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The Measurement and Evaluation of Technology Transfer Activities:

Indicators for University and Research Institution

Seong Sang Lee* & Jae Min Cho**

Contents

* *Corresponding author*, Mokwon University, Assistant professor.
** Konkuk University, Ph.D. candidate.

Abstract

Not surprisingly, there are many factors which affect technology transfer activities of public research institutions. Therefore, to map out more effective strategy for promoting technology transfer, we need a wide range of information related to technology transfer activities and also proper tool for evaluating and analyzing them. However, development of comprehensive indicators that can measure the level and capability of technology transfer activities by institution and utilization thereof have virtually not been accomplished. In this context, we developed indicators to measure and analyze technology transfer capacities and performances of university and research institution. This paper presents structures and application results of *Indicators for Evaluation of Technology Transfer Activities*(IETTA) and explores implications for promoting technology transfer of public research institution. Especially, we group PRIs into 6 categories by comparing the values of evaluation areas, and propose group-tailored policies for each group. A data set from 181 PRIs with nonzero R&D expenditures (including 116 universities) in Korea is studied. Results show that IETTA can be an appropriate approach to better understand substantial variations across institutions in resources or capacities for technology transfer activities, and map out more effective strategy for promoting technology transfer.

Keywords

technology transfer, indicator, research institution

I. Introduction

Many universities and research institutions("PRIs"[1] hereinafter) recognize the importance of successful spread and transfer of their intellectual properties and technological assets for the benefit of the general public.[2] At the same time, PRIs make efforts to generate more revenues from their intellectual properties and technological assets. Also, governments show great interest in the effectiveness and efficiency of the innovation processes performed by both public and private sectors. The structure for generating profits from scientific and technological outputs had been so weak that it caused the governments to emphasize the commercialization-oriented policies. Especially, the role of PRIs as creator and disseminator of new technologies has been growing.

The technology transfers from public sector exhibited a steady growth over the past few years. The PRIs' revenues from technology transfers has increased by 2.5 times from 49 billion wons in 2003 to 124.5 billion wons in 2010, and the number of technology transfers has also increased by more than 4 times from 1076 in 2004 to 4259 in 2010. Furthermore, universities' revenues from technology transfers have grown by more than 14 times, which also led the univeristies' share of the total revenues generated by PRIs to grow from 4.6% in 2003 to 26.2% in 2010.[3]

Despite the growth of technology transfers and the technology transfer revenues in PRIs, only the top 7 universities and research institutions

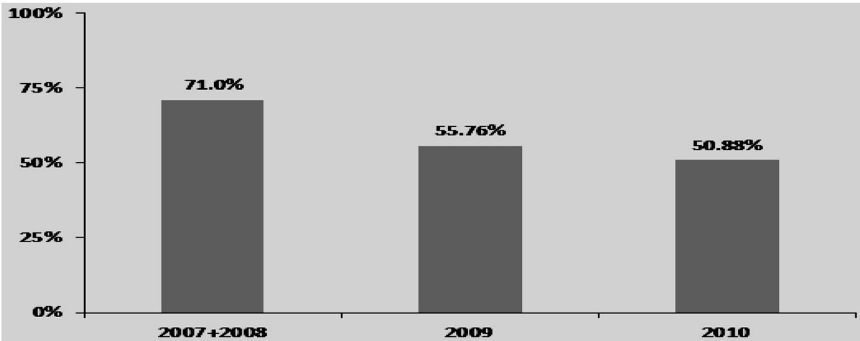
1) Universities, government laboratories and other research organizations receiving significant public research funds are typical examples of public research institutions in this paper.

2) In the research of Thursby et al.(2001), unlike the private sector which is interested in the profit through technology transfer, universities are expected to contribute to economic development as well as royalty income.

3) Lee, S. S., Kim, Y.K. & Lee, S. K., "Analysis of efficiency of universities and PRIs in technology transfer and its determinants", *The Journal of Intellectual Property*, Vol.7 No.3(2012), p.165.

account for the 37% of the total number of technology transfers and 51% of the total amount of technology transfer revenues(as of 2010).

[Figure 1] Top 7 institutions' shares of total technology transfers revenues by year



* Source: Lee et al.(2012)[4)]

This result shows that a substantial variation exists in resources or capacities for technology transfer activities across institutions and we need differentiated strategies according to technology transfer capacities of PRIs. And, not surprisingly, there are many factors which affect technology transfer activities of PRIs. Therefore, to map out more effective strategy for promoting technology transfer, we have to evaluate and analyze the present condition and we need a wide range of information related to technology transfer activities and also a proper tool for evaluating and analyzing them. In this context, indicator may be an effective tool. Namely, indicator is considered as a tool used to better understand certain phenomena's state, trend, and direction and to collect a wide range of information. Also, we can use indicators as statistics and measure for policy making, conducting, analysis, and evaluation in many areas. Unfortunately, however, there are few cases which use general methods of indicator to measure and analyze

4) Ibid, p.166.

technology transfer activities. So, we have developed a proper indicator to measure and analyze technology transfer capacities and performances of PRIs.

The objective of this study lies in presenting structures and application results of *Indicators for Evaluation of Technology Transfer Activities*(IETTA) and exploring implications for promoting technology transfer of PRIs. To do this, we group PRIs into 6 categories by comparing the values of evaluation areas, and propose group-tailored policies for each group. The dataset of 181 PRIs(including 116 universities) with nonzero R&D expenditures in Korea is studied.

The rest of the paper is organized as follows. In section 2, the structure of IETTA is briefly explained along with its evaluation areas and the basic variables that comprise them. In section 3, the results of IETTA are presented by year and type. And then, we divide PRIs into six groups by the estimated values of IETTA in each of the evaluation areas, and examine whether different strategies are needed for different types of institutions, mainly types B and C, depending on technology transfer capacities. Finally. section 4 displays the conclusions and future work.

II. Structure of Indicators for Evaluation of Technology Transfer Activities

In recent years, the number of PRIs that adopted more commercially oriented and entrepreneurial activities for technology commercialization has increased. However, PRIs have traditionally exploited and commercialized their intellectual property by licensing it to industry. IETTA is focused on technology transfer activities of PRIs. Although there are literatures that measured and analyzed technology transfer activities through the use of indicators, they use only a limited number of output variables such as gross license revenue received.[5)]

Basic purpose of IETTA is to establish a technology transfer promotion strategy that fits characteristics of each institution by quantifying and evaluating a wide range of information that are related to technology transfer activities of universities and research institutions. Therefore, the IETTA should be able to diagnose the reasons why input elements for technology transfer activities do not lead to desired results and should be able to grasp necessary tasks that to enhance efficiency and the result of technology transfer activities by type of institution. But with existing researches, there was a limitation to constitute an evaluation index with emphasis on output variables of each stage in technology transfer. For example, Composite Index for Technology Transfer Effectiveness(CITTE) has constituted indicators with emphasis on 6 outputs of technology transfer by stage which was proposed in the study carried out by Rogers et al. (2000) that served as the theoretical background.

When viewed from this perspective, the structure of IETTA is based on the input-output model that is widely applied in the measurement of technology transfer efficiency. Previous studies that measure technology transfer efficiency such as Thursby and Kemp(2002) and Kim(2013) start with the fact that technology transfer results vary depending on individual university or research institution despite close relationship between R&D investment and technology transfer result. Accordingly, in most of the preceding studies that analyzed technology transfer efficiency, R&D expenditure is used as an input factor. However, definitions for input variables and output variables of technology transfer activities excluding the R&D expenditure vary depending on the researcher. Rogers et

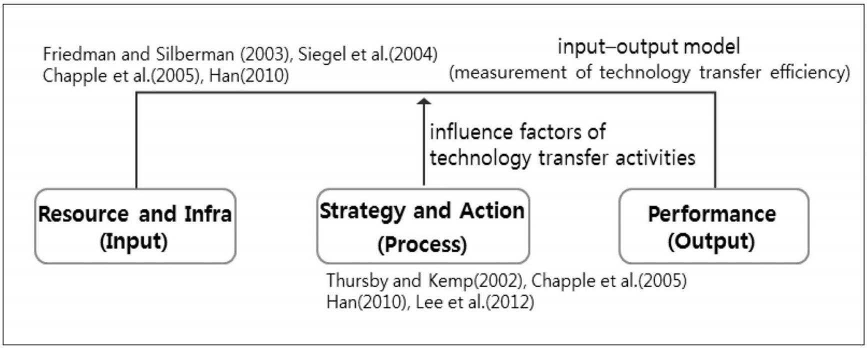
5) See for example Coccia and Rolfo(2002), Anderson et al.(2007) and Patel and Vega(1999).

al.(2000), Thursby and Kemp(2002), Carlsson and Fridh(2002), Anderson et al.(2007) and Kim(2013) used the number of invention disclosures or patents as output variable. In contrast, Friedman and Silberman(2003), Siegel et al.(2004), Chapple et al.(2005) and Han(2010) used the number of invention disclosures, the number of TLO employee, technology management cost, and expenses related to intellectual property rights together with R&D expenditure as input variable. As for output variable vis-a-vis input, technology transfer revenue, the number of technology transfer contracts, and the number of start-ups were used.

Although invention disclosure and patent are output of R&D activities, these variables can be regarded as intermediate output if these are viewed as part of technology transfer activities. A good example of this is the three-stage DEA modeling process presented by Thursby and Thursby(2002). Accordingly, in this study, R&D expense, the number of TLO employee, the number of patents, and the amount of activity expenses and operating expenses associated with technology transfer activities including expenses related to intellectual property right were set as input variable as seen in the case of Friedman and Silberman(2003), Siegel et al.(2004), Chapple et al.(2005) and Han(2010), and output variable was set with emphasis on the number of technology transfer contracts and technology transfer revenue. Combining this kind of input variable and output variable, resource and infra(input variable) that are evaluation area of the indicators and result(output variable) area were constituted. Expecially, employees' ability for technology transfer, which has not been treated in existing studies, was also included as variable in resource and infra area.

The input-output model, which was widely applied in the measurement of technology transfer efficiency, has certain limitations in the sense that factors affecting the process in which input is converted to output are not included. For this reason, factors affecting technology transfer efficiency that has been measured through a comparison of input-output relationship were analyzed as econometric models in studies carried out by Thursby and Kemp(2002) and Chapple et al.(2005). Hence, to achieve the goal of IETTA, consideration of factors affecting the process in which input factors for technology transfer activities is converted to outputs is essential. Accordingly, as shown in [Fig. 2], resource and infra, which are based on input-output model, and strategy and practice area, which combined factors affecting the process in which input is converted to output together with result area, were set as the evaluation area of IETTA. The strategy and

[Figure 2] Structure of indicators for evaluation of technology transfer activities



practice area evaluates whether technology, manpower, and activity expenses, which are input factors of technology transfer, are well managed and whether technology transfer activities, which utilize this kind of input factors, are well managed. Furthermore, it also measures whether the institutional system supporting technology transfer activities and related strategies are well established. Elements included in the strategy and practice area are notably technology management, marketing activities, and support system for technology transfer of institutions. A number of studies including Han(2010) have analyzed that compensation for researchers enhances technology transfer efficiency. Lee et al.(2012) also analyzed that technology marketing activities have a positive influence on technology transfer efficiency. Therefore, we take into account many variables which may be a better indicator for analyzing technology transfer process and patterns. For example, the factors that are considered include the number of hosting or participating in the technology transfer fair or information session, revenue-splitting policies for inventors and status of holding a roadmap for promoting the technology transfer activities.

Each of these three evaluation areas is broken down into 2~4 key performance indicator(KPI) and these KPIs have 30 basic variables(see [Appendix 1] for the statistics and descriptions of basic variables included in the study). We quantify core items as KPI for clearing up objects and desirable results.

<Table 1> Evaluation areas of IETTA

Evaluation Areas	Description	KPI
resource & infra	- related to technology transfer environments and resources - technology, human resource, investment	1. technology assets 2. investment and infra for technology transfer 3. employees' ability for technology transfer
strategy & action	- related to technology transfer process - managing and utilizing resources - technology transfer strategies and marketing	1. technology transfer strategy 2. technology and information management 3. cooperation for technology transfer 4.technology transfer process
performance	- related to technology transfer result - utilizing technology assets, profit from technology transfer	1. utilization rate 2. technology transfer revenue

We normalize basic variables with standard deviations to deal with differences of units. Normalizing with standard deviation is used frequently since it has good statistic manners and is easy to get the sum of the sub-values. It particularly has an advantage to control biased values(outliers). The standardized value(STD value) is calculated as follows:

$$STD\ value = \frac{X - \bar{X}}{S}$$

where X is the original value, $\bar{X}$ the average value of PRIs and S the standard deviation. The weighting is determined by calculating the AHP(Analytic Hierarchy Process) weight of KPIs.

Data used for the analysis of this study are based on the *Survey on Technology Transfer and Commercialization of Public Research Institutions* conducted by the Korea Institute for Advancement of Technology in 2012. This survey is being carried out each year with about 275 universities and research institutions. As the response rate is higher than 90% each year, it is possible to review current status and result of technology transfer activities of Korea's universities and research institutions. Of the PRIs that responded to the survey, 181 institutions(116 universities and 65 research institutes) that are in possession of one or more technologies and responded to all items that are necessary for calculation of the indicators were finally selected.

III. The Application of Indicators

IETTA has significance in that it can be utilized in establishing a technology transfer strategy that fits characteristics of each institution by integrally measuring and analyzing input factors and output factors that are related to technology transfer activities, and factors affecting the process in which the input factors are converted to outputs. The results of IETTA presented in <Table 2> show that government-supported research institutes perform better in all evaluation areas than public universities and private universities, and public universities perform better than private universities.

<Table 2> IETTA results by types of institutes

Average=10	Resource & Infra			Strategy & Action			Performance		
	2012	2011	2010	2012	2011	2010	2012	2011	2010
Public Univ.	11.35	12.68	11.82	11.23	12.97	11.17	10.05	10.28	10.06
Private Univ.	9.23	9.09	9.20	8.94	8.91	9.26	8.38	8.54	8.45
Government-supported research institute	15.72	16.60	15.29	17.65	16.50	15.68	19.47	19.76	19.37
Other PRIs	8.14	7.38	7.94	7.94	7.57	8.06	9.16	8.42	8.45

Also we perform correlation analysis. The correlation coefficient between resource-infra area and strategy-action area is as high as 0.839. On the other hand, correlation coefficients between performance area and other areas are relatively low. It implies that there are many cases that technology, human resource, supporting system, and management system are not connected to technology transfer outcomes.

Universities show low performance compared to similar PRIs. The universities' correlation coefficient between strategy & action area and performance area is 0.569 and that between resource & infra area and performance area is 0.472. These figures are lower than the corresponding figures for research institutions, which are 0.759 and 0.673 respectively.

In theory, technology transfer performance is expected to improve with more resources and developed infrastructure required for technology transfer and with better strategies for practicing technology transfer and marketing performance, and cooperation with external institutions. However, as can be seen from the correlation analysis between three evaluation areas, there are institutions with low technology transfer

<Table 3> Correlation between evaluation areas by institutes

		Resource & infra	Strategy & action	Performance
All institutes	resource & infra	1		
	strategy & action	0.839*	1	
	performance	0.557*	0.628*	1
Universities	resource & infra	1		
	strategy & action	0.824*	1	
	performance	0.472*	0.569*	1
Non-universities	resource & infra	1		
	strategy & action	0.848*	1	
	performance	0.673*	0.759*	1

* Significant at the 1% level(2-tailed)

performance in spite of having the required resources and strong infrastructure or in spite of having the effective technology transfer strategies and marketing strategies. Therefore, by classifying the PRIs into 6 groups by the values of indicators for three evaluation areas and comparing them, we can identify the problems with the groups such as Type B and Type C and build strategies for promoting technology transfer that are appropriate for the characteristics of the institutions.

<Table 4> 6 types by the values of indicators

	Resource & Infra	Strategy & Action	Performance
Type A	High (〉10)	High (〉10)	High (〉10)
Type B	Low (〈10)	Low (〈10)	Low (〈10)
Type C	High (〉10)	High (〉10)	Low (〈10)
Type D	Low (〈10)	Low (〈10)	High (〉10)
Type E	High/Low	Low/High	High (〉10)
Type F	High/Low	Low/High	Low (〈10)

PRIs with values higher than average in all evaluation areas are categorized to type A. In contrast, type B institutions have values lower than average in all areas. Institutions in type C are bad performers in spite of good scores in other 2 evaluation areas and therefore should try to improve performance. On the contrary, type D institutions show higher performance than other similar institutiones. We can expect better performance with improved environment and infra. Institutions in type E and F show different performances with similar environments.

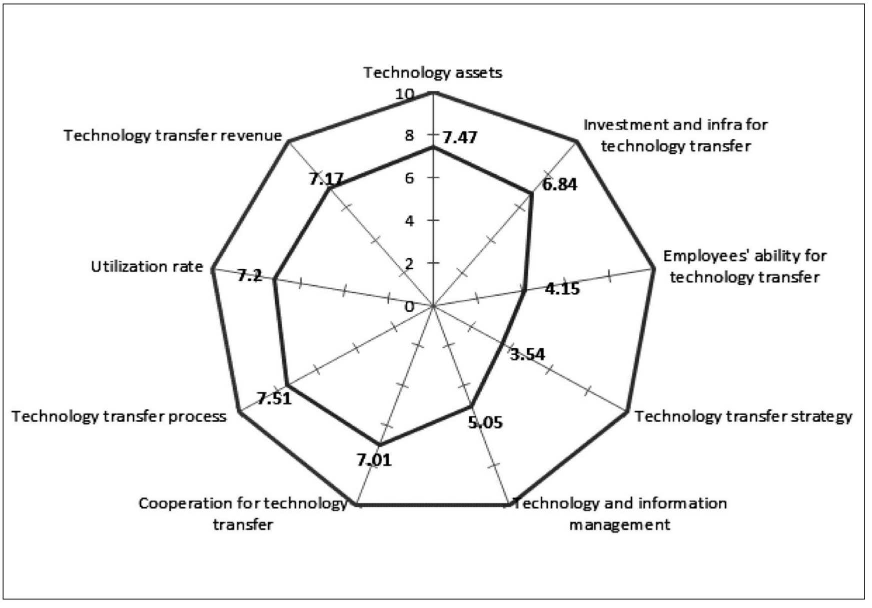
As seen in <Table 5>, 66.8% of all institutes are types A and B with high correlation between evaluation areas. But it is remarkable that type C occupies 12.2%.

<Table 5> Types of institutions

	All (2011)	All (2012)	Public university	Private university	Government-supported research institute	Other public research institute
Type A	22.0%	21.5%	21.4%	15.9%	51.9%	13.2%
Type B	49.7%	45.3%	21.4%	53.4%	18.5%	63.2%
Type C	8.1%	12.2%	21.4%	11.4%	14.8%	5.3%
Type D	2.3%	3.9%	7.1%	1.1%	0.0%	10.5%
Type E	4.6%	2.2%	7.1%	2.3%	0.0%	0.0%
Type F	13.3%	14.9%	21.4%	15.9%	14.8%	7.9%

We derive some implications from the application results of IETTA. First, type B institutes with low values in all evaluation areas need to improve infrastructures. Long-term investment in all evaluation areas is essential. Particularly, we propose type B institutes to invest in education program to improve their capacities for technology transfer and to build better technology transfer strategies because they are behind in 2 KPIs, employees' ability for technology transfer and technology transfer strategy. Therefore, it is important to develop education program to raise members' understanding about technology transfer activities. Also, specific strategies and action plans are essential to achieve the vision and goals for technology transfer and commercialization.

[Figure 3] KPI of type B



Second, institutes in type C are behind in performance area and should improve their technology transfer output. They need systematic evaluation and management for technology transfer performance and need to review the value and effect of technology commercialization. As can be seen in <Table 6>, type C institutes fare badly in technology assets compared to type A which have environments similar to type C. Therefore, they need strategies to secure good technology assets. This point is confirmed in type E and F. They are similar in resource & infra area and strategy & action area but different in performance area. Type E shows the half of the values of type F for the two KPIs of technology assets and technology commercialization process, which are highly correlated with performance area.

<Table 6> KPI of type C

Type	A	C	Type C/Type A
Technology assets	16.64	9.27	0.56
Investment and infra for technology transfer	14.70	12.39	0.84
Employees' ability for technology transfer	19.36	15.00	0.77
Technology transfer strategy	19.99	16.64	0.83
Technology and information management	18.38	15.53	0.84
Cooperation for technology transfer	18.25	9.88	0.54
Technology transfer process	17.35	9.62	0.55

Although this study examined the implication with emphasis on Type B and Type C institutions that are in problem situation in technology transfer activities, implications can be sought from other type of institutions in order to enhance efficiency of technology transfer activities using an identical method.

IV. Conclusion and Future Work

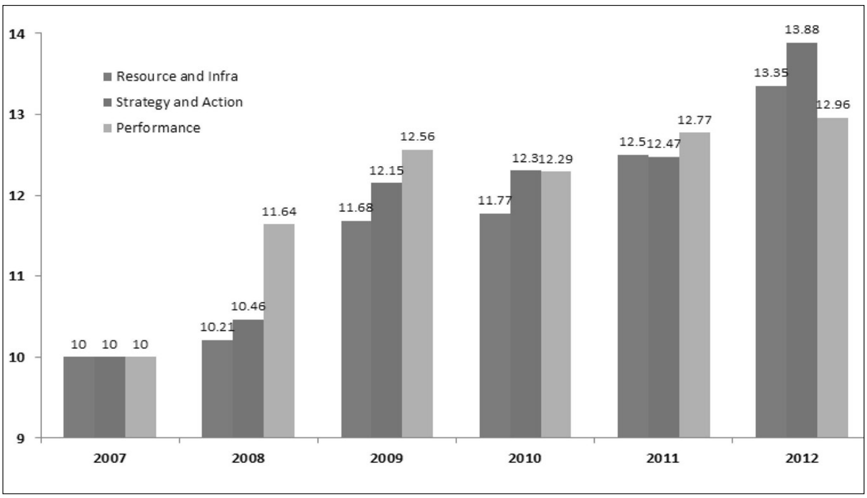
To map out more effective strategy for promoting technology transfer, we need a wide range of information related to technology transfer activities and also proper tool for evaluating and analyzing them. However, development of comprehensive indicators that can measure the level and capability of technology transfer activities is not being carried out.

Although there are examples that measured and analyzed technology transfer activities of individual institutions like CITTE(Composite Index for Technology Transfer Effectiveness) that is prepared by Arizona University based on AUTM survey data using an indicator/index approach, they have certain limitations in evaluating and analyzing overall level and capability of technology transfer activities since they use only a limited number of output variables such as gross license revenue received, invention disclosure, and U. S. patent applications filed. In this context, we developed IETTA to measure and analyze technology transfer capacities and performances of PRIs.

This paper presents IETTA can be an appropriate approach to better understand substantial variations across institutions in resources or capacities for technology transfer activities. Especially noteworthy in this regard is the fact that in this study efforts were made to divide universities and research institutions into 6 types and to grasp tasks that are necessary to enhance the efficiency and performance of technology transfer activities by type.

Basic purpose of IETTA is to establish a technology transfer promotion strategy that fits characteristics of each institution by quantifying and evaluating a wide range of information that are related to technology transfer activities of universities and research institutions. At the same time, IETTA has significance in that it can be utilized as a useful instrument for establishing and evaluating governmental policy for technology transfer promotion. Collection and management of technology transfer related statistical data is an important task for establishing effective governmental policies. Especially, in view of the fact that efforts to enhance capability and performance of technology transfer of PRIs as technology market is growing, policy efficiency can be enhanced if a proper indicator is developed that can compare, diagnose, and analyze the level and capability of technology transfer of individual institutions and utilize it in establishing, enforcing, analyzing, and evaluating technology transfer policies. A desirable indicator should be a performance management tool that can be used to evaluate technology transfer activities and reflect the results on various policies.[6)] When viewed from this perspective, IETTA can secure measurement value of a particular time-point as reference point index, compare it with the level and capability of technology transfer at the reference point by 3 evaluation areas in an effort to identify what kind of changes are occurring. [Fig.4] shows the results from estimating the changes in PRIs' technology transfer capacities and accomplishments in the last 6 years from 2007 to 2012. To address the problem caused by the responding institutions changing every year, we calculated 2008 index using only the institutions that were also used in calculating the 2009 index, and compared it with the 2007 index.

[Figure 4] Change in the technology transfer capacity and accomplishment



6) Choi, S. H. & Moon, H. S., "A study on the development of national technology commercialization indicators", *Journal of Korea Technology Innovation Society*, Vol.9 No.1(2006), p.32

As an indicator for accurately measuring technology transfer activities and performance, IETTA should be equipped with feasibility and confidence. At the same time, it should possess capability to conduct an objective and quantitative survey and measurement at a particular time-point. It will become a more desirable indicators if it can be used in comparing different regions and states.[7] However, as IETTA is using too much information already, there is certain limitation to use it as an instrument to compare different regions and states. Especially, since there is higher rate of qualitative variable in comparison to quantitative variable, there is a tendency to regard a comparison of correlations between evaluation areas as more important factor than measurement of technology transfer level and competitiveness of individual institutions. Therefore, future research should be carried out to complement this shortcoming.

7) Ibid.

[Appendix 1] Statistics and descriptions of major basic variables

Basic variables	Description	statistics
KPI: Technology assets		
Number of new technologies secured	Number of new technologies secured per 1 billion Won of R&D expenditure	3.11
Weighted domestic patent	Number of domestic patent granted in the past 5 years (weighting: total claims)	2365.6
Weighted international patent	Number of international patent granted in the past 5 years (weighting: citation index)	38.0
Patent application	Number of patent application in the past 5 years	363.7
KPI: Investment and infra for technology transfer		
Technology Licensing Office	Value 1: TLO existence	0.87
Employees for licensing #1	Number of employees for technology transfer and marketing / Number of researchers (exclusive of employees for R&D management)	1.58%
Employees for licensing #2	Number of employees for technology transfer and marketing (exclusive of R&D management)	3.7
Investment for technology transfer activities #1	Investment for technology transfer activities / total R&D expenditure	3.29%
Investment for technology transfer activities #2	Investment for technology transfer activities (100million won)	8.22
Incentive for employee-inventor #1	Value 1: provide monetary or non-monetary incentives for employee's patent application	0.71
Incentive for licensing employees	Value 1: provide monetary or non-monetary incentives for employee-inventors as revenues resulting from the use of the invention by third-party	0.46
Incentive for employee-inventor #2	Revenue splitting for employee-inventor	56.6%
KPI: Employees' ability for technology transfer		
Employees' experience and ability for technology transfer	Employees' experience and ability for technology transfer (nornmalized)	3.14
Education	Number of education for employees (technology transfer and management)	7.35

KPI: Technology transfer strategy		
Strategy and plan	Status of holding a roadmap for promoting the technology transfer activities (nornmalized)	0.47
Support system for technology transfer and commercialization	Operation state of the support system for technology development, technology transfer, and commercialization (normalized)	0.64
KPI: Cooperation for technology transfer		
Joint application	Number of joint application in the past 3 years	45.8
Cooperation agreement	Number of cooperation agreement with licensing-related institutes (current year)	2.1
Number of business requests	Number of requests made to an institution in relation to technology transfer activities for the year	5.09
KPI: Technology transfer process		
Technology marketing	Number of hosting or participating in the technology transfer fair or information session (current year)	2.98
Number of PR events for technology in possession	Number of PR events introducing technology in possession for the year	26.79
KPI: Utilization rate		
Licensing contract	Number of licensing contracts (current year) (count 0.5 for gratuitous contract)	18.4
Startups formed	Number of start-ups were formed for the year that were dependent upon the licensing of institution's technology for initiation (including laboratory start-up, subsidiary start-up of a technology holding company...)	0.73
Transferred technologies	Number of different technologies included in licensing contract	28.12
KPI: Technology transfer revenue		
Licensing revenue #1	Licensing revenue (current year) (100million won)	6.89
Licensing revenue #2	Licensing revenue in the past 5 years (100million won)	31.87
Productivity	Licensing revenue (current year) / total R&D expenditure	0.86%

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대학, 연구기관의 기술이전 활동의 측정과 평가를 위한 지표 개발과 활용

이성상 · 조재민

국문 초록

대학, 연구기관의 기술이전 활동에는 다양한 요인들이 영향을 미치게 된다. 따라서 기술이전 활동과 관련된 광범위한 정보를 수치화하여 평가할 수 있는 적합한 분석도구를 개발하여 활용한다면 보다 효과적인 기술이전 촉진 전략을 수립할 수 있을 것이다. 그러나 기관별 기술이전 활동의 수준과 역량을 측정할 수 있는 종합적인 지표의 개발 및 활용은 거의 이루어지지 않고 있다. 본 연구는 대학, 공공연구기관의 기술이전 활동의 수준과 역량을 종합적으로 측정 · 분석할 수 있는 도구로써 기술이전 활동 지표를 제안하고, 지표의 구조를 제시한다. 또한 지표를 활용하여 181개 기관(116개 대학, 65개 연구기관)의 기술이전 활동을 측정, 분석한 결과를 제시한다. 본 연구에서는 기관별로 기술이전 지표의 세 평가영역 간의 상관관계가 다르게 나타난다는데 주목하여 대학, 공공연구기관을 6개 유형으로 구분한다. 이러한 유형 분류를 통해 기술, 인력, 활동비, 지원 제도 등과 이것을 관리하고 활용하는 활동이 기술이전 성과로 이어지지 못하는 원인을 진단할 수 있으며 기관의 유형별로 기술이전 활동의 효율성과 성과를 높이기 위해 필요한 과제들을 파악할 수 있다.

주제어

기술이전, 지표, 공공연구기관