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Research on technology contribution evaluation model for commercialization

Heung Su Kim *

Division of Convergence Business, Korea University, Seoul, South Korea

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ABSTRACT

The purpose of this study is to calculate the quantitative and qualitative contribution of intellectual property rights owned by startups for successful commercialization. In the 4th industrial revolution economy, intellectual property rights, which play an important role in job creation and economic growth, play a very important role for startups. In particular, intellectual property rights are the most important asset for startups, and it is necessary to promote the sustainable growth of startups through efficient intellectual property management. This study evaluated the relative contribution of technology, human resources, and market assets, which are the sources of intangible assets for successful business start-ups through intellectual property transfer and technology trade. The contribution of the case companies to intangible assets was calculated by comprehensively judging four technologies related to each other. To this end, we find a strategy for the successful commercialization of intellectual property rights owned by startups by calculating the relative contribution of technical assets, human assets, and market assets, which are the sources of intangible assets. The contribution of the example company to intangible assets is calculated by comprehensively judging the four related intellectual property rights of the startup. In future research, we look forward to a follow-up study that can help companies make strategic decisions by comparing and analyzing various companies in consideration of industry and size.

1. Introduction

This study is the objectivity of capitalization of intellectual property rights for the collective security system of intellectual property rights, unification of technology and credit evaluation, asset structure change, mergers and acquisition (M&A), transaction price calculation for transfer transactions and commercialization, strategy, financial support, investment decision making, and litigation. In order to secure rationality, it is meaningful to establish a revenue approach evaluation mode. Through this, it is expected that the contents of this study can be actively used in intellectual property management strategies for corporate sustainability in the 4th industrial revolution economy. Recently even with COVID-19, the 'second venture boom' has arrived, with the start-up/venture index recording an all-time high and foreign institutions also positively evaluating the domestic start-up/venture ecosystem. Emerging as a new growth engine for the number of new corporations in 2020 is the highest ever, including 123,000 won in venture investment, 4.3 trillion won in venture investment, and 6.6 trillion won in venture funds, and the number of unicorn companies increased from 3 (2017) to 15 (July 2021). As of June 2021, the total employment of ventures increased by 67,000 compared to the previous year.

It is necessary to establish an accurate and reliable valuation system to activate technology and intellectual property (IP) transfers and transactions, which are the basis for corporate innovative growth and rapid technology development. To this end, the importance of intangible assets such as technology and know-how is increasing with the spread of the 4th industrial revolution, and it is very important to activate technology transfer and trade to support innovative growth and advanced technology development of companies in line with this.

However, technology transfer and transaction are stagnant due to the lack of 'accurate and reliable

* Corresponding Author.
Email Address: khsu@korea.ac.kr
https://doi.org/10.21833/ijaas.2022.09.001
Corresponding author's ORCID profile:
https://orcid.org/0000-0001-7085-3269

valuation,' which is a prerequisite for technology/IP transfer and transaction activation.

Therefore, the purpose of this study is to calculate the contribution of technological assets, market assets, and human assets to fair and objective valuation in order to support growth through the commercialization of start-ups that are rapidly expanding.

This study is to evaluate the relative contribution of technology, human, and market factors, which are the source of intangible assets for successful start-up of case companies through intellectual property transfer and technology transactions. The contributions of the intangible assets of the case firms are calculated by comprehensively judging the four technologies related to each other. This study is about the commercialization through the transfer and technology transaction of 19 intellectual property rights held by the startup company Changhae Biotechnology Research Institute.

The commercialization of intellectual property rights is planned to be promoted by commercialization by S, which is an independent branch business of Changhae Biotechnology Research Institute, by acquiring technology transfer or exclusive licenses. It was evaluated based on the current situation. S, a company that will receive technology transfer, is a spin-off company launched with a capital of 500 million won, and CEO Kim, who served as managing director at C Corporation, is the chief executive officer, and vaccine researcher at Changhae Biotechnology Research Institute, including Dr. Jeong, who served as the head of the center, and nine doctors and five masters, participated. More than 90% of them are composed of researchers and do not have their own facilities, but they are continuously conducting research and development by utilizing all the facilities at Changhae Biotechnology Research Institute. In addition, it has a technical advisory committee composed of eight academic personnel, such as Jang Dean of the School of Medicine, Korea University.

2. Related works

Various studies have been conducted to apply existing methodologies or to propose new methods for the evaluation of the technological contribution, and these prior studies are as follows.

Baek et al. (2007) prepared a technology contribution matrix considering industry and technology characteristics to evaluate technology contribution in evaluating technology value using the profit approach and real options method. It is difficult to accurately measure the technological contribution, so the level of importance as an industrial competitiveness factor, the rarity of technology, and the development potential are set and divided into levels one to nine to determine the range of technological contribution and apply an adjustment factor to determine the final technological contribution.

Cho and Choi (2011) used the Analytic Hierarchy Process (AHP) to evaluate the value of intellectual property patents, one of the company's intangible assets, to estimate the value of patents from the point of view of a company providing patents. The hierarchical structure for patent value evaluation was designed through literature study and expert interviews. For patent value evaluation, the technology core, cost area, product market, and competition area were divided into four areas, and under each area, the scope of application, competitiveness, R&D cost, transfer cost, product life cycle, and the number of suppliers were divided into detailed areas for evaluation (Chiu and Chen, 2007).

As a study that suggested the use of a new index without using the concept of technology contribution in evaluating technology contribution, Yang and Min (2007) excluded technology contribution and suggested using the technology commercialization success rate. Technology contribution is not easy to measure due to arbitrary and subjective intervention, but the success rate of technology commercialization is the industry that has been supported since 1995 through the 'Industrial Technology Support Project Performance Analysis' research report hosted by the Korea Institute of Industrial Technology Assessment in July 2005. It is used by examining the success rate of technology commercialization for a technology development project task and has the advantage that it can be used without much measurement process.

The limitations of the paper are as follows. First, there is no explanation for evaluating the contribution of tangible and intangible assets of start-ups, including technology assets. Most of these papers are limited to a company's technological assets and are difficult to use in practice because they do not specifically describe human assets and market assets. Human assets and market assets are very important assets for start-ups, especially for qualitative analysis (Lee and Khoe, 2015). Second, the contents of most previous studies are limited to quantitative analysis, and actual case analysis is not sufficient. Start-ups with a large proportion of intangible assets in their assets require a quantitative and qualitative approach (Oh, 2015; Park et al., 2009). Therefore, a comprehensive approach is required to secure the reliability and objectivity of valuation for the commercialization of start-up companies. The purpose of this study is to examine the theoretical and practical aspects of the method and procedure for evaluating the contribution of tangible and intangible assets to the commercialization of start-up companies, human assets, and market assets.

3. Research method

Technology value evaluation is the conversion of excess profit generated in the future from a specific business unit or product in which the technology to be evaluated is implemented, to the present value.

The excess value converted to the present value generally corresponds to the concept of goodwill or intangible assets and evaluating what is the source of intangible assets and how much is derived from technological assets.

Therefore, the technology value evaluation evaluates the proportion of technological assets among the total intangible asset value. After evaluating the relative contribution of the technical factors, market factors, and human factors of C, the technical contribution is calculated to obtain the intangible value. It is reflected in the asset value.

Technology valuation is the conversion of excess profit generated in the future from a specific business unit or product in which the technology to be evaluated is implemented, to the present value. The excess value converted to the present value generally corresponds to the concept of goodwill or intangible assets and evaluating what is the source of intangible assets and how much is derived from technological assets. Therefore, the technology value evaluation evaluates the proportion of technological assets among the total intangible asset value. After evaluating the relative contribution of the technical factors, market factors, and human factors of the company, the technical contribution is calculated to obtain the intangible value. It is reflected in the asset value. The evaluation method applied in this study is as follows:

$$Technical\ value = [((Excess\ profit\ t \times current\ coefficient\ t) + residual\ value \times current\ coefficient\ n] \times technical\ contribution$$

where, t is the revenue estimation period.

3.1. Business feasibility

The Changhae Biotechnology Research Institute is a non-profit research corporation established for the first time in Korea in May 1991. It has a track record of developing hepatitis diagnostic reagents, AIDS diagnostic reagents, etc., and is the top research foundation approved by the Ministry of Science and Technology. It is a research institute that has gained worldwide recognition, including being designated as a research institute.

S Co., Ltd. is a spin-off company established within the research center to promote the commercialization of hepatitis vaccine treatment and various related products that the Changhae Biotechnology Research Institute has accumulated based on 27 years of research experience. Most of the research personnel who worked in the vaccine team of the Engineering Research Institute have been transferred to the company and are focusing on R&D. In addition, the company is pursuing a business by transferring 19 patents owned by the Changhae Biotechnology Research Institute. The company is planning to secure royalty sales through product sales, and a substantial number of sales is expected from the second half of 2021.

The company intends to reduce the risks associated with the development of new drugs. Hepatitis B treatment vaccine and Tsutsugamushi preventive vaccine plan to achieve a certain amount of sales within a short period of time through technology transfer (license-out), and plan product sales by completing clinical trials in the future.

Securing profits by technology transfer is a business method that has recently been highlighted in this field. If technology transfer is successful, it is a high value-added business form that can secure royalties according to technology transfer fees and product sales. It is a field that requires sufficient funds for long-term development as it is not possible to expect a clear profit until previous success. As the company plans to mainly cover R&D expenses from outsourced R&D funds for technology transfer, securing cash flow is considered to be the key to business success.

As described above, the hepatitis B treatment vaccine has completed the preclinical phase and is preparing for clinical trials and plans to transfer technology to clinical phase two after two to three years. As a result of the preclinical stage, it is showing relatively good commercialization progress.

The Tsutsugamushi vaccine is a live vaccine that can be said to be the first-generation vaccine, and the development success and commercialization potential are generally higher than that of the hepatitis B treatment vaccine, which is a specific antigen-extracting vaccine. After the technology transfer in 2003 and the completion of domestic clinical trials in 2005, it has a domestic sales plan.

The hepatitis C vaccine is being developed in the form of a DNA prophylactic vaccine and a therapeutic agent such as the hepatitis B vaccine. Initially, after the completion of the development of the hepatitis B vaccine, the company plans to commercialize the treatment product within a short period of time. As of now, there is no specific progress. On the other hand, the DNA hepatitis vaccine is currently being tested on animals.

Since the company expects to secure profits on 2023-2024, it is expected that no full-fledged profits will be generated for the next two to three years. Although external income is expected, cash flow is somewhat liquid.

However, judging by the research results and success potential of the company's research team on evaluation technology, and the recognition it has secured at home and abroad, the feasibility of the company's overall business plan is judged to be good.

3.2. Excess profit and discount rate

Title Contribution calculation is the process of converting the excess profit in the future to the present value. The excess cost is calculated by subtracting the cost of sales, sales and general management expenses, corporate taxes, etc. from the sales resulting from the sale of specific technologies

and products, and subtracting the capital cost for the investment capital.

In principle, operating revenue and operating expenses should be estimated for all the permanent periods in the future, but since this is practically impossible, it is possible to estimate the profit for a certain period of time, and the performance after the estimation period is added to the residual value. The residual value is a summary of the performance of all future periods expected after the estimated period. As there are no more favorable investment opportunities during the remaining period, there is no new investment and no profit growth. On the other hand, it is necessary to estimate the discount rate in order to convert the excess profit in the future to the present value and obtain the capital cost in exchange for investment capital. The discount rate is calculated by weighting the weighted average of each capital composition to the cost of each capital source.

3.3. Technology contribution

As for the commercialization of intellectual property rights, S Co., Ltd. plans to promote commercialization by acquiring technology transfer or exclusive license, so the feasibility evaluation is based on the management status and commercialization of S Co., Ltd., the business entity.

The contribution of intangible assets is to evaluate the relative contribution of technology, human, and market factors, which are the source of intangible assets, to find out how much the intellectual property rights, such as technology, human, and market assets, contribute to the excess income generated by the company. Relative contribution is not about how much an individual metric meets any absolute criteria, but rather how much a particular metric can account for the overall excess (Contractor, 2001). Each evaluation element is composed of four sub-items, and each of these sub-items is assigned a score according to a five-point scale. The sum of scores for each evaluation element contributes to each element, which can be expressed as follows (Fernandez, 2001).

$$\begin{aligned} &Contribution\ to\ intangible\ assets \\ &\quad = (Technical\ assets \\ &\quad + Market\ assets \\ &\quad + Human\ assets)\ Score \\ &\quad / (Technical\ assets + Market\ assets \\ &\quad + Human\ assets) \end{aligned}$$

An additional factor to consider when evaluating technology assets is technology completion. The degree of completion of technology is about how much the technology to be evaluated is completed as of the evaluation reference date, which adjusts the effect of the degree of completion of the technology on the volatility of future earnings estimates (Bodie et al., 2012). The degree of completion of technology is given from 1/4 to 1 considering the stage of development of technology. For example, 1/4 is applied to the stage of business design or prototype development, and 1 is applied when it is successfully commercialized and secures a stable market. In this study, the target intellectual property right was "the completion of the prototype and the commercialization feasibility confirmation stage in preparation for clinical trials, so 1/3 was applied (Xitiz et al., 2017).

4. Qualitative contribution evaluation

4.1. Technology asset

Technology assets are evaluated in terms of technological excellence, technological potential, commercialization capability, and stability as follows:

1. Technology excellence: Application technology is a field of drug development that requires a high level of technology and long-term clinical trials. The company's technology includes mass cultivation technology of pathogens, antigen purification technology, pathogen inactivation technology, and manufacturing technology of excellent antigens and diagnostic reagents obtained accordingly. It is difficult for other companies to overtake the results in the short term as this is the result of research over the years. It is currently in the preclinical stage, and it is judged to have a relatively high probability of passing the preclinical and clinical trials (Mohammed, 2019).
2. Technology potential: It is judged that it possesses a number of liposome-related patents and technologies for peptides. Using these technologies, we possess basic technologies for the development of various types of vaccine treatments and preventive vaccines. It is judged to be excellent.
3. Productization capability: Currently, preclinical trials for hepatitis B treatment have been completed, and prophylactic vaccines are under animal trials, so the commercialization capability is somewhat flexible as of now, as it requires two to three years of clinical trials to be commercialized.
4. Stability: New drug development is a high-tech field that can create high added value in the future and has a significant technological ripple effect, but the possibility of product failure is relatively high compared to other industries, so the technological stability is judged to be somewhat inferior.

4.2. Market assets

Market assets are evaluated in terms of brand value, customer loyalty, advantageous market position, and stability as follows:

1. Brand value: S is a project spin-off company of the Changhae Biotechnology Research Institute, and its business experience is very short, but it is expected that the company's image and brand value will be well formed due to its relationship with the Changhae Biotechnology Research Institute Co., Ltd.
2. Customer faithfulness: The level of product service for customers seems to be good considering the overall management level of the company and management's mindset.
3. Advantageous market position: Hepatitis B treatment is a product that has not yet been commercialized worldwide, and although some companies have progressed through clinical phase 2, there are not many competitors developing the product worldwide, and the company plans to license technology in this phase. As the vaccine is currently being tested on animals, there appears to be no special competitor, so there is no big difficulty in securing the market. In addition, it seems that it has a favorable environment for market development as it plans to receive support for new drug license, clinical, production, distribution, and sales marketing, as well as infrastructures such as information communication, finance, and accounting from Cross Co., Ltd.
4. Stability: Since hepatitis B treatment and vaccines have not yet been commercialized, the market is expected to be very stable as demand increases.

4.3. Human assets

Human assets are evaluated in terms of job knowledge/ capability dependence, education/ experience level, managerial leadership, and stability as follows:

1. Business knowledge, dependence on ability: Work knowledge and ability mean the knowledge and ability necessary to understand and perform work in a specific field. The manpower is largely composed of technical, sales, and managerial positions. Since S's technical manpower is a form of absorbing former researchers of the Changhae Biotechnology Research Institute, all employees are considered to have a very high level of understanding of work in related fields. In particular, the CEO seems to be relatively well aware of the technology trends related to the same industry based on his experience as a managing director at Cross Co., Ltd (Yoon and Kim, 2019).
2. Education level, experience level: A total of 17 persons from the Changhae Biotechnology Research Institute participated, including Dr. Jeong, who served as the director of the vaccine research center of the Changhae Life Research Institute, and nine doctors and five masters. In addition, there is a technical advisory committee composed of eight academic personnel including Jang, the president of Korea University Medical School, and the education level is excellent.
3. Executive leadership: The leadership of managers is a comprehensive evaluation item for managers' ability, expressed in the form of management strategy, management philosophy, and corporate culture, and has a dominant effect on employee morale and loyalty. The CEO of S is a professional manager who has served as a manager at Cross Co., Ltd. And is recognized for its corporate management and corporate management capabilities.
4. Stability: A representative indicator of human asset stability is the turnover rate, which is measured by the number of retired employees/average number of employees. Since the company was established in the early stages, there are no retirees yet, but the bio industry's turnover rate was rather high.

5. Quantitative contribution evaluation

5.1. Technology asset composition ratio

Technology contribution is to evaluate the relative contribution of technology among technology, human, and market factors that are the source of intangible assets to find out how much technology contributed to the excess revenue generated by the company. Relative contribution does not look at how well an individual evaluation indicator meets an absolute criterion but evaluates how much a specific indicator can explain the overall excess profit.

Each evaluation element consists of four sub-items, and each of these sub-items is given a score according to a 5-point scale. The sum of scores for each evaluation factor becomes the contribution of each factor, which can be expressed as follows:

$$\begin{aligned} &Technology\ Contribution \\ &\quad = (Technical\ Assets \\ &\quad + Market\ Assets \\ &\quad + Human\ Assets)\ Rating \\ &\quad / (Technical\ Assets + Market\ Assets \\ &\quad + Human\ Assets)\ Points \end{aligned}$$

In this evaluation, the degree of technological contribution was calculated by comprehensively judging the four technologies that were related to each other. Table 1 shows the technical contribution calculation results.

$$\begin{aligned} &(Technical\ Assets + Market\ Assets \\ &\quad + Human\ Assets)\ Rating \\ &\quad / (Technical\ Assets + Market\ Assets \\ &\quad + Human\ Assets)\ Allotment \\ &\quad = 47/60 \end{aligned}$$

5.2. Technology completion factor

An additional factor to consider when evaluating technology assets is technology completion. The degree of completion of technology is about how much the technology to be evaluated is completed as of the evaluation reference date, which adjusts the

effect of the degree of completion of the technology on the volatility of future earnings estimates. The degree of completion of technology is given from 1/4 to 1 considering the stage of development of technology. For example, 1/4 is applied to the stage of business design or prototype development, and 1 is applied when it is successfully commercialized and secures a stable market (Singh, 2019). In this study, the target intellectual property right was "the completion of the prototype and the commercialization feasibility confirmation stage in preparation for clinical trials, so 1/3 was applied. This section describes the process of calculating the technology contribution to the applied technology among various factors as part of the process of evaluating technology value. In order to calculate the technology contribution, the ratio of the technology assets and the technology completion factor is obtained, respectively.

Table 1: Technology asset composition ratio

Division	Evaluation item	Allotment	Rating	Basis for calculation
Technology assets	Excellence in technology	5	5	Technical difficulty level
	Technical potential	5	5	Characteristics of New Drug Development
	Product capacity	5	2	Difficulty Level of New Drug Productivity
	Stability	5	3	Possibility of Failure
Market assets	Brand value	5	4	Company's recognition
	Customer faithfulness	5	3	Overall management system
	Advantageous market position	5	4	Market potential
	Stability	5	4	Considering the Characteristics of the product
Human assets	Business knowledge, dependence on ability	5	5	Development experience
	Education level, experience level	5	5	Composed of master's and doctorate-level personnel
	Executive leadership	5	4	Professional manage
	Stability	5	3	Same industry characteristic reflection
	Sum	60	47	

Technology assets that have been commercialized and successfully put on the market will have more value than those that are in the stage of developing an idea or prototype. In the case of technology assets in an ideal state or technology assets under R&D, it is difficult to determine the commercialization potential and the uncertainty of future market forecasts is high, so the risk is high.

However, uncertainty in the estimation of future earnings caused by the low level of technological assets is not considered in the stage of estimating operating revenue.

In other words, if it is judged that commercialization is possible through technical feasibility analysis, operating profit is estimated based on several possible expected profit scenarios in the case of successful commercialization in the future, regardless of the completeness of the technological asset.

The uncertainty inherent in the expected earnings scenario is adjusted ex-post by devaluing the value of intangible assets using the completeness adjustment factor.

The completeness adjustment coefficient subdivides the process from idea conception to securing a stable market and applies the technology asset completeness coefficient differently to each stage. The completeness adjustment coefficient is applied separately for existing businesses and startups. In particular, when investing in a venture business in the early stages of a startup, the required rate of return expected by investors is very high, so the corresponding risk adjustment is deducted. In general, venture business investors demand nearly 50% of a rate of return that reflects risk for a project that is in the early stage of technology development.

Here, the completeness adjustment factor is calculated using the risk premium assumed based on this general experience rate. The completeness adjustment coefficient below distinguishes the cases in which start-ups and existing firms develop new products. Existing firms have higher stability than start-up firms, so they can be approached from a more relaxed perspective.

In other words, since the degree of completeness reflects the possibility of recovering the investment in technology asset development through the sale of products, it can be considered that the degree of risk related to the uncertainty of ultimately securing the product market is reflected. Therefore, even if a new technology is being developed, if the market is secured, the risk will be low. For example, if a party with a continuous business relationship concludes a product supply contract accompanying the development of a new technology asset, the degree of completion will be considered high even if the development of the technology asset is in progress. Table 2 shows the perfection adjustment factor.

In this evaluation, the degree of technology contribution was calculated by comprehensively judging these four technologies related to each other. Thus, the applied technology is "the stage of confirming the possibility of commercialization in preparation for clinical trials after completing the

prototype, so the result of calculating the technology contribution by applying 1/3 of the technology completion factor is shown in Table 2. The technology asset composition ratio X technology completion factor is

$= 47/60\ X\ 0.333\ =\ 0.26.$

Table 3 shows the contribution to intangible assets.

Table 2: Perfection adjustment factor

	Division	Factor of completeness
Existing business	Products that have secured a large number of customers through existing business	1
	In addition to the existing business, new technological assets are being developed and the market is secured	7/8
	In addition to the existing business, new technological assets are being developed and the market must be pioneered	6/8
New business	Confirmation of market feasibility. The market is rapidly growing and the facility is fully operational and new investment is being considered.	5/8
	Investors began to step in as awareness increased	4/8
	Mass production success stage: the process technology is stable and the target manufacturing yield is achieved	3/8
	Equipment construction, manufacturing technology acquisition and production start stage	1/3
	Prototype completion and commercialization feasibility check stage Product conception and R&D stage	1/4

Table 3: Contribution to intangible assets

Division	Grade	Composition of technical assets	Completeness factor	Technology contribution
Technology asset	15			
Market assets	15	78.33%	1/3 (0.333)	26%
Human assets	17			

6. Conclusion

This study evaluated the relative contributions of technological assets, human assets, and the market president, which are the sources of intangible assets so that startups with a high proportion of intangible assets can successfully commercialize them through intellectual property transfer and technology trading. The contribution of the case companies to intangible assets was calculated by comprehensively judging the four technologies related to each other, and the results of calculating the contribution to intangible assets were presented. We expect more efficient and successful technology commercialization through strategic selection and concentration on the relative importance of startups' technological assets, market assets, and human assets.

This study aims at the capitalization of intellectual property rights, unification of technology and credit evaluation, asset structure change, M&A, transaction price calculation for transfer transaction and commercialization, strategy, financial support, and investment decision making. In order to secure rationality for the purpose, it is meaningful to establish a profit approach evaluation model that reflects expected future benefits in various evaluation methods. Through this, it is expected that the contents of this study can be actively utilized in intellectual property management strategies for corporate sustainability in the era of the 4th industrial revolution economy.

In future research, we look forward to a follow-up study that can help companies make strategic decisions by comparing and analyzing various companies in consideration of industry and size.

Compliance with ethical standards

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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