The Economic Value of Intellectual Capital and Patents in South Korea

S. Lim and T. Ryu

***Abstract*—As knowledge is key resource in national growth, understanding the distribution of intellectual capital across the national economic sector should precede national policy making for the strength of national competitiveness. This study measure the value of intellectual capital and patent using dataset covering financial statements of 18,733 firms and 214,405 firm-year observations in the period of 1995~2011. The resulting value of intellectual capital is 57.4 billion Korean won in 2010, which is about 52.1% of GDP. And the patent related value in intellectual capital is 4.5 billion Korean won, which is 8% of intellectual capital and 40% of structural capital of a firm in average.**

***Index Terms*—Intellectual capital, CIV, capitalization, patent.**

I. Introduction

In knowledge based economic paradigm, knowledge is key resource in national growth. Recent study [1] shows that the impact of innovation on U.S. economic growth was increased from 25% during 1997~1995 to 35% during 1996~2003. World Bank study also found that a 20 % increase in the number of patents is associated with 3.8 % increase in economic output [2].

The growing importance of knowledge is accompanied by the necessity of measuring the national intellectual capital. Understanding the distribution of intellectual capital across the national economic sector should precede national policy making for the strength of national competitiveness.

The term 'intellectual capital' is often used as a synonym of 'intangible assets' or 'knowledge capital'. Recently the 'intellectual capital' is considered as a subset of 'intangible assets' [3]. Reference [4] defines 'intellectual capital' as a set of intellectual properties (patents, copyrights, and so on), database, management knowhow and economic idea.

This study measure the economic value of intellectual capital of South Korea in the period of 1997~2011 using CIV (Calculated Intangible Value) method developed by [5]. CIV method is a firm based measurement tool for the monetary value of intellectual capital. And, this study classifies the intellectual capital to human capital, structural capital and customer capital using the information of balance sheet of firms. Finally, we measure the economic value of patents which is a part of structural capital.

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So-Jin Lim is with Korea Institute of Intellectual Property, South Korea (e-mail: sjlim@kiip.re.kr).

II. Measurement of Intellectual Capital

A. Methodology and Data

The methodologies for measuring the monetary value of intellectual capital are largely divided to market capitalization (MC) approach and return on assets (ROA) approach. MC approach assumes intangible assets including intellectual capital is calculated by subtracting the tangible book value from the market capitalization of a given company. Previous studies often use MC approach because of its convenience. However there are many limitations that the intellectual capital calculated by MC approach is sensitive to short term economic fluctuation, and it can be applicable only to public companies with market value. This study adopts ROA approach which assumes the intellectual capital as excess return of tangible assets. Among ROA approaches, we select Calculated Intangible Value (CIV) developed by the NCI Research group [5]. In CIV method, the intellectual capital is defined as "firm's ability to use its intangible assets to outperform other firms in its industry.

The calculation step of a firm's intellectual capital using CIV method is as follows.

- Calculate the firm's average pretax earnings for the past three years.
- Calculate the firm's average tangible assets for the past three years.
- Calculate the industry average return on assets (ROA) for the same three-year period as in Step 2.
- Calculate the firm's excess return by subtracting the product of the industry average ROA by the average tangible assets calculated in Step 2 from the pretax earnings.
- Calculate the three-year average corporate tax rate and multiply by the excess return. Deduct the result from the excess return.
- Calculate the net present value of the after-tax excess return. Use the firm's cost of capital as a discount rate. We calculate the firm's cost of capital using capital asset pricing model (CAPM).

National intellectual capital is in not only firms seeking profit but also the non-profit organizations including public research institutes, universities and associations. However, to measure its economic value, the owner should acquire economic benefit through utilizing the intellectual capital.

Therefore we include only firms, which have an external audit because of their asset size more than 7 billion won. The total dataset includes financial statements of 18,733

non-financial firms in the period of 1995~2011, resulting 214,405 firm-year observations.

B. Results

Table I shows the result of measuring monetary value of intellectual capital in the period of 1997~2011. The value is sharply increased from 5.14 billion Korean won in 1997 to 55.5 billion Korean won in 2011.

TABLE I: THE VALUE OF INTELLECTUAL CAPITAL

Year	Sum of intellectual capital (billion Korean won)	Number of firms
1997	5.14	6,456
1998	4.47	7,269
1999	6.16	8,999
2000	9.84	10,019
2001	9.83	10,891
2002	16.3	11,816
2003	20.8	12,504
2004	30.9	13,129
2005	26.6	13,771
2006	23.6	14,674
2007	26.9	15,562
2008	32.5	16,307
2009	40.0	17,209
2010	57.4	17,980
2011	55.5	17,756

As for the industrial distribution of intellectual capital, the ratios of intellectual capital in agriculture, mining, paper ware manufacturing industries decreased, and the ratios of intellectual capital in chemical product, precision instrument, automobile manufacturing and recycling, environmental remediation industry sharply increased in the period of 1997~2011.

III. COMPOSITION OF INTELLECTUAL CAPITAL

A. Three Categories of Intellectual Capital

The intellectual capital of firms can be categorized to three parts: human capital, structural capital and customer (or relational) capital.

TABLE II: THREE CATEGORIES OF INTELLECTUAL CAPITAL

Type	Definition
Human capital	Specialty, experience, problem solving skill, leadership, entrepreneurship creativity of employee
Structural capital	Infrastructure, organization process, information system, intellectual property (patent, design, business secret, know-how)
Customer capital	Brand, relationship with customers and suppliers, industry network, distribution channels

Table II shows the definition of each capital. However, those three capitals are not exclusive and interact with each other. Therefore it is very difficult to separate human, structural and customer capital based on an objective standard.

B. Methodology

1) Categorize expenditure on human, structural and customer capital

The primary information about the composition of intellectual capital is a firm's expenditure on each type of capital. For examples, if a firm's R&D expenditure takes a larger share of total cost, the firm might have more structural capital than other firms.

Table III shows the result. The ratio of expenditure related to human capital is decreased from 63% in 1997 to 55% in 2011, and the ratio of structural capital related expenditure has doubled in the same period.

TABLE III: THE COMPOSITION OF EXPENDITURE

Year	Human capital related	Structural capital related	Customer capital related
1997	0.63	0.06	0.31
1998	0.60	0.05	0.34
-	-	-	-
2009	0.53	0.13	0.34
2010	0.53	0.11	0.36
2011	0.55	0.10	0.35

C. Measure the Contribution Ratio of Intellectual Capital Related Expenditure

However the effects of expenditures related to human, structural and customer capital are different each other on the firm's intellectual capital. Thus we should examine how much the intellectual capital related expenditures are capitalized to a firm's intellectual capital.

Many studies on the capitalization of costs related to intellectual capital are focused on labor costs and R&D expenditure. As a study on the capitalization of R&D expenditure, [6] shows positive relationship between price-earnings ratio and profit calculated after capitalization of R&D expenditure. Reference [7] examines the value of firms' R&D expenditure using [8]'s residual income model (RIM) and models the capitalizing process of R&D expenditure. As a study on the capitalization of labor costs, [9] measures the value of human capital by capitalizing labor costs using RIM. Reference [9] shows the depreciation ratio of human capital is 34% and the human capital contributes to 5% of firm's value.

To examine how much costs related to intellectual capital are capitalized to firm value, this study use the firm value equation (1) considering the capitalization of intellectual capital related costs [6], [7], [9], [10].

$$V_t = A_t - \left[\frac{\omega}{1+R-\omega}R\right]A_{t-1} + \frac{\omega}{1+R-\omega}E_t + \left[1-\frac{\omega}{1+R-\omega}R\right]\frac{\alpha_h}{\delta_h}Z_{ht} + \left[1-\frac{\omega}{1+R-\omega}R\right]\frac{\alpha_s}{\delta_s}Z_{st} + \left[1-\frac{\omega}{1+R-\omega}R\right]\frac{\alpha_c}{\delta_c}Z_{ct} \quad (1)$$

where V_t: firm value at time *t*, A_t: total assets at time *t*, ω:durability of excess earnings, R: cost of equity capital, E_t: business profits at time *t*, α_h, α_s, α_c: conversion rate of human, structural and customer capital related costs to assets, δ_h, δ_s, δ_c: depreciation rate of human, structural and customer capital, Z_{ht}, Z_{st}, Z_{ct}: human, structural and customer capital related costs at time *t*.

$\frac{\alpha}{\delta}$ is the conversion multiplier of intellectual capital related costs. The assumption of equation (1) is that the intellectual capital related costs remains steady in the future. In the equation (1), the firm value V_t including both tangible and intangible assets is expressed by observable opened information in financial statements.

We estimate ω, R, $\frac{\alpha_h}{\delta_h}$, $\frac{\alpha_s}{\delta_s}$, $\frac{\alpha_c}{\delta_c}$ in equation (1) using non-linear least square regression.

D. Results

The resulting value of estimation is as follows. The conversion multipliers of human, structural and customer capital related costs are 1.015, 2.011 and 1.546 respectively. It means the expenditure on structural capital contributes twice as effective as that on human capital on a firm's intellectual capital.

TABLE IV: RESULTS OF NON-LINEAR REGRESSION

	coefficient	t-value
ω	0.847	3.015
R	0.019	6.335
$\frac{\alpha_h}{\delta_h}$	1.015	2.044
$\frac{\alpha_s}{\delta_s}$	2.011	9.364
$\frac{\alpha_c}{\delta_c}$	1.546	6.014

TABLE V: THE COMPOSITION OF INTELLECTUAL CAPITAL

Year	Human capital	Structural capital	Customer capita
1997	54.00%	9.70%	36.30%
1998	57.40%	9.70%	32.90%
1999	47.20%	13.40%	39.40%
2000	39.50%	24.40%	36.00%
2001	46.10%	17.70%	36.20%
2002	41.80%	23.10%	35.10%
2003	41.40%	22.00%	36.60%
2004	42.10%	25.40%	32.50%
2005	44.30%	24.10%	31.60%
2006	45.80%	23.60%	30.60%
2007	45.40%	19.90%	34.70%
2008	43.10%	18.70%	38.20%
2009	44.20%	19.90%	35.90%
2010	42.60%	20.10%	37.30%
2011	44.20%	17.40%	38.40%

Using the resulting conversion multipliers and actual expenditure on human, structural and customer capital of each firm, we calculate the composition of firms' intellectual capital as Table V. In this study, we assume that the firm's intellectual capital is composed by only human, structural and customer capital.

The time trend in Table V shows that the structural capital including intellectual property, infrastructure, organizational process supporting human and customer capital is becoming a more important factor in intellectual capital than human capital.

IV. THE ECONOMIC VALUE OF PATENTS

A. Model

In the early stage of innovation research, the variable of R&D investment was used as a proxy for innovation of a firm. However, there are many limitations because the information on R&D investment is not accurate and the relationship with knowledge is not significant.

Later studies [11], [12] use the variable of patents as an index for innovation. The patent data has the information on the 'success' of R&D investment. To solve the problem of non-uniformly distributed value across patents, additional information about the patent quality including citation [13], renewal [14], [15], and the number of claims is considered.

In this sector, we estimate the effects of applied patents, granted patents and the quality of patents on a firm's intellectual capital for measuring the patent related monetary value. We regress equation (2) using two way fixed effect panel model, which could consider the time and firm effect.

$$V_{it} = f\left(PAT\_AP_{it}, \frac{PAT\_GR_{it}}{PAT\_AP_{it}}, \frac{PAT\_CL_{it}}{PAT\_GR_{it}} \right) \quad (2)$$

PAT_AP_{it}: applied patent stock of firm *i* at time *t*

PAT_GR_{it}: granted patent stock of firm *i* at time *t*

PAT_CL_{it}: claim stock of firm *i* at time *t*

The effect of patents from R&D on a firm's intellectual capital can be divided to three steps. Firstly, applied patent can be an index for successful R&D. In equation (2), 'PAT_AP_{it}' is a variable for analyzing the effect of applied patents from R&D on the increase of a firm's intellectual capital.

Secondly, as an applied patent is registered, it brings the firm additional profit by being commercialized. '$\frac{PAT\_GR_{it}}{PAT\_AP_{it}}$' in equation (2) is granted patent stock of one unit of applied patent stock, and is for estimating the additional effect of registration of applied patent stock on a firm's intellectual capital.

Thirdly, a firm's intellectual capital is also influenced by the quality of granted patents. Because the citation information of patents is not available in South Korea, we use the number of claims of granted patents as an index for patent value. $\frac{PAT\_CL_{it}}{PAT\_GR_{it}}$ in equation (2) is an average number of claims of one unit of granted patent stock.

B. Variables and Data

To calculate patent stock, we use following equation (3). We apply 30% depreciation ratio [16].

$$\text{Patent stock}_t = \text{Patent}_t + (1-\delta)\ \text{Patent stock}_{t-1} \quad (3)$$

δ : the depreciation ratio of a patent

Table VI shows the other variables influencing a firm's intellectual capital. The influence factors are a firm's ability to yield profit [17], [18], asset value and its composition [19], [20], [18], financial solvency [18].

TABLE VI: DEFINITION OF VARIABLES

		Variable	Definition
Sales scale		Lnsalest	log(sales)
Asset value and its composition	Size of asset	Lnasset	log(total assets)
	Ratio of liquid assets	Liq_asset	Liquid assets / total assets
Financial solvency	Debt-to-equity ratio	Debt_ratio	debt/total ownership interest
Innovation assets		lnR&D	log(R&D expenditure)
		Mar_app	Applied patent stock /log(R&D)
		App	Applied patent stock
		Mar_gra	Granted patent stock /applied patent stock
		Mar_cla	Claim stock /granted patent stock
Time effect		Year dummy	
Industry effect		Considered in fixed panel model	

C. Results

Table VII shows the results of estimating two way fixed panel model. Model 1 includes the variables of R&D investment and applied patent stock per R&D investment instead of applied patent stock. With the R&D investment variable, the variable of applied patent stock per R&D investment is not significant. Model 2, 3 and 4 exclude the R&D investment variable.

In the period of 1997~2011, three patent related variables - applied patent stock, granted patent stock per applied patent stock and the average number of claims of granted patent stock - positively influence on a firm's intellectual capital.

The patent strategy of firms in South Korea has been changing from quantitative patenting to qualitative patenting since 2005. Thus we divide the period to pre- and post-2005. The effect of applied patent stock is negative in pre-2005 and positive in post-2005 on a firm's intellectual capital. It means that the quantitative patenting strategy regardless of the patent value could rather decrease the firm's intellectual capital.

The effect of granted patent stock per applied patent stock is significantly positive only in pre-2005, meaning that the patents which can positively influence on a firm's intellectual capital are registered in post-2005, but it is not in pre-2005.

Finally, the effect of the patent quality is positive only in pre-2005. This implies that the value is more non-uniformly distributed across the granted patent resulting from the patenting strategy regardless of the value in pre-2005. Thus the intellectual capital could be more fluctuated by the value of granted patents.

By using the coefficients in model 2, we estimate the patent related value in intellectual capital. As a result, the economic value of intellectual capital from patent is 4.5 billion Korean won in the year of 2010, which is about 8% of intellectual capital and 40% of structural capital. And the intellectual capital from the quality of patents was more sharply increased than that of applied and granted patents.

TABLE VII: RESULTS OF FIXED PANEL ANALYSIS

	1997~2011		1997~2004	2005~2011
	Model 1	Model 2	Model 3	Model 4
contant	-7.49E+11**	-9.18E+11**	-5.19E+11**	-1.13E+12**
$Lnsales_t$	2.26E+10**	2.51E+10**	2.38E+10	2.52E+10**
Liq_asset_t	5.58E+10**	7.09E+10**	3.84E+10	6.65E+10**
$Debt\_ratio_t$	3.38E+05	1514125	716741.5	937111.5
$Lnasset_t$	7.72E+09*	1.13E+10**	-2.52E+09	2.32E+10**
$lnR\&D_{t-1}$	2.24E+10**	-	-	-
Mar_app_t	1.03E+10	-	-	-
App_t	-	1.37E+09**	-5.84E+07*	9.44E+08**
Mar_gra_t	2.33E+10**	2.00E+10**	3.71E+09	1.51E+10*
Mar_cla_t	9.81E+07*	1.46E+08**	2.42E+09**	4.44E+07
Year dummy	included	included	included	included

Note: ** p-value < 0.01, * p-value < 0.05

V. CONCLUSION

This study measures the economic value of intellectual capital and patents using CIV method and panel data analysis. The resulting value of intellectual capital is 57.4 billion Korean won in 2010, which is about 52.1% of GDP.

In intellectual capital is divided to human, structural and customer capital and those ratios are 43%, 20% and 37% respectively. The ratio of structural capital is 20%, while the ratio of structural capital related costs is 10%. It means the expenditure on structural capital is more effective in increasing intellectual capital of the firm.

The patent related value in intellectual capital is 4.5 billion Korean won in 2010, which is 8% of intellectual capital and 40% of structural capital of a firm in average.

The information on the value distribution of national intellectual capital and patents shows the trend of industrial restructuring. The result of this study shows that the intellectual capital has been going from traditional industries over to chemical product, precision instrument, automobile manufacturing and recycling, environmental remediation industry.

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So-Jin Lim was born in Seoul, South Korea, In October 14, 1978. She received BS of life science in Korea University, 2002; MA of Economics in Seoul National University, 2005; Ph. D. of Economics in technology management, economics and policy program (TEMEP), Seoul National University, 2011. She is an associate researcher fellow in Korea Institute of Intellectual Property located in Seoul.

Tae-Kyu Ryu was born in Jinju, South Korea in 28th March, 1970. He received the BS degree in department of Electrical engineering, Seoul National University in 1998. Also, he received MS., Ph.D. degree in Economics from technology management, economics and policy program (TEMEP), Seoul National University in 2001, 2005 respectively. He was a researcher in Technology Transfer and Commercialization Center at Korea Institute of Science and Technology (KIST) and an adjunct professor in University of Science & Technology (UST). At present he is a research follow in Korea Institute of Intellectual Property (KIIP) located in Seoul. His research interests are technology transfer and commercialization, Policy and Strategy of Intellectual Property, Performance Measure and Indicator, and Valuation or Spillover Effect of Patent and Technology.