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Determinants and Influential Factors in Technology Valuation in Korea

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ABSTRACT

This study empirically analyzes the characteristics of the various attributes of technology that influence the economic values of technologies, based on the cases of technology valuation carried out in Korea. To do so, we collect the cases of technology valuation carried out by major technology valuation institutions in Korea and extract from these data the information about various characteristics of the subject technologies of valuation and the primary factors applied to the technology valuation. Based on such extracted information, we examine the overall trends of technology valuation in Korea and analyze how the main factors of technology valuation vary with the attributes of technology.

Keywords: *technology valuation, discounted cash flow, determinants of technology value, intrinsic attributes, application attributes*

1. INTRODUCTION

This research investigates the actual cases of technology valuation in Korea to analyze the characteristics and influences of the primary factors that influence the determination of technology values. To do so, we first collect the data of technology valuation carried out by major institutions of technology valuation and observe the general trends and characteristics of determinants of technology valuation. Then, we analyze how technology value, life span of technology, discount rate, and level of contribution of technology vary with the intellectual property right type, stage of commercialization, evaluation purpose, technology field, and industry field, and how these determinants of technology valuation influence the final technology value.

In this paper, the analysis is carried out based on the publicized cases of technology valuation conducted by professional institutions and the actual cases from which information needed for analysis could be extracted. Much of the contents of technology valuation are not fundamentally open to public since the technologies developed or owned by private corporations are related with the business secrets. Therefore, it is a reality that the quantitatively limited cases of the analysis serve as the obstacles to reliable results and empirical analysis for extracting objective implications.

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2. ANALYTICAL FRAMEWORK OF INFLUENTIAL FACTORS IN TECHNOLOGY VALUATION

2.1 Determination of Technology Values

Models or techniques for valuation are diverse just as usages of technology valuation are diverse, and it is a reality that even the same model shows diverse features according to analyzers in applying variables that significantly impact on values of technology.

In particular, in applying DCF (discounted cash flow) based Income Approach, economic life span of technology must be estimated for calculation of the future income flow produced by commercialization of the subjects of technology valuation, and level of contribution of technology must be judged in order to separate the part that the technology has contributed from the flow of total income. In addition, a proper discount rate must be determined in order to convert future cash flow into present values. Besides, establishing various assumptions and determining variables are required in valuation methods of general income approach.

First of all, various methods can be applied for determining economic life span of technology. In case when the subject of technology valuation is patent technology, the legal life span of patent can be simply considered or the analyses of applicants or citations using information of patent applications of relevant fields in the past can be utilized. In addition, period of life span of products with application of relevant technologies can be referenced. As methodologies for analyses of life span of utilized or methodologies such as analyses of rankings and trends using database, citation analysis, co-word, and co-citation can be also utilized.

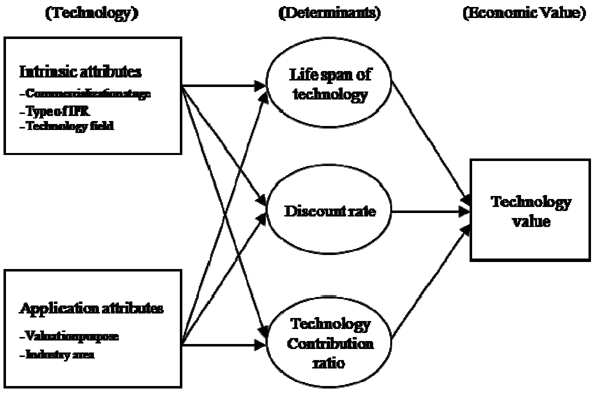

Fig. 1. Determination of Technology Value

In determining the level of contribution of technology, various methods are utilized. The most common method of determining the contribution level of technologies is technology factor method; technology factor means the scope that technology itself takes among estimated portions of increase of cash flow generated by uses of specific technologies within specific corporations. This technology factor method is said to have been suggested by Arthur D. Little [6]. According to this, the scope of changes of technology factor is determined by the number evaluated in quantity of the contribution to corporations made by superior competitiveness of technology. Before this, Dow Chemical had measured technology factor using utility attributes and competitiveness attributes after evaluating present values of additional cash flow. The US National Technology Transfer Center is carrying out evaluation regarding possibility of commercial survival of technologies by expanding indices for evaluating utility attributes and competitiveness attributes with technology factor method of Dow Chemical as a basic model. Inavisis, San Diego based IP management company, is calculating techno-logy factors in consideration of industrial factors and individual technology ratings. On the other hand, UNIDO explains about technology pricing in technology transfer through the concept of LSLP (licensor's share of licensee's profit) [10], which can be also said to share the same meaning with the concept of the level of contribution of technology. Besides, rules of thumb, in which a certain part (25% or 33%) of income flow produced by commercialization of technologies is considered the contribution of technologies, are also used [7].

Consequent risks of commercialization of technologies are classified largely into systematic risks and non-systematic risks. Systematic risks are caused by common factors of the entire capital market and are difficult to remove or to avoid. Non-systematic risks are caused by unique factors of corporations and are possible to remove. As the methods of determining discount rate for converting the future cash flow into present value by reflecting these risks, WACC (weighted average cost of capital), Risk Premium or Built-up Method are utilized, and required rate of return applied by venture capitalists in the technologies, information analyses such as bibliometrics can be United States when estimating new venture investments is also utilized.

Because the establishment of various assumptions and the estimation of various variables besides the above important variables are accompanied and change final amounts of valuation, it can be said that feasibility and credibility of valuations are determined by on how much reliable and objective ground estimations or calculations of these variable are carried out.

2.2 Method of Analysis

In order to analyze the influential factors of determination of technology values, with the estimated amount of technology value as a dependent variable and valuation purpose, stage of commercialization, type of intellectual property right, technology field, and industry area as explanatory variables, categorical regression analysis is carried out. Categorical regression is a method of converting categorical variables into optimum scale for finding out which variable provides important impacts on dependent variables and observing which variable among each several categorical variables is important.

Ordinary regression analysis is the statistical technique that aims at explaining or predicting the relation between a dependent variable and independent variables. Here, in case when independent variables are continuous, linear regression is utilized if a dependent variable is also continuous while logistic regression is utilized if a dependent variable is binary.

However, if independent variables are categorical data, it may be difficult to apply the ordinary regression model. This is because the data violate the assumptions of normality or homoscedasticity on error terms. In these cases, the general linear model can be utilized, but categorical regression analysis can be used to gain more useful results. Ordinary regression analysis estimates regression coefficients by least squares. On the other hand, categorical regression analysis acquires optimized linear regression equation using variables transformed through optimal scaling using alternating least squares. The analysis produces an optimal level for nominal, ordinal or continuous variables, and do not need to have the assumptions on the distribution of variables. In categorical regression, optimal scaling means a method of data analysis in which the measurement characteristics of data are reflected but observed categories are granted numerical values so that the relation between observations and data analysis model can be optimized. Alternating least squares means an algorithm which carries out repeatedly the stage of model estimation by least squares and the stage of optimal scaling of data in turn.

3. CHARACTERISTICS OF TECHNOLOGY VALUATION IN KOREA

3.1 Characteristics of Collected Data

This study performed the analysis based on the data of the latter half of 2000s, when technology valuation, along with technology transfer and commercialization, and technology investment, got into its stride. The contents of technology valuation are rarely publicized because they include the internal information of corporations. It was therefore very difficult to obtain the data for analysis.

Specifically, the valuation reports of the organizations that have professionally conducted technology valuation, such as Korea Technology Transfer Center, Korea Technology Finance Corporation, Korea Invention Promotion Association, Korea Institute of Science and Technology Information, and Korea Development Bank, were used for research. Additionally, valuation data that were open to public and could provide information needed for analysis were collected from Korea Valuation Association, some universities and patent offices.

Among the entire valuation data collected for analysis, 956 cases include substantial information needed for the analysis of the main variables that reflect technology value. The estimated amount of technology value varied from 0 to 61,622 million won, and the average was 1,175.8 million won.

3.2 General Characteristics of Technology Valuation in Korea

We can examine the general characteristics of technology valuation in Korea in terms of the attributes of subject technologies, such as purpose of valuation, stage of commercialization, type of intellectual property right (IPR), technology field, and industry area.

To begin with, when the cases of technology valuation are classified by valuation purposes, among the entire 956 cases of valuation, there are 165 cases for technology transfer and transaction, 149 cases for technology investment, 67 cases for investment promotion, 466 cases for loan on security, accounting for 48.7%, the highest percentage, and 106 other cases, as in Tab. 1. The economic value of technologies was the highest in investment promotion with the average of 3,360.5 million won and in technology transfer with the average of 2,189.7 million won. On the other hand, lawsuit brings about the lowest with the average of 177.3 million won and technology investment and loan on security have the relatively low averages.

Table 1. Technology Valuation by Purpose of Valuation

Valuation Purpose	Number of Cases (%)	Technology Value (million won)		
		Minimum	Maximum	Average
Technology Transfer	165 (17.3)	0.0	61,622.0	2,189.7
Technology investment	149 (15.6)	10.0	21,659.0	856.8
Investment promotion	67 (7.0)	167.0	15,241.0	3,360.5
Loan on security	466 (48.7)	50.0	6,683.0	749.9
Lawsuit	3 (0.3)	61.0	398.0	177.3
Others	106 (11.1)	13.0	3,756.0	565.8

Note: Million Korean won = US$850

Next, when the cases are classified by stages of commercialization, there are 6 cases at the idea stage of technology, 75 cases at the research and development, 109 cases at the completion of R&D, 217 cases at the completion of prototype, 132 cases at the completion of product, and 417 cases at the production and sale, which accounts for the largest percentage of 43.6%, shown in Tab. 2. At the stage of completion of product and research & development, technologies were valued the highest with averages of 1,720.5 and 1,429.0 million won. On the other hand, the stages of idea generation and completion of R&D show the lowest averages.

Table 2. Technology Valuation by Stage of Commercialization

Commercialization Stage	Number of Cases (%)	Technology Value (million won)		
		Minimum	Maximum	Average
Idea generation	6 (0.6)	61.0	832.0	414.0
Research & development	75 (7.8)	0.0	21,659.0	1,429.0
Completion of R&D	109 (11.4)	8.0	33,956.0	875.9
Completion of prototype	217 (22.7)	1.0	61,622.0	1,151.0
Completion of product	132 (13.8)	3.6	20,450.0	1,720.2
Production & Sale	417 (43.6)	8.0	16,510.0	1,060.2

Third, when the cases are classified by the types of intellectual property rights, there are 799 cases of patent registration, accounting for a majority of 83.6%, 74 cases of patent application, 33 cases of utility model registration, and 38 cases of no IPR, summarized in Tab. 3. Technologies that do not have IPR were valued the highest and software technologies were valued the lowest.

Table 3. Technology Valuation by Type of IPR

IPR Type	Number of Cases (%)	Technology Value (million won)		
		Minimum	Maximum	Average
Patent registration	799 (83.6)	0.0	61,622.0	1,139.8
Patent application	74 (7.7)	8.0	33,956.0	1,406.2
Utility Model registration	33 (3.5)	1.0	11,273.0	1,227.7
Utility Model application	5 (0.5)	253.0	1,000.0	665.6
Software registration	5 (0.5)	20.0	634.0	338.4
Other type of IPR	2 (0.2)	690.0	752.0	721.0
No IPR	38 (4.0)	55.0	12,009.0	1,640.8

Fourth, Tab. 4 shows the cases classified by technology field. As seen in the table, machinery accounts for 233 cases with the highest percentage of 24.4%, the largest number of cases, information & communication 161 cases, electricity & electronics 138 cases and materials 104 cases, shown in Table 5. Natural science including physical science, chemistry, and earth science has only 13 cases and energy & resources has 24 cases. Economic value of technologies was the highest in the fields of life science, and relatively high in the fields of energy & resources and environment, while low in the fields of natural science, chemical engineering, construction & transportation, information & communication, etc.

Table 4. Technology Valuation by Technology Field

Technology Field	Number of Cases (%)	Technology Value (million won)		
		Minimum	Maximum	Average
Natural science	13 (10.3)	71.0	1,633.0	628.7
Life science	46 (4.8)	11.0	61,622.9	2,310.8
Health and medicine	58 (6.1)	10.0	6,120.0	1,140.3
Machinery	233 (24.4)	8.0	18,227.0	972.7
Materials	104 (10.9)	0.0	21,659.0	1,457.0
Chemical engineering	50 (5.2)	78.0	7,455.0	847.3
Electricity & electronics	138 (14.4)	3.6	33,956.0	1,399.6
Information & communication	161 (16.8)	13.0	12,009.0	924.8
Energy & resources	24 (2.5)	83.0	16,510.0	1,740.2
Environment	37 (3.9)	150.0	11,709.0	1,639.5
Const. & transportation	92 (9.6)	34.0	7,332.0	853.1

Fifth, Tab. 5 displays the cases classified by industry area. In particular, industrial machinery area accounts for 283 cases, the largest number of cases, electricity & electronics 174 cases, and service industry 142 cases, shown in Table 6. Transportation equipment, furniture & other products, and food, clothing and lumber areas have the relatively small number of cases. The economic value of technologies was evaluated the highest in the areas of petroleum & chemistry, nonmetallic mineral product and transportation equipment, and the lowest in the areas of food, clothing & lumber, furniture & other products, and service industry.

Table 5. Technology Valuation by Industry Area

Industry Area	Number of Cases (%)	Technology Value (million won)		
		Minimum	Maximum	Average
Food, clothing & lumber	40 (4.2)	19.0	2,262.0	676.0
Petroleum & chemistry	96 (10.0)	10.0	61,622.0	1,792.8
Nonmetallic mineral product	61 (6.4)	40.0	20,450.0	1,731.0
Metal product	62 (6.5)	0.0	11,681.0	1,143.6
Industrial machinery	263 (27.5)	1.0	18,227.0	946.6
Electricity & electronics	174 (18.2)	12.0	33,956.0	1,443.4
Transportation equipment	27 (2.8)	134.0	11,273.0	1,658.9
Furniture & other products	21 (2.2)	30.0	2,798.0	759.4
Construction	52 (5.4)	101.0	10,034.0	1,044.0
Service industry	142 (14.9)	20.0	5,071.0	698.4
Other industries	18 (1.9)	24.0	11,709.0	1,896.3

4. INFLUENTIAL FACTORS IN DETERMINING TECHNOLOGY VALUES

4.1 Importance of Technology Attributes

We executed a categorical regression analysis with a dependent variable, the economic values of technologies as a continuous variable and independent variables including purpose of valuation, stage of commercialization, type of intellectual property, technology field, and industry area as categorical variables. The results of analysis are as follows.

The table of coefficients in Tab. 6 shows the categorical regression model estimated through betas of coefficients as follows. In the model, each variable indicates a standardized one. According to beta coefficients in the table, valuation purpose is the most influential variable and the IPR type is the least influential variable on the economic value of a certain technology in technology valuation.

Table 6. Coefficients

	Standardized Coefficients		d.f.	F	Sig.
	B	Std. Error			
Valuation Purpose	-.370	.030	5	151.481	.000
Stage of Commercialization	.139	.031	5	20.486	.000
Type of IPR	.097	.031	6	10.035	.000
Technology Field	.121	.031	10	15.358	.000
Industry Area	-.157	.031	10	25.808	.000

$R2 = .190$, $F = 5.937$ (.000)

Table 7. Correlation Coefficients

	correlation coefficient			Importance
	tolerance	Partial	part	
Valuation Purpose	-.372	-.376	-.366	.730
Stage of Commercialization	.154	.148	.134	.113
Type of IPR	.030	.104	.094	.016
Technology Field	.078	.128	.116	.050
Industry Area	-.109	-.165	-.151	.091

Correlation coefficients are shown in Tab. 7, in which the values of importance tell how each variable has an influence on technology values. In this table, the importance of valuation purpose is the greatest with the value of 0.730 as seen in beta coefficients. The values of importance are proportioned to the absolute value of standardized regression coefficients. Next to valuation purpose, technology field, the stage of commercialization, and industry area are relatively more important while IPR type and technology field are the least important in technology valuation.

From the above, we can see that the application attributes of a subject technology such as valuation purpose and industry area are more important than the intrinsic attributes of the technology in technology valuation. This could mean that the economic value of a certain technology depends largely on how the technology is utilized.

4.2 Influence of Technology Attributes

Tab. 8 summarizes the optimally scaled values of categorical variables. In valuation purpose, investment promotion is the category that is expected to have the highest values for technology, considering that the sign of the standardized regression coefficient of valuation purpose is negative in Table 7. In the stage of commercialization, completion of product is the category that is expected to have the highest values of technologies while idea generation is expected to have the lowest values of technologies. In the type of IPR, no IPR is the category that is expected to have high values of technologies while utility model registration is expected to have lower values of technologies.

Table 8. Quantification of Variables

category		frequency	quantification
Valuation Purpose	Technology transfer	165	-.655
	Technology investment	149	.973
	Investment promotion	67	-3.172
	Loan on security	466	.232
	Lawsuit	3	1.692
	Others	106	.586
Stage of Commercialization	Idea generation	6	-5.097
	Research & development	75	-.443
	Completion of R&D	109	-1.865
	Completion of prototype	217	-.584
	Completion of product	132	1.253
	Production & sale	417	.548
Type of IPR	Patent registration	799	.077
	Patent application	74	.476
	Utility Model registration	33	-4.883
	Utility Model application	5	4.479
	Software registration	5	-.019
	Other type of IPR	2	-.198
	No IPR	38	1.116

Technology Field	Natural science	13	-2.565
	Life science	46	-1.165
	Health & medicine	58	.494
	Machinery	233	-.250
	Materials	104	-1.008
	Chemical engineering	50	-2.032
	Electricity & electronics	138	.031
	Information & communication	161	.786
	Energy & resources	37	2.599
	Environment	92	2.208
	Construction & transportation	24	.522
Industry Area	Food, clothing & lumber	40	.745
	Petroleum & chemistry	96	-1.549
	Nonmetallic mineral product	61	-.870
	Metal product	62	-.348
	Industrial machinery	263	.368
	Electricity & electronics	174	-.468
	Transportation equipment	27	-1.906
	Furniture & other products	21	.449
	Construction	52	1.226
	Service industry	142	1.416
	Other industries	18	-2.483

In technology field, technologies in the fields of energy & resources and environment are the categories that are expected to have higher values while technologies in the fields of natural science and chemical engineering are expected to have low values. In industry area, technologies in the areas of petroleum & chemistry and transportation equipment are the categories that are expected to have the highest values while technologies in the areas of service industry and construction are expected to have the lowest values, considering the negative sign of the standardized regression coefficient of industry area in Tab. 6.

5. CONCLUSION

We, using the cases of technology valuation in Korea, reviewed how technology value and the determinants of valuation by DCF-based income approach including life span of technology, discount rate, and technology contribution ratio are determined, and analyzed how differences are made in the 3 determinant factors according to the purpose of valuation, stage of commercialization, type of IPR, techno-logy field, and industry area of subject technologies. In addition, we attempted to analyze how each factor affects the determination of technology value.

Based on the collected data, we analyzed the characteristics of technology valuation in Korea in various aspects. First of all, we found out that the economic values of technologies showed differences on average according to purposes of valuation, technology field and industry area. Next, we identified differences in determinants applied to valuation approach, and therefore differences of estimated technology values, depending upon technological attributes of each subject technology.

In addition, we carried out the influential factors in determining technology value, and made certain that the attributes of technology have different impacts on final value of technology. More interestingly, the application attributes of technologies such as valuation purpose and industry area have more importance and influence that the intrinsic attribute in technology valuation in Korea.

We need to point out that the analyses in this paper were based on the limited information on technology valuation, and therefore, be cautious when interpreting the results of the analyses. We will be able to perform more reasonable, empirical and theoretical verification of determinants of technology valuation if we collect much broader cases of technology valuation and secure additional information on valuation factors in the future. We believe that systematic accumulation of information and continuous research can help establish methodology for more objective technology valuation, and implement more efficient technology transfer and commercialization.

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