Intellectual Property Rights and Innovation in Economic Development in Korea

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Outlines

- 1. Introduction
- 2. IPR Protection and Innovation in Korea
- 3. Hypothesis and Empirical Results
- 4. Concluding Remarks

1. Introduction

1. Introduction

Rapid Accumulation of Technological Capabilities of Korea since the mid 80s

- U.S. patents granted to Koreans rose from 14 in 1982 to 3,562 in 1999
- The share of Koreans in U.S. patents granted rose from 0.01% to 2.32% over the same period (USPTO, 2009).
- By 1999, Korea ranked seventh in terms of U.S. patents granted, behind the U.S., Japan, Germany, France, Taiwan, and the U.K.

What drove such a rapid upgrade or development of technological capability in Korea?

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Dynamic perspective of IPR protection

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Utility models (or petit patents)

1. Introduction

Dynamic Perspective of IPR Protection

Earlier stage of Korea's economic development

- Due to the lack of local technological capability before the mid 80s, Korea adopting imitation-oriented strategy was rather passive in patent protection and negligent in patent utilization
- Instead, utility models, second-tier protection for minor inventions, were intensively exploited.

Later stage of Korea's economic development

- As Korea has built up its technological capabilities since the mid 80s, a need to use the IP system to protect and generate patents has increased.

1. Introduction: Previous Literature

- Current academic and policy debates have mostly focused on the effects of strong IPRs, particularly patent protection, on innovation and economic growth.
  - Raising developing country standards to developed country levels
  - Restricting imitation, piracy and infringement in developing country.

- Differential effects on countries at different stages of economic development
  - Eicher and Penalosa (2008), Grossman and Lai (2004), Falvey et al. (2006)

- However, less attention has been given to the effects of intermediate levels or alternative form of IPRs, such as utility models.
  - Anecdotal evidence on utility model such as Kumar (2002), The World Bank (2002), and time-series analysis of utility models' impacts on Japanese TFP (Maskus and McDaniel, 1999)

1. Introduction: Research Agenda

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(1) It empirically analyzes how patent right protection in Korea has affected innovation, addressing the varying role of patent right protection by stage of economic development;

(2) It empirically analyzes how the utility models in Korea have affected innovation/firm growth at the stage of imitation or innovation; and

(3) Both time-series and firm-level panel data of South Korea

2. IPR Protection and Innovation in Korea

2.1. IPR system in Korea: Patent Rights Index of Korea

Appendix: Patent Rights Index (1961-2002)

	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
1) Coverage																					
Patentability of pharmaceuticals																					
Patentability of chemicals																					
Patentability of food																					
Patentability of planet and animal varieties													1	1	1	1	1	1	1	1	1
Patentability of surgical products	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Patentability of microorganisms																					1
Patentability of utility models	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Patentability of software																					
	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.50
2) Membership in international treaties																					
Paris convention and revisions																				1	1
Patent cooperation treaty																					
Protection of new varieties																					
TRIPS																					
Budapest Treaty																					
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.20
3) Loss of protection measures against losses																					
Working requirements																					
Compulsory licensing					0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Revocation of patents																					
	0.00	0.00	0.00	0.00	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
4) Enforcement																					
Preliminary injunctions	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Contributory infringement	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Burden-of-proof reversal	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5) Duration																					
Grant-based standard	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
App-based standard																					
Patent Rights Index	1.96	1.96	1.96	1.96	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.45	2.57

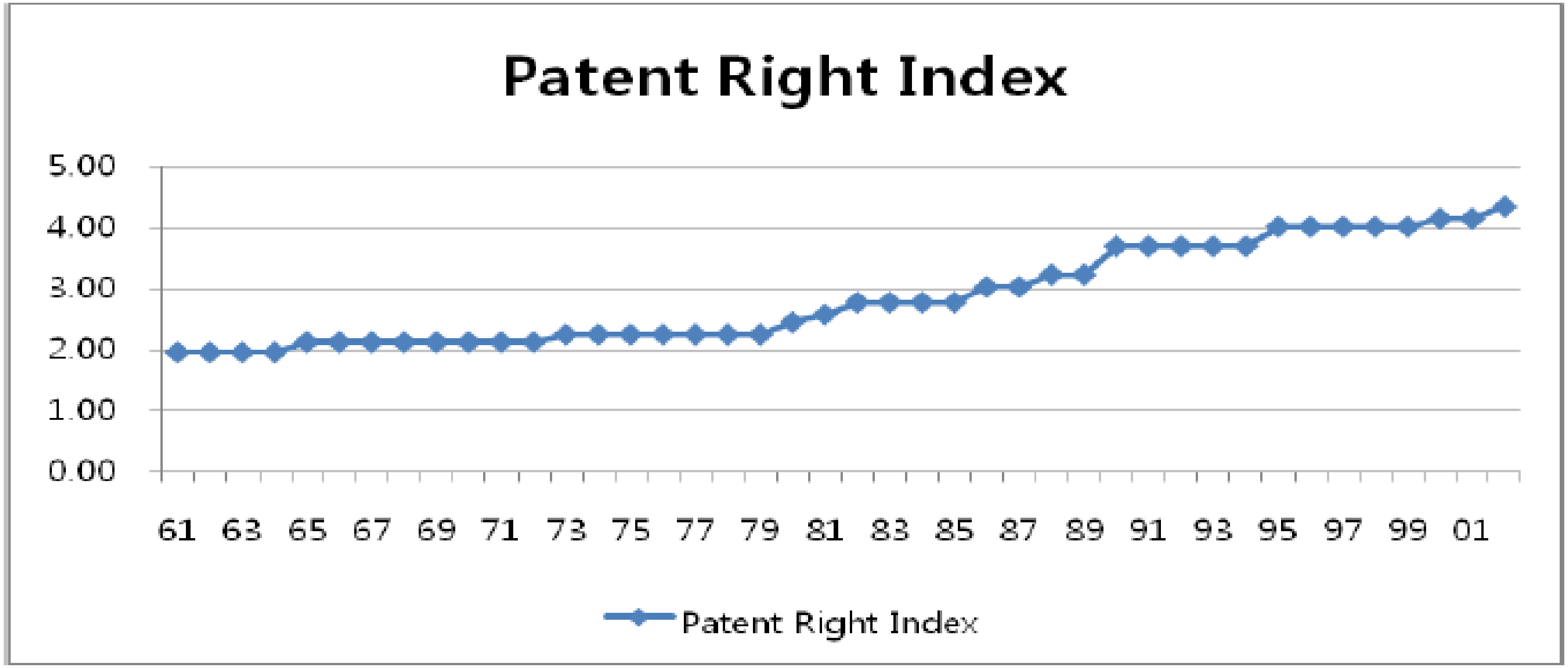
2.1. IPR system in Korea: Patent Rights Index of Korea (Cont'd)

Appendix: Patent Rights Index (1961-2002) (Continued)

	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02
1) Coverage																					
Patentability of pharmaceuticals					1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Patentability of chemicals					1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Patentability of food									1	1	1	1	1	1	1	1	1	1	1	1	1
Patentability of planet and animal varieties	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Patentability of surgical products	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Patentability of microorganisms	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Patentability of utility models	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Patentability of software																			1	1	1
	0.50	0.50	0.50	0.50	0.75	0.75	0.75	0.75	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	1.00	1.00	1.00
2) Membership in international treaties																					
Paris convention and revisions	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Patent cooperation treaty	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Protection of new varieties																					1
TRIPS														1	1	1	1	1	1	1	1
Budapest Treaty							1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	0.40	0.40	0.40	0.40	0.40	0.40	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.80	0.80	0.80	0.80	0.80	0.80	0.80	1.00
3) Loss of protection measures against losses																					
Working requirements									0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Compulsory licensing	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Revocation of patents					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
4) Enforcement																					
Preliminary injunctions	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Contributory infringement	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Burden-of-proof reversal	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5) Duration																					
Grant-based standard	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.88	0.88	0.88	0.88	0.88								
App-based standard														1	1	1	1	1	1	1	1
Patent Rights Index	2.77	2.77	2.77	2.77	3.02	3.02	3.22	3.22	3.69	3.69	3.69	3.69	3.69	4.01	4.01	4.01	4.01	4.01	4.13	4.13	4.33

2.1. IPR system in Korea: Patent Rights Index of Korea

Figure 1: Patent Rights Index in Korea (1961-2002)



Note: Revision of Choi and Lee (2005)

2.1. IPR system in Korea: Evolution of Korean IPR system

Year	Science and technology related facts
1908	The first national laws on the protection of patent, design and trademark promulgated (Japan influence)
1910	Japanese IP law imposed after Japanese occupation
1946	After the liberation, the first modern-type industrial law promulgated (US influence): first-to-invent principle, plant and substance patents, 17-year term of patent protection
1949	Established Patent Bureau as an extended bureau of the Ministry of Commerce and Industry
1961	The first revision to the Patent law, the Utility Model Law, the Design law, and the Unfair Competition Prevention Law, 12-year term of patent protection
1963	Revision of the Trademark Law
1966	Establishment of the Korea Institute of Science and Technology
1967	Establishment of the Bureau of Science and Technology, the Science and Technology Promotion Law enacted
1972	The Technology Development Promotion Act enacted
1973	Korea Patent Association (KPA) established
1974	The treaty on IP rights between Japan and Korea
1977	Established Korea Industrial Property Office(KIPO)
1978	The treaty on IP rights between US and Korea
1979	Joined World Intellectual Property Organization (WIPO)
1980	Joined Paris Convention
1982	Establishment of the Special National R&D Program, R&D to GDP ratio exceeded 1 percent
1984	Joined Patent Cooperation Treaty (PCT), shift of technology import system from approval system to reporting system
1986	The invention of pharmaceuticals, method of producing pharmaceuticals, substance, and substance-use became patentable, 15-year term of patent protection
1987	Samsung vs. Texas Instruments legal case
1992	R&D to GDP ratio exceeded 2 percent
1994	Korea Invention Promotion Association (KIPA) founded under the provision of the Invention Promotion Act
1995	Korea Industrial Property Rights Information Center established. In compliance with TRIPs, the scope of patentable subjects enlarged and the patent term extended to 20 years.
1996	Korea Industrial Property Business Arrangement Center established
1997	Intellectual Property Rights Research Center established
1998	Patent Court opened , Korean Industrial Property Office (KIPO) established an on-line application system called KIPOnet, Introduction of the Quick Registration System (QRS) for utility models, Joined Strasbourg Agreement concerning the IPC and Nice Agreement Concerning the International Classification of Goods and Services for the Purposes of the Registration of Marks
2000	The Technology Transfer Promotion law enacted
2002	Joined Trademark Law Treaty and International Convention for the Protection of New Varieties of Plants
2003	Joined Protocol Relating to the Madrid Agreement Concerning the International Registration of Marks
2004	Joined WIPO Copyright Treaty
2006	QRS abolished and transformed to the after-registration system
2008	KIPO introduced Customer-tailored three-track IP administration

Source: Lee et al. (2003) and Korea Intellectual Property Office (KIPO) website (www.kipo.go.kr/en/)

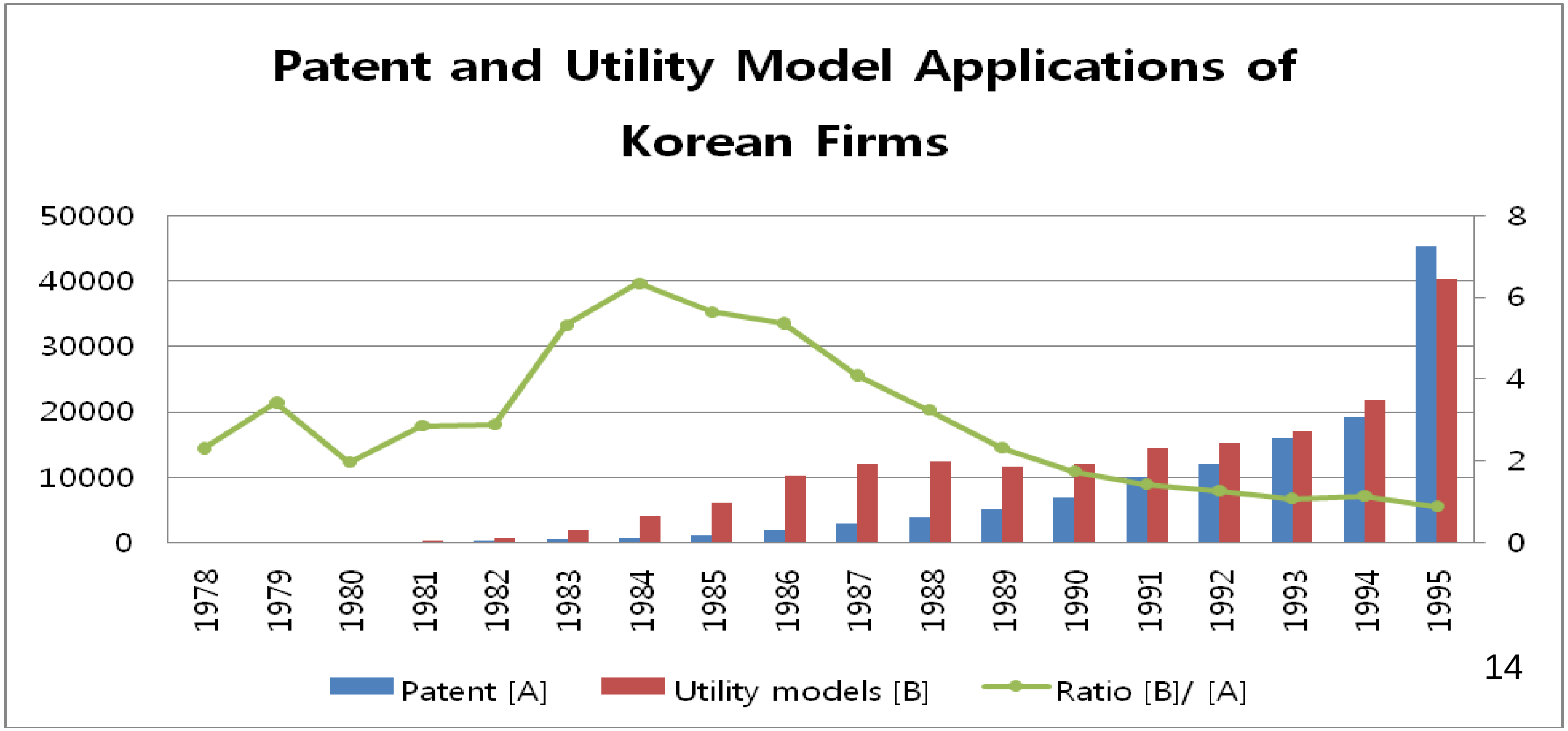
2.2. Utility model system in Korea: Utility models vs. Patents

Utility Models	Patents
Second-tier protection for minor inventions; The inventive step required is small; a practical or functional advantage over existing prior art	Granted for inventions that are novel, non-obvious, and have industrial applicability
Processes or methods of production are typically excluded	Cover products and processes
Typically 6 – 10 years duration of protection	20 years duration from the date of application
Less expensive to apply for and do not require substantive examination	Undergo substantive examination, and are costly to obtain (filing fees, search and examination fees, attorney costs, and translation fees, where applicable)

2.2. Utility model system in Korea:
Utility model and patent applications of Korean firms

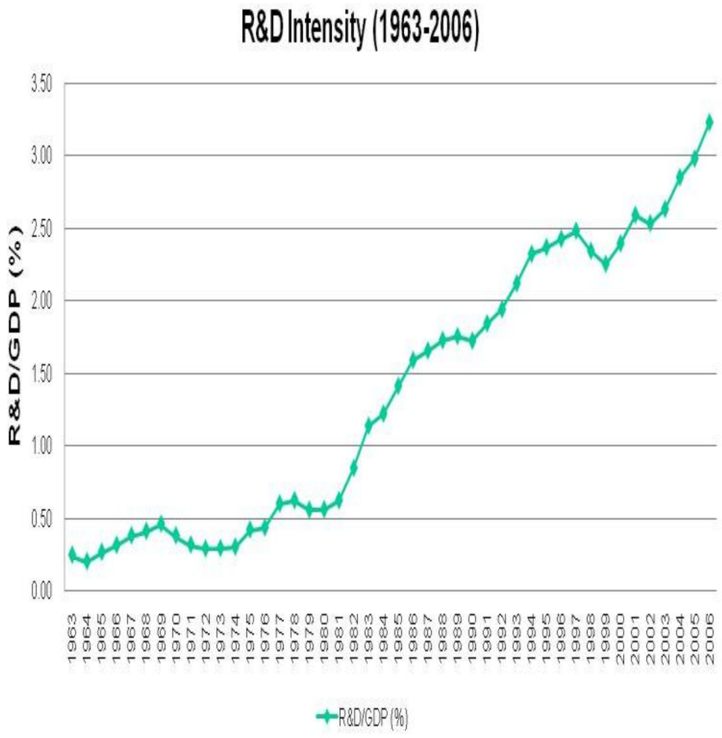
- Due to its limited technological capability before the mid-1980s, it depended heavily on *reverse engineering, imports of equipment and technology, and imitation* in order to fulfill its technological needs (Lee et al. (2003)).

- A much large number of utility models than invention patents during the 1960s and 1970s. Since the mid-80s, the ratio of utility models to patent applications has fallen significantly and both were roughly in parity in 1993.

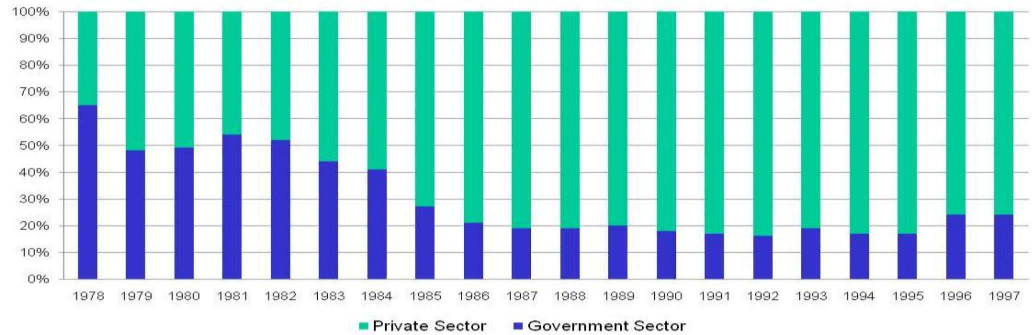


2.3. Growth of Technological Capabilities in Korea: The Mid-80s as a Turning Point for Korea

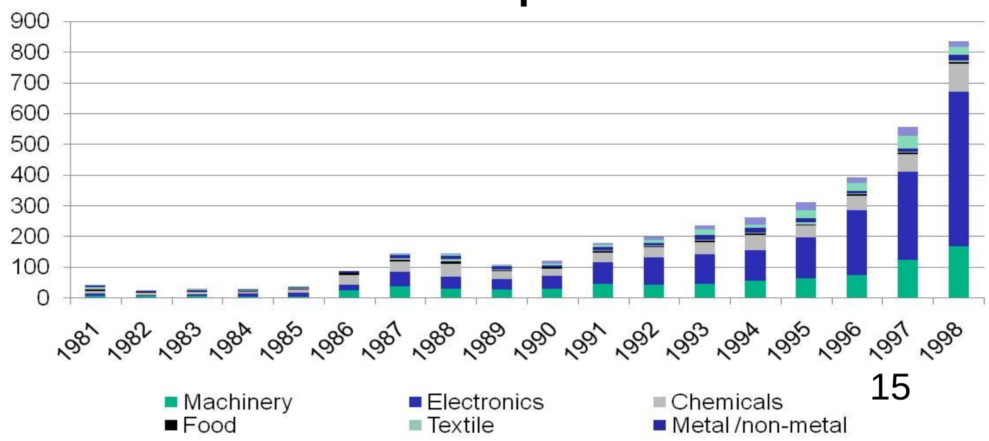
- By the early ‘80s, the share of public R&D ≈ that of private R&D ≈ about 50%.
- The share of private R&D accounted for more than 70% of the total R&D in Korea since the mid-1980s
- The accumulated number of accumulated corporate R&D centers: 3 (1967)→14 (1976) → 261 (1986) → 1162 (1992)



Composition of R&D Expenditure in Korea



Establishment of Corporate R&D Center



3. Hypothesis and Empirical Results

3.1. Patent Protection and Innovation

3.1.1. Time-series Analysis

Hypothesis I: In Korea, patent protection has been positively associated with innovation only after Korea acquired greater technological capabilities

Time Series Model Specification

(1) $$\Delta(\text{log of no. of patent application})_t = \alpha_1 + \alpha_2(\Delta(\text{log of } RD)_t + \alpha_3(\Delta(\text{log of } GDP)_t + \alpha_4 \cdot IPR\ \text{dummy2}_t + \alpha_4 \cdot IPR\ \text{dummy3}_t + \cdots + \alpha_6 \cdot IPR\ \text{dummy6}_t + e_t$$

(2) $$\Delta(\text{log of no. of patent application})_t = \alpha_1' + \alpha_2'(\Delta(\text{log of } RD)_t + \alpha_3'(\Delta(\text{log of } GDP)_t + \alpha_4' \cdot High\ IPR\ Dummy_t + e_t$$

DATA

Yearly data from 1965 to 2001

Source:

Korea Institute of Patent Information and the Bank of Korea

3.1. Patent Protection and Innovation: Time-series Analysis

Table 3: Impacts of Patent Rights Index on the Changes in Patent Applications: Time Series

Dependent Variable: Δ(log of no. of patent application)		
	(1)	(2)
Δ(log of *RD*)	**0.494 (1.93)***	**0.543 (2.26)****
Δ(log of *GDP*)	1.034 (1.13)	0.216 (0.38)
IPR dummy 2 (1973-1979)	-0.093 (-0.89)	
IPR dummy 3 (1980-1985)	0.076 (0.72)	
IPR dummy 4 (1986-1989)	**0.209 (2.51)****	
IPR dummy 5 (1990-1994)	**0.141 (1.78)***	
IPR dummy 6 (1995-2001)	0.241 (1.59)	
High IPR dummy (1986-2001)		**0.132 (2.22)****
Constant	-0.271 (-1.37)	-0.106 (-1.09)
Adjusted R^2	0.184	0.224
F value	2.194	4.562
Observations	36	36

Note: White-Sandwich standard errors are used.

Result:

Positive influence of IPR on the technology changes began to be positively significant since 1986

3.1. Patent Protection and Innovation

3.1.2. Firm Level Analysis

Hypothesis I (Firm-level Panel Analysis)

$$(3)\quad (No.\ of\ patent_{it}) = exp\left(\begin{array}{l} \gamma_0 + \gamma_1 (log\ of\ \text{R \& D}\ expenditure_{it}) + \gamma_2 (\ log\ of\ \text{patent rights index}_{t-1}) \\ +\gamma_3\ firm\ age_{it} + \gamma_4\ firm\ size_{it} + \gamma_5 (\ log\ of\ \text{patent rights index}_{t-1})^{*}\ time\ \text{trend} \\ +\gamma_6\ time\ trend_t + \gamma_7\ industry\ dummies_j \end{array}\right)$$

where i = firm, j = industry, t = period

Knowledge Production Function augmented with IPR index

DATA

Firm-level panel data from 1970 to 1995

***Source*:**

Korea Intellectual Property Rights Information System (KIPRIS),
Lee et al. (2007, 2008)

Estimation Method:
Negative Binomial Model

3.1. Patent Protection and Innovation

3.1.2. Firm Level Analysis

Table 4: Hypothesis I: Relationship between Innovation and IPR

	Dependent Variable: No. of Patent Application by Firms			
	(1) Pooled	(2) Pooled	(3) RE	(4) RE
Log of R&D expenditure$_t$	0.105***	0.105***	0.0815***	0.0830***
	(8.327)	(7.940)	(8.120)	(8.282)
Log of patent rights index$_{t-1}$	-0.29	-8.317*	-1.985	-6.589**
	(-0.0671)	(-1.684)	(-0.642)	(-2.060)
Time* (Log of patent rights index)$_{t-1}$		1.999***		1.305***
		(2.583)		(2.886)
Time	1.246**	-0.407	1.551***	0.329
	(2.061)	(-0.501)	(3.612)	(0.607)
Firm age$_t$	-0.0117**	-0.0124***	-0.0046	-0.00477
	(-2.492)	(-2.602)	(-1.014)	(-1.051)
(Log of employees)$_t$	1.180***	1.189***	0.725***	0.720***
	(21.000)	(21.020)	(16.060)	(16.040)
Constant	-15.06***	-6.724*	-10.54***	-5.081**
	(-7.793)	(-1.767)	(-6.625)	(-2.090)
Industry dummy	Yes	Yes	Yes	Yes
Observations	4516	4516	4516	4516
Log likelihood	-2883.74	-2878.48	-2804.19	-2800.01
Wald chi2	4045.586	3901.3	1452.238	1568.567
Prob>chi2	0.000	0.000	0.000	0.000
Number of firms	2093	2093	2093	2093

Note: All data are five-year averaged. *** $p<0.01$, ** $p<0.05$, * $p<0.1$, t-statistics are in parentheses; 21 industry dummies are included, White-Sandwich standard errors are used for pooled regression

Results:

In (3), patent rights index is found to be negative but insignificant.
In (4), the interaction term with time trend is found to be significantly positive.

Finding I:

Strong conventional patent protection induces more patent generation at a later stage of development only in Korea.

3.2. Utility Model and Innovation/ Firm Performance

- ## 3.2.1. Utility Models leading to Regular Patents

  - Evenson and Westphal(1995): Utility model system is an institutions to protect incremental innovative activities rather than radical innovation
  - Kumar (2002), Suthersanen (2006): imitative innovation protected by utility models can be a stepping stone to building the capability to generate future patent inventions.

Hypothesis II: Experience with producing minor inventions is an important determinant of a firm's technological capability to produce inventive innovations.

$$(4)\quad (No.\ of\ patent_{it}) = exp\begin{pmatrix} \lambda_0 + \lambda_1 (log\ of\ R\&D\ expenditure_{it}) + \lambda_2 (utility\ \mathrm{mod}el_{it-1}) \\ +\lambda_3 (utility\ \mathrm{mod}el_{it-1}) * time\ trend_t + \lambda_4\ firm\ age_{it} + \lambda_5\ firm\ size_i \\ +\lambda_6\ time\ trend_t + \lambda_6\ industry\ dummies_j \end{pmatrix}$$

where $\mathrm{i} = \mathrm{firm},\ \mathrm{j} = \mathrm{industry},\ \mathrm{t} = \mathrm{period}$

3.2. Utility Model and Innovation/ Firm Performance

- **3.2.1. Utility Models leading to Regular Patents**

Table 5: Impact of Utility Models on New Knowledge Generation

	Dependent variable: No. of patent application			
	(1) Pooled	(2) Pooled	(3) RE	(4) RE
(Log of R&D expenditure)$_t$	0.150***	0.150***	0.107***	0.105***
	(11.130)	(10.630)	(11.200)	(10.810)
Firm age	0.00715	0.00697	0.00194	0.00233
	(1.157)	(1.054)	(0.415)	(0.498)
Firm size dummy(50-300 employees)	-0.12	0.201	0.215	0.23
	(-0.859)	(0.840)	(0.884)	(0.943)
Firm size dummy(300- 1,000 employees)	0.624***	1.156***	0.933***	0.966***
	(2.895)	(4.038)	(3.540)	(3.657)
Firm size dummy(more than employees)	2.657***	3.376***	2.207***	2.248***
	(9.963)	(9.770)	(7.938)	(8.043)
Time	0.953***	1.344***	1.214***	1.327***
	(12.680)	(11.950)	(21.670)	(16.780)
(Utility model)$_{t-1}$	1.038***	3.045***	0.461***	1.170***
	(7.971)	(5.323)	(4.916)	(3.365)
(Utility model)$_{t-1}$* time		-0.577***		-0.207**
		(-3.642)		(-2.116)
Constant	-7.809***	-10.19***	-7.775***	-8.332***
	(-11.55)	(-11.26)	(-9.079)	(-9.256)
Observations	8372	8372	8372	8372
Log likelihood	-3835.83	-3097.09	-2948.94	-2946.67
prob>chi2	0.00	0.00	0.00	0.00
Wald chi2	1572.864	4389.655	1613.697	1492.969
Number of firms	2093	2093	2093	2093

Note: All data are five-year averaged. *** p<0.01, ** p<0.05, * p<0.1, t-statistics are in parentheses; 21 industry dummies are included; White-Sandwich standard errors are used for pooled regression.

Finding II:

Utility models have a positive impact on patent generation,
but their impact decreases with the eventual enhancement of technological capabilities

3.2.Utility Model and Innovation/ Firm Performance

3.2.2. The Impact of Utility Model on Firm Performance

- Patents help a firm achieve sufficient returns on its investment through commercialization (Geroski et al, 1993; Geroski and Machin, 1993; Granstrand, 1999)
- Technologically lagged firms are limited in achieving sufficient returns due to inability to prevent other firms from copying the technology, high cost of or limited access to capital or related technology , challenges of putting a product into production in tie and the high cost of marketing, etc. (Lee et al, 2003)

- ***Hypothesis III***
- *Firm growth is positively associated with the minor inventive activity, particularly if a firm is technologically lagging.*

$$(4)\quad (\textit{Sales Growth}_{it}) = \begin{pmatrix} \delta_0 + \delta_1 (\textit{log of R \& D}\ \text{intensity}_{i,t-1}) + \delta_2 (\textit{utility}\ \text{model}_{it}) \\ +\delta_3 (\textit{utility}\ \text{model}_{it}) * \textit{time trend}_t + \delta_4 (\text{log of investment}_{it}) \\ +\delta_5 (\text{log of } \textit{firm age}_{it}) + \delta_6 (\text{log of employees}_{it}) + \delta_7 \textit{time trend}_t \\ +\delta_8\ \textit{industry dummies}_j + \delta_i + \upsilon_{it} \end{pmatrix}$$

where i = firm, j = industry, t = period

3.2.Utility Model and Innovation/ Firm Performance

3.2.2. The Impact of Utility Model on Firm Performance

Table 6: Hypothesis III: Impacts of Utility Models on the Sales Growth of Firms

	Dependent Variable: Five-year average sales growth rate			
	(1) OLS	(2) OLS	(3) Fixed Effect	(4) Fixed Effect
(Log of R&D intensity)$_{t-1}$	0.0718***	0.0719***	0.0345***	0.0356***
	(5.999)	(6.009)	(2.859)	(2.954)
(Log of Investment)$_t$	0.244***	0.244***	0.132***	0.132***
	(8.228)	(8.226)	(3.880)	(3.898)
Utility model	0.0127	0.205	-0.0172	0.478*
	(0.411)	(0.858)	(-0.345)	(1.918)
Utility model * time		-0.0424		-0.114**
		(-0.814)		(-2.028)
(Log of firm age)$_t$	-0.362***	-0.362***	-0.693***	-0.683***
	(-7.660)	(-7.657)	(-3.870)	(-3.822)
(Log of employees)$_t$	0.0787***	0.0782***	0.355***	0.361***
	(5.486)	(5.442)	(6.160)	(6.275)
Time	-0.0108	0.0132	-0.00825	0.0563
	(-0.390)	(0.321)	(-0.151)	(0.893)
Constant	1.275***	1.172***	0.509	0.167
	(6.290)	(4.839)	(1.173)	(0.360)
Observations	1668	1668	1668	1668
R-squared	0.32	0.32	0.215	0.22
F-stat	18	17.5	27.81	24.55
Prob	0.00	0.00	0.00	0.00
Number of firms	1051	1051	1051	1051

Note: All data are five-year averaged. *** $p<0.01$, ** $p<0.05$, * $p<0.1$, t-statistics are in parentheses; 21 industry dummies are included, investment rates are investment ratio to assets, White-Sandwich standard errors are used.

Finding III:

Firms with utility models are associated with better performance during the early stage of economic development, while such impact decreases over time.

4. Concluding Remarks

4. Concluding Remarks

- Given Korea's experience, the design and strength of IPR systems should be tailored to the level of the local technological capabilities of a country to provide appropriate incentives for incremental or adaptive innovation.

- In particular, utility model systems, a second-tier IPR, is the right device for developing countries to encourage incremental innovation, which may be more suitable for local needs and be a stepping stone for further technological progress.

- Only after technological capabilities have reached a certain threshold level would the policy to strengthen patent rights protection to induce more R&D investment become more valid and effective.

- **Thank You**
- **Q&A**

[KDI International Conference on Intellectual Property for Economic Development: Issues and Policy Implications]

Intellectual Property Rights and Innovation in Economic Development in Korea

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KDI Main Conference Hall, Seoul, Korea
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1. Introduction

While the rapid economic growth of Korea has often been associated with the role of the government, another stream of research has focused on the role of upgrading technological capability in the course of economic development (L. Kim 1997). After the 1980s, Korea became one of the world's leading patenting nations. The U.S. patents owned by the Koreans rose from 14 in 1982 to 3,562 in 1999, and the share of the Koreans in U.S. patents rose from 0.01% to 2.32% over the same period (United States Patent and Trademark office (USPTO), 2009). In 1999, Korea ranked seventh in terms of patents granted in the U.S. behind the U.S., Japan, Germany, France, Taiwan, and the U.K. What drove such a rapid upgrade or development of technological capability in Korea? This paper aims to address this issue by investigating the role of industrial property rights. While the World Intellectual Property Organization (WIPO) report by Lee at al. (2003) pursued a similar issue through a survey and qualitative analysis using descriptive data, this paper will conduct an econometric analysis using both time series and firm-level data.

This paper analyzes the role of intellectual property rights (IPRs) from two different perspectives. First, we take a dynamic perspective to analyze the changing role of the IPRs over the course of economic growth. At an earlier stage in economic growth, catch-up economies tend to pursue an imitation-oriented technology strategy and are passive in protecting IP or negligent in utilizing IP as a tool for their catch-up strategy. However, as their technological capabilities grow in later stages, they feel an increasing need to use the IP system as a tool for this strategy. With this in mind, we will use both time series and panel data, and the index of the patent rights to analyze the dynamic role of patent rights in technological development.

Second, we will examine the role of utility models (or petit patents) in the technological development of Korea, as utility models might be important in the early days of its development. Due to the lack of local technological capability before the 1980s, Korea depended heavily on reverse engineering and importing equipment and machinery from foreign countries (Lee et al. 2003). Thus, minor inventions that modify imported products were qualified for utility model protection, not conventional patents. The number of utility model applications was greater than that of the traditional invention patents up until the late 1980s (Lee et al. 2003, Lee and Kim 2010). Korean inventors were very active in filing utility model protection. Thus, the role of utility models as a stepping stone to real innovations over the course of Korea's catch-up process is worthy of being analyzed. Nevertheless, few addressed the role of the utility models in Korea's economic growth and firm performance, with a possible exception of Kim et al. (2009). This study aims to contribute to bringing out the important role of the utility model system in Korea's technological progress by analyzing extensive firm-level data covering 1970 to 1995.

In sum, this paper focuses on two issues. First, it empirically analyzes how IPR protection in Korea has affected innovation, addressing the varying role of IPR protection by stage of economic development. For the analysis, both time series analysis using aggregate data and firm-level panel data from 1970 to 1995 are to be used. Second, it empirically analyzes how the utility models in Korea have affected innovation/firm growth at the stage of imitation or innovation.

2. IPR Protection and Innovation in Korea

Can strong IPR protection generally stimulate more innovations regardless of the stages of economic development? Current academic and policy debates have focused on the effects of strong IPR protection in general, on raising developing country standards to developed country levels, and on restricting imitation, piracy, and infringement in developing countries. However, the possibility that stronger and different types of IPRs could have differential effects on countries at different stages of economic development has been acknowledged in the literature. There are theoretical models that *explicitly* consider the stage of economic development in determining the effect of stronger IPRs. For example, Eicher and Penalosa (2008) develop a theoretical model in which the size of the market must reach a certain minimum level for stronger IPRs to stimulate innovation and economic growth. The idea is that the value of innovation should be sufficiently high to make it economically worthwhile to create and invest in IPR institutions. Alternatively, it is possible for IPR to have a *negative* effect on innovation for a country below critical market size. Grossman and Lai (2004) show that the optimal level of IPR depends on an economy's market size and innovative capacity. The smaller the size of the market and the weaker the innovative capacity is, the lower the optimal strength of IPRs should be. The intuition is that the deadweight losses of IPR are greater if innovative capacity is too weak to compensate. Furthermore, the marginal benefits of stronger IPRs are greater if market size is greater. As developing countries have both smaller markets and lower innovative capacity, the balancing of marginal costs and marginal benefits of IPR occurs at a lower level of IPRs than that in the North. Hence, obliging the South to adopt Northern standards of IPR would entail Southern economies to have a level of intellectual property protection that exceeds their optimal level. Southern innovation can therefore be adversely affected in developing countries if their IPRs are raised above a level suitable for their environment of adaptive, incremental R&D and smaller market size.

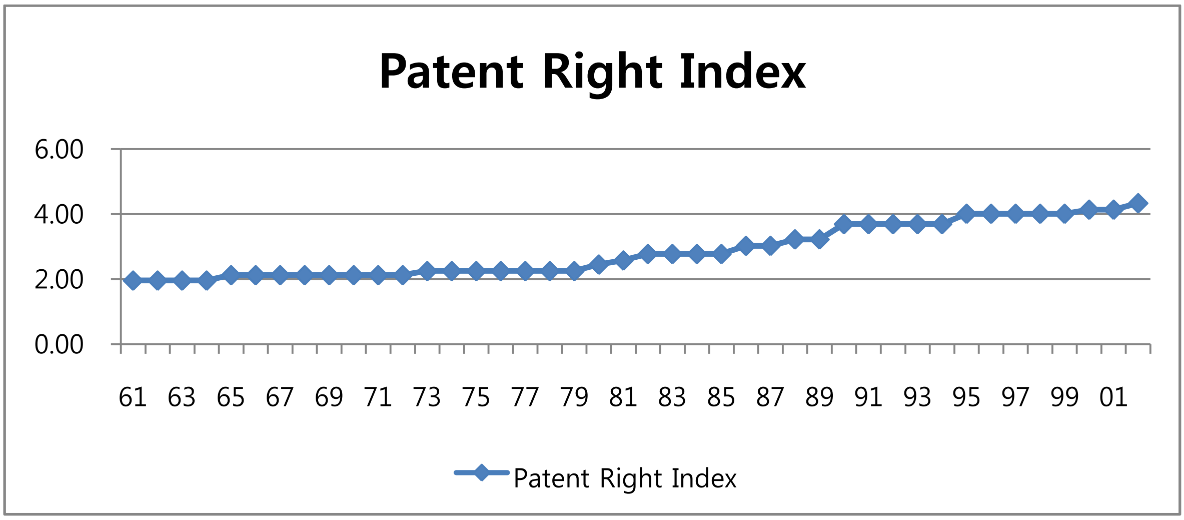
There is empirical evidence on the differential impact of IPR on both economic growth and innovation at different income levels. Falvey et al. (2006) use threshold regression analysis on a panel data of 79 countries from 1975-1995. Controlling for country and time effects, they find that the response of economic growth to IPR varies at different threshold levels of income. Empirical evidence on the effects of utility models on innovation and growth is based largely on anecdotal evidence. Kumar (2002) argues that in East Asia, utility models help initiate a culture of patenting and innovation, and that in contrast, India does not provide utility model protection. Kumar (2002) also suggests that this may have adversely affected local engineering industries. The World Bank (2002) documents case studies in the farm machinery sector in Brazil and the rice sector in the Philippines where utility models allow domestic producers to adapt foreign innovations to local needs and conditions. Econometric evidence is provided in Maskus and McDaniel (1999), which finds that such protection on balance has positive impacts on the growth of Japanese total factor productivity. Some development economists have paid closer attention to the role of utility models.

In sum, our study extends previous empirical studies in the following ways: (1) we examine both patents right protection and utility models as potential determinants of innovation and economic growth; (2) we control for the technological capabilities or economic development stage of Korea; and (3) we utilize both time-series data and firm-level panel data in analyzing the impact of patent protection. Previous econometric work has largely treated the country as the unit of analysis. We begin with a time-series analysis and then examine the experience of Korean firms to illustrate how patent protection and utility models affect firm growth or innovation at different phases of technological development.

2.1.IPR System in Korea

While Lee et al. (2003) elaborate on the institutional changes regarding the IPR regimes in Korea, the study did not try to measure the level of the IPR protection. This paper creates patent rights index of Korea by adopting the methodology of Ginarte and Park (1997). For this purpose, we thoroughly reviewed the Korean Patent Laws. The patent rights index was originally constructed by Ginarte and Park (1997) for 110 countries quinquennially from 1960 to 1990 based on each country's national patent laws and was recently revised (Park, 2008). Five categories of the patent laws were examined: (1) extent of coverage, (2) membership in international patent agreements, (3) provisions for loss of protection, (4) enforcement mechanisms, and (5) duration of protection. A value ranging from 0 to 1 is scored for each of these categories (per country, per period). The unweighted sum of these five values constitutes the overall value of the patent rights index. The index, therefore, ranges in value from 0 to 5. Higher values of the index indicate stronger levels of protection. Except for the duration category (explained in the following section), each category consists of several *conditions* which, if satisfied, indicate a strong level of protection in that category. Each condition is of a binary character; yes if it is satisfied or no if it is not. For example, if a country satisfies all three conditions required for strong enforcement, it scores 3 out of 3 and earns a value of 1 for enforcement; if it satisfies only one condition, it receives a score of 1/3 for enforcement. This way, our research team created a patent rights series shown in Figure 1. Further details are presented in the Appendix

Figure 1: Patent Rights Index in Korea (1961-2002)



Note: Revision of Choi and Lee (2005)

Figure 1 shows the major changes in Korea's IP system. As Korea's IP system was initially established in the early 1960s by adopting the first-to-file (apply) rule and a 12-year term of protection and compulsory licensing, it substantially changed in the 1980s by joining international patent treaties, which is presented as major jumps in Figure 1. For example, Korea became a member of the WIPO in 1979 and acceded both to the Paris Convention in 1980 and to the Patent Cooperation Treaty in 1984.

Consistent with international standards, the laws extended the patent protection term from 12 to 15 years. Nevertheless, the IPR system in Korea was relatively weak compared with other advanced countries until the early 1980s. The average patent rights index of high-income countries in 1985 was 2.89, which is higher than 2.77 in 1985. However, the revision of the patent law in 1986 and 1987 introduced the substance patent for pharmaceutical and chemical materials and product patent protection, and for computer software and materials, respectively. The term of patent right protection was extended from 12 to 15 years. Subsequent revisions of the IPR system in 1990, 1993, and 1995 included the patentability of plant patent (1990 revision), the World Trade Organization/Trade-related Aspects of Intellectual Property Rights (WTO/TRIPS)-related revision effective January 1995, which extended the term of patents to 20 years, and the IP Tribunal established in 1998 (1995 revision). This pattern was reversed in the 1990s. In 1990, the average patent rights index of high-income countries was 3.08, whereas that of Korea was 3.69. Thus, 1986 marks an important period in Korean patent law history (see Lee and Kim 2010).

2.2.Utility Model System in Korea

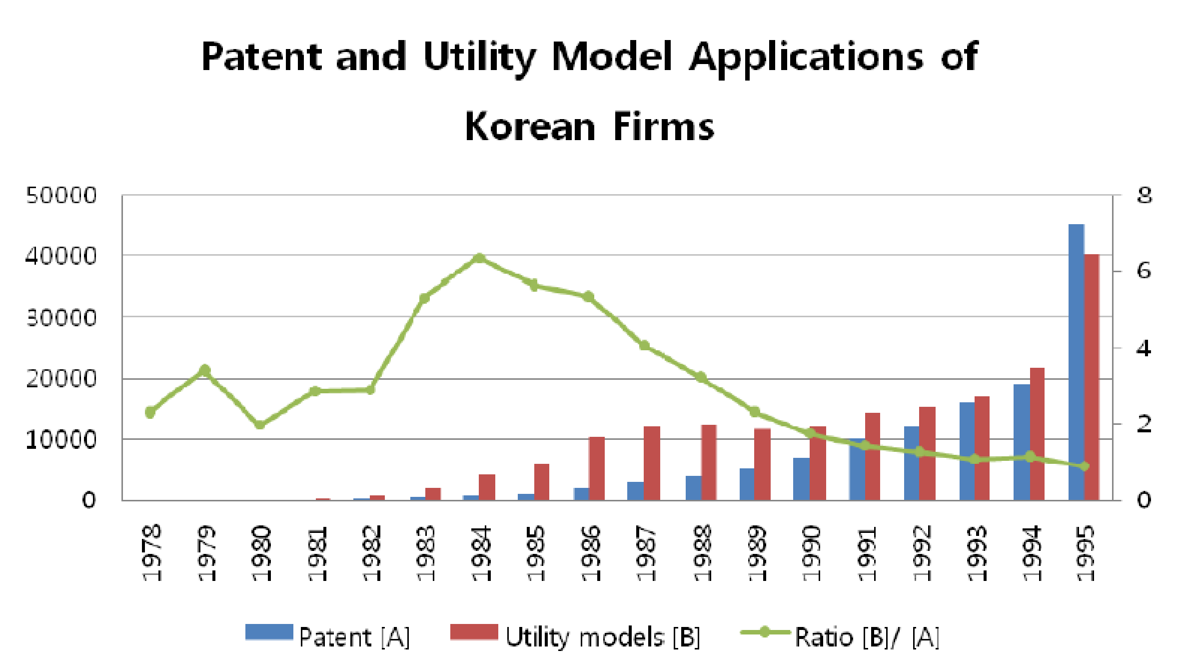
Utility models are second-tier protection for minor inventions, such as devices, tools, and implements, particularly in the mechanical, optical, and electronic fields. Processes or methods of production are typically excluded (Kim et al. 2009). The duration of protection is typically 6 to 10 years, and technical details must be disclosed. Utility models are generally less expensive to apply for and do not require substantive examination. While the inventive step required is small, the invention typically must exhibit a practical or functional advantage over existing prior art (Beneito, 2006). For example, utility models are granted to devices embodying a creative idea applicable to the shape, structure, or other technological aspects of a product. In sum, utility models and patents differ in that they protect different types of innovations. In other words, patents protect innovations with relatively high inventiveness, while utility models protect innovations with relatively low inventiveness. Thus, utility model protection is easier to acquire, particularly for smaller inventors. The standard of inventiveness can vary within and between countries.

Korea is among the developing countries where utility models have been intensively exploited. As the technological capabilities of Korean firms lagged during the 1960s and 1970s, and as firms did not possess the resources to conduct highly innovative R&D, firms relied heavily on imported technologies and on reverse engineering, adapting them for local needs (L. Kim, 1997, Lee et al. 2003). In Korea, the strength of utility model protection has changed; for example, the duration of protection has changed from 12 years to 15 years, and then to 10 years from the date of application since 1998. Furthermore, Korea does not allow for the renewal of utility model protection, whereas Thailand does for up to four years (i.e., two renewals for a period of two years each).

The law of utility models of Korea was enacted in 1961 and has been revised several times. Initially, utility models were subject to substantive examination, and converted application was allowed. However, to facilitate the application process for utility models, Korea Intellectual Property Office (KIPO) adopted its "Quick Registration System (QRS)" in 1999. Under this system, utility models could be registered promptly after filling out a check-on form and submitting the basic requirements, but it did not conduct substantive examination. Substantive examinations were made only if there was an infringement in utility model rights. This system was adopted because protection was required earlier than for utility models owing to the shorter life cycle of products that incorporated them. Under this system, dual application instead of converted application was adopted. However, this QRS was abandoned in 2006 due to the surge in unqualified utility models. Consequently, the substantive examination was reintroduced. Again, the converted application was reintroduced. For filings after July 1, 1999 in Korea, the term of protection was 10 years from the date of filing for utility models, which is shorter than 20 years for patents.

Due to the lagging technological capabilities of Korea in its early developmental stage, the number of utility model applications exceeded that of the traditional invention patents until the early 1990s (see Figure 1). In the 1970s and the early 1980s, the ratio of utility models to patents was nearly two to three. This ratio began to decline after 1984 when the ratio peaked to over six that year. Although the levels of patents and utility models application were both rising, the mixture began to shift. By 1995, patent applications exceeded the number of utility model applications. These trends correspond with the transformation of Korea from a nation with limited technological resources and capabilities to one of the leading patenting nations.

Figure 2: Patent and Utility Model Applications of Korean Firms



Source: data are compiled by the authors using KIPRIS data downloadable from KIPRIS (Korean Intellectual Property Rights Information Service) website

3. Growth of Technological Capabilities in Korea

The mid 1980s was a turning point for Korea. It divided the period of Korea's economic development into the two eras. Before the mid 1980s, Korea was relatively resource-poor and technologically lagging behind, whereas beginning the mid 1980s, Korea's indigenous R&D capabilities began to grow markedly and began to be technologically advanced. As evidence, we take large increases of both in-house R&D activities of private sectors and corporate R&D centers in Korea in the mid 1980s that account for this division.

Korea has built up its technological capabilities since the mid 1980s by emphasizing in-house R&D in private sectors and increasing aggregate R&D/GDP ratio beyond 1% to reach 2.5% or higher eventually. Along the path of development, latecomer firms eventually reached the stage wherein in-house R&D was the main form of technology acquisition. In the case of Korea, the motivations for transition from licensed technology to in-house R&D were three-fold (Organisation for Economic Co-operation and Development [OECD] 1996, pp.91-92). First, foreign firms became more reluctant to provide core technology. Second, after the early 1980s, Korea lost its comparative advantages associated with cheap and skilled labor. As a result, Korean firms recognized the need to develop their own technological capabilities. Third, government policy also changed to support private R&D. For example, the Korean government enacted the Technology Development Promotion Act in 1972. The share of R&D in sales in private firms was around 0.5% in 1982, and it soon reached 1% by the mid-1980s and surpassed 2% by the early 1990s (OECD, 1996). While incomparable to the public R&D in the 1970s, the size of R&D soon matched the size of public R&D by the mid-1980s, and it accounted for more than 80% of the total R&D in Korea since the early 1990s, as shown in Table 1.

Table 1: Composition of R&D Expenditure in Korea

Year	Total		Government Sector			Non-government/Private Sector		
	Amount	Percent change	Amount	Percent change	Share (%)	Amount	Percent change	Share (%)
1978	1,836		1,056		57.52	780		42.48
1979	2,986	62.6	2,194	107.8	73.48	792	1.5	26.52
1980	2,825	-5.4	1,800	-18.0	63.72	1,025	29.4	36.28
1981	3,668	29.8	2,016	12.0	54.96	1,652	61.2	45.04
1982	5,331	45.3	2,643	31.1	49.58	2,688	62.7	50.42
1983	6,822	28.0	2,312	-12.5	33.89	4,510	67.8	66.11
1984	9,072	33.0	2,515	8.8	27.72	6,557	45.4	72.28
1985	12,371	36.4	3,068	22.0	24.8	9,303	41.9	75.2
1986	16,069	29.9	3,743	22.0	23.29	12,326	32.5	76.71
1987	19,852	23.5	4,902	31.0	24.69	14,950	21.3	75.31
1988	24,542	23.6	5,230	6.7	21.31	19,312	29.2	78.69
1989	28,173	14.8	5,750	9.9	20.41	22,423	16.1	79.59
1990	33,499	18.9	6,510	13.2	19.43	26,989	20.4	80.57
1991	41,584	24.1	8,158	25.3	19.62	33,426	23.9	80.38
1992	49,890	20.0	8,785	7.7	17.61	41,105	23.0	82.39
1993	61,530	23.3	10,390	18.3	16.89	51,140	24.4	83.11
1994	78,947	28.3	12,602	21.3	15.96	66,345	29.7	84.04
1995	94,406	19.6	17,809	41.3	18.86	76,597	15.5	81.14
1996	108,780	15.2	24,113	35.4	22.17	84,667	10.5	77.83
1997	121,858	12.0	28,625	18.7	23.49	93,233	10.1	76.51

Source: Science and Technology Annual 1999 available at the Korea Industrial Technology Association Web page (www.koita.or.kr) Unit 100Million Korean Won, Foreign sector is not included.

The number of corporate R&D centers in Korea also began to increase substantially after the mid-1980s. Since large Korean firms opened R&D laboratories in major industries in the late 1960s (Amsden, 1989), the number of corporate centers rose from three in 1967, to 14 in 1976 (Amsden, 1989). As shown in Table 2, there were 45 such centers in 1981. By 1986, a mere five years later, the number increased more than fivefold. In particular, in 1986, the percentage change of the establishing research institutes abruptly increased by more than 100%, and the number of corporate R&D centers was more than 200 in 1986. It amounted to more than 500 in 1988 and finally to 1,000 in 1991, as shown in Table 2. The rise in the number of corporate R&D centers indicates that more Korean firms were able to fund their own internal R&D activities. The primary purpose of such laboratories originally lay in facilitating the transfer of designs and production processes from overseas. However, their roles later began to be more focused on the development of new products (Amsden, 1989).

Table 2: The Establishment of Corporate R&D Centers by Year and Field

Year	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**
New establishment	45	26	31	31	39	89	145	146	110	121
Accumulated No.	45	71	102	133	172	261	406	552	662	783
Year	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**Total (as of 1998)**	
New establishment	179	200	238	263	313	394	556	834	3,760	
Accumulated No.	962	1162	1400	1663	1976	2370	2926	3760		

Source: Korea Industrial Technology Association available at www.koita.or.kr

Overall, Korea' indigenous R&D capabilities began to grow markedly since the mid-1980s; the growth rate of utility model filings began to decline, and the number of patent applications began to rise. In addition, patent protection began to be relatively strong with major reforms in patent law since the mid-1980s. Thus, the question is whether all these events are connected: did patent protection or utility model protection provide incentives to innovate and help pave the way for increased technological development?

4. **Hypothesis and Empirical Results**

4.1.**Patent Protection and Innovations**

Based on the previous discussion, we set up a hypothesis to examine how IPR protection affected innovation differently across the stages of economic development in Korea. As a developing country with lower innovative capacity, a relatively lower level of IPR protection might have been more suitable for incremental or adaptive innovations, as it permitted Korea to imitate the technologies of advanced countries and could have led to its eventual rapid progress in technological capabilities. However, once Korea's technological capacity grew further, Korea would need to establish a stronger IP system to protect its innovations. This hypothesis will be tested in both time series analysis and firm-level panel analysis.

Hypothesis I:

In Korea, patent protection has been positively associated with innovation only after Korea acquired greater technological capabilities.

For Hypothesis I to test the linkage between IPR and innovation, both time series analysis and panel data analysis are conducted. The dynamic effect of IPR can be captured by time-series data, but we reinforce our analysis with firm-level panel analysis, which has many advantages over time-series analysis. First, panel data can control for individual heterogeneity. Second, panel data with a large number of data points improves the efficiency of econometric estimates by increasing the degrees of freedom and reducing the collinearity among explanatory variables (see Hsiao, 2003).

4.1.1. Time Series Analysis

For the time series analysis, yearly data from 1965 to 2001 were used. Data were acquired from the Korea Institute of Patent Information and the Bank of Korea. The variables were first-differenced to resolve the non-stationary problem. The dependent variable is the growth rate of the total number of patents in Korea ($\Delta(\log \text{ of no. of patent application})$). The main explanatory variable, patent rights index, is the revision of Choi and Lee (2005), which reconstructed the patent rights index of Ginarte and Park (1997) as the annual time series data for Korea. Choi and Lee (2005) was revised following Park (2008)[1]. To control for other factors that could influence the growth of patent applications, we included two control variables such as R&D expenditure ($\Delta(\log \text{ of } RD)$) and GDP ($\Delta(\log \text{ of } GDP)$). The former is the input of innovation, while the latter is to control for the high propensity of generating innovations as an economy becomes more advanced and knowledge based. To estimate the effect of patent rights protection, which can differ period by period, we examined the regression using IPR dummy variables. Model (1) uses dummy variables dividing the entire 36 years into six sub-periods in which the level of patent rights protection remains constant throughout a sub-period. Model (2) uses a high-IPR dummy that divides the entire period into

[1] The main revision involved adding new categories such as patentability of software, TRIPS, and Budapest Treaty.

two high/low patent rights protection periods. The threshold year is 1986, which is when Korea's technological capacity began to rise. The models are specified as follows.

Time Series Model Specification

$$
\begin{aligned}
\text{(1)}\ \Delta(\log\ \text{of no. of patent application})_t = {} & \alpha_1 + \alpha_2(\Delta(\log\ \text{of}\ RD)_t + \alpha_3(\Delta(\log\ \text{of}\ GDP)_t \\
& + \alpha_4 \cdot IPR\ \text{dummy}2_t + \alpha_4 \cdot IPR\ \text{dummy}3_t \\
& + \cdots + \alpha_6 \cdot IPR\ \text{dummy}6_t + e_t
\end{aligned}
$$

$$
\begin{aligned}
\text{(2)}\ \Delta(\log\ \text{of no. of patent application})_t = {} & \alpha_1^{'} + \alpha_2^{'}(\Delta(\log\ \text{of}\ RD)_t + \alpha_3^{'}(\Delta(\log\ \text{of}\ GDP)_t \\
& + \alpha_4^{'} \cdot High\ IPR\ Dummy_t + e_t
\end{aligned}
$$

Model (1) and (2) aims to test whether the impact of patent rights index on the growth of patent application differs by periods.

The regression results in Table 3 show that the influence of IPR dummy is insignificant during the early stage of development, while the positive influence of IPR on the technology changes began to be significant since 1986 in model (1). However, the IPR dummy 6 is found to be insignificant, which may suggest that too strong protection would reinforce the patent holder's monopoly and discourage potential innovators to enter. Nevertheless, overall, strong patent protection is found to be positively associated with innovations after Korea began to engage in in-house R&D activities since 1986. Model (2) supports this hypothesis. It uses a single IPR dummy variable to compare its impact before and after 1986 (IPR dummy for 1965 to 1986 = 0, IPR dummy for 1986 to 2001 = 1). The dummy variable has a positive and significant coefficient, indicating that patent rights protection began to be a critical key determinant of innovations only after 1986 when Korea began to engage in R&D activities. These results suggest that the policy to strengthen patent protection is more appropriate for countries that have acquired a certain level of technological capabilities than those whose technologies are at low levels. Thus, the phase of technological development needs to be considered in designing patent protection policy.

Table 3: Impacts of Patent Rights Index on the Changes in Patent Applications: Time Series

Dependent Variable: Δ(log of no. of patent application)		
	(1)	(2)
$\Delta(\log \text{ of } RD)$	**0.494 (1.93)***	**0.543 (2.26)****
$\Delta(\log \text{ of } GDP)$	1.034 (1.13)	0.216 (0.38)
IPR dummy 2 (1973-1979)	-0.093 (-0.89)	
IPR dummy 3 (1980-1985)	0.076 (0.72)	
IPR dummy 4 (1986-1989)	**0.209 (2.51)****	
IPR dummy 5 (1990-1994)	**0.141 (1.78)***	
IPR dummy 6 (1995-2001)	0.241 (1.59)	
High IPR dummy (1986-2001)		**0.132 (2.22)****
Constant	-0.271 (-1.37)	-0.106 (-1.09)
Adjusted R^2	0.184	0.224
F value	2.194	4.562
Observations	36	36

Note: White-Sandwich standard errors are used.

4.1.2. Firm-level Panel Analysis

While we analyzed Korea as the unit of analysis in the previous section, the dynamic perspective of IPR on innovations can also be analyzed by firm-level panel data. Firm-level panel analysis can provide a better understanding at the micro-level on how Korean firms changed their innovative activities under the different patent protection regimes. Firm level data of Korea cover the period of 1970-1995. This specific period in the course of Korea's economic development should suffice for our analysis as it covers the transition of Korea from a low or middle-income country to a high-income, industrialized country.

We compiled a detailed database of firm-level patenting (also utility model data for the further analysis) and matched that data to standard financial data of the firms. Patent application and utility model data were downloaded from the *Korea Intellectual Property Rights Information System* (KIPRIS), and standard financial data were from Lee et al. (2007, 2008)[2]. These data are the most extensive firm level data in Korea. From a population of 17,165 firms in the dataset, we identified 3,635 firms. The selection criterion was that a firm should have applied for at least one utility model or patent. We limited the analysis to this

[2] Lee et al. (2007, 2008) constructed their data mainly from the firm-level database of the *Korea Information Service* (KIS) as well as other sources.

subset of the data, as our goal was to understand the impacts of utility models on firm performance as well as the direct impact of utility models and patent protection on patenting.

To test the impact of patent right protection on innovations, knowledge production function (e.g., Pakes and Griliches 1980, Hausman, Hall, and Griliches 1984) was augmented by adding the relevant interested variable of patent rights index. In other words, this examined the impact of our interested variable, patent rights index, after controlling for the input of R&D expenditure. We used contemporaneous R&D following the extensive literature (e.g., Hall et al 1986). Evidence suggests that R&D activities and innovations occur somewhat simultaneously. Moreover, if a firm attempts to patent an innovation, it files the application while the innovation is being developed or very shortly afterwards (Hall et al., 1986). The one-period lagged patent rights index was used to control for potential endogeneity between IPR protection and innovation. In this specification, we used a negative binomial model as the number of patents applied by a firm in a particular year was a nonnegative count variable with a large portion of zeros.

To control business fluctuation, all variables were five-year averaged. For other control variables, firm size helps control for economies of scale in generating patents due to the fixed costs of maintaining a legal department that handles intellectual property matters (Lerner, 1995 and Lanjouw and Lerner, 1996). Firm age helps control for efficiencies due to entrepreneurs learning their abilities over time (Jovanovic, 1982; Evans, 1987). Further, other control variables include time trend and industry dummy variables. Time trend controls the general economic conditions and market environments that can change over time. Further, firms may vary in their propensities to introduce innovations by industries with different technology regimes. The model specification is as follows.

Hypothesis I (Firm-level Panel Analysis)

$$(3)\quad \left(No.\ of\ patent_{it}\right) = exp\begin{pmatrix} \gamma_0 + \gamma_1\left(log\ of\ R\&D\ expenditure_{it}\right) + \gamma_2\left(\ log\ of\ \text{patent rights index}_{t-1}\right) \\ +\gamma_3\ firm\ age_{it} + \gamma_4\ firm\ size_{it} + \gamma_5\left(\ log\ of\ \text{patent rights index}_{t-1}\right) * time\ \text{trend} \\ +\gamma_6\ time\ trend_t + \gamma_7\ industry\ dummies_j \end{pmatrix}$$

where i = firm, j = industry, t = period

Table 4 presents the firm-level results of Hypothesis I regarding the impact of patent rights index on knowledge generation. Both pooled negative binomial and random effect negative binomial methods are adopted. However, the firm-specific random effect negative binomial model is preferable given that the likelihood ratio test, which compares the panel estimator with the pooled estimator, is statistically significant ($\overline{\chi^2}$(01)=1093.09, p-value=0.00 for model (3) and $\overline{\chi^2}$(01)=1091.78, p-value=0.00 for model (4). Thus, the interpretation is based on model (3) and (4). In (3), R&D expenditure is found to be positively significant, whereas patent rights index is found to be negative but insignificant. Overall, this indicates that strong patent rights protection does not spur innovations, but rather higher R&D input increases the probability of patent generations.

However, the impact of patent rights protection on patent generation could differ as technological capabilities grow. To capture how the impact of patent rights protection changes, an interactive term of patent rights index with time trend is included. The result of model (4) with the interaction term with time trend supports Hypothesis I, as it finds the interaction term to be significantly positive even after controlling for R&D expenditure. This supports the proposition that strong IPR is positively associated with patent only after firms are technologically advanced. We note that larger firms (by size of employment) tend to produce more patentable innovations, which is a feature of Schumpeterian-type models, while the age of a firm has an insignificant and negative association with patent generation.

Table 4: Hypothesis I: Relationship between Innovation and IPR

Dependent Variable: No. of Patent Application by Firms				
	(1) Pooled	(2) Pooled	(3) RE	(4) RE
Log of R&D expenditure$_t$	0.105***	0.105***	0.0815***	0.0830***
	(8.327)	(7.940)	(8.120)	(8.282)
Log of patent rights index$_{t-1}$	-0.29	-8.317*	-1.985	-6.589**
	(-0.0671)	(-1.684)	(-0.642)	(-2.060)
Time* (Log of patent rights index)$_{t-1}$		1.999***		1.305***
		(2.583)		(2.886)
Time	1.246**	-0.407	1.551***	0.329
	(2.061)	(-0.501)	(3.612)	(0.607)
Firm age$_t$	-0.0117**	-0.0124***	-0.0046	-0.00477
	(-2.492)	(-2.602)	(-1.014)	(-1.051)
(Log of employees)$_t$	1.180***	1.189***	0.725***	0.720***
	(21.000)	(21.020)	(16.060)	(16.040)
Constant	-15.06***	-6.724*	-10.54***	-5.081**
	(-7.793)	(-1.767)	(-6.625)	(-2.090)
Industry dummy	Yes	Yes	Yes	Yes
Observations	4516	4516	4516	4516
Log likelihood	-2883.74	-2878.48	-2804.19	-2800.01
Wald chi2	4045.586	3901.3	1452.238	1568.567
Prob>chi2	0.000	0.000	0.000	0.000
Number of firms	2093	2093	2093	2093

Note: All data are five-year averaged. *** p<0.01, ** p<0.05, * p<0.1, t-statistics are in parentheses; 21 industry dummies are included, White-Sandwich standard errors are used for pooled regression

4.2. **Utility Models and Innovations/Firm Performance**

As verified in the previous section, a strong patent rights index was not a determinant in spurring patent applications when Korean technologically lagged behind. Rather, weak patent protection could have encouraged Korean firms to acquire foreign advanced technologies. Indeed, some scholars (e.g., Hanson, 2008) pointed out that the Korean government tried "to minimize patent rights protection to help domestic firms use foreign intellectual property during its manufacturing 'imitation' stage, and laws and regulations were formulated in such a way to meet minimal international standards." However, it is hard to believe that rapid accumulation of technological capability could have been automatically achieved with minimal patent protection only. For example, in contrast with Korea, India's weak patent protection did not spur much economic or technological growth. Thus, it seems unreasonable to attribute Korea's rapid success totally to its weak patent rights protection.

Instead, this paper focuses on a second-tier form of intellectual property protection, that is, utility models as a useful stimulus to a developing country's technological capacity. Rather than a traditional patent, the innovations they produce may merit a second-tier IPR. Thus, the institutions to protect incremental innovative activities rather than radical innovation would be more effective in encouraging their activities and hence economic growth. The utility model system is potentially considered such an institution (Evenson and Westphal, 1995). Kumar (2002) suggests that in Korea's unprecedented rapid catch-up experience, imitative innovation protected by utility models can be a stepping stone to building the capability to generate future patentable inventions. Through adaptation, imitation, and incremental innovation, firms in developing countries acquire knowledge and enjoy learning-by-doing (Suthersanen, 2006). While Korea's patent rights protection deserves credit for innovations at the later stage of technological development, it was the availability of utility models that gave incentives to small inventors with fewer resources or limited technological capabilities. This enabled them to acquire and accumulate knowledge by learning-by-doing and provided them a stepping stone for further technological progress.

4.2.1. **Utility Models Leading to Regular Patents**

Thus, we aim to test whether a utility model system can eventually stimulate regular inventions. This hypothesis is in contrast with the view that underplays the value of technological imitation. Rather, imitation and diffusion of technologies must be seen as a continuation of the innovative process (Silverberg, 1990, p.179). Therefore, to some extent, creativity is needed to copy technologies developed abroad. Cimoli and Dosi (1995, pp.258-259) point out that the sequences that run from copy to creativity are two sides of the same process. Thus, we test the hypothesis that experiences with producing minor inventions (i.e., utility models) are an important determinant of a firm's technological capacity to produce inventive innovations (i.e., patents). This proposition concerning the learning effect of utility models is tested using Equation (4).

Hypothesis II:

Experience with producing minor inventions is an important determinant of a firm's technological capability to produce inventive innovations.

$$(4)\quad \left(No.\ of\ \ patent_{it}\right)=exp\begin{pmatrix}\lambda_0+\lambda_1\left(log\ \ of\ \ R\&D\ expenditure_{it}\right)+\lambda_2\left(utility\ \mathrm{mod}\,el_{it-1}\right)\\ +\lambda_3\left(utility\ \mathrm{mod}\,el_{it-1}\right)*time\ trend_t+\lambda_4\ firm\ age_{it}+\lambda_5\ firm\ size_i\\ +\lambda_6\ \ time\ trend_t+\lambda_6\ \ industry\ dummies_j\end{pmatrix}$$

where $\mathrm{i=firm,\ \ j=industry,\ \ t=period}$

The model for Hypothesis II includes utility model and R&D expenditure to measure the amount of available knowledge within the firm. The key variable is the utility model, which has a binary value. It is equal to 1 if the firm is applied for more than one utility model in a particular year; otherwise, it is 0. Thus, the utility model variable may have a variation between 0 and 1 within a firm depending on the year. To test whether knowledge acquired through past utility models provides a stepping stone for further technological progress, we include lagged utility models (i.e., one period is equivalent to a five-year lag) in the model. The logic behind learning-by-doing is that in generating minor improved inventions, firms acquire knowledge by gaining access to or learning from existing advanced technologies. However, accumulating knowledge that allows firms to generate future new patentable inventions is an incremental process and therefore takes some time. For this reason, we modeled and examined relatively long lag lengths (e.g., five years, i.e., a one period lag means taking values from five years before). As for the control variables, firm size helps control for economies of scale in generating due to the fixed costs of maintaining a legal department that handles intellectual property matters (Lerner, 1995, Lanjouw and Lerner, 1996).

Table 5: Impact of Utility Models on New Knowledge Generation

	Dependent variable: No. of patent application			
	(1) Pooled	(2) Pooled	(3) RE	(4) RE
(Log of R&D expenditure)$_t$	0.150***	0.150***	0.107***	0.105***
	(11.130)	(10.630)	(11.200)	(10.810)
Firm age	0.00715	0.00697	0.00194	0.00233
	(1.157)	(1.054)	(0.415)	(0.498)
Firm size dummy(50-300 employees)	-0.12	0.201	0.215	0.23
	(-0.859)	(0.840)	(0.884)	(0.943)
Firm size dummy(300- 1,000 employees)	0.624***	1.156***	0.933***	0.966***
	(2.895)	(4.038)	(3.540)	(3.657)
Firm size dummy(more than employees)	2.657***	3.376***	2.207***	2.248***
	(9.963)	(9.770)	(7.938)	(8.043)
Time	0.953***	1.344***	1.214***	1.327***
	(12.680)	(11.950)	(21.670)	(16.780)
(Utility model)$_{t-1}$	1.038***	3.045***	0.461***	1.170***
	(7.971)	(5.323)	(4.916)	(3.365)
(Utility model)$_{t-1}$* time		-0.577***		-0.207**
		(-3.642)		(-2.116)
Constant	-7.809***	-10.19***	-7.775***	-8.332***
	(-11.55)	(-11.26)	(-9.079)	(-9.256)
Observations	8372	8372	8372	8372
Log likelihood	-3835.83	-3097.09	-2948.94	-2946.67
prob>chi2	0.00	0.00	0.00	0.00
Wald chi2	1572.864	4389.655	1613.697	1492.969
Number of firms	2093	2093	2093	2093

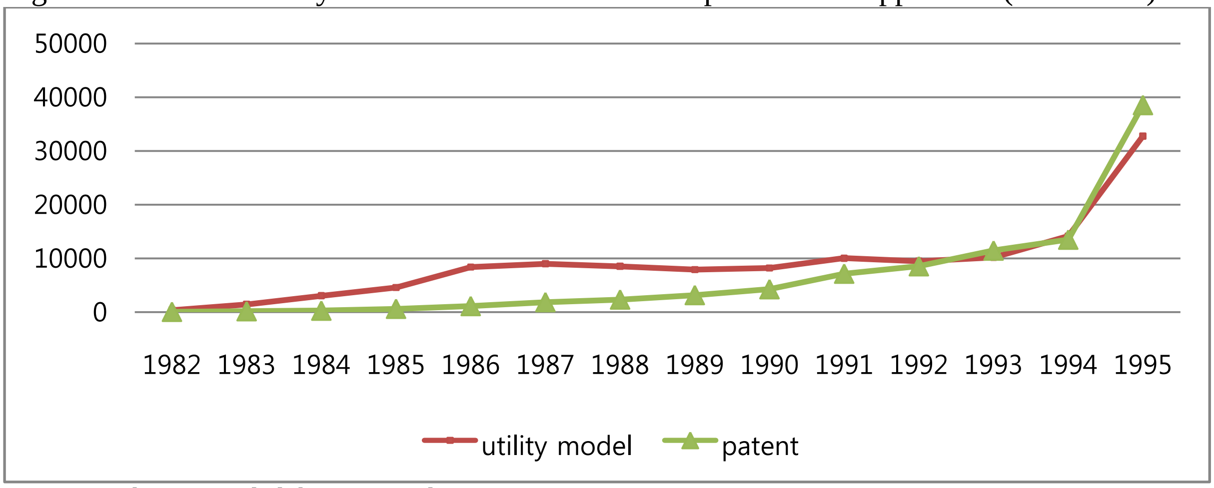
Note: All data are five-year averaged. *** p<0.01, ** p<0.05, * p<0.1, t-statistics are in parentheses; 21 industry dummies are included; White-Sandwich standard errors are used for pooled regression.

Table 5 shows the result of Hypothesis II in testing whether utility models tend to stimulate innovative inventions at later stages. As the likelihood ratio test prefers the random effect negative binomial models to the pooled negative binomial model (($\overline{\chi}^2$(01)=1233.08, p-value=0.00 for model (3) and $\overline{\chi}^2$(01)=1195.25, p-value=0.00 for model (4), the interpretation will be based on model (3) and model (4). Model (3) in Table 5 indicates that firms with utility models have higher probability to apply for the new patent even after controlling for R&D expenditure. Empirically, utility models are found to be beneficial in enhancing their technological capabilities. That is, new patentable innovations of firms build upon their utility model knowledge as well as upon more R&D activities. The results support the hypothesis that through adaptation, imitation, and incremental innovation, firms acquire some learning-by-doing (Suthersanen, 2006).

However, the relative importance of utility models is reduced as firms' technological capabilities grow to be able to conduct R&D activities targeting higher level of innovation. Model (4) tests whether such impacts on the flow of new patents differ as firms' technology develops over time. Such impact is captured by the interaction term of utility model and time trend. The result in model (4) indicates that utility models increase the probability of patent application, whereas such impact as the knowledge source for patents generation diminishes as Korea's technological capabilities rise. The same results hold when we add both a variable for time trend and a full set of dummy variables for each year.[3] Therefore, this result supports the hypothesis that the utility models system is beneficial to developing countries or technologically poor companies.

Further, this diminishing impact of utility models implies that Korea's current technological capabilities are the outcome of both adaptive innovation efforts (utility models) during the early stage of development and real innovation activities encouraged by strong patent rights protection during the later stage of development. In other words, lack of either one may not guarantee technological development. Thus, the proper design and strength of an IPR system tailored to the indigenous technological capacities is required to achieve successfully industrial dynamics such as in Korea.

Figure 3: Trend of Utility Models versus Patents of Top 10 Patent Applicants (as of 1995)



Source: Authors compiled the KIPRIS data.

Data presented in Figure 3 show that the top 10 patent applicants of Korean firms as of 1995 tended to apply for more utility models prior to the early 1990s, which supports the role

[3] The results are available upon request.

of learning mechanism of utility models. The top 10 patent applicants include Samsung Electronics, LG Electronics, Daewoo Electronics, Hyundai Automotives, and so on. In sum, Korea's experience suggests that the design and strength of IPR systems should be tailored to the indigenous technological capacities of the developing countries to provide the appropriate incentives for innovation.

4.2.2. The Impact of Utility Model on Firm Performance

A key function of a patent is to help a company achieve sufficient returns on its investment when commercializing a new technology through better positioning in the market (Geroski et al, 1993; Geroski and Machin, 1993, Granstrand, 1999). Thus, if this function is fulfilled, the product of the innovative process may be associated with superior performance. Previous empirical findings show a positive association between patents and corporate performance at the firm level. However, several limiting factors make it difficult to profit from innovations, such as inability to prevent other firms from copying the technology, high cost of or limited access to capital or related technology, challenges of putting a product into production in time, and the high cost of marketing, as shown by a firm survey in Lee et al. (2003). Thus, firms at their early development stages with poor resources may find incremental innovation important in helping to position themselves in existing markets with low cost. Consequently, utility models, which represent incremental innovations, are expected to be positively associated with the performance of firms when they are at the early stage of growth.

Therefore, the hypothesis can be set up as follows.

Hypothesis III

Firm growth is positively associated with the minor inventive activity, particularly if a firm is technologically lagging.

$$(4)\quad (Sales\ \text{Growth}_{it}) = \begin{pmatrix} \delta_0 + \delta_1 \left(log\ of\ R\&D\ \text{intensity}_{i,t-1} \right) + \delta_2 \left(utility\ \text{mod}\,el_{it} \right) \\ +\delta_3 \left(utility\ \text{mod}\,el_{it} \right) * time\ trend_t + \delta_4 (\text{log of investment}_{it}) \\ +\delta_5 (\text{log of }\ firm\ age_{it}) + \delta_6 (\text{log of employees}_{it}) +\ \delta_7 time\ trend_t \\ +\delta_8\ industry\ dummies_j + \delta_i + \upsilon_{it} \end{pmatrix}$$

where $\text{i} = \text{firm},\ \text{j} = \text{industry},\ \text{t} = \text{period}$

Hypothesis III is tested using the sales growth equation with a variable for utility model application after controlling for the R&D intensity (i.e., R&D expenditures to sales), investment, size of employment, and firm age. R&D intensity is lagged in this model, considering the time lag between R&D activities and product manufacture. The investment and employment variables are used to control for the effects of factor inputs. Firm age helps control for efficiencies due to entrepreneurs learning about their abilities over time (Jovanovic, 1982; Evans, 1987). Table 6 presents the results of regression analysis for Hypothesis III. Here, performance is assessed using a firm's five-year average sales growth. Firm heterogeneity is controlled with fixed effect estimation. As the Hausman test rejected the null hypothesis that the coefficients estimated by the efficient random effects estimator are the same as the ones estimated by the consistent fixed effects estimator, we report the fixed effect results ((χ^2 (06)=43.98, p-value=0.00 for model (3) and (χ^2(07)=46.43, p-value=0.00 for model (4).

Model (3) in Table 6 suggests that the firms with utility models show no better performance for the entire period. However, the impact of utility models changes by period. When utility model is interacted with time trend as in (4), the coefficient of the utility model dummy is found to be significant and positive. Such positive impact decreases as time passes; the negative and significant coefficient of the interaction term of the utility model and time trend indicates that the importance of utility model decreased as Korea began to acquire greater technological and R&D capabilities. The same results hold when we try the system of generalized method of moments (GMM) estimation not with a dummy for utility model but with a variable showing the number of utility applications.[4]

[4] The results with the number of utility applications are not reported here but in Kim et al. (2009). In Kim et al. (2009), internal innovative knowledge is measured by patents instead of R&D intensity.

The implication is that utility models are likely to be appropriate for companies that are resource poor or are below the technological frontier. R&D intensity, investment, and labor control variables each has significant positive associations with sales growth, while the age of a firm has a significant negative association (i.e., younger firms generally have faster growth in sales). The latter results are consistent with Jovanovic (1982) and Evans (1987).

Table 6: Hypothesis III: Impacts of Utility Models on the Sales Growth of Firms

Dependent Variable: Five-year average sales growth rate				
	(1) OLS	(2) OLS	(3) Fixed Effect	(4) Fixed Effect
(Log of R&D intensity)$_{t-1}$	0.0718***	0.0719***	0.0345***	0.0356***
	(5.999)	(6.009)	(2.859)	(2.954)
(Log of Investment)$_t$	0.244***	0.244***	0.132***	0.132***
	(8.228)	(8.226)	(3.880)	(3.898)
Utility model $_t$	0.0127	0.205	-0.0172	0.478*
	(0.411)	(0.858)	(-0.345)	(1.918)
Utility model $_t$ * time		-0.0424		-0.114**
		(-0.814)		(-2.028)
(Log of firm age)$_t$	-0.362***	-0.362***	-0.693***	-0.683***
	(-7.660)	(-7.657)	(-3.870)	(-3.822)
(Log of employees)$_t$	0.0787***	0.0782***	0.355***	0.361***
	(5.486)	(5.442)	(6.160)	(6.275)
Time	-0.0108	0.0132	-0.00825	0.0563
	(-0.390)	(0.321)	(-0.151)	(0.893)
Constant	1.275***	1.172***	0.509	0.167
	(6.290)	(4.839)	(1.173)	(0.360)
Observations	1668	1668	1668	1668
R-squared	0.32	0.32	0.215	0.22
F-stat	18	17.5	27.81	24.55
Prob	0.00	0.00	0.00	0.00
Number of firms	1051	1051	1051	1051

Note: All data are five-year averaged. *** p<0.01, ** p<0.05, * p<0.1, t-statistics are in parentheses; 21 industry dummies are included, investment rates are investment ratio to assets, White-Sandwich standard errors are used.

5. Concluding Remarks

Among diverse factors associated with the rapid technological development of Korea, this paper has focused on the role of the IPR system. In particular, two dimensions of the system were considered: the conventional patent protection system measured by the patent rights index and the second-tier protection system for minor adaptive inventions, that is, the utility model system. This paper took a dynamic perspective to analyze the changing role of IPRs through the course of economic growth and examined the role of utility models (or petit patents) in the technological development of Korea, particularly in the early days of development.

The major findings are as follows. First, strong conventional patent protection measured by the patent rights index induces more patent generation at a later stage of development only in Korea. Second, utility models have a positive impact on patent generation, but their impact decrease with the eventual enhancement of technological capabilities. Third, firms with utility models are associated with better performance during the early stage of economic development, while such impact decreases over time. Overall, these empirical findings on the Korean firm level data as well as the time series data imply that strengthening only the level of IPR protection regardless of the level of economic development may not be appropriate for developing countries with less technological capabilities.

Rather, Korea's experience suggests that the design and strength of IPR systems should be tailored to the level of the local technological capabilities of a country to provide appropriate incentives for incremental or adaptive innovation. In particular, utility model systems, a second-tier IPR, is the right device for developing countries to encourage incremental innovation, which may be more suitable for local needs and be a stepping stone for further technological progress. Only after technological capabilities have reached a certain threshold level would the policy to strengthen patent rights protection to induce more R&D investment become more valid and effective. Nevertheless, current academic and policy debates have focused on the effects of strong IPRs in general and on raising developing country standards to developed country levels. Accordingly, less attention has been given to the effects of intermediate levels or different types of IPRs. This is one of the aspects to which this paper contributes in this field of research.

However, some limitations of this research remain. First, it would be better if a patent rights index would be constructed with possible data availability later, reflecting not only the laws and regulations but also the actual enforcement of the laws. It would be useful to investigate the issues sector by sector to see if there would be any difference across sectors, for example, in agriculture, electronics, and machinery.

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[Appendix: Descriptive Statistics and Correlation]

Table A. Summary Statistics of Time Series

Variable	Mean	Standard deviation
Δ(log of no. of patent application)	0.13	0.17
Δ(log of *RD*)	0.25	0.18
Δ(log of *GDP*)	0.18	0.08
Patent rights index	2.92	0.76

Table B. Correlation Matrix of Time Series

	Δ(log of no. of patent application)	Δ(log of *RD*)	Δ(log of *GDP*)	Patent rights index
Δ(log of no. of patent application)	1.000			
Δ(log of *RD*)	0.4327	1.000		
Δ(log of *GDP*)	0.1518	0.5827	1.000	
Patent rights index	0.0483	-0.4461	-0.8014	1.000

Table C. Descriptive Statistics of Firm-level Panel Data

Variable	Mean	Std. Dev.
R&D expenditure	42272.6	1978668
Patent rights index	2.81	0.61
Firm age	8.98	10.96
Employees	1140.74	7083.49
R&D intensity	0.02	0.97
Patent	1.33	61.83
investment	5.1	14.12
5-year average sales growth	0.56	0.75
Utility model	0.02	0.13

Note: Unit for the R&D expenditure: 1,000 Korean Won; R&D expenditure is deflated with industry-level GDP deflator.

Table D. Correlation of Firm-level Panel Data

	R&D expenditure	Patent rights index	Firm Age	Employees	R&D intensity	Patent	investment	Five-year average sales growth	Utility model
R&D expenditure	1								
Patent rights index	0.04	1							
Firm age	0.04	-0.03	1						
Employees	0.55	-0.12	0.14	1					
R&D intensity	0.19	0.10	-0.05	0.06	1				
Patent	0.75	0.04	0.03	0.40	0.10	1			
Investment	0.04	-0.04	-0.02	0.05	0.06	0.03	1		
Five-year average Sales growth	0.03	-0.09	-0.26	0.04	0.09	0.02	0.20	1	
Utility model	0.14	0.02	0.01	0.21	0.07	0.1	0.05	0.07	1

Appendix: Patent Rights Index (1961-2002)

	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
1) Coverage																					
Patentability of pharmaceuticals																					
Patentability of chemicals																					
Patentability of food																					
Patentability of planet and animal varieties													1	1	1	1	1	1	1	1	1
Patentability of surgical products	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Patentability of microorganisms																					1
Patentability of utility models	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Patentability of software																					
	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.50
2) Membership in international treaties																					
Paris convention and revisions																				1	1
Patent cooperation treaty																					
Protection of new varieties																					
TRIPS																					
Budapest Treaty																					
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.20
3) Loss of protection measures against losses																					
Working requirements																					
Compulsory licensing					0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Revocation of patents																					
	0.00	0.00	0.00	0.00	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
4) Enforcement																					
Preliminary injunctions	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Contributory infringement	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Burden-of-proof reversal	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5) Duration																					
Grant-based standard	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
App-based standard																					
Patent Rights Index	1.96	1.96	1.96	1.96	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.45	2.57

Appendix: Patent Rights Index (1961-2002) (Continued)

	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02
1) Coverage																					
Patentability of pharmaceuticals					1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Patentability of chemicals					1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Patentability of food									1	1	1	1	1	1	1	1	1	1	1	1	1
Patentability of planet and animal varieties	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Patentability of surgical products	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Patentability of microorganisms	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Patentability of utility models	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Patentability of software																			1	1	1
	0.50	0.50	0.50	0.50	0.75	0.75	0.75	0.75	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	1.00	1.00	1.00
2) Membership in international treaties																					
Paris convention and revisions	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Patent cooperation treaty	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Protection of new varieties																					1
TRIPS														1	1	1	1	1	1	1	1
Budapest Treaty							1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	0.40	0.40	0.40	0.40	0.40	0.40	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.80	0.80	0.80	0.80	0.80	0.80	0.80	1.00
3) Loss of protection measures against losses																					
Working requirements									0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Compulsory licensing	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Revocation of patents					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
4) Enforcement																					
Preliminary injunctions	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Contributory infringement	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Burden-of-proof reversal	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5) Duration																					
Grant-based standard	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.88	0.88	0.88	0.88	0.88								
App-based standard														1	1	1	1	1	1	1	1
Patent Rights Index	2.77	2.77	2.77	2.77	3.02	3.02	3.22	3.22	3.69	3.69	3.69	3.69	3.69	4.01	4.01	4.01	4.01	4.01	4.13	4.13	4.33

Note) Revised from Choi and Lee (2005)