paid to the methods that determine the value of academic technologies.

In evaluating the "value" of something, the usefulness and desirability of it must be measured [18, 1]. In the past, the usefulness and desirability of a technology were presented in non-monetary value and monetary value, respectively. The non-monetary value can be a subjective grading by experts, whereas the value of technology is more frequently reflected by specified indicators. In terms of other classifications, the patent value is evaluated by monetary value, the cost approach, the market approach, and the income approach, which are typical technology valuation methods. The non-monetary value can be a measurement indicator for technology value, but in order to finish the commercialization procedure of technology, a specific monetary value is still indispensable. Therefore, this study aims at the presentation and implementation of academic-developed technology in monetary value.

The previous academic literature has introduced several valuation methods with different complexities presenting technology value in monetary value, but how these methods are implemented in Taiwan's universities is still unknown. Based on this motive, this study aims to discuss the subjects about executing technology valuation, including understanding the technology valuation methods used by Taiwan's universities in technology transfer, the factors that influence implementing these methods, and the difficulties in implementing a valuation. Based on the interview findings and previous studies, this study further designs a technology valuation framework for Taiwan universities. The framework are applied herein to evaluate the value of the patented technology of duck viral hepatitis vaccines owned by University NC in Taiwan, so as to illustrate the practical application of the framework. At the end of the article, the interview and practical application are presented, the technology valuation method is comprehensively concluded, and the reference for a university's technology transfer units to execute technology valuation is proposed.

II. LITERATURE REVIEW

This study focuses on the valuation of technology, and so this section reviews the concepts and methods about patent valuation. The difference between the terms valuation and pricing is briefly introduced first, and then the patent valuation methods are introduced.

The terms valuation and pricing have close meanings. In patent valuation, the term valuation refers to the direct output of using valuation tools and methods, disregarding the package that makes the patent attract a third party or be accepted by a third party. The term pricing refers to reaching an agreement on the valuation result by internal or external communication concerning the value [12]. The valuation

calculates the value of a patent and forecasts the total value gained after an economic activity of the patent is implemented. The purpose of pricing is to draft a mutually agreed conversion price; the final market conversion price is not required to be the same as the value [5]; but the value can be the reference for initial price in a mutual agreement [17]. In terms of output quantity, the valuation may tend to produce values in a range, so as to reflect the results of different methods, or to express the uncertainty of the value; while the pricing produces one value [12]. Generally, the valuation is the appraised value without any real transaction. In order to convey the meaning of the estimated value clearly, the intellectual property is valuated and the terms of trade must be described [16].

Table 1 lists the methods applicable to assessing technologies. The cost approach, market approach, and income approach are the most common valuation methods. Many new valuation methods are based on these three approaches [16]. The Monte Carlo method and option-pricing models are derived from the income approach, but scholars often separate the two approaches as new methods. The technology factor is also derived from the income approach. Razgaitis [12] proposed additional industry standards, rules of thumb, and auctions according to practical common technology valuation methods.

The cost approach calculates the value based on cost. This approach is based on the principles of the substitution effect and equilibrium price in economics. These principles believe that the amount paid by the investor for an investment case will not exceed the cost of an investment case with the same utility [13].

The market approach is based on the principles of competition and equilibrium in Economics. These principles believe that in the free open market, the supplying and demanding sides impel anything to reach an equilibrium price [13], and the buyer will not buy a new asset at a cost higher than the cost of a similar intangible on the market [16]. The market approach observes the transaction value and transaction information identical with or similar to the intangible asset to be appraised in the open market and compares the transaction information with the asset to be appraised. The asset value is adjusted appropriately according to the comparison result [16].

The income approach is based on the principle of anticipation in economics. It believes that the value of a resource is the value of the anticipated economic returns of the resource [13]. This approach estimates the present value of the economic returns of the asset in the future during the effective life of an intangible asset and uses the present value as the value of intellectual property [16]. The future returns can be discounted by using the net present value equation. Therefore, the mathematical operation using an equation to calculate value is not difficult; the most complicated point is the information of profit amount, income form, and risk factor for the income approach.

The amount of profit, income form, and risk factor have different combination modes. The traditional combination mode uses an equation to generate the estimation of one net present value. The recent combination method generates different estimations under multiple scenarios. The Monte Carlo method is the most famous method [6], while the risk-adjusted net present value method (rNPV) also calculates the net present value based on multiple scenarios. In addition, the traditional income approach assumes that the investment for intellectual property cannot be delayed. The option-pricing models loosen this assumption in valuation [16].

Industry standards use the closing cost of related technologies and transactions in industry as the value reference of the technology to be evaluated [12]. A technology is also valuated according to the rules of thumb in the market. For example, 25% of profit or cost reduction resulting from the technology to be valuated is taken as the value of the technology to be evaluated. Auctions use a free competitive mechanism to determine the price of technology. The bidders consider the risk themselves and estimate the acceptable price, with the highest one winning the bid in the end. This method is applicable to technology with multiple potential buyers [12].

TABLE 1 SCHOLARS AND VALUATION METHODS

Method	Smith & Parr [16]	Andriessen [1]	Razgaitis [12]	Reily & Schweihs [13]	Khoury [3]
Cost approach	✓	✓		✓	
Market approach	✓	✓		✓	
Income approach	✓	✓	✓	✓	
Monte Carlo method	✓		✓		
Option-pricing models	✓	✓			
Industry standards			✓		
Rules of thumb			✓		
Auctions			✓		
Technology factor		✓			✓

The aforementioned valuation methods are in practice developed mostly based on the patent transaction and licensing cases between enterprises. However, the patent transaction in industry-academia cooperation is different from the inter-industrial patent transaction. It is unknown whether these methods can be fully employed to evaluate the value of a university patent. For example, universities aim at the diffusion of knowledge and public interest. They often hope that an innovation achievement can be used extensively by industry and hope to achieve more licensees. The amount of the license fee is not the only consideration in determining the licensee. Since universities do not have production equipment to apply the patented technology to new products and enter the market, they sell, transfer, or license out the patent right through patent commercialization or set up new companies based on the patented technology. The commercialization activity not only compensate for expensive maintenance fee, but also implements the diffusion and application of academic achievements in industries [14, 7, 15, 10]. On the contrary, profit-making enterprises hope to protect the licensed knowledge through an exclusive license [14]. In addition, when commercializing university technologies, the technology provider (university) and the acceptor (enterprise) are in a highly dependent public and private partnership. The university and enterprise can combine mutual complementary assets, and technology commercialization is completed by a partnership, so as to obtain their respective interests. The measurement of value shall be influenced by the contextual factors of person, time, space, and event scenarios during valuation [11, 4, 20]. These examples are enough to note that evaluating the monetary value of university technology requires new views and thoughts, and thus new valuation models need to be built.

III. RESEARCH PROCESS AND METHOD

Following the motive, purpose, and literature review, this section introduces the data collection and analytical methods. This study has two purposes. One is to know the technology valuation methods used by Taiwan's universities for technology transfer and the difficulties in valuation; the other is to develop a framework to evaluating academic technologies and illustrating the usage of the framework. Different research processes and methods are used for the two purposes, as described below.

A. Process of valuation methods and difficulties

For the first purpose, the process involves data collection, drafting interview outline, inviting interviewees, handling in-depth interviews, and analyzing interview data. The journal articles and information in official website were collected and compiled to preliminarily know the status of technology transfer and valuation of Taiwan's universities, so as to find out which information related to valuation practices in Taiwan must be clarified and reinforced by interviewing the personnel in technology transfer offices (TTO) of universities. After the information was identified, the in-depth interview outline was formulated. The in-depth interview outline is described below.

A. What are the technology valuation methods used by your university?
B. What problems do you encounter in current technology valuation practices?
C. How do you evaluate the potential of academic technologies to be transferred?
D. Have you encountered problems in negotiating price with the licensed firms during transfer process?
E. How do your TTO train the staffs for valuation ability?
F. Do the present regulations of technology valuation contribute to industry-academy cooperation?

Following this, the interviewees were searched out. TTOs of important universities in Taiwan were contacted by calls and e-mails, and five TTOs accepted the request. Table 2 shows the background of the five universities, interview time and the experts. After in-depth interviews, the record data were translated into a literal draft, and the interview content was analyzed to obtain the findings.

TABLE 2. BACKGROUND OF INTERVIEWED UNIVERSITIES

Univ. code	No. of students	TTO code	Institution	Interview time	Interviewed expert
A	11,643	TTO1	Center of Technology Promotion	2014/7/8	Clerk
B	7290	TTO2	Office for Operation of Industry and University Cooperation- Division of Intellectual Property Rights Protection and Technology Management	2014/8/14	Manager
C	9,414	TTO3	Office of Industrial Collaboration and Continuing Education Affairs ◆ Division of Intellectual Property Rights and Technology Transfer ◆ Division of Academia-Industrial Cooperation ◆ Division of Innovation Incubation	2014/8/14	Deputy Director ◆ Project Manager ◆ Senior Administrator ◆ Supervisor
D	17,252	TTO4	Center of Intellectual Property Rights	2014/8/19	Senior Manager
E	17,503	TTO5	Executive Operation Center for Industry-Academia Cooperation	2014/8/26	Project Manager and Admin. Clerk

B. Process of evaluation of technology value

Based on evaluation methods proposed by previous studies and our interview findings, this study develop a framework to evaluating academic technologies. This study applies the framework to evaluate a patented technology of duck viral hepatitis vaccines owned by University NC in Taiwan, so as to illustrate how to implement the framework. During implementation, the research process is a collection of secondary data, expert interviews, and evaluation of vaccines of duck viral hepatitis. First, journal reports were searched, and information from the Council of Agriculture, Executive Yuan, Duck Association and related websites were referenced. Duck farmers were then visited personally, followed by the vaccines inventor of duck viral hepatitis, who is an in-service teachers of University NC; and two animal vaccine manufacturers and research institutions of Taiwan were interviewed by calls. Finally, the obtained information was used in the actual valuation method to obtain the value of patented technology of duck hepatitis vaccine.

IV. RESEARCH RESULTS

A. Technology valuation and influencing factors

After the in-depth interviews with the five universities, this study summarizes the findings as four concepts shown in Fig. 1, where TTO1-TTO5 represent the TTO of the five universities, respectively.

1. Valuation methods

Among the interviewed universities, one university's TTO does not have a specific valuation method and procedure, as the price of technology is negotiated with the manufacturer by the professor. The other interviewed TTOs valuate the technology before discussing matters about technology transfer with manufacturers as the standard or floor price in negotiation with manufacturers. Among the valuation methods, the cost approach is used most extensively (TTO2-TTO5, the symbol means TTO2, TTO3, TTO4 and TTO5 express so in interview). The TTOs used the market approach, income approach, and auctions to determine the value of technology in some cases. The option-pricing models and Monte Carlo method were not used by the universities.

For the application of the cost approach, the costs considered by the university TTOs include the research and development expenses, patent application fee and patent maintenance cost, and the staff cost, while handling cost and equipment use cost must be estimated. On the value basis obtained by the cost approach, the TTOs have different pricings. TTO2 increases the aforesaid total cost by 30% to 50% as the basis of bargaining. To obtain the licensed price, TTO3 adjusts the aforesaid total cost according to the industry trend and market opportunity analysis results. TTO4 does not increase the total cost for the manufacturer to bargain against.

TTO2 uses the market approach for new drugs. The market quotation of a new drug development case is about NT$50 million.

The income approach evaluates the future of technology. When a TTO uses this approach, staffs in the TTO discusses the future of the technology with professors and off-campus experts having a related technology background, so as to determine the present value of technology (TTO2-TTO5). Even so, it is still difficult to implement the income approach (TTO2, TTO3, TTO5), because the technologies developed by universities are mostly embryonic technologies, and future development is considerably uncertain (TTO2, TTO3). A TTO must probe into the industry content applicable to the technology, so as to obtain the future potential income of the technology. For example, how much process cost can be saved for the industry, what products can be derived from the material, what changes will happen to the market, or what business opportunities will be created? Based on these factors, the reasonable future income of a technology can be evaluated. As a matter of fact, the manufacturers are sometimes more aware of the details and cost information of the industrial process than the TTOs, such that a TTO's appraised value is often challenged (TTO3).

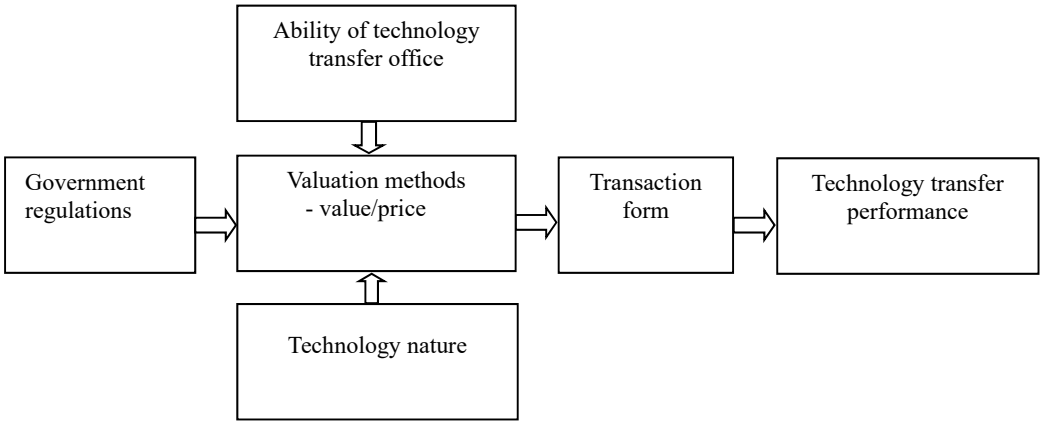

Fig. 1. Technology valuation methods and influential factors

TTO4 and TTO5 use auctions to determine the value of certain technologies. The two TTOs determine the floor bid price at an in-campus meeting, and the floor price is disclosed on the platform for interested manufacturers to bid in public. The auction platform increases the exposure of technology and the value of technology. TTO2 believes the technology of the university is inapplicable to auctions, and so does not use this method.

2. Technology nature

The nature of technology influences the valuation method adopted by the university. Since the technologies developed by universities are mostly embryonic, it is difficult to find transaction price as a reference for these technologies in Taiwan's trading market, and so it is not easy to use the market approach (TTO3). The future marketability of these embryonic technologies is uncertain, and manufacturers must invest resources in them in order to commercialize the technologies successfully, and hence the income approach is inapplicable (TTO3). Sometimes the technologies developed by professors exhibit complementarity, and if so the TTO packs them as a patent portfolio and uses auctions to determine the portfolio value (TTO4).

3. TTO ability

Taiwan has professional valuation companies, but the valuation cost is very high. Among the cases contacted by the five interviewed TTOs, only one case was evaluated by an external company, with the rest valuated by the universities (TTO1-TTO5), and so the ability of the TTO influences the adopted valuation method, procedure, and valuation quality. The university does not require the applicant to have valuation ability when employing a professional manager. In this case, one TTO can recruit professional managers with valuation ability (TTO2), with the other TTOs without valuation ability must be trained to enhance this aspect. Some TTOs with abundant funds arrange training courses for staffs, e.g. attending courses held by juridical persons and foundations (TTO3-TTO5). As long as there is a formal application, the university can subsidize the training cost (TTO3-TTO5). However, some universities are large in scale and do not pay attention to the business of technology transfer, and thus the expense and manpower of TTOs are limited, with no course for the insiders (TTO1).

In order to value technologies, the TTO personnel need to have the knowledge of technology valuation method, understand the valuated technologies, and master the industrial developments and market trends. An active TTO can buy multiple industrial databases for staffs to query at any time or for industrial analysis. Staffs can also actively attend various technology and industry learning courses, such as patent retrieval and analysis, technology competitiveness analysis, intellectual property, market opportunity analysis, so as to enhance the professional ability of TTO personnel (TTO3). The personnel can exchange experiences with other universities' personnel in these courses, in order to absorb the advantages of other TTOs and help in valuation activity (TTO5).

4. Government regulations

The "Government Scientific and Technological Research and Development Results Ownership and Utilization Regulations" specifies that the research and development achievement of the government program can be licensed to foreign enterprises only if there is no entity willing to accept it in Taiwan, there is no entity able to accept it in Taiwan, and the competitiveness of Taiwan's manufacturers is not affected. Such strict conditions make the licensees mostly Taiwanese enterprises, reducing the license price of technology. If foreign manufacturers flexibly cooperate, then the license price can be higher (TTO4, TTO5).

5. Transaction form

When the university and manufacturer agree on the price, the transaction follows the agreed price. The transaction forms include receiving license fee, royalty, premium, and stocks. The government encourages the university to hold firms' shares or equities contributed by transferred technologies (TTO2). However, TTO3 has a conservative opinion on holding the shares. TTO3 has not held firms' shares contributed by transferred technologies up to now, because it is worried about the future development of firms. TTO3 accepts the form of holding firms' shares only when the licensee is a major company or an enterprise that is socially well-known (TTO3). TTO4 has one case of technology share, but the TTO personnel are unfamiliar with the operation of the stock market, and thus they do not know when the shares can or should be sold, and so this type of holding shares has been avoided.

B. Framework of technology valuation

1. Building the framework

The interview findings indicate that cost approach, income approach and market approach used frequently and government regulations, including restrictions on transferee, affect the final value of academic technologies. These two findings offer this study important guidance in developing framework. By extending the studies of Vega-Gonzalez et al. [19], this study builds a technology valuation framework, shown in Fig. 2 The valuation framework of Vega-Gonzalez et al. [19] uses a combination of several common methods and pragmatic price considerations [9]. The framework obtains base technology value (BT_V) by cost approach, upper range technology value (U_RT_V) by market approach and intermediate technology value (IT_V) by income approach. Final technology value (FT_V) is the sum of IT_V and organization's intellectual capital scoring value (OIC_{SV}).

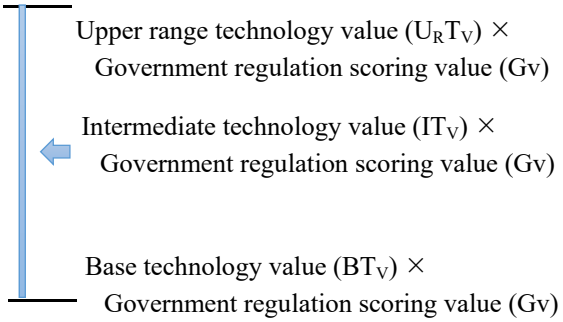

Fig. 2. Technology value scale

Based on the interview findings, this study modifies the concept of OIC_{SV} as government regulation scoring value (G_{sv}), which is an adjusting factors and represents the effects of government regulation and transferee capability. Previous studies has used subjective scoring value to adjust technology value [9]. Therefore, this study proposes that TTOs can adjust the technology value after they obtain base technology value by cost approach, upper range technology value by market approach and intermediate technology value by income approach. The final contract negotiation price depends on TTO's capability. For the case that TTOs can collect the commercial price of similar technology for the evaluated technology (i.e. market approach), the value U_RT_V adjusted by G_{sv} is suggested as a final negotiation price. If the market value is not available and TTOs have the capability to projects income and risk, the value IT_V adjusted by G_{sv} is suggested as a negotiation price. If TTO's capability is too weak to obtain either commercial price or net present value of income, adjusted BT_V is suggested as a negotiation price. Table 3 is the suggested factors and the directions of adjusting the technology value.

TABLE 3 GOVERNMENT REGULATION SCORING FACTORS

Factor	Adjustment direction
Complement capability to implement transferred technology	+
- Manufacturing capability	
- Development capability	
- Marketing & Sales capability	
- Reputation	
Cooperation experience with transferee	Yes (+) vs. No (-)
Size of transferee	Large (+) vs. small and medium enterprises (-)
Type of license	Exclusive license (+) vs. non-exclusive license (-)
Transferred term	Technology share (-)

2. Illustrative application

This study takes the patented technology of duck hepatitis vaccine owned by University NC as an example and uses the cost approach, market approach, and income approach as valuation methods, so as to calculate the technology value. The vaccine inventor was interviewed to collect the information for valuation.

a. Cost approach for base technology value

According to the interview and the data collected, the costs of developing the duck hepatitis vaccine included NT$250,000 for conducting the polymerase chain reaction experiment and the required consumables, NT$80,000 for conducting the western blotting (for testing antibody) experiment and the required consumables, NT$250,000 for conducting the protein purification experiment and the required consumables, NT$70,000 for conducting the DNA electrophoresis experiment and the required consumables, NT$200,000 for executing the enzyme-linked immunosorbent assay and the required consumables, NT$50,000 for bacteria culture medium, NT$20,000 for 1000 green ducks as experimental samples, about NT$20,000 for patent application and two years' maintenance, and NT$200,000 of labor cost. The sum total is NT$1,100,000.

b. Market approach for upper range technology value

Two largest companies of animal vaccines in Taiwan were contacted for an inquiry about the market value of duck hepatitis vaccine technology, and other biotechnological vaccine manufacturers of Taiwan were also called along with the Animal Health Research Institute, Council of Agriculture, Executive Yuan. Some companies said they have not developed vaccine technologies, while some said they have completed the research and development, but the products have not come into the market. Finally, some said relevant vaccine technologies have come into the market, but relevant information is confidential. Therefore, this study fails to obtain the market value of duck hepatitis vaccine technology.

c. Income approach for intermediate technology value

The types of duck hepatitis vaccines include killed virus vaccine, live vaccine, subunit vaccine, and nucleic acid vaccine. The duck hepatitis vaccine of University NC is a subunit vaccine, which has higher safety than traditional live virus and killed virus vaccines. The most conventional vaccine on the existing market is a live virus vaccine. The price per dose is NT$0.5, and the survival rate of ducklings inoculated with this vaccine is 70% to 80%. The price per dose of a subunit vaccine is NT$1, and the survival rate of ducklings is higher than 90%. The nucleic acid vaccine is still in academic research stage and cannot yet be commercialized.

The duck hepatitis vaccine is injected only into ducklings, and so the annual number of ducklings is the basis of vaccine profit. This study collected the historical data of ducklings in Taiwan (see Table 4). The number of ducklings change slightly in the past 8 years. The results of regression analysis indicate that no significant linear relationship exists between the number of ducklings and time, and so the time series data of the number of ducklings has no trend component.

TABLE 4 QUANTITY OF DUCKLINGS Unit: 10,000

Year	Mule duck	Male Muscovy duck	Pekin duck	Laying duck
2006	2700	163	950	220
2007	2150	180	720	220
2008	1700	162	850	220
2009	2284	160	890	220
2010	2231	130	780	220
2011	2386	172	580	220
2012	2337	181	530	220
2013	2490	164	710	220

Source: Duck Association, Taiwan

According to the data in Table 4, the future number of ducklings is forecast by exponential smoothing. This study substitutes 0.1, 0.2, 0.3 to 0.9 in the smoothing factor α in exponential smoothing, when α=0.9, and the Sum of Squares for Forecast Error (SSE) and Mean Absolute Deviation (MAE) are minimized. In addition, when α=0.9, the forecasted final number of ducklings is 3553, and thus this study estimates that the number of ducklings is 3553 in the next five years.

The demand for ducklings willing to be treated by the new vaccine of University NC in the next five years is forecast according to the growth curve approach. The performance of a technology usually presents S-shaped growth trajectory, and so the growth curve is sometimes called an S-curve. This study uses the Pearl curve of growth curve for forecasting, shown as (1):

$$y = \frac{L}{1 + e^{a+bt}} \tag{1}$$

where t is the time, y is the market quantity at time t, L is the limits to growth, i.e. the market potential, and a and b are parameters, determining the shape and growth rate of the curve.

After the technology transfer, the manufacturer needs some time to set up production equipment and instruct the duck farmers. Therefore, this study believes that the time to market of a subunit vaccine may be postponed to 2017. When the subunit vaccine is saturated in the market, it approximately replaces 80% of the existing live virus vaccine market, i.e. the market potential L is 80% of 3553. The growth of demand is forecast by (1), and the results are shown in Fig. 3.

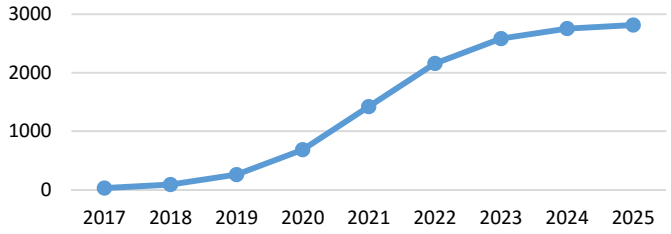

Fig. 3. Market growth estimate of the subunit vaccine

Referring to the inflation rate in Taiwan in the last five years, this study assumes that the future inflation rate may be 2%. According to the interviews with duck farmers, a dose of duck hepatitis vaccine costs NT$1, including NT$0.6 for wage and NT$0.4 for pharmaceuticals. Therefore, this study assumes that the real profit from a dose of vaccine is NT$0.4. The vaccine inventor agrees to take the profit in the five years after the vaccine has come into the market. Therefore, according to these previous two assumptions and the market demand estimation of the subunit vaccine, this study estimates the net present value of income by the subunit vaccine from 2016 to 2021 as (2) (in NT$10,000):

$$NPV = \frac{0}{(1+2\%)} + \frac{284 \cdot 0.4}{(1+2\%)^2} + \frac{88 \cdot 0.4}{(1+2\%)^3} + \frac{260 \cdot 0.4}{(1+2\%)^4} + \frac{684 \cdot 0.4}{(1+2\%)^5} + \frac{1421 \cdot 0.4}{(1+2\%)^6} = 973 \tag{2}$$

The net present value of income by the subunit duck hepatitis vaccine in the Taiwan market can be NT$9.73 million by 2021. This vaccine can also be offered to mainland China and Southeast Asia in the future, but it will compete with more overseas companies. If it succeeds in competition, the income will be higher.

Finally, because no firm formally contracts the TTO of University NC for licensing the duck hepatitis vaccine technology, this study do not adjust base technology value and intermediate technology value based on government regulation scoring value (G_{sv}).

V. CONCLUSION AND SUGGESTIONS

Following the legislative spirit of the Bayh-Dole Act, Taiwan implemented the Fundamental Science and Technology Act at the beginning of 1999. The implementation of this act initiated the opportunity for interaction and cooperation between Taiwan's industries and academia. This study focuses on the topics related to technology valuation. After interviewing managers and staffs in five TTOs of Taiwanese universities, this study obtains that cost approach is used most extensively among all the valuation methods and TTOs used the market approach, income approach, and auctions to determine the value of technology in some cases. The embryonic nature of academic technologies, TTO abilities and government regulations are the factors affecting universities in implementing the valuation methods. After the interview, this study further uses cost approach, market approach and income approach to valuing the vaccines of duck viral hepatitis owned by a Taiwan university.

Based on the interview and practical implementation on the technology valuation, this study finds that it is not easy to put valuation methods into practice. Many TTOs in Taiwan

lack staffs with professional valuation ability. As a result, the study suggests that TTOs must active provide training courses related to valuation for staffs. The staffs with valuation knowledge can eliminate the gaps between firms and professors, which is helpful in achieving consistent consensus in technological value and leading to a successful technological transfer.

When evaluating the "value" of something, the usefulness and desirability of it must be measured [1]. The frequently used technology valuation methods are cost approach, market approach and income approach. This study argues that market approach and income approach can measure the usefulness and desirability of technology and market aspects, but the usefulness and desirability are more than the two aspects from transferee perspective. Therefore, this study designs a technology valuation framework which includes the effects of government regulations and transferee capability by adjusting the technology value based on government regulation scoring value. The framework differs from technology valuation frameworks proposed by previous studies [19, 9, 2] and is appropriate to evaluate academic technologies.

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