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An Analysis of Public Sector Practical Guidelines for Valuation of Technology in Korea

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Abstract The Practical Guide of Technology Valuation (the guide) by the Ministry of Industry, Trade and Energy is dominant in technology valuation in the public sector in Korea. The guide was released in 2011 and revised every three years. However, there are several guidelines or manuals for technology valuation issued by other agencies under different ministries. This paper compares the several guidelines for technology valuation and figures out the similarity and differences, from the view of the US and international standards of valuation. The first aspect found is that the guide is evolving toward the basic principles of valuation. Second, all the guidelines should comply with the guide but have sector-specific characteristics in methods, variables and data. Third, although the guide recommends only two valuation methods, some guidelines introduce various other methods. Fourth, the methods are still too complex and having unnecessary ingredients. Finally, this paper suggests further development of the guide and other guidelines.

Keywords Technology valuation, the practical guide of technology valuation, comparison of technology valuation guidelines, Korea valuation association, sector-specific standards

I. Introduction

Korea's technology valuation has started in the mid-1990s (Ji and Seol, 2019). This activity led to the establishment, in 2000, of the Technology Exchange Center in the public sector and the Korea Valuation Association in the private sector. In particular, the Technology Transfer and Commercialization Promotion Law has supported technology valuation as a kind of valuation since 2006 by the Ministry of Industry, Trade and Energy (hereafter Ministry of Industry). The ministry set the Practical Guide of Technology Valuation (hereafter the guide) that must be followed by the Technology Evaluation Agencies designated by the Ministry in 2011.

Since the guide originates from a legal basis, all evaluation agencies must comply with this guide. However, since this guide is an average standard, it was

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rigid at first, and there were some parts not suitable for each technical field. The guide allowed the specificity of each technical field from the 2014 version. As a result, since 2015, various evaluation agencies have proposed technology valuation guides in the name of guides and manuals.

However, there is no research on what these guides have in common and how they differ. There is also no research on the advantages and disadvantages of public sector technology valuation. Therefore, this study will compare all guides and manuals related to technology valuation in the public sector and analyze commonalities and differences. Furthermore, this article will propose development suggestions by comparing them with the International Valuation Standards.

To this end, section 2 reviews the existing studies and international valuation standards as a basis of comparison, and section 3 and 4 examine the Practical Guide of Technology Valuation of the Ministry of Industry and other public sectors. In the last section, I propose development suggestions.

II. Theoretical Consideration

1. Existing Studies

Park (2010) analyzed the cases of technology valuation in Korea and reported which methodology is used. Ji and Seol (2019) introduce the evolution of Japan's intellectual property valuation model. However, no study compares and analyzes the entire public sector technology valuation. Therefore, this study will analyze the Korean public sector technology valuation in the context of international valuation standards and principles.

2. Determination of Valuation Standards and Principles

Valuations began when humanity began to exchange. The trading of grain and fish between people is the root of valuation itself. The advent of value theory, however, came after the market developed in earnest. As the market expanded in the 18th century in the UK, the concept of production cost value, exchange value, and labor value emerged, and gradually, the valuation standards and principles became socially problematic. After the British Empire expanded, even different terms were used in the same English region, and the problems from different methods and principles occurred. This fact led to the establishment of a valuation body in the UK and the creation of valuation principles and standards.

In particular, the courts play an important role in Common law countries, such as Britain and America, where there is no defined law. New theoretical models in valuation are used, and their validity is often determined in court. Therefore, disputes related to valuation have led to more sophisticated principles through courts. As a result, the ever-evolving British and American valuation principles and standards become global standards and are dominant today (Seol, Oh and Park, 2012).

In 1975, the UK-led International Valuation Standard (IVS) was enacted, and in 1981, the International Valuation Standards Council (IVSC) was established in discussion with US professional bodies. In 2008, it developed into an independent international organization.

However, the United States has developed its professional bodies and uses its principles and standards. Representatives include the Professional Standards of the National Association of Certified Valuation Analysts (NACVA), an organization in the field of company valuation, and the Appraisal Foundation's Uniform Standards of Professional Appraisal Practice (USPAP) in the appraisal.

In accounting, the International Accounting Standards Board began to provide its valuation principles after the Lehman Brothers incident in the late 2000s. International Financial Reporting Standards (IFRS) 13, used since 2013, is the standard for fair value measurement.

3. Valuation Principles and Approaches

The valuation principle is surprisingly simple. The concept of value and market value (fair market value in the US) is defined, and three valuation principles are presented (Seol et al., 2002; 2010; Seol and Cho, 2018). The three principles are the principles of market valuation, the principle of prioritizing real input, and the use of various methodologies.

First, the principle of market value is to carry out a valuation with the concept of market value. "Market Value is the estimated amount for which an asset or liability should exchange on the valuation date between a willing buyer and a willing seller in an arm's length transaction, after proper marketing and where the parties had each acted knowledgeably, prudently and without compulsion (IVS 2017, IVS 104 Bases of Value, 30.1.)".

Second, information used for valuation should be actual data and information. IFRS 13 divides input (data) into active market input, market input, and virtual input, and requires that active market data be prioritized. On the other hand, in valuation, active market data is not easy, so it prioritizes actual information obtained from the market.

Third, the principle of using multiple methodologies is to use multiple methods to reduce valuation errors. Where there is an active market such as

financial markets, only one method can be used. But for intangible assets including technology, International Standards urge the use of several methodologies (IVS 2017, Asset Standards). International Standards classify valuation methodologies into three categories: the market approach, income approach and cost approach (IVS 2017, IVS 105, paragraph 10.3).

III. Practical Guide of Ministry of Industry

1. Legal Foundation and Valuation Principle

The Ministry of Industry's Guide was first issued in 2011, and revised editions were released in 2014 and 2017. This guide is based on the Operating Guidelines for Technology Evaluation and the Technology Evaluation Quality Control Guidelines, which are acting guidelines of the Technology Transfer and Commercialization Promotion Law. It is revised every three years. Since the Technology Evaluation Agencies designated by this Act is a certified appraiser in the court, the results of the technology valuation performed by them are recognized as the money input by the court. Therefore, compliance with the guide is a necessary procedure.

The valuation principles adopted by the guide can be found in the Operating Guidelines, the higher guidelines. The operating guidelines include ethical standards, valuation principles, valuation methods, input information, and reporting standards. It is gradually evolving compared to the operating guidelines first introduced in 2011 and is largely analogous to the principles of international standards, although there are some differences.

2. Major Contents of the Guide

2.1 Economic Life of Technology

The Guide determines the economic life of technology by “comparing multiple methods to ensure objectivity if multiple methods are applicable (2017 Guide, p. 47), or by expert consensus method (2017, p. 47 and 48). " In practice, however, most of them use technology cycle time (TCT).

TCT is the median age of the patents cited in a specific patent. Statistics of TCT are provided by analyzing US registered patents on four subclasses of the International Patent Classification (IPC). The median Q2, however, can be changed depending on the strength of the subject technology. For example, if the subject is weak because of a lot of competition, decide between Q2 and Q1 (lower 25%) and strong because of rare competition between Q2 and Q3 (higher 25%). Two models are introduced to calculate economic life. The difference

between the two models is in the calculation of the influencing factor, not its significance. The calculation procedure of Model 1 is as follows:

Model 1

Step 1: Evaluate the factors affecting technology life

Step 2: Calculate Economic Life Span by Influencing Factor Score on TCT

Economic lifespan = TCT lifespan (Q2) × (1 + Factor Score / 20)

Step 3: Determine Application Period reflecting patent life

Application period = Economic lifespan - years since registration

Step 4: Determine the economic lifetime of the technology

If Application Life < Patent Life ⇒ Application Life

If Application Life > Patent Life ⇒ Patent (Legal) Life

Step 5: Determine the cash flow estimation period

Estimated Cash Flow = Preparation period + Economic Life

Factors affecting the lifespan are five items of technology and five items of marketability, and the score is from -2 to 2. Therefore, the perfect total score is 20 (2*10). The sum of the evaluation scores to the perfect score applies to the TCT of the technology.

2.2 Estimation of Cash Flow

The method of estimating cash flow recommended is direct estimation reflecting the business plan, the use of financial information of similar companies, the use of average financial information of similar sectors, and a combination of each method. However, priority is recommended as follows.

Direct Estimation > Mixed Estimation > Similar Company > Average

In the cash flow estimation, there are some problems; it's too basic. For sales estimation, three methods are recommended, such as sales volume forecast, market share forecast, and demand forecast. However, the sales of companies on genetic engineering with no sales for years on the stock market are not predicted by the above three methods. Some examples of sales estimates are needed.

Second, the value creation type of technology is too simple, such as new market creation, existing market replacement, and cost reduction process improvement. For example, there are cases where additional sales are generated in the existing market. This recommendation is too basic.

2.3 Discount Rate

The guide said, "It is a principle to directly measure the risks arising from the commercialization of the target technology and reflect them in the discount rate. However, it is difficult in practice. Therefore, the weighted average cost of capital (WACC) is used applying adjustment factors or additional spreads or risk premiums." The derivations are made as follows.

Small business cost of equity (s)
= Listed company CAPM + (size + commercialization) risk premium
* Listed company CAPM = Risk-free rate + beta × MRP
** Market risk premium = KOSPI return - expected return
** Risk-free interest rate = yield on Treasury Bond maturity
** Beta: average beta by listed companies
* Private equity risk premium: large / medium / small / start-ups

Cost of debt (d) = Cost of debt of listed companies + additional risk spread

WACC = s × equity ratio + d × (1 - tax rate) × debt ratio

Table 1 Premium conversion table of technology commercialization Risks

Score	50	49	48	47	46	45	44
Premium	0.18%	0.36%	0.54%	0.73%	0.93%	1.13%	1.33%
Score	43	42	41	40	39	38	37
Premium	1.55%	1.76%	1.99%	2.22%	2.46%	2.71%	2.97%
Score	36	35	34	33	32	31	30
Premium	3.24%	3.51%	3.80%	4.10%	4.42%	4.75%	5.10%
Score	29	28	27	26	25	24	23
Premium	5.46%	5.84%	6.25%	6.68%	7.14%	7.62%	8.15%
Score	22	21	20	20↓			
Premium	8.72%	9.33%	10.01%	NR			

Note: The black at score 36 is for the following calculation.

Unlisted size risk premium provided is derived from the beta of publicly-traded companies with the classification of large companies (low 60%), SMEs (low 70%), small companies (low 80%), and start-ups (low 90%).

The analyst should assess the technology commercialization risk premium in each of the five categories of technology risk and market/business risk, and convert to a premium in the conversion table with a predetermined rating. The

premium conversion table is derived by setting a maximum premium of 10%. Table 1 is a conversion table.

The cost of debt is reflected in the additional risk in capital costs of listed companies in the same sector. The additional risk is based on the corporate bond yield data of the private bond appraisers and is classified into four categories: large unlisted companies, small and medium-sized enterprises, small businesses and start-ups. However, the total cost of debt, including additional risk premiums, is also provided as a pre-calculated value. The share of debt derived from the interest-bearing debt ratio of guaranteed companies of the Technology Credit Guarantee Fund. These statistics are also provided every three years.

The table below is a discount rate calculation table calculated using pre-converted conversion tables, taking an unlisted midsize company in the information and communication device industry as an example.

Example: Telecommunication Devices - Unlisted Medium Business

- Select industry CAPM, size risk premium, cost of debt, equity ratio
- The risk premium was converted to 3.24% with a commercialization risk score of 36 in the Table 1.
- Calculate the WACC after calculating the cost of equity and cost of debt : cost of equity 12.68%, cost of debt 7.1%, income tax 20%

Equity cost	Commercialization risk premium	CAPM + size risk premium	Total
	3.24%	9.44%	12.68%
Debt cost	7.1%		
Equity ratio 53.80%, Debt ratio 46.20%			
WACC	9.45% [12.68×0.5380+(7.1×0.4620) × (1-0.2)]		

2.4 Technology Contribution Ratio

"Technology contribution ratio refers to the degree to which the target technology contributes to revenue generation or cost reduction. The technology factor method represents the relative contribution of technology assets that contributed to the net present value (2017 Guide, p. 82)." A technology factor is a size (or extent) in which a technology asset contributes to the economic benefits generated through commercialization.

The method of estimating the technology contribution introduced comprises direct estimation, empirical law, and technology factor method, and recommends expert participation in evaluation regardless of the method.

However, most technology evaluation agencies or analysts calculate the technology contribution by the mechanical application of the technology element method.

Technology value is calculated from business value and technology factors. The main data needed for the calculation process is provided out of financial information from the industry. Therefore, the analyst only needs to calculate the Individual Technology Strength. Individual technology strength is measured by the ratio of the scores of 10 points for 10 items each for technology and business feasibility.

Technology Value (TV) = Business Value × Technology Factors (TF)

TF = Industry TF (ITF) × Individual Technology Strength (ITS)
ITF = Maximum IA Value Ratio × Average Technology Asset Ratio
* Intangible Asset (IA) Value = Business Value - Net Asset Value
** Business Value = Market Capitalization + Debt value
* Maximum IA Value Ratio = IA Value / Business Value
* Technology Asset Ratio = R&D / (R&D + Advertising + Training)
ITS = Technology (Score*Weight) + Business (Score*Weight)

As discussed later in the development suggestion, industrial technology factors are unnecessary in deriving technology factors.

2.5 Royalty Rate

The key to the royalty method is the royalty rate and lifetime. In the guide, life is explained by TCT, and royalty is calculated in two ways. But, model 1 is for government-owned technologies, so we introduce model 2.

Model 2

TV = Revenue × Reasonable royalty rate × (1-tax rate) × IP Effectiveness

Reasonable royalty rate = reference rate × adjustment factor
* Reference rate: Median/average of similar cases or industry average
* Adjustment factor: Score of royalty influencers / perfect score
IP Protection Ratio: The percentage of protection by IP (0~100%)
IP Effectiveness = Score of effectiveness / perfect score
* Perfect score = 2 categories × 4 items × 5 points = Total 40.

Reference royalty rates are derived from similar or sector average cases. The adjustment factor reflects the evaluation of technology performance and business feasibility to adjust the difference between the valuation target and the

industry average. The adjustment also is the rating ratio to perfect score by evaluating the technology or business feasibility. There are five categories in technological characteristics such as difference, innovativeness, ripples, prospect, and substitution, and five indicators of business feasibility are demand, profitability, and ease of production, growth, and competitiveness.
Protection ratio refers to the legally protected parts of the entire product. Derivation of the protection ratio is achieved by disassembling the product by technology, for example, using the tables provided. Note the entire market value rule, which is only occasionally mentioned in the text. Even in case of a partial technology, a rule allows entire market value to be applied to a technology that affects overall value. The IP effectiveness means the effectiveness in rights and marketability of IP which is used for IP collateral or marketability check.

IV. Other Guide and System

1. Star-Value System

KISTI's Star-Value System (Science and Technology Information Analysis for R&D-Value System) is an online technology valuation platform. The open version has been available since 2011 and is currently using version 5.0. There are two types of web hosting and technology transfer, in which both systems and DBs are transferred. Compared to universities and public institutions, corporate fees are higher. The transfer fee is higher than web hosting. More than 40 institutions are in use, including 70% of universities and public institutions and 30% of private companies. Firms are mainly assessment, investment and consulting-related.

Since KISTI is also one of the technology valuation agencies, it follows the valuation methods and procedures specified in the guide. Common to the guides: first, it provides the field-specific TCT data in deriving the technology life. Second, both institutions provide industry average financial information for the income approach. Third, both of them use the same formula for technology contribution. Fourth, the same discount rate formula is used. Fifth, both of them provide royalty data of each technology field.

The difference from the guide is as follows: First, the working guide is updated every three years, whereas Star-Value is updated every year. Second, the guide introduces only the technology factor method and the royalty method, while Star-Value enables two revenue approaches, three market approaches, and two cost approaches. Third, royalties and case data are much larger. Recently, about 4,500 annual technology valuations have been carried out. Fourth, technology life is derived entirely from TCT.

The star-value system is an online valuation system. Therefore, many analysts mechanically use the data given to the various methodologies and key applications, against the intention of the system designer.

2. The Guideline for Intellectual Property

KIPO's Intellectual Property Valuation Guide (IP guide) was incorporated into the Ministry of Industry' Guide in 2014. In terms of method, the IP guide adopted only the royalty-relief method. If the royalty method is difficult to apply, it allows different approaches (p. 1). It recommends assembling a valuation team made up of multidisciplinary experts in technology, IP, market and business.

The IP guide provides a formula for IP valuation, which was originally designed for calculating the collateral value. The base formula is the same as that of the guide aforementioned. Besides, this guide uses the discount rate data of the guide. The calculation of the lifespan is the big difference from the guide. This guideline allowed the adjustment of TCT along with the strength of each IP (ratio of the score of technology/market factors to perfect score)

IP lifespan = TCT × score of life influencers
* Life influencers = (score of technology & market factors) / perfect score
* Life influencer has been deleted since 2014.
Discount rate = CAPM + (commercialization + stability + size) premium
* Stability premium has been deleted since 2014.

The 2013 version measured IP life in two ways. One is the CLT (cited patent lifetime) index, which was used in the 2011 guide, but not since the 2014 edition. The second is the data on the number of years of registration, which represents statistics on the number of registration years of domestic patents by IPC classification.

The discount rate is WACC, like the guide. However, the capital cost is the sum of CAPM of the listed, commercialization risk premium, stability risk premium, and scale risk premium. The stability risk premium is added to the guide's formula.

3. ICT Guidelines for Technology Valuation

Compared with other technologies, ICT has a short product life, relatively early technologies, and broad categories such as hardware, software, contents, service, and wide application leading inter-industry convergence. The Institute of Information and Communication Technology Planning and Evaluation (IITP) provided a guideline for ICT valuation in 2015. And Korea Electronics and

Telecommunications Research Institute (ETRI) had also produced its guidelines in 2018.

The guidelines of these agencies include the following basic principles: First, most of the principles and methods of technology valuation are similar to the guide. Also, they provide various statistical data. Second, however, it reflects expert judgment in determining key variables such as life span, discount rate, and technology contribution, reflecting industry-specific characteristics. They are different from the guide as shown in Table 3.

Table 3 Difference of ICT guideline

Variables	Difference
Qualitative evaluation	The evaluation items such as technology, rights, and marketability, royalty rate differ from the guide
Lifespan	The TCT is "must be avoided and should be considered in a professionally agreed manner, taking into account technology and market factors." "Consideration of initial investment period before commercialization" (2018 Guide, 33)
Cash flow	"It is desirable to make reasonable estimates with expert agreement from the most conservative perspective." "In using standard financial information, it should not be applied simply and conveniently, and it is desirable not to apply it uniformly." (2018 Guide, p. 41)
Discount rate	The 2015 guide provided its data, but the 2018 guide relies on the guide but changes it slightly.
Technology contribution	Decision after the consensus by the evaluators of each part on a full understanding of the evaluation indicators

In the formula for the discount rate of the IITP (2015), the technology completion risk premium was added instead of the scale risk premium in the guide. Besides, the risk premium for the technology commercialization risk was set higher than the guide. The risk of ICT technology commercialization is high. The technology completion risk premium has placed 9 levels of Technology Completion from 0% - 43%.

However, ETRI's 2018 guide returned to the guide. The ETRI guide allows the modification of the guide as follows. 1) Direct calculation is possible with a clear presentation of the calculation procedure and rationale. 2) The analysts may not apply the scale risk premium if the subject is judged as very stable financial performance or sales.

4. The Guide for Agriculture

The Technology Valuation Guidelines of the Foundation of Agricultural Technology Commercialization and Transfer (2016) consists of agricultural food products and plant varieties. This guideline is also subject to the guide. However, looking at the details, there are several differences.

Table 4 Difference in agricultural guide

Valuables	Difference
Information	- Detailed classification of the field - Financial information and TCT by sub-field
Royalty	- Using Georgia Pacific Factors generalized in the US - Royalty data of technology provider and technology importer
Discount rate	- Technology completeness premium instead of size premium - r= WACC + (commercialization + completion) premium - Risk-free rate and market risk premium of the field - Beta of sub-field average - Completeness premium with 5 stages ranges from 0~10%.
Technology contribution	- Field evaluation table for independent technology strength - Industry-specific statistics for industrial technology factor

The Plant Variety Guidelines encompass plant varieties consisting of food crops, vegetable crops, fruit trees, flowers, specialty and medicinal crops, mushrooms, and others. The guidelines follow the guide but differ in detail, like the agricultural guidelines.

Table 5 Difference of plant variety guidelines

Valuables	Difference
Information	- Only allows Royalty-relief method - Average royalty rate and TCT by the variety
Lifespan	- Influence factors for each variety differ in weights
Discount rate	- Commercialization risk assessment is the same as the guide - Technology completion risk premium is very high, from 0-43%

5. The Guidelines for Healthcare

The characteristics of healthcare technology are summed up by the enormous R&D costs, the long and complex stages of development, and the low probability of success. Besides, the valuation of these factors is reflected in the value of the development process and industrial characteristics. Further, sales are generated only during the patent period, even if there are very little sales

after the patent period. The Valuation Guidelines of Healthcare Technology by the Korea Health Industry Development Institute (2015) reflects these characteristics of health technology. The health guidelines are being upgraded for the inclusion of medical devices, health functional foods, and cosmetics.

The 2015 Guideline targets only drug, and the rNPV method is recommended for valuation methodology. This guideline is characterized by "trying to comply with global standards in the valuation, accounting or finance to support the internationalization of the Korean biotechnology industry" rather than its application to mechanical formulas. The information provided is as follows.

- Development Process: Outline of drug, target market analysis, development strategy, etc.
- Feasibility studies: Methods related to market size, sales and cost estimation
- rNPV method and application
- Information: Success probability by disease and stage, discount rate by phase and size

6. The Manual of Construction and Transportation

As the construction and transportation sector is not a standardized business, the specificity by technology and company is greater than the general technology or industry average. Unlike other industries, this means that judgment by case, such as direct estimation and expert judgment, is more important than the concept of the industry average. The Korea Agency for Infrastructure Technology Advancement has been upgrading the Technology Valuation Manual for construction and transportation technologies every year since 2016 to account for the comprehensive category of the field or to overcome problems in the application.

Table 6 Difference of manual for construction and transportation sector

Valuables	Difference
Influencer	- Sector-specific items in technology or marketability evaluation
Lifespan	- TCT for lifespan, but focuses more on expert consensus - Introducing the protection period for designated new technology
Finance and sales	- Recommend direct estimates for financial information - If using industry average, use five-digit industry code - Sales forecasts with conservative estimates
Discount rate	- The same formula with the guide - Sector-specific commercialization risks and weights by analysts - Providing discount rates by sub-sector
Technology contribution	- Recommend expert evaluation over the technology factor method - Individual Technology Strength is applied but the weight by expert

The manual has its classification system, average financial information by sub-sector, the qualitative evaluation table for technology and marketability factors, valuation methods, and differences in key variables. This manual (2018) also applies the basic principles of the guide, but there are differences over the details. The qualitative evaluation for technology and marketability factors is quite different from the guide reflecting the sector-specific characteristics.

V. Discussions and Conclusion

1. Comparison

1.1 Principles and Methods

The Ministry of Industry's Guide is the legal basis of technology valuation. Therefore, it is inevitable to influence technology valuation based on other laws. Therefore, the technology evaluation agencies designated by this law should accept the method specified in the guide and reflects only the characteristics of the field. While the guidelines of other organizations may be specific to each sector, the valuation principles or methods of the guide should be followed.

Table 7 Comparison of the guide and other guidelines

	The Guide 2017	KISTI's Star-Value	Others
Coverage	All technologies		Each sector
Renewal	3 yrs	Every yr	Several yrs
Cases	300/yr	4,000/yr	Dozens each
Methods	Technology factor, Royalty	7	Health: rNPV Plant/IP: Royalty
Characteristics	Mechanical	Online/system	Health: int'l standards Construction: experts

Table 7 shows the similarities and differences between the guide and other sector-specific guidelines. Both the guide and the Star-Value System can be applied to all technologies. However, the guide is updated every three years, and Star-Value is updated every year. The Star-Value system has many cases because all cases conducted are accumulated in the system. In the valuation method, the practical guide introduces only the technology factor method and the royalty method. But Star-Value can use seven methods such as the technology factor method, the real options method, the royalty-relief method,

the income sharing method, the royalty case method, the alternative cost method, and the SW valuation model.

A feature of other guidelines is the health guide. This guide adopts the international standards for the internationalization of healthcare technologies. Therefore, they recommend the global valuation method for the healthcare sector, rather than the guide. On the other hand, the guidelines of the construction and transportation sector emphasize expert judgment rather than the mechanical formula of the guide. Most methodologies of many guidelines follow the guide. But it is characterized by the rNPV method in the healthcare sector, especially new drug development, and royalty method in plant variety and IP.

1.2 Common Variables

Table 8 shows the differences in technology life decisions, which are key variables in all technology valuation methods. In the area of construction and transportation and ICT, TCT is used, but the judgment of experts is important, and the healthcare sector uses separate international life statistics. The adjusting factor for the lifespan of TCT is derived from the guide's scoring table, having five categories of technology performance and marketability each. The agro-food sector and the healthcare sector, however, use different evaluations for adjustments.

Table 8 Determination of technology life

Index	The guide 2017	Others
Method	TCT × scores	Construction / ICT: Adjustment of TCT is essential Health: sector-specific life
Adjustment	Scores of tech/market items	Agro-food/health: sector items

1.3 Discount Rate

The formula for the discount rate in the guide is (CAPM + commercialization P + scale P), but that of the agricultural sector is (CAPM + commercialization P + completion P). The agricultural guidelines provide a separate set of completion risk premiums (completion P), which are significantly higher (0-43% for plant varieties) than the scale risk premium (scale P). The market risk premiums are evaluated by the difference between the KOSPI yield and the 3-year government yield in the guide, but in the agricultural sector, data from the sectors are provided separately.

1.4 Variables in the Income Approach

The difference in income approach is found in the calculation of cash flow and technology contribution. The guide refers to direct estimates, similar cases, industry averages, and mixtures of them as cash flow estimation methods, but the explanation mainly suggests industry averages. On the other hand, in the area of construction and healthcare, direct estimation is recommended. The technology contribution also mentions several methods in the guide but explains the technology factor method. On the other hand, the construction transportation sector, as well as health care, recommends direct estimation. On the other hand, the ICT sector requires that qualitative evaluation be added when using the technology factor method.

1.5 Royalty Method

The royalty method differs from the royalty rate calculation items. The guide is more complex than the international formula. The recommended formula for royalty rates in the agricultural sector, on the other hand, is the same as the international one. The base royalty rates by the other organizations are from the relevant sectors, and the adjustment factor is derived considering the characteristics of each sector.

1.6 Influencer / Adjustment Score

There is a little difference in items evaluating technology and marketability in the guide and other guidelines. However, the difference between purposes is bigger than the difference between guidelines. There are many items for evaluating qualitative aspects: the commercialization risk premium, technology life, individual technology strength, and royalty rate. All of these items are from both technology and marketability. However, the detailed items differ by purpose.

2. Suggestions for Further Development

There was a big gap in the 2011 edition in terms of the principles and standards of international valuation. In technology valuation, the application of a single methodology of the technology factor method was a key issue. The technology cycle time (TCT) and the technology contribution formula were also problems.

Over time, however, the 2017 guide after the third revision, at least declaratively, accepts valuation principles and methodologies of international standards. The guide has also been significantly improved. However, for better development, the guide needs to meet international standards. Therefore, we suggest the following.

2.1 Principles and Methodology

Any valuation should be prioritized, not the methodology, but rather the nature of the subject valued, the circumstances at the time of valuation, and its further purpose and use. These principles result in different methodology choices and different techniques for selecting individual variables. In this regard, the guides are making progress, and each sector is providing guides accordingly. However, in practice, the application of the mechanical technology factor method or the royalty method still takes place. The future guide needs to clarify the precautions related to the mechanical application of the various methodologies or methods.

2.2 Technology Contribution

Technology contribution is a contribution to the value creation of technology. It is a matter of sharing among technology, developers, investors, and business entities. On the other hand, it is a matter of sharing profits with other entities of business activities, such as marketing, capital, production, and management. From the accounting point of view, it is the residual value excluding the contributions made by various tangible assets and other intangible assets.

The guide drives the technology value by multiplying the technology factor (technology contribution) by the business value using the technology. However, the process of deriving the technology factor is complicated, and the logic is not appropriate. First, why the industrial technology factor is introduced is unknown. The US or international industry practices do not introduce this variable. Second, although it is an unnecessary concept because we do not agree with the industrial technology factor itself, the definition of the average technology asset ratio has a problem. This ratio is defined as the ratio of R&D expenses to the sum of R&D expenses, advertising expenses, and education and training expenses. In this formula, many enablers composing intangibles of a company such as hardware, software, people, and systems are not mentioned at all. Due to the lack of understanding of technology assets, the concept of the average technology assets ratio itself is wrong. Therefore, the concept of industrial technology factor is also problematic.

A good example of a technology contribution is royalties. Royalties set technology's share only on the premise that other developers do business. In many cases, royalties cannot be greater than the technology contribution, as the developer's know-how, additional applications, and the right of further development are not guaranteed. In any case, it is important to note that royalties are the result of the agreement between the technology owner and the commercialization entity on the net profit generated by the technology.

Technology contributions can also be derived from appropriate consensus levels, data from the same or similar cases, industry case averages, or derived from expert judgment. International practice does not require more. It only

requires an argument about how the contribution was derived and justification for that calculation.

2.3 Discount Rate

In addition to the discount rate formula of the guide, it is a developmental change in the guide that allows other institutions to use different calculations reflecting the technology completion ratio. However, there are two types of formula for deriving the discount rate in the public sector, even though there are various methods for calculating the discount rate. There is also a lot of opposition to CAPM. Therefore, if the logic is clear, it is necessary to allow models other than CAPM by referring to the following formulas used in the industry. For example, the cost of capital is the same as the expected return for the investor. Why do we have to calculate the discount rate only from the internal view? Consider (discount rate = cost of capital = expected return). The industry often asks the expected rate from purchasers or potential investors for a particular asset and averages it as the discount rate.

2.4 Adjustment of Evaluation Items

Although many items on technology and marketability or business feasibility are evaluated to decide or adjust several key variables, the items differ depending on the purpose of the evaluation. These items should be reorganized like that of the Korea Valuation Association.

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