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The Effects of Patent and Paper Evaluation Indicators on the National Technology Level: The Case of Smart Services and Information Protection

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Abstract: It is important job of every government to inject the proper amount of research and development investment regarding the economical situation and develop strategies to enhance the efficiency of the budget. However, in investing such budget, there is a lack of concrete measures and objective grounds that allows each country's characteristic to assess and reflect. Therefore, in terms of smart services and information security technologies, this study will first examine whether the four objective evaluation indicators (patent activity, patent citation, paper activity and paper citation) which are based on patents and statistics from academic literature have a significant effect on the technology level that is based on the subjective answers of experts. The study then aims to suggest a practical model for evaluating a level of technology based on patent and paper evaluation indicators which has a significant effect on the technology level in the Delphi Survey. Many countrie's technology level is greatly influenced by patent and paper citations, that is, the product of R&D which is related to the quality of patents and papers. In addition, it was found that Delphi Survey's values given by experts do have a significant effect on the number of patent applications, patent citations and paper citations but does not present any significant effect on the number of papers. It is believed that this is because the exclusive rights to a patent have a greater direct effect on the market than those of a paper. In other words, a patent application is the ultimate consequence of the products of a technology to exercise exclusive rights in the market. Therefore, all technologies are racing against time for patent applications and filings to secure exclusive rights and win the upper hand. Due to such activities, patents cause a greater effect on the Delphi Survey's values compared to papers. It is expected that future research will develop a more holistic model of the technology level evaluation of each country that integrates patent and paper indicators through a further comparative analysis of a variety of industries.

Key words: Patent evaluation indicator, paper competitiveness, technological level, paper indicator, information protection, smart service

INTRODUCTION

Developed countries are establishing and executing investment strategies for research and development in order to enhance the efficiency and effectiveness of their massive investments into smart services and information security.

To this end, it is essential to evaluate the technology level of countries in terms of smart services and information protection technologies. In order to evaluate countrie's technology level, it is necessary to overcome the limits of the survey method which is dependent on the subjective opinions of experts. Accordingly, there is a growing demand for measurement methods and evaluation of the national technology level through patents and paper indicators which arethe result of R&D (Ueno *et al*., 2005; Anastasi *et al*., 2005; Busic and Fourneau, 2012).

This study will calculate patents and the values of the paper evaluation index for each country using the statistics on smart services and information protection technologies. By doing, so, the aim of the study is to examine whether the patents and paper evaluation indicators have a significant effect on the Delphi Survey's technology level.

Literature review

Technology Level Evaluation (TLE): Since, the country's competitiveness in the future depends on scientific technology, many indicators have been widely researched to measure changes in scientific technology capabilities over decades. As a result, the indicators have also been used to predict national technological level assess market environments and improve national technological level (Porter *et al*., 2001).

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Table 1: Literature

	Patent statistics										
Studies	NP	PGPA	PCPA	NF	CI	CII	TS	TCT	NC	TI	RPA
Huang *et al.* (2003)	*				*			*		*	
Park *et al.* (2005)	*				*						
Guellec and Potterie (2000)	*			*							
Ernst (2003)	*	*	*	*	*						
Chen and Chang (2010)	*	*	*		*	*	*	*			
Breitzman and Thomas (2002)	*								*		
Archibugi and Planta (1996)				*	*						
Schmoch (1993)											*
Griliches (1991)	*				*	*		*		*	
Trajtenberg (1990)									*		
Chia (2004)	*	*			*	*		*	*		
Narin (1995)	*					*		*			

Table 2: Patent evaluation indicators

Variables	Definitions
PAI: Patent Activity Index	The total of filed patents from a specific country/the total of filed patents from all countries
PCI: Patent Citation Index	The total of cited patents from a specific country/the total of cited patents from all countries

Table 3: Paper evaluation indicators

Variables	Definitions
BAI: Bibliometric Activity Index	The total published papers from a specific country/the total registered papers from major countries
BCI: Bibliometric Citation Index	The total cited papers from a specific country/the total cited papers from major countries

However, thus far, no standardizedtechnological level evaluation methods have been proposed. The existed methodologies include expert interviews, surveys and the Delphi method (Cho and Park, 2015).

In such evaluations, technology level is defined as the "measured value of the performance of a specific technology at a specific point in time" (ChoI and Lee, 2014).

Patent indexes: A patent index is a tool to analyze technological properties from macro and micro perspectives. It explains the grounds thatsupport the national innovation system, tracks the level of knowledge dissemination between states, industries, technology fields and enterprises. Furthermore, it is used to measure research and development outcomes as well as the structure and development level of specific technologies and industries; ultimately, it can be the most logical tool to measure or evaluate technological outcomes (Ernst, 2003).

A patent indicator is an index that measures the innovational and technological values of a patent based on bibliographical data found in the relevantdocuments, that is, the number of patent applications and families, citations, triadic patents and patents registered in the US. Patent indexes were defined as a tool that measures the quality and properties of a patent (Schankerman and Pakes, 1986), it is possible to measure the various creditable data that a patent possesses by using theseindicators (Harhoff *et al*., 2003).

As suggested in Table 1, eleven patent indicators are categorized and suggested which are important for analyzing technology strategy (Tseng *et al*., 2011). Table 2 suggests two patent evaluation indicators based on the patent filed number and patent cited number.

Paper indicators: Thesis information provides a foundation for the quantitative evaluation of the level of human development including scientific technology (Hood and Wilson, 2001). A paper indicator is a tool to analyze the outcomes and levels of research projects. Numerous researchers are investing effort tofurther study this matter.

Qualitative or quantitative statistics in papers can be used to study the status of cooperation and competition in scientific technologies between countries (King, 2004). In general, paper indicators consist of the number of published papers which evaluates the quantitative aspect, while the number of paper citations evaluates the qualitative aspect. The number of published papers and paper citations can be used as indexes to measure R&D productivity and the effect of scientific technologies (Rinia *et al*., 1998). As shown in Table 3, two paper evaluation indicators (BAI and BCI) are suggested as paper quantity and quality measuring indicators.

MATERIALS AND METHODS

Study design

Study model: Figure 1 shows the study model. This study validates whether the patent and paper indicators (patent activity, patent citation, bibliometric activity, bibliometric citation) affect the Delphi Survey's

technology level. Based on these indicators that affect the Delphi Survey's technology levels, a new technological level evaluation model is then proposed.

Hypothesis setting

PAI: The PAI is used to measure the relative level of technology sectors between countries. The PAI value increases in proportion to national R&D investment. Thus, the following hypothesis (H_1) is formulated:

- H_1: PAI has a positive effect on Delphi Survey's technology level

PCI: The numberof patent citations of a country on a specific technology is positively influenced on the national technology level. Thus, the next hypothesis (H_2) is as follows:

- H_2: PCI has a positive effect on Delphi Survey's technology level

BAI: The BAI is used to measure the relative level of technology sectors between countries. The BAI value increases in proportion to R&D investment, thereby resulting in more registered papers. As a result, the BAI is positively influenced on the national technology level. Thus, following hypothesis (H_3) is formulated:

- H_3: BAI has a positive effect on Delphi Survey's technology level

BCI: The number of paper citations of a country on a specific technology is positively influenced on the national technology level. Hence, the formulated hypothesis is as follows:

- H_4: BCI has a positive effect on Delphi Survey's technology level

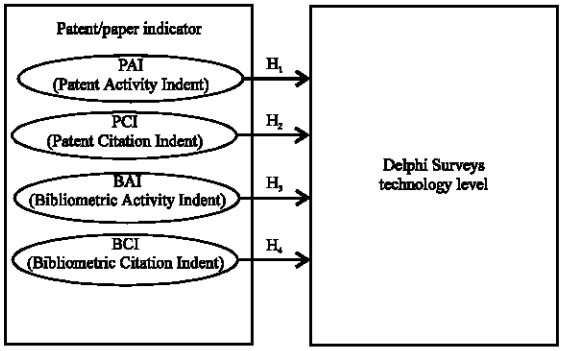

Fig. 1: Study model

Study process: To validate the study model proposed herein, this study follows four stages targeting smart services and information protection technologies in the ICT sector. First, the technology tree of the smart service and information protection are classified and the search keywords are indentified. Then, patent and paper data are gathered. Based on the collected patent and paper data, four indicators are calculated. Lastly, multiple regression analysis is performed to analyze the effect of the patent and paper indicators on Delphi Survey's technology level.

RESULTS AND DISCUSSION

Empirical analysis

Technology tree: Table 4 shows the target technologies and the technological classification of smart services and information protection technologies, they are used by experts in universities, industries and research institutions under the Korean Ministry of Science.

Patent analysis data: Patent data were extracted through keyword searches according to the technology classifications in Table 4. They were based on patents with filing disclosure dates between January 1, 2000 and December 31, 2014 as disclosed by the patent offices of the Republic of Korea, the United States, Japan and Europe.

As shown in Table 5, the total number of patents filed in the five countries with the most patent applications on the related technologies during the 15 years from 2000 to 2014 are 142,252 and the total with patent citations are 386,715.

Table 4: Classifications of smart services and information protection technologies

Classifications	Technologies
Smart services	Internet of Things (IoT)
	Smart home
	Smart media
	Device
	RFID/USN
Information protection	Common-based security
	Service security
	Physical security
	System security
	Convergence security

Table 5: Patent statistics on smart services and information protection

Statistical items	Patent filed number	Patent cited number (USPTO)	Total
CN	5,664	1,253	25,844
JP	20,141	44,390	148,899
KR	12,699	19,027	81,834
EU	34,565	33,025	259,346
US	69,183	289,020	721,667
Total	142,252	386,715	1,237,590

Table 6: Aggregate paper statistics on smart services and information protection

Statistical items	No. of papers	No. of paper citations	Total
CN	27,961	115,713	143,674
JP	5,560	42,805	48,365
KR	5,600	38,418	44,018
EU	35,564	437,076	472,640
US	29,583	587,853	617,436
Total	104,268	1,221,865	1,326,133

CN stands for China; JP, Japan; KR, Republic of Korea; EU, The European Union; SW, Sweden and US, The United States

Paper analysis data: The paper data were extracted through keyword searches according to the technology classifications in Table 5. As shown in Table 4, the paper analysis data of this table are papers from the SCOPUS database during the period January 1, 2000 to December 31, 2014. The evaluation of paper indicators was conducted based on the number of paper registrations and citations of the five countries

As shown in Table 6, the total number of paper publications of the five countries having the highest registration rate of papers on related technologies during the last 15 years from 2000-2014 is104,268 and the total of paper citations are 1,221,865.

Paper analysis data: The paper data were extracted through keyword searches according to the technology classifications in Table 5. As shown in Table 4, the paper analysis data of this table are papers from the SCOPUS database during the period January 1, 2000 to December 31, 2014. The evaluation of paper indicators was conducted based on the number of paper registrations and citations of the 5 countries.

As shown in Table 6, the total number of paper publications of the five countries having the highest registration rate of papers on related technologies during the last 15 years from 2000-2014 is 104, 268 and the total of paper citations are 1,221,865.

Patent and paper evaluation indicators: Based on the 142,252 filed patents, 386,715 patent citations, 104,268 published papers and 1,221,865 paper citations of the 51 subsectors in the smart services and information protection technology sectors from 2000-2014, four indicators were calculated on each of all technologies subsectors. The calculated indicators were transformed into square roots. The TLE values of the Delphi Survey are the results of a research conducted by experts in the universities, industries and research institutions under the Korean Ministry of Science, ICT (Yoon and You, 2015).

Table 7: TLE among nations

Nation	PAI	PCI	BAI	BCI	Delphisurvey'sTLE
CN	0.22	0.29	0.51	0.33	54.26
JP	0.30	0.91	0.25	0.19	41.61
KR	0.36	0.72	0.29	0.24	45.81
EU	0.42	0.85	0.56	0.58	67.53
US	0.69	1.10	0.47	0.63	67.27

TLE: Technology Level Evaluation

Multiple regression analysis: Multiple regression analysis was performed to verify whether the values of the four patent and paper evaluation indicators (PAI, PCI, BAI and BCI) of smart services and information protections technologies have a significant effect on Delphi Survey's TLE (Table 7).

In order to conduct multiple regression analysis, multicollinearity was verified between the dependent variable which is the autocorrelation of the TLE values and the independent variables, patent and paper evaluation indicators (PAI, PCI, BAI and BCI). Durbin Watson statistic was used to test for the auto correlation of the dependent variable. The statistic calculated 1.268 for the estimated TLE values for the five countries. Since, this result is close to 2 and it is neither close to 0 nor 4, it is independent and not auto-correlated. The VIF (Variance Inflation Factor) was used to test for multicollinearity in the independent variables. All the VIF values were below 10. Thus, it can be concluded that the data are suitable for regression analysis Table 7.

Table 8 shows the results of the multiple regression analysis. PAI ($p<0.05$), PCI ($p<0.05$) and BCI ($p<0.05$) have a significant effect on Delphi Survey's TLE. The higher the PAI (B value (113.253)), PCI (B value (22.112)) and BCI (B value (27.535)), the higher the TLE; the explanatory power of these independent variables was 76.2% in explaining the variation in the dependent variables. However, BAI ($p>0.05$) did not have any significant effect on Delphi Survey's TLE.

Hypothesis validation: The hypothesis test results are presented in Table 9. In PAI, the standardized regression coefficients (β) have a positive (+) effect and the level of significance shows a significant result; thus, H_1 is accepted.

In PCI, the standardized regression coefficients (β) have a positive (+) effect and the level of significance shows a significant result, thus, H_2 is accepted. BAI does not show any significant result and therefore is rejected. In BCI, the standardized regression coefficients (β) have a (+) positive effect and the level of significance shows a significant result, thus, H_4 is accepted.

Table 8: Regression analysis results

Dependent variable	Independent variables	B	SE	β	t-test	p-values	VIF
DS_TLE	Constant	68.600	1,655	-	41,453	0.000	-
	PAI	113.253	15.204	0.610	7.449	0.000*	3.019
	PCI	22,112	8.322	0.171	2.657	0.009*	1.870
	BAI	-7.996	4.240	-0.100	-1.886	0.062	1.267
	BCI	27.535	8.828	0.218	3.119	0.002*	2.189

R^2 = 0.873; Modified R^2= 0.762; Regression df = 4; Residual df = 107; F = 85.701; p = 0.000; Durbin Watson = 1.268; *p<0.05; DS_TLE is Delphi Survey's TLE

Table 9: Hypothesis test results

Hypothesis	H_1 (PAI)	H_2 (PCI)	H_3 (BAI)	H_4 (BCI)
DS_TLE	β = 0.610; p = 0.000*	β = 0.171; p = 0.009*	β = -0.100; p = 0.062	β = 0.218; p = 0.002*
Support	Yes	Yes	No	Yes

*p<0.05; DS_TLE is Delphi Survey's TLE

CONCLUSION

In this research, empirical analysis was conducted on smart services and information protection technologies to examine whether the four patent and paper evaluation indicators (that is PAI, PCI, BAI and BCI) have a significant effect on Delphi Survey's TLE values.

The results of the research are as follows. PAI, PCI and BCI have a positive (+) effect on Delphi Survey's TLE values. In contrast, BAI does not have any significant effect.

The results of this study show that many countrie's technology level is greatly influenced by patent and paper citations, that is, the product of R&D which are related to the quality of patents and papers. In addition, it was found that Delphi Survey's TLE values given by experts do have a significant effect on the number of patent applications, patent citations and paper citations but does not present any significant effect on the number of papers. It is believedthat this is because the exclusive rights to a patent havea greater direct effect on the market than those of a paper. In other words, a patent application is the ultimate consequence of the products of a technology to exercise exclusive rights in the market. Therefore, all technologies are racing against time for patent applications and filings to secure exclusive rights and win the upper hand. Due to such activities, patents cause a greater effect on the Delphi Survey's TLE values compared to papers.

RECOMMENDATIONS

Lastly, this research studied the effect of the relations between the Delphi Survey's TLE values given by experts and the quantitative four evaluation indicators of patents and papers. However, there still remains much room to study the effectsthat patent and paper evaluation indicators have on a country's technology level. It is expected that future research will develop a more holistic model of the technology level evaluation of each country that integrates patent and paper indicators through a further comparative analysis of a variety of industries.

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