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Commercialization of Government-Sponsored Information and Telecommunication Technologies in Korea*

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<요 약>

본 고는 우리나라 정보통신산업에 있어서 정부사용목적의 연구개발투자를 제외한 국가지원 연구개발투자에 따른 기술의 상용화 전략특성에 관해 연구한 논문이다. 연구의 주요내용을 보면 기술상용화에 관한 기존연구 결과에 대한 분석을 통하여 기술상용화에 영향을 미치는 요인들을 도출하였으며, 상용화 프로세스모형에 대한 프레임워크를 제시하였다.

나아가 상용화 영향요인과 사용화 전략과의 관계, 상용화 성과와 영향요인과의 관계에 관한 연구모형을 설정하였으며, 정보통신 개발기술의 상용화 경험을 가지고 있는 기업을 대상으로 한 설문조사를 통하여 실증분석을 하였다. 본 연구의 분석에 사용된 설문지는 전체 상용화 건수 중에서 상용화 경험이 있는 기업의 대표적인 기술을 대상으로 조사되었다.

이러한 분석의 결과를 기반으로 정보통신 기술상용화의 촉진을 위한 효율적인 정책도출을 위한 다음의 대안을 제시하였다. 상용화를 촉진하기 위해서는 산학연간의 협력관계, 기술상용화 인프라의 구축, 정부의 상용화 프로그램에 대한 올바른 정보의 제공, 상용화 네트워크의 구축, 신기술/제품에 대한 초기 시장보호 및 침투 지원 등이 이루어져야 하겠다.

Key Words : Technology commercialization, Government-sponsored R&D, Technology user, Technology infra

핵심어 : 기술상용화, 정부지원 연구개발, 기술상용화 프로세스모형, 기술사용자-제공자, 기술인프라, 신제품 초기시장보호, 기술상용화네트워크

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I. Introduction

Since early 1980s the focus of national technology policy in the Advanced Developing Countries (ADCs) has been shifted gradually from the technology-push to demand-pull development. The main goal of this policy shift is to achieve global competitiveness through full exploitations of technologies that would be successful in the market. Many ADCs put an emphasis on transfer, diffusion, and commercialization of technologies into actual economic prosperity (OECD, 1997). They also raise the level of protection on the Intellectual Property Rights (IPRs) including knowledge assets to provide more favorable environment for commercialization

On the contrary, many Less Developed Countries (LDCs) have focused on technology-push policy that has turned out to be very unsuccessful in utilizing technologies and difficult in diffusing and commercializing them to the market. As a result technology-push policy does not foster development of technology- intensive small and medium-sized companies and will not lead to competitive advantage of firms, industries, and nations.

Korean government has been putting efforts to promote development of technologies by government sponsored labs and to transfer, diffuse, and commercialize these technologies in private sector since mid 1980s. In spite of these efforts, utilization of government-sponsored technology remains in the very low level. According to the survey conducted by Korea Intellectual and Patent Office (1999), the ratio of unused industrial property rights including patents was above 60% of total industrial property rights. Survey on the information and telecommunication(IT) industry done by the Institute of Information Technology Assessment (IITA) in 1999 shows thatthe utilization ratio of government-sponsored technologies is about 55.8%. Out of total 620 government-sponsored technologies development cases, 139 cases (22.4%) were actually led to commercialization and 212 cases (34.2%) are in the process of commercialization.These survey results indicate that government-sponsored projects are not fully utilized even though projects produce potentially useful technological innovations. This is especially true where government is not the primary or end-user of technologies. In this

respect, empirical and systematic study exploring why government-sponsored projects do not meet the expected standards of technology commercialization.

This paper is an explanatory study in Korean IT industry. The purposes of this paper are to (1) identify factors influencing technology commercialization, (2) develop a framework for technology commercialization model among factors, commercialization, and performance of commercialization, (3) empirically investigates the framework, and (4) suggest policy alternatives for more effective technology commercialization in the areas of information and communication technology industries.

II. Literature Review

2.1.Factors Influencing Technology Commercialization

While there are many studies investigating technology commercialization of federally-sponsored or -initiated technological innovation including influencing factors, relationship with commercialization strategy and performance of commercialization in ADCs, only a few numbers of studies (no empirical research) have been presented in Korea.

Little (1976) studied commercialization of six federal R&D programs and found two important factors that influence technology commercialization: (1) user needs and (2) favorable risk factors, the existence or creation of risk-taking environment in the form of pursing technological change. Based on 24 federal demonstration projects, Baer et al.(1976) suggest the following major factors that promote successful commercial diffusion of R&D project: (1) critical technological problems to be solved before demonstration, (2) cost and risk sharing with federal sponsored, (3) project initiated and organized by private sector, (4) strong existing industrial system (potential markets and manufactures), (5) planning included potential purchasers, manufacturers, regulators and agencies, and (6) the absence of tight, externally imposed time constraints.

McEachron et al (1978) surveyed 46 projects in various programs of 11 federal agencies through intensive interviews. The findings indicate three major factors facilitating the transfer of Federal R&D to the market places: (1) R&D agent's orientation to meet producer and user requirements, (2) communication and collaboration between the principal parties, and (3) market responsiveness of R&D management. In similar way, Ettlie's study (1982) of 40 federally sponsored innovation projects from five government agencies suggest 43 items in 10 categories that will determine the success of these projects.[1] Among them, the three most critical factors are: (1) degree of incremental innovations, (2) pricing potentials of product or process, and (3) the ease of introduction and implementation of the innovation.[2]

McMullan and Melnyk (1988) analyzed the characteristics of academic venture formation as a new supporting mechanism on transferring efficiently university-owned technologies to corporations. Through the questionnaire survey to 16 professor-venture businessmen in Calgary University, they suggest major factors that are necessary to rear the talented manpower for developing prototypes and tools of marketing research. The Major factors for commercialization of university initiated technology are: (1) ability of marketingresearch, (2) understanding of the interested technology, (3) discovery and utilization of sources of useful information, and (4) understanding of knowledge on the industrial design, technology transfer and venture business.

Based on the Cooper's (1986) Commercialization Cycle Model,Lester (1988) studied the critical success factors for new product development through commercialization of new technology, which. The success factors of commercialization are 16 variables in five groups: (1) senior management commitment, (2) organizational structure and process, (3) developing attractive new product concepts, (4) forming the venture team, and (5) project management.[3]

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1) Ten (10) categories are market potential, pricing potential, ease of implementation, incremental technology, first-use rationale of government involvement, value of agency market studies, user understanding, regulations stimulus, user-buyer benefit stimulus, and financial requirement.

2) Degree of incremental innovations means the ease of linking and sharing new technology with the established business. Pricing potentials of product or process means sufficient volume for manufacturer to become cost efficient. The ease of introduction and implementation of the innovation means production feasibility, stage of development and visibility.

3) The detailed variables are: vision and sponsored of management, organizational culture of innovations,

Goel et al. (1991) developed guidelinesthat managers of government-sponsored R&D could use in identifying appropriate technology transfer strategy. In this study, they suggested three criteria on transferring technology to industry sector. Technological criteria that appear to be particularly relevant to the selection of strategy are: (1) nature of technology (process or product), (2) nature of R&D (exploratory or applied), (3) complexity, (4) nature of information (degree of appropriateness), and (5) technological uncertainty. Market criteria are divided to two factors: (1) breadth of possible application (unified or diverse) and (2) nature of industry (degree of concentration measured by the number of firms and their market power). Finally, two Policy criteria are considered: (1) the level of government support and (2) desired time-line (time to market).

Based on comprehensive literature review, Rothwell (1992) summarized 21 factors in the study of successful industrial innovation in the 1990s. First eight factors are taken from results of nine studies undertaken during 1950s, 1960s and 1970s: (1) establishment of good internal and external communication, (2) treating innovation as a corporate-wide task, (3) implementing careful planning and project control procedures, (4) efficiency in development work and high quality production, (5) strong market orientation, (6) providing a good technical service to customers, (7) the presence of certain key individuals, and (8) high quality of management. Six factors were added from the strategic level: (1) top management commitment and visible support, (2) importance of long-term corporate strategy, (3) needs to long-term commitment to major project, (4) corporate flexibility and responsiveness to change, (5) top managementacceptance of risk, and (6) creation of innovation-accepting and entrepreneurship-accommodating organizational culture. They are the essential pre-conditions for sustained innovation. Additional seven factors were driven finally from the System Integration and Networking (SIN) model in the 5th generation of innovation: (1) inter-firm

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cross-functional teams, organization of new product development, sharing of common interests on the process of new product development, in-depth knowledge and experience in particular technology and market, team member skills and expertise, sharing of efforts and responsibilities for new product development, clearing goals and milestone measurements in new product development, communication t about management process, and reevaluation based on the newest information.

integration and networking, (2) technological accumulation, (3) integrated production and product strategy, (4) organizational flexibility, (5) product quality and performance, (6) the environment, and (7) speed to market.

Radosevich and Smith (1997) suggested two groups and seven factors as the determinant of commercialization in a generalized entrepreneurship model for the commercialization of public sector technology. One group was technology source that has 6 factors: (1) develop and mature technologies jointly with partners, (2) identify and assess commercial applications, (3) protect intellectual property, (4) type of commercialization, (5) determine role of inventor employee, and (6) use surrogate entrepreneur alternative. The other group is external commercialization interface, which means various interactions with market and external organizations.

To explore influencing factors in Korean setting, Lee et al (1999) analyzed the characteristics of commercialization through the questionnaire survey of 40 cases in Korean telecommunication and information technology. In this study, they found twenty-four factors with four groups as the determinant of commercialization. The first group is characteristics of technology user that have six factors: (1) management support for technology commercialization, (2) risk taking in new technology, (3) trust on research institutes, (4) information on technology and technology commercialization program, (5) existence of technology commercialization experts, and (6) financing and technology capabilities. The second group is characteristics of technology supplier that have five factors: (1) collaboration among industry, academia, and research, (2) prior experience of technology commercialization, (3) mutual understanding of R&D goals, (4) recognition on technology commercialization, and (5) practicality of technology. The third group is characteristics of technology that have five factors: (1) maturity of technology, (2) reliability of technology, (3) enough investment period on technology, (4) linkage to with existing technology, and (5) technology Infrastructure for technology commercialization. The fourth group is characteristics of environment that have eight factors: (1) technology commercialization network, (2) technology commercialization over basic research in government-sponsored institutes, (3) protection on new technologies and

products, (4) government support for technology commercialization, (5) protection on initial market penetration, (6) inspection, testing, and certification, (7) consistency of government R&D policy, and (8) linkage of government policy with commercialization.

2.2. Commercialization Strategy

Commercialization was defined as a multi-staged process of innovationor business decision-making process of exploiting new technology by many researchers.[4] Ehretsment et al. (1989) analyzed the mode and characteristics of commercialization strategy based on the study of commercializing stagnant technologies. They classified two types of strategy: one as external joint venture and the other as internal venturing to create new business division according to the degree of involvement and commitment level of resources.

Gibson (1997) defined the concept of commercialization and transfer of technology as an interactive process with s great deal of back-and forth exchange among individuals over an extended period of time. He suggested three major types of inter-organizational technology transfer from research to application: (1) spinning out technologies into start-up companies, (2) transferring technologies from research organization to established firms, and (3) spinning technologies within organizations and in-house utilization. Type (1) and (2) are usually used in the commercialization of technologies that are developed by government-sponsored labs.

Jolly (1997) explained commercialization strategy as a two-staged interaction model that has the primary multi-faced activities and the secondary supporting activities. He suggested an efficient commercialization of new technology as a continuous process with five steps: (1) suggestion of idea, (2) incubating, (3) product demonstration, (4) promotion of product

4) Cooper (1986) divided the commercialization process of new technology into four steps and thirteen discrete activities. Four steps are developing concept of new product, evaluating technical and business validity, demonstrating new product in the marketplace, and expanding production of new product to marketable size. Knox and Denison (1990) suggested a two-staged transfer of innovation. The one is transfer of innovative ideas betweencustomer and manufacturer, or within organization, and the other is transfer of final product between customer and manufacturer. DuPont Corporation (1995) explained it as a process with six activities that are idea, recruiting, project planning, prototype, market launch and utilization, and product supporting.

adaptation, and (5) extension of product life cycle of market-launched product from imaging of idea to market launch.

Radosevich (1992) and Radosevich and Smith (1997) studied a model for entrepreneurship infrastructure development in the creation of technopolis. In their study, they analyzed how to commercialize technologies that are developed by public sector institutions. The two primary modes of commercialization are transferring the technology to an existing firm, i.e. inventor-entrepreneur model, or working with a new entrepreneurial effort, i.e. external entrepreneur model. They suggested also a useful commercialization process by the latter mode, which has five steps: (1) venture packaging, (2) venture launch, (3) initial commercialization, (4) steady-state operations, and (5) recycle the entrepreneur.

Based on their empirical study, Lee et al. (1999) revised the Jolly's (1997) model and suggested an interaction model with the continuous process of six steps: (1) initiating, (2) imaging, (3) incubating, (4) demonstrating and engineering, (5) locating and producing, and (6) marketing and continuous diffusion. This model is more suitable for explainingcommercialization of new technology that is developed by public or private sector with market-needs orientation and customer's interaction. They further suggested a five-steps for commercializing technologies that are developed by government-sponsored labs. The five steps are (1) developing & transferring technology, (2) incubation and review of business opportunity, (3) making prototype and testing, (4) production and test market, and (5) realizing amount of economic performance through mass production and sustaining market shares.

2.3. Performance of Commercialization

It is not easy to find appropriate variables and to measure the performance of commercialization. Since the effect of commercialization will be appeared differently according to characteristics of business, time dimension of diffusion, degree of complexity and accomplishment in the transferred technology, market condition and characteristics of related business, and technology infrastructures.

In general, performance of commercialization is classified as two categories: business strategic performances and technological performance. Business strategic performances are measured such as profitability and marketability. Chakrvartyhy (1986) defines profitability measures as (1) return on investment (ROI), (2) return on sales (ROS), and (3) return on total capital (ROTC). Marketability measures can be operationalized as (1) increase of sales volume and (2) increase of market share (Venkatraman and Ramanujam 1986). Technological performances can be measured by several factors: (1) shortening technological gap, (2) increasing technological competitiveness, and (3) development of new product. (Dowling and Ruefli, 1992; Bozeman 1991).

Ⅲ. Research Methodology

3.1. Research Model

In this study, Commercialization Model and influencing factors on technology commercialization of Lee et al. (1999) was adopted on the following grounds: (1) very comprehensive since it incorporates previous research results and (2) applicable in Korean setting. The research model and influencing factors are summarized in Figure 1 and Table 1. In the study of commercialization of government-sponsored technology, the focuses of analysis are two-folded: the one is relationship between influencing factors and commercialization strategy and the other is relationship between influencing factors and performance of commercialization. There has been no study implying relationship between commercialization strategy and performance of commercialization

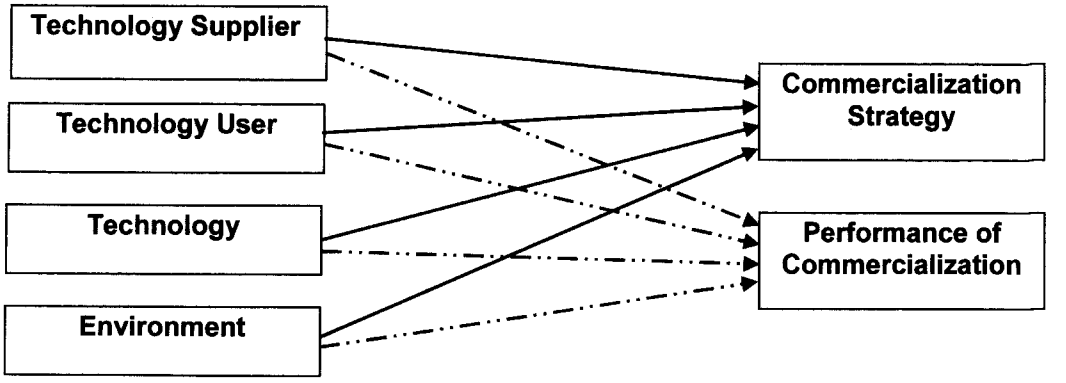

Figure 1. Framework of Research Model

3.2. Sample

As of 1999, 346 commercialization cases have been reported in information and telecommunication(IT) industry. In 1999, IITA recognizes 240 prospective companies that have reported one or more successful commercialization cases. These 240 companies were selected as the target sample.

The questionnaire was sent and administered to CTO of 240 companies in March 2000. Whenever necessary, research assistants actually visited companies to collect questionnaires. Out of 240 questionnaires, 59 returned and 3 were unusable. Therefore, the final response rate was 23.33% (56 questionnaires). Demographic analysis (comparison of size and sales between respondent and non-respondent companies) does not reveal any significance to suspect sample bias.

3.3. Measures

Through pilot test and interview with Chief Technology Officers (CTOs) of Korean Information firms, weexclude two factors, such as consistency of government R&D policy, and linkage of government policy on commercialization, among 24 factors for influencing

Table 1. Factors Influencing Commercialization

			Researcher Relationship	
Technology Supplier	Collaboration among industry, academia, and research	(COLLAB)	McEachron	/+
	Experience of TC(Technology Commercialization)	(EXPERI)	Lee et al	/+
	Mutual understanding of R&D goals	(GOAL)	Lester	/+
	Recognition on TC	(RECOG)	Radosevich & Smith	/+
	Orientation of Practical use technology	(PRATICAL)	McEachron	/+
Technology User	Management support for TC	(MGMT)	McMullan &Melnyk	/+
	Risk taking in new technology	(RISK)	Little, Rothwell	/+
	Trust on technology and research institutes	(TRUST)	McEachron	/+
	Information on technology and TC program	(INFO)	McMullan & Melnyk	/+
	Existence of TC Experts	(EXPERT)	Ettlie, Rothwell	/+
	Financing and technology capabilities	(FINANCE)	Rothwell, Lee et al	/+
Technology	Maturity of technology	(MATURE)	Goel	/-
	Reliability of technology	(RELIABLE)	Little, Goel	/+
	Enough investment period on technology	(INVEST)	Little, Goel	/-
	Linkage to with existing technology	(LINKAGE)	Lee et al	/+
	Technology Infrastructure for TC	(IMFRA)	Lee et al	/+
Environ-men t	TC network	(NETWORK)	Cooper, Rothwell	/+
	TC over basic research in national institutes	(PRIORITY)	Lee et al	/+
	Protection on new technologies and products	(PROTECT)	Ettlie, Lester	/+
	Government support for TC	(GOVT)	Goel	/+
	Initial market penetration and response	(MARKET)	Little, McEachron	/+
	Inspection, testing, & certification	(TEST)	Lee et al	/+

commercialization strategy.

We define also commercialization stage as Lee at al.'s (1999) definition. Commercialization is measured as degree of progress in the continuous process: (1) developing & transferring technology, (2) incubationand review of business opportunity, (3) making prototype and

testing, (4) production and test market, (5) realizing amount of economic performance through mass production and sustaining market shares.

Finally, we will measure the performance of commercialization by two variables: (1) increase of sales amount, (2) shorting technology gap. Because Korea is not technology advanced and leading country but smart following country in telecommunication and information industry, and Korea has a little short-term history, withinfive or seven years of technology commercialization. And so, many companies that developed or received government-sponsored technology can't get financial performances, and technological performances. In the pilot study, we can find that the most appropriate performances variables are increase of sales amount, and shortening technology gap

IV. Research Results

4.1. Reliability and Validity of Research Variables

Reliability refers to the stability of measures over a variety of conditions (Nunally, 1978). The amount of error made by any measure is determined by Cronbach's alpha test applied tointeritem scores and to the overall measures. The results of reliability test on CSF's measures are shown in Table 2. There is no absolute standard for interpreting Cronbach's alpha. Generally, Nunally (1978) argues that the satisfactory level of exploratory study is 0.7 or above. Cronbach's alphas () are on the far right column of Table 3 and all variables are above or very close to Nunally's recommendation. Therefore, reliability of measures is concluded to be satisfactory and all 22 variables will be used in subsequent analyses.

Table 2. Descriptive Statistics of Research Variables

[illegible]		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
22	COLLABORATE	4.55	1.31	4	Technology Supplier	5.21	0.7111
10	EXPERIENCE	5.34	1.10				
13	GOAL	5.29	1.07				
9	RECOG	5.39	1.06				
6	PRACTICAL	5.32	0.87				
1	MGMT	5.88	0.81	1	Technology User	5.43	0.6957
19	RISK	5.02	1.00				
20	TRUST	4.82	1.29				
5	INFO	5.50	0.97				
4	EXPERT	5.57	1.23				
2	FINANCE	5.75	1.05				
6	MATURE	5.46	0.97	2	Technology	5.27	0.7008
8	RELIABLE	5.45	0.97				
21	INVEST	4.63	1.02				
15	LINKAGE	5.23	1.03				
3	INFRA	5.59	0.83				
17	NETWORK	5.09	1.15	3	Environment	5.22	0.7364
18	PRORITY	5.05	1.10				
10	PROTECT	5.34	1.08				
16	GOVT	5.20	1.18				
14	MARKET	5.27	1.14				
10	TEST	5.34	1.28				

To investigate the validity of measures, factor analysis was performed. All 22 variables have high loadings (above 0.5000). Thus, validity of measures is generally supported.

4.2. Descriptive Analysis

As Table 2 shows, respondents rated MGMT (management support for TTC) as the most influencing factor on commercialization, followed by FINANCE (Financing and technology

capabilities), INFRA (Technology Infrastructure for TTC), EXPERT (Existence of TTC Experts), and INFO (Information on technology and TC program). Also MATURE (Maturity of technology), PRACTICAL (Practicality of technology), RELIABLE (Reliability of technology), and RECOG (Recognition on TTC) were considered to be critical. On the other hand, COLLABORATE (Collaboration among industry, academia, and research) was rated as the least critical factor, followed by INVEST (Enough investment period on technology), TRUST (Trust on research institutes), RISK (Risk taking in new technology), and PRIORITY (TTC over basic research in government-sponsored institutes). Interestingly 4 of top 5 factors belong to category of "technology user"while most factors in "technology supplier" were not evaluated as important. The category level analysis shows that "technology user"as the most influencing category, followed by "technology." This confirms the recent emphasis on "demand pull" rather than "technology push" approach.

These ratings of factors on commercialization are perceptional and relative since CTO's evaluate each factor based on their prior experience and educated guess. Thus it may not accurately reflect objective contribution of factors on commercialization and/or performance of commercialization.

4.3. Relationship between Factors and Commercialization Stage

To investigate importance of each individual factor on commercialization stage, regression analysis was performed (refer to Table 3). On the category level (technology supplier, technology user, technology, and environment), none of four categories have significant explanatory power for commercialization stage. This result is quite contrary to the belief that factors influencing technology commercialization and commercialization stage should have a positive relationship. Korean government has been criticized as being lack of detailed and tailored commercialization stage and this criticism may reflect the above week association.

On the variable level, COLLABORATE (Collaboration among industry, academia, and research) shows statistically significant explanatory power at the 5% significance level and

INFO (Information on technology and TC program), FINANCE (Financing and technology capabilities), and INFRA (Technology Infrastructure for TTC) at the 10% level. Negative coefficients such as MGMT (management support for TTC) and EXPERT (Existence of TTC Experts) seem to be the results of lack of management support and expert of technology commercialization in Korean IT firms.

Table 3. Regression Analysis of Factors on Commercialization Strategy

Category	Variable		t value	P > |t|	R^2	P > F
Technology Supplier	COLLABORATE	0.3470	2.207	0.0320	0.1217	0.2564
	EXPERIENCE	0.2379	1.428	0.1596		
	GOAL	0.0236	0.146	0.8847		
	RECOG	0.1225	0.791	0.4330		
	PRACTICAL	-0.1951	-1.200	0.2360		
Technology User	MGMT	-0.0692	-0.428	0.6706	0.1167	0.4287
	RISK	0.0857	0.513	0.6107		
	TRUST	0.0085	0.049	0.9608		
	INFO	0.2756	1.699	0.0961		
	EXPERT	-0.0547	-0.316	0.7536		
	FINANCE	0.2742	1.709	0.0941		
Technology	MATURE	0.1098	0.731	0.4683	0.1103	0.3281
	RELIABLE	0.1738	1.063	0.2929		
	INVEST	-0.0206	-0.123	0.9028		
	LINKAGE	-0.1380	-0.843	0.4036		
	INFRA	0.2586	1.832	0.0731		
Environment	NETWORK	0.0700	0.391	0.7978	0.1010	0.5166
	PRIORITY	0.0729	0.443	0.6596		
	PROTECT	0.1895	0.996	0.3241		
	GOVT	-0.1413	-0.774	0.4431		
	MARKET	0.0385	0.199	0.8433		
	TEST	-0.2446	-1.416	0.1635		

4.4. Relationship between Factors and Performance

To analyze importance of each individual factor on performance of commercialization measured by sales growth, regression analysis was performed (refer to Table 4). On the

category level (technology supplier, technology user, technology, and environment), all four categories have significant explanatory power for performance of commercialization. This result confirms the belief that factors influencing technology commercialization do affect performance of commercialization.

On the variable level, COLLABORATE (Collaboration among industry, academia, and research), RISK (Risk taking in new technology), TRUST (Trust on research institutes), INVEST (Enough investment period on technology), and MARKET show statistically significant explanatory power at the 5% significance level and FINANCE (Financing and

Table 4. Regression Analysis of Factors on Performance Measured by Sales Growth

Category	Variable		t value	P > |t|	R2	P > prf
Technology Supplier	COLLABORATE	0.4336	2.894	0.0057	0.1999	0.0466
	EXPERIENCE	0.0530	0.335	0.7388		
	GOAL	-0.0208	-0.137	0.8918		
	RECOG	-0.0229	-0.154	0.8784		
	PRACTICAL	-0.1029	-0.663	0.5105		
Technology User	MGMT	0.0929	0.661	0.5120	0.3128	0.0054
	RISK	-0.3847	-2.652	0.0109		
	TRUST	0.4571	3.054	0.0037		
	INFO	-0.2090	-1.522	0.1348		
	EXPERT	0.1872	1.225	0.2266		
	FINANCE	0.2524	1.828	0.0738		
Technology	MATURE	-0.0375	-0.268	0.7844	0.2033	0.0429
	RELIABLE	-0.0417	-0.274	0.7851		
	INVEST	0.3885	2.521	0.0150		
	LINKAGE	0.1479	0.972	0.3359		
	INFRA	-0.1685	-1.273	0.2092		
Environment	NETWORK	0.4149	2.519	0.0515	0.2301	0.0421
	PRIORITY	0.1074	0.738	0.4644		
	PROTECT	-0.2695	-1.587	0.1191		
	GOVT	-0.1166	-0.696	0.4900		
	MARKET	0.3997	2.252	0.0289		
	TEST	-0.0734	-0.467	0.6423		

technology capabilities), and NETWORK (TTC Network) at the 10% level.Again, negative coefficients such as GOAL (Mutual understanding of R&D goals) and RECOG (Recognition on TTC) may be interpreted as the results of multi-collinearity among independent variables.

Another regression analysis was performed to investigate importance of each individual factor on performance of commercialization measured by technology gap reduction, (refer to Table5). On the category level (technology supplier, technology user, technology, and environment), all four categories have significant explanatory power for performance of

Table 5. Regression Analysis of Factors on Performance Measured by Technology Gap Reduction

Category	Variable		t value	P < prt	R2	P < prt
Technology Supplier	COLLABORATE	0.3273	2.235	0.0300	0.2357	0.0187
	EXPERIENCE	-0.2362	-1.527	0.1332		
	GOAL	0.2899	1.950	0.0570		
	RECOG	0.0693	0.475	0.6374		
	PRACTICAL	0.1098	0.724	0.4724		
Technology User	MGMT	0.1024	0.717	0.4768	0.2908	0.0100
	RISK	0.2787	1.898	0.0647		
	TRUST	-0.1452	-0.955	0.3444		
	INFO	0.1522	1.091	0.2810		
	EXPERT	0.3707	2.388	0.0210		
	FINANCE	-0.1791	-1.277	0.2079		
Technology	MATURE	0.1111	0.813	0.4204	0.2426	0.0155
	RELIABLE	-0.0006	-0.004	0.9965		
	INVEST	0.3275	2.180	0.0341		
	LINKAGE	0.1888	1.272	0.2093		
	INFRA	-0.0115	-0.089	0.9292		
Environment	NETWORK	0.3923	2.412	0.0198	0.2489	0.0265
	PRIORITY	0.1674	1.167	0.2488		
	PROTECT	-0.0438	-0.261	0.7951		
	GOVT	0.0060	0.037	0.9708		
	MARKET	0.1985	1.132	0.2631		
	TEST	-0.0643	-0.415	0.6802		

commercialization. This result again reinforces the common assumption that factors influencing technology commercialization have strong association with performance of commercialization.

On the variable level, COLLABORATE (Collaboration among industry, academia, and research), EXPERT (Existence of TTC Experts), INVEST (Enough investment period on technology), and NETWORK (TTC Network) show statistically significant explanatory power at the 5% significance level and GOAL (Mutual understanding of R&D goals) and RISK (Risk taking in new technology) at the 10% level. Again negative coefficients such as EXPERIENCE (Prior experience of TTC) and TRUST (Trust on research institutes) seem to be the results of multi-collinearity among independent variables.

V. Conclusion

This paper empirically investigates the factors influencing information and communication technology commercialization and its relationships with commercialization strategy and performance of commercialization. Based on the results of this study, the following technology commercialization policy alternatives are suggested.

First, technology suppliers are the ones that develop technologies and provide necessary and prominent technologies into the market. In this sense technology suppliers play critical roles in igniting technology transfer and commercialization process. In short, without supplying technologies, there would not be any commercialization of technologies. To further facilitate commercialization of government-sponsored R&D projects, collaboration among industry, academia, and research is the most critical factor as the research results show. Thus active participation from industry, academia, and research is required all through commercialization process. Also researchers in government-sponsored projects should consider the practicality or marketability of technologies they are developing.

Second, technology itself is important. As the research results indicate, technology infrastructure for technology commercialization is one of the most critical factors. The fact

that maturity of technology is low and need for additional research is for government-sponsored projects confirms the lack of technology infrastructure. Thus policy consideration is requested to implement and manage technology infrastructure including basic R&D and training. Since long investment period has bad effect on performance of commercialization, more financial support is recommended in the early stage of commercialization process.

Third, technology users are the actual major players in technology commercialization process. Research results indicate that technology users should be provided with more information about government commercializationprograms and technologies since most technology users are not fully aware of what kind of technologies are available. Also government-sponsored research institutes need to build more trust on their technologies from technology users. To solve above issues technology users and research institutes should seriously consider establishing strategic unit dealing commercialization process as well as training technology commercialization experts.

Fourth and finally, government needs to improve environment ofcommercialization including commercialization network building and market penetration support. Government should devise policy to support services that technology suppliers and users want rather than provide what government thinks is necessary for commercialization

This paper is a preliminary study and has several weak points in the empirical analysis. One of them is caused from operating the dependent variable that is the stage of commercialization. We will measure success or failure of commercialization and use multiple regression model in the next study that will be finished on the end of June, 2004. Another is the short time period of commercialization in the most IT firms. They can't have abundant opportunities of recognizing and evaluating the performances of commercialization. And we will also measure and analyze the performances after four years from this study in the next study.

References

Arthur D. Little, Inc., *Federal Funding of Civilian Research and Development*, Vol. 1: Summary, USGPO, Washington, D.C., 1976.

Bears, E. C.,et al., *Analysis of Federally Funded Demonstration Projects, Executive summary*, R-1926, Rand Corp., April 1976

Bozeman, B., "Evaluating Government Technology Transfer: Can the new cooperative technology development paradigm enhance U.S. Industries competitiveness?" *International Conference on Changing Technology Environment and Policy Response*, STEPI, Seoul, 1991, pp. 35-65.

Chakravarthy, B. S., " Measuring Strategic Performance", *Strategic Management Journal*, Vol. 7, 1986, pp. 437-458.

Cooper, R. G., *Winning at New Products, Addison-Wesley* Pub., 1986.

Dowling, M. J. and Ruefli, T. W., "Technological Innovation as a Gateway to Entry: The Case of the Telecommunication Equipment Industry", *Research Policy*, Vol. 21, 1992, pp. 63-67.

Ehrestmann, J., Hinkly, A., Minty, A., and Pearson, A. W., "The Commercialization of stagnant technologies", *R&D Management*, Vol. 19, March 1989, pp. 231-242

Ettlie, J. E., " The commercialization of Federally Sponsored Technological Innovations", *Research Policy* Vol. 11, 1982, pp. 173-192.

Gibson, D. V., "Inter-Organizational Technology Transfer: From Standard Packages to Spin-Offs", J.B. Sedaitis (ed), *Commercializing High Technology: East and West*, Rowman & Littlefield Pub., 1997, pp. 77-94.

Goel, R. K., Brown, M. A., and Berry, L. G., "Guidelines for Successfully Transferring Government-Sponsored Innovations", *Research Policy*, Vol. 20, 1991, pp. 121-143.

IITA, *Survey on the Performance of Government-Sponsored Information Technologies in Korea*, Institute of Information Technology Assessment, 1999.

Jolly, V. K., *Commercializing New Technologies*, Harvard Business School Press, 1997.

KIPO, *Survey on the Practice of Utilizing Intellectual Property Rights in Korea*, Korean

Intellectual Patent Office, 1999.

Knox, S. D.and Denison, T. J., "R&D Centered Innovation: Extending the Supply Side Paradigm", *R&D Management,* Vol. 20, January 1990, pp.25-34.

Lee, Young-Duck, et al., *Maneuvering and Establishing a Center for Supporting Commercialization in Government-Sponsored Technology in the Korean Information and Telecommunication Industry*, Research report of IITA, Seoul, Korea, December 1999.

Lester, D. H., "Critical Success Factors for New Product Development", *Research · Technology Management,* January-February 1988, pp. 36-44.

McEachron, N. B., *Management of Federal R&D for Commercialization, Executive Summary and Final Report,* SRI International, September 1978.

McMullan, W. E.and Melnyk, K., "University Innovation Centers and Academic Venture Formation", *R&D Management,* Vol. 18, January 1988, pp. 5-12.

Nunally, Jum C., *Psychometric Theory*, New York: McGraw-Hill, 1978

OECD, *Diffusing Technology to Industry: Government Policies and Programs*, OECD/GD (97) 60, 1997

Radosevich, R., "A Mixed-Strategy and Case Example of Federal Technology Transfer in the USA", *International Journal of Technology Management*, Vol. 8, 1993, pp. 596-611.

Radosevich, R. and Smith, G. S., "A Model for Entrepreneurship Infrastructure Development in the Creation of Technopolis", J.B. Sedaitis (ed), *Commercializing High Technology: East and West,* Rowman & Littlefield Pub., 1997, pp. 95-118.

Rothwell, R., "Successful Industrial Innovation: Critical Factors for the 1990s", *R&D Management*, Vol. 22, 3, 1992, pp. 221-239.

Venkatraman, N. and Ramanujam, V., "Measurement of Business Performance in Strategy Research: A Comparison of Approaches", *Academy of Management Review*, 1986, No. 4, pp. 801-814.