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Technology Commercialization and Business Promotion in Science Park : Case Study of Taedok Science Town

Deog-seong Oh
Chungnam National University
Byung-su Kang
Chungnam National University

1. Introduction

In recent years there has been growing interests in regional development policies which emphasize high technology and regional innovation(Oh and Masser, 1995). The emphasis on the stimulation of high-tech industry through technopolises and other initiatives by so many countries around the world is based on the assumption that technological innovation leads to economic growth(Simmie et al, 1993). There remain unanswered questions and important issues concerning the dynamics of creating and sustaining technopolises or science parks that need to be addressed and better understood. The most important issues are how effective technopolis or science park can be as an instrument of regional innovation policy and for stimulating technology-led economic development.

Since the end of the 1980s, therefore, many local authorities in Korea have been anxious to foster high technology industries and to establish development plans for technopolises or science parks in their area. But the technopolis concept is not new to Korea. This can be seen from the fact that the National Science Town in Taedok was started in 1973 and is now at a position where its impact on regional and national development can be evaluated.

It is argued that it usually takes about 20-30 years after constructing science parks to commercialize the research results as spin-offs for regional economic development in the advanced countries(Lin, 1996; Massey, 1992). Taedok Science Town also arrives at the time to have such powerful spin off effects on the regional economy. Until now, however, Taedok Science Town has not had significant relationship with regional economy, and furthermore it was far from nurturing the high-tech based venture business. But the situation is changing very rapidly after the Korean Advanced Institute of Science and Technology(KAIST) opened

the Technology Innovation Center(TIC) and the Technology Business Incubator (TBI) to stimulate commercialization of researchers' innovative research results from the beginning of 1990s. There are several other approaches like Technopark, and Technology Business Incubator to reinforce the weakness of technopolis programme.

With these considerations in mind, this paper aims to find out the way of supporting the technology commercialization and business promotion in technopolises or science parks. The paper begins with theoretical review of mechanisms for technology based business promotion in science parks or technopolises. The second part of the paper describes the experience of Taedok Science Town in terms of infrastructure and their role for the development. The third section discusses key issues for the technology commercialization and suggests the development strategies for the future.

2. Theoretical Review : Science Park and Technology Commercialization

1) Science park : Tool for Creating High-tech based SME's

An increasingly popular tool for creating high technology based venture businesses is the science park. Hence, many universities and cities promote science parks since small and medium sized venture businesses from science parks create employment and aid municipal tax bases. These are the reasons for nurturing small businesses and science parks as an effective method of local economic development. As a matter of fact, among strategic resources of a business the cultural climate is the most important factor. Strategic resources of a business do not lie only in capital or technology, but also human capacities and adaptability.

A Science Park is a property-based initiative which (UKSPA 1989):

- has formal links with a university or other higher educational and research institution (HEI);
- is designed to encourage the formation and growth of knowledge based businesses and other organizations normally resident on site;
- has a management function which is actively engaged in the transfer of technology and business skills to the organizations on site.

Within this definition, it is also possible to identify several sub-forms which complement other initiatives designed to stimulate a more productive relationship between industry and academia. Innovation and Incubation Centers are defined as developments within a restricted space intended primarily for new start-up firms; Science Parks or Technology Parks are defined as "larger areas of land suitable for knowledge-

based firms of different sizes and stages of development, usually, though not necessarily in landscaped surroundings". The planning framework should be sufficiently flexible to permit 'light manufacturing'. Research Parks are defined as being similar to Science Parks but the planning framework is more rigid, permitting only prototype manufacturing(Monck et al, 1988).

The Technopolis concept emphasized the need for a balanced approach to high technology development. Instead of only focusing on technology it involves the creation of new settlements, complete with research parks, new universities, technology centers, housing and cultural facilities (Tatuno, 1986). Masser (1991) has pointed out that Technopolises are larger in scale and often linked to the development of infrastructure and facilities on the new town model, whereas Science Parks are more limited in scope. Technopolises also tend to be more production oriented than Science Parks.

At the core of the science-park phenomenon lies a view about how technologies are created. Science parks constitute a channel by which academic science is linked to commerce. This, then, is a highly particular model of

Table 1. Key features of Science Park / Technopolis

Types	Physical characteristics	Focus	Examples
Incubation Centre	development within restricted Space	mainly intended for start-up firms	BIG, Berlin, Germany SP incubator, Manchester, UK
Science Park/ Technology park	larger area of land suitable for knowledge-based firms	R&D (but permitting light production)	Cambridge SP, UK Dortmund TP, Germany
Research Park	larger area of land suitable for knowledge-based firms	basic R&D (permitting only prototype development)	Surrey Research Park, UK
Technopolis	creation of new settlement (research park, new town) including production activity	High-tech production R&D centers, industrial parks new town	Tsukuba, Japan Taedok, Korea Hshinju, Taiwan

scientific research and industrial innovation. Fundamentally, it is linear model, in which there is a chain of successive, interrelated activities. These begin with basic scientific research and pass through applied and more developmental research activities, the development of new product and process ideas, the evolution and testing of proto-types, to commercial production and finally to diffusion. According to Massey, Quintas, and Wield(1992: 58), two major policy questions have historically emerged from the linear model. The first is how to increase the supply of basic research ideas available for development. The second major question has been how to quicken the development and commercialization of basic ideas. The science-park model fits as one possible means of solving the second problem. The purpose of science park model is to nurture high technology-based small and medium sized firms for local economic development as spin-offs from science parks.

2) University and Business Incubator/Technology」 Commercialization Center : Instrument for Stimulating entrepreneurship and business in Science Park

Business incubator is one of the major instruments for stimulating entrepreneurship and venture business development in the science park. Small business incubators are facilities that support new and small firms by providing affordable space, shared office services, financial services and management assistance. According to Allen(1985), the incubator concept must include four dimensions, such as a local network, multi-tenant space, shared services and management consulting assistance.

Sponsorship of small business incubators falls into five major categories: (1) public entities; (2) non-profit organizations; (3) universities; (4) private corporations; (5) public private partnerships (Kuratko and LaFollette 1987; MacDonald 1986). Differing sponsorship has tended to mean variation in incubator objectives and administration. Public sector and non-profit organization sponsors seek to create jobs, diversify the economy, and expand the tax base. Universities become involved in incubator sponsorship as a mean of creating a working laboratory for students or to provide a vehicle for marketing the products of faculty research. This causes them to be a bit more relaxed in their policies regarding tenant admission. Like publicly-sponsored incubators, they are more likely to establish a time limit for individual tenant occupancy due to concern that they might otherwise be seen as providing an inequitable advantage to private entities (Demuth 1984). Univer-

sity incubators tend to support high technology-oriented tenants over other industries (Campbell 1984).

Technology Commercialization Center is also one of the major instruments for stimulating entrepreneurship and venture business development in the science park. Commercialization of innovations and technology transfer are, in effect, an extension of the evaluation and the patent activities, although in some cases the university may intercept and improve innovations that have already been deemed marketable and, perhaps, even patented. The emphasis is on: a) identification of potential uses of a product or process; b) preliminary determination of a depth of demand; and c) identification of an economically efficient production process. Again, university faculty and staff involved in these activities will likely have backgrounds in science, medicine, and engineering. Operations of this sort may deal with new and relatively untested innovations or, potentially, they could even focus on new industrial applications for established technologies(Lay Gibson 1992:28-29).

3. Basic Infrastructures for Technology Commercialization in Taedok Science Town (TST)

1) Overview of TST'S Development

(1) Growth

Taedok Science Town(TST) brings together national and regional development policy efforts from the last 20 years. The plan represents a concerted attempt by the central government to create a high-tech centre outside the capital region. The area was farming land before being designated as the national science town by the government in 1973. The initial area of development was limited to the academic and research use which was 1,078 acres, only 16% of the present area. Five government research institutes and three R&D centers from privates firms, as well as Chungnam National University, were operating in this area by 1979. In 1981 the master plan was changed and 38.5% of the TST site was designated as a research and education area so that research facilities could be established there. This research and education area was again increased to 3,202 acres in 1985, 46.6% of the whole site (see Table 2)

Most of government research institutes in the capital region had to be moved to TST as part of the policy of decentralized central government in 1980's. These included 12 research institutes, 3 central government administrative offices and the Korea Advanced Institute of Science and Technology(KAIST). The relocation of KAIST has an important symbolic

Table 2. Land Use Allocation according to the Development Phases.

Land use	1st master plan, 1973~1980(acres)	2nd master plan, 1981~1985(acres)	3rd master plan, 1986~1992(acres)
Academic and research	1,078(16.4%)	2,633(38.5%)	3,203(46.6%)
Residential	566(8.2%)	577(8.4%)	577(8.4%)
Greenbelt	645(9.8%)	1,127(16.4%)	1,048(15.3%)
Other uses	4,328(65.6%)	884(36.7%)	2,036(29.7%)
Total	6,617	5,221	6,864*

* Development area: 6,680 acre
Source: Oh, D.S. et al.(1992).

function in reinforcing the image of TST as the centre of high-technology development in Korea. Nevertheless, a number of private firms were sceptical of the success of TST before the declaration of the relocation of the third administrative headquarters of central government to Dunsan New Town next to TST, and the publicity associated with the 1993 World Exposition in TST. Most of private firms began to construct their research facilities from 1990 onward(Oh and Park 1990). As of 1997, there are 25 private research labs and 22 public research institutes and 3 universities in TST.

At present the total area of Taedok Science Town(TST) was 6,680 acres (27.6㎢). This is about the same size as the central research and education district in Tsukuba Science City in Japan (6,669 acres)and the Research Triangle Park in North Carolina in the US(6,700 acres)(Oh and Masser, 1995). TST has a population of approximately 50,000 inhabitants. The financial investment for TST is about 4,831 million US $ up till 1995 (see Table 3).

One of the major expected achievements accruing from the implementation of the development plan is that TST, as the largest high-tech centre in Korea, will become a national technopolis with public and private R&D centers. As a result, Taedok can be considered a focus for high-tech development in Korea.

(2) Main Sector of Activity

The institutions in TST are based toward R&D rather than production. At the planning stage, the central government decided that TST researchers should carry out long-range investigations of a basic research nature

Table 3. Financial Investment for the Science Town's Development

(unit: thousand us $)

Section	Total	Research institute construction	Basic construction	Housing & Educational institutions	Public institutions & Cultural welfare facilities
Government	1,575,156 (100%)	1,016,406 (64.5%)	461,250 (29.4%)	61,250 (3.8%)	36,250 (2.3%)
Government -invested Institutes	955,468 (100%)	431,250 (45.1%)	524,218 (54.9%)	-	-
Industry research laboratories	2,301,093 (100%)	812,656 (35.3%)	281,875 (12.2%)	1,163,437 (50.5%)	43,125 (2%)
Total	4,831,717	2,260,312	1,267,343	1,224,687	79,375

Source: TAO of MOST, 1997.

and not be distracted by short-term product-oriented research. Some 40% of all Korean government research institutes with these objectives are located in TST.

In terms of the major characteristics of R&D centers, there was an interesting change around 1990. As suggested earlier, through large-scale government projects like EXPO '93 in Taejon and the relocation of the third central government headquarters from Seoul, the establishment of private R&D centers has been aggressively promoted. If 16 R&D centers are fully established by 2000, the proportion of private R&D will be two thirds of all research facilities in TST. These private R&D labs differ in both activity and focus from the government institutes. Most of them focus on the commercialization of their R&D results.

The main sectors of activity of R&D centers are listed in Table 4. This shows that the research activities are becoming diversified through the location of public research institutes and R&D centers of private firms. This variety of activity is important, because it suggests that the potential of future development in TST as well its mother city of Taejon, can be attractive to a wide range of research-focused technologically advanced, and innovative activities, not just to a few specific sectors.

2) Universities : Base for Technology Transfer and Commercialization

The concentration of high-level educational institutions in TST means that the site has access to the important resource of highly skilled scientific and technical personnel. Two national universities and one private college are located within the area of TST. They play a pivotal role in cultivating a highly specialised workforce, as well as pursuing the close linkage between research and education(Most, 1992). In particular the different roles of the two universities in TST are interesting in respect of high-tech development.

Chungnam National University acts as a intermediary between the research centers in TST and the industries in Taejon, because its position in the city is secure as a locally-based national university with a variety of faculties: It has since developed several programmes for close collaboration with research institutes in TST as well as industries in Taejon city. These collaboration programmes with the R&D centers in TST include the exchange of staff and co-operative research. The university faculty and post-graduate students assist the industrial labs and institutes through consulting and research. At the same time researchers in TST supervise post-graduate students, as the university offers them the status of visiting professor. The university has also been keen to initiate adult education and night courses which would strengthen university-industry links, particularly with the industries in Taejon city(Oh, 1991).

On the other hand, Korea Advanced Institute of Science and Technology (KAIST)[1] focuses on research activ-

Table 4. Fields of Research & Development

Field	Number of Organization	Field	Number of Organization
new materials	13	energy · resources	9
precision chemistry		Standard · basic	4
electronics	5	complex research	4
informations		education · research	3
aerospace · machinery	3	others	3
life engineering	3	total	47

Source: TAO of MOST, 1997.

ities and has closer linkages with the research centers in TST as well as those in the whole country. KAIST, a successful experimental technological university, is exclusively a technological university with only one faculty specializing in different types of engineering training. About 70% of its students are postgraduate students enrolled mainly in masters level courses. MOST(Ministry of Science and Technology) is the major sponsor of its research activities, and it also has strong links with the government institutes and the research labs of private firms through the indirect support of central government. The location of KAIST has been evaluated by the incoming private firms as the most crucial locational factor, and recruitment of graduates from the university is one of the main consideration in their decision to settle in the area(Oh, 1995).[2)]

At present both universities develop the technology business incubator aiming to accelerate technology transfer between academic and research institutions and private firms. Although it is only at the planning stage, the KAIST incubator and CNU Technology collaboration centre with tenant units for start up firms are very interesting examples of university efforts to promote technology transfer and spin-offs from the university. In particular KAIST will develop technopark named High-Tech Complex within its premises, because these are increasing demands for business incubation units and medium sized R&D centers for collaboration between private firms and university staffs.

It is expected that scientific entrepreneurs from universities or R&D centers in TST will mature at this centers to the point where they can graduate from the incubator and continue their development as viable enterprises. These figures tell us something about the university based incubator or technopark and their possible utility to the local community as tool for enhancing economic development.

4. Potential for Technology Commercialization in TST

1) Circumstances

(1) Concentration of high qualified manpower and R&D centers

As of 1996, there are 44 private or public centers and 3 universities where 15,000 researchers and workers in TST. There is 12 incoming R&D centers with 2809 employee in the near future(see Table 5).

High qualified research manpower in

Table 5. Status of R&D Centers and Their Employee

Organization	In-town Organization		Organizations about to move into Town		Total	
	Number	Employee	Number	Employee	Number	Employee
Research Institute	44	11,956	12	2,806	56	14,722
Government · Supported Institutes	17	7,277	2	116	19	7,393
Industry Research Laboratories	21	3,278	9	1,290	30	4,528
Government · Invested Institute	6	1,401	1	1,400	7	2,801
High Educational Institutions	3	2,792	-	-	3	2,792
Government Agencies	5	327	4	185	9	512
Grand Total	52	15,075	16	2,991	68	18,066

Source: TAO of MOST, 1997.

public and private R&D centers are highly concentrated in TST. This means that there is a high possibility of commercialization of research results or high-tech commodity from high-tech research in TST. It can be argued that there is a high potentiality in TST because there are about 2,000 Ph. D. degree holders.

(2) Growth of R&D centers in private sector

One of the reasonable indicators which measure the vitality of TST is a degree of R&D investment. Table 6 shows the size of private sector R&D investment from 1981 to 1996. As be seen in Table 6, private research institute and the number of researchers in Korea were increased very high between 1986 and 1991, however private sector R&D investment and number of researchers in TST were highly increased between 1991 and 1996. The growth rate of private sector R&D investment in TST between 1991 and 1996 is 296%. It is expected that these investment in private R&D will be continuously high through the location of 16 private R&D centers in the near future.

Table 6. Growth of Private Sector R&D Institutes in TST and Nation as a whole

content \ year	1981	1986	1991	1996	Growth rate(%)		
					81-86	86-91	91-96
# of private sector R&D institutes <Nation>	3 <122>	3 <290>	5 <1,109>	25	0 <237>	166 <382>	500
# of researchers <Nation>	1,390 <5,054>	1,390 <12,576>	1,666 <28,725>	4,475	0 <248>	119 <228>	268
Total investment in R&D (billion won) <Nation>	2,783 <3,424>	2,783 <8,521>	3,235 <22,640>	9,594	0 <246>	116 <265>	296

(3) Interaction between research institutes and industries

In terms of the generation of new technologies, a major issue has been the interaction between public research and the scientific establishment on the one hand and private sector enterprises on the other, leading to joint R&D and spin-off firms(Oh, 1995). Research institutes in TST carried out 31 projects in behalf of the companies in Taejon City in 1994, 122 projects in 1995, 96 projects in 1996.

To analyze the relationship between TST and regional economy, an interview survey was done. Interviewee were directors of each research institute which located in TST. About 63% of interviewee mentioned that TST has a positive effect to the development of regional economy in Taejon and 89% of the interviewee answered that TST might have more positive effects in the future. Among the positive effects of which TST posses to the development of economy in Taejon, employment (33.3%) was first in the hierarchy and next was use of research results (29.6%). It was revealed that 85.1% of research institutes in TST let construction companies in Taejon do repair of facilities, extension or reconstruction of their buildings.

There are, however, some problems to solve in terms of technology transfer. About 66.7% of the research institutes in TST say that research results of the TST are not so much contributed to the development of the companies which are located in Taejon City. Only one thirds of the R&D centers have regular connection with the firms in Taejon city in terms of collaborative research, technical supervision, etc.

2) Spin-offs from R&D centers

(1) Active spin-offs from R&D centers

Recently active spin-out motion from R&D centers is happening in TST. For last 10 years 58 spin off companies from the R&D centers in TST have been found out in the survey of Taejon metropolitan city. There were 3 cases of spin-off in TST in 1991, but it grew to 9 cases in 1995 and 20 cases in 1996. About 70% of business inauguration related with spin-off is happening in Taejon City during last four years.

If spin-off effects of TST for the last 10 years is analyzed in terms of employment, 857 new jobs were created. If job creation of employment is analyzed in year base, 25 persons were employed in 1988, it grew up to 161 employees in 1991, and employment in 1996 soared up to 189 persons.

Fifty eight spin-off companies were born from nine public research institutes in TST as of October 1977. Twenty four spin-off firms were born from Korea Electric and communication Institute. Ten spin-off companies were created from Korea Advanced Institute of Science and Technology(KAIST) and Korea Standard Science Research Institute each. These three institutes are the main bodies, where the active technology commercialization have been made. (see table 8)

According to the survey results of these firms, 80% of them have 5~10 engineers. All of them started the businesses with less than 200 thousand US dollars.

The attitude of private centers is not so open-minded for these active spin-off activities. Research results produced from TST is not allowed to be used by researchers who want to open their new business. There is no spin-off company from private research institutes in TST so far. This could mean that private research company does not contribute much to regional economic development such as public research institutes do. In addition only 15% of research institutions in TST permits researchers using their research results, but about 52% of research institutes do not allow researchers using their research results. If this climate is changed into the other way, business inauguration from TST might be much easier.

Table 7. Number of Spin-off Companies from TST

Year	88	89	90	91	92	93	94	95	96	97	Total
# of spin-off firms	1	1	2	3	6	3	7	9	20	6	58
# of job creation	25	21	35	161	84	70	96	91	189	81	857

Table 8. Research Institutes in TST and Their Spin-offs

Name of research institute from which spin-off firms were born	Area of research, production, and activities	# of spin -off firms
·Korea Electric and Communication Institute	Development, supply, and expansion of information and communication skill	24
·Korea Standard Science Research Institute	Establishment and distribution of national standard skill	10
·Korea Advanced Institute of Science and Technology (KAIST)	University emphasized in Science and Technology	10
·Korea Nuclear Institute	Development of skill in nuclear fuel	5
·Korea Chemistry Research Institute	Creation of new materials and development of new production system	3
·Military Science Research Institute	On-line diagnosis system of electric facilities	2
·Life Science Research Institute	Expansion of research environment for life science	2
·Korea Institute of Machine and Materials	Development of new skill for machine system in the field of transportation, environment and energy	1
·Center for Artificial Satellite		1
Total		58

(2) Support mechanism

There is, on the other hand, the high potential in Taejon City in terms of business incubation and collaboration between universities and industries. The TBI(Technology Business Incubator) and TIC(Technology Innovation Center) at KAIST promote start-ups of small and medium-sized companies which have difficulty in commercializing research results because of little capital and lack of manpower, and help enhance national competitiveness through execution of industry-oriented projects. The Collaboration Centre in CNU has a similar concept of development.

Their major activities are as follows:

- ○ to encourage entrepreneurship and new ventures
- ○ to promote start-ups of small and medium-sized companies
- ○ business promotion and education of entrepreneurs

In Technical Business Incubator in KAIST, 21 new graduate business companies have started there business in Taejon. In addition, 6 start up firms are beginning their activities in CNU. Taejon one stop service center for small and medium sized enterprises will be in operation in next year. With this supporting organizations and TBI facilities,

business inauguration is becoming relatively active in Taejon compared with other cities in Korea

3) Need of Technology Commercialization

In order to do research on technology start-up needs in Taedok Science Town, this study used the survey results of the professors and graduate students who had relatively high possibilities for their venture start-ups at Chung-Nam National University in TST(The survey was administered in June of 1996). Then, considering researchers' start-up needs in Taedok Science Town, the study used the survey results of 54 start up firms which was conducted by Taejon metropolitan city in August, 1997.

(1) Commercialization of research results and start-up needs

On investigation of commercialization of research results, 12.8% of professors have already had experiences for it. And then, the number of professors who directly contact with the private corporations for commercialization of their research results amounts to 26.5%. However, in the case of graduate students, even they had comparatively many start-up related ideas and technologies for hatching venture businesses, they had hardly touched with the private corporations for commercialization of their research results.

Even till now, it is unusual that professors and researchers open their venture business based on high technology. In this survey, approximately 85.3% professors and 58.3% graduate students had thought about their start-up business. Moreover, it showed that 36.3% of professors and 6% graduate students had been thought about their venture businesses specifically.

If the circumstance permits, 52.9% of professors and 27.8% graduate students who would like to establish their own businesses directly. Observing the

Table 9. Experiences of Commercialization

	Professor	Graduate	Total
Yes	13 (12.8%)	9 (6.0%)	36 (14.2%)
No	75 (73.5%)	141 (93.4%)	217 (85.8%)
N.A.	0 (0.0%)	1 (0.7%)	1 (0.4%)
Total	102 (100.0%)	151 (100.1%)	253 (100.0%)

Table 10. Start-up Needs

	Professor	Graduate	Total
Thought Specifically	37 (36.3%)	9 (6.0%)	46 (18.2%)
Thought Vaguely	50 (49.0%)	79 (52.3%)	129 (51.0%)
Never Thought	13 (12.8%)	61 (40.4%)	74 (29.2%)
N.A.	2 (2.0%)	2 (1.3%)	4 (1.6%)
Total	102 (100.1%)	151 (100.0%)	253 (100.0%)

start-ups related ideas and technologies they had, 99% of professors and 94% of graduate students had those things.

(2) Demands for business promotion

The most difficult things when professors tried to start their businesses were as follows; funding capital(79%), lack of demand for products and marketing(75.9%), shortage of managerial know-how(75.9%), complicated administrative procedures for opening businesses(50.5%). However, solution of technical problems(35.2%) and fear to failure (31.5%) were not considered to the major difficulties in starting business. The table 12 showed that the graduate students had similar tendencies with professors; funding capital (73.8%), shortage of managerial know-how(61.9%), lack of demand for products and marketing(54.8%), complicated administrative procedures for opening businesses(40.5%) were their expected difficulties alike previous were. Both solution of technical problems and fear to failure(21.4%) were relatively minor ones.

When the professors tried to establish their venture businesses, the most their needed supports from community were capital supports (38.9 %), administrative supports including simplifying the complicated procedure for start-ups(35.2%), and information support(20.4%), managerial support(16.7%), and equipment support (14.8%). And last one needed was technical support (11.1%). For graduate students, they showed a little different opinions as compared with professors.

The survey results of 54 venture firms from TST show us the clear pictures of real demands for technology commercialization : They need the capital support (80%), technology transfer from research institutes (14%) and providing more affordable space (62%).

Table 11. The Expected Difficulties in Strarting Business

	Professor	Graduate	Total
Funding capital	43 (79.6%)	31 (73.8%)	74 (77.1%)
Lack of demand for products and marketing	41 (75.9%)	23 (54.8%)	64 (66.7%)
Fear to failure	17 (31.5%)	9 (21.4%)	26 (27.1%)
Shortage of managerial know-how	41 (75.9%)	26 (61.9%)	67 (69.8%)
Complicated administrative procedure for opening businesses	27 (50.0%)	17 (40.5%)	44 (45.8%)
Solution of technical problems	19 (32.2%)	14 (33.3%)	33 (34.4%)
Total	54 (100.0%)	42 (100.0%)	96 (100.0%)

Table 12. Supports Needed for Starting Business

	Professor	Graduate	Total
Capital support	21 (38.9%)	18 (42.9%)	39 (40.6%)
Managerial support	9 (16.7%)	4 (9.5%)	13 (13.5%)
Technical support	6 (11.1%)	9 (21.4%)	15 (15.6%)
Information support	11 (20.4%)	8 (19.1%)	19 (19.8%)
Administrative support including simplifying the complicated procedure for start-ups	19 (35.2%)	7 (16.7%)	26 (27.1%)
Equipment support	8 (14.8%)	3 (7.1%)	11 (11.5%)
Total	54 (100.0%)	42 (100.0%)	96 (100.0%)

5. Development Strategy

1) Development Concept : Complex Model

According to the development goals and the functions of the park, technopolis development concept can be divided into three types(Oh and Kang, 1992): incubation centre (innovation and incubation center at the universities), research park (R&D-oriented) and industrial park (productive-oriented). Although the functions of parks are different, they must be intimately related to upgrade and strengthen the industrial structure. In the initial stage of technopolis a research park can be located within a precinct to attract research technicians and technology companies. After development of research park reaches a certain phase, an industrial park needs to be constructed to produce the results of the R&D oriented park. In the same aspect the incubation centre needs to be established next to those parks for the purpose of supporting the business environment for the R&D and industrial activities. Through the combination of those 3 parks, the high-tech industries can be developed.

This kind of developmental relationship can be seen clearly in the development strategy of technopolis in Taejon: As TST permits basic research & prototype manufacturing, there should be another industrial park, which has no limit on the amount of manufacturing performed so long as it is related to the R&D activity. In that area, the main activities of their organizations are for research applications and productions, rather than for research. By attaching a high-tech industrial park close to the TST, R&D functions can be tied directly to the industrial activities in the region. At the same time, incubation centre needs to be established for the purpose of supporting the spin-off activities from R&D centers of universities in TST. In particular new start-up companies, after having been successfully matured in the incubation centre will then enter the productive-oriented industrial park. Thus the development process of technopolis is completed. The combination of these three sectors(research park, high-tech industrial park and incubation centre) can be a kind of complex model of technopolis: research, production and business incubation.

2) Policies for Business Incubation

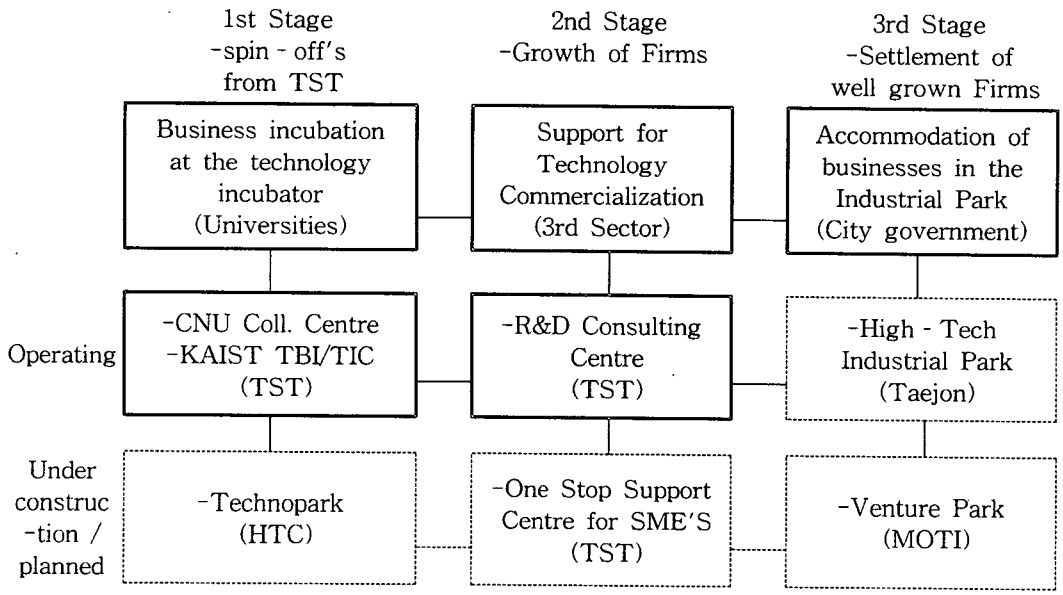
The higher portion of R&D Centers in Taejon shows the better possibility of developing concept (complex of R&D and industry) than any other regions in Korea. Especially the development concept of business incubation for supporting the spin-off activities must be emphasized in the area of Taejon,

which is the mother city of TST. But, the resident labor force in Taejon is disproportionately concentrated on commercial and service occupants. They are employed mostly in semi-skilled and low-skilled occupations. With the consideration of this situation, there needs to be innovative strategies to attract scientific entrepeneurs from universities and R&D centers in TST and to mature to the point of development as viable enterprise. As mentioned above incubation centers can play the role of this innovative strategies. The development strategies of business incubation and support mechanism in Taejon can be identified as follows(see Figure 1).

(1) First stage : development of business incubator

A model type of incubation centre was established in TST, which provided an interface between research and production in the field of high-technology. Its main aim is to support the spin off activities from the TST and to promote the expansion of those start-up firms. It is funded mainly through public subsidies. At present these kind of incubation centers are now operating at the universities in TST. It provides about 21 units in KAIST-incubator(TBI) and further 15-20 tenant units in the CNU(Collaboration Research Centre) will be leased to start-up firms in the field of high-technology which focuses on new

Figure 1. Development Stages of High-tech Firms in Taejon Metropolitan City.



materials, computer science and telecommunication. The business in these centers has a more advantageous position than the firms in other industrial estates because of the reasonable technology and business supports. For example, the incubators provides inexpensive space to high-tech start-up companies, which also provides common business services. They receive technical assistance through the Technology Commercialization Center and can receive financing through the seed-capital corporation. Four kinds of supportive activities, low-cost space, shared services, technical assistance, and financing, are the major advantages that start-up business requires to begin operating. The seed-capital fund and the technical-assistance operation also draw business to the incubator and all reinforce one another. This support is offered in the first 3~5 years of a new firm's existence, the most crucial period in its ultimate survival.

(2) Second stage: development of technological support/ technology commercialization center

At the second stage it is important to establish the mechanism for technological support, collaborative research and technology commercialization. In TST there is The R&D Consulting Center at KORDIC(Korea R&D Information Center)of KIST(Korea Institute of Science & Technology) connects industries with government-supported institute to develop domestic industrial technologies and promote international competitiveness.

Its major activities are as follows :

- efficient utilization of R&D resources, such as manpower, equipment, technology and domestic and foreign technological information
- to support high-tech small and medium-sized firms by providing information on technological know-how, funds, etc.

In addition Technology Commercialization Center which is an office charged specifically of providing businesses with direct access to the research institutes in the science town, the universities' and private firms in the city will be established in the TST. This centre also should have the capacity to pay the experts of university and research institutes to consult for small companies which need specific help in developing their technology-oriented businesses. More importantly, the centre can act as a window out for scientists seeking to commercialize their research results. This center as a linking mechanism is very essential to TST because both research institutes and universities do not know what kinds of specific

researches industry wants, and industry does not recognize what kinds of research are done. With this technical-assistance mechanism of Technology Commercialization Center, a non-profit investment corporation will be set up by universities, the research institutes, the city and private sector. It should have a seed-capital and lending fund to encourage entrepreneurship and new job creation in the industrial park with a particular emphasis on high technology start-ups in TST. The investment corporation can make both loans and equity investments. The one-stop support centre, which will be opened next year, has this kind of investment corporation. Only through the connection with the R&D consulting centre we can cover the need of support mechanism for SME'S, in particular the spin offs' from TST.

(3) Third stage : support for the settlement of well grown high-tech firms

By the incentive effect of university based incubation centers at the beginning stage, venture park in the other areas close to TST will be built at the development stage of incubation policy. The Taejon high-tech industrial park can be the good places for it.3) These development are envisaged to promote the third sector planning concept to help business spin out from either the host organizations or other large corporations within the area of Taejon. These parks will essentially have lower service level than that of the first incubation center, but they have more rooms and site for the developing firms. There will also be more flexibility of units, leases, and other service activities.

In addition, the public organization will give support to the businesses which have been successfully developed through the first and second stage. In the high-tech industrial park the city of Taejon will provide them with a site which can accommodate businesses requiring self-containing, prestigious, stand alone building of their critical mass. They can also construct their production facilities in any other industrial estates of Taejon. When the start-up firms succeed in standing alone at one of those industrial parks, it is truly the final stage for the incubation of spin-off activities. This is one of the important functions of the new high-tech industrial park, which will have a significant influence on the economic development in Taejon.

6. Conclusion

In this paper, the infrastructure and support mechanism for technology commercialization in the science park has been evaluated with particular reference to Taedok Science Town. The

critical question is what can be learnt from the experiences of Taedok Science Town as to how science park should develop in order to support the technology commercialization and business promotion and also to benefit the regional economy as well as the local industrial structure. There are several important findings from Taedok Science Town's experience which are crucial to the future development of local high-tech centers in Korea.

Firstly, these is the role of a high-grade university, the location of a variety of research facilities, and the attractiveness of the area to highly-qualified workers and entrepreneurs as a place to live and work together. These are almost certainly essential background for the development of science parks.

Secondly, there is a need to create business incubators and technological and financial support mechanism to maximize the opportunities for technology transfer between academic and research facilities and private firms. In particular, the experience of Taedok Science Town shows how university-linked agencies can promote their development

Thirdly, there is the need for local initiatives to reinforce technology-led economic development. Their efforts should focus on attracting high-tech industries and establishing promotional organizations. The establishment of industrial parks (Taejon Technopark) where R and D activities can be promoted and commercialized, makes sense in this respect.

Finally, Taedok has shown that technological spin-offs and firm creation are of more importance than the relocation of basic research establishments to ensure successful regional economic development and local industrial progress. It also appears likely that policies to promote spin-offs and foster new firms will be a key element in the successful development of technopolis in other localities.

Although unique in several respects, these aspects of Korea's experiences may thus carry policy implications that will be of interest to governments who want to enhance their country's indigenous technological potential, in particularly developing countries.

Even the study identified that technological spin-offs and several action programs for technological transfer in TST are in a fever, relationship between TST and regional economy has not reached a sufficient level. One of the major reasons of the weak relationship is that Taejon has not developed a strong linking mechanism, which is largely composed of action programs, that combines each resource of research institutes, universities, and a community. More importantly, the action programs will act as a window for TST, universities, and a community

including business society seeking to commercialize research results and relate commercializtion of research results to vitalization of regional economy.

The linking mechanism may be very essential to Taedok Science Town because both research institutes and universities do not know what kinds of specific researches industry wants, and industry does not recognize what kinds of research is done. In order to foster regional econmy via commercialization of TST research results, more designated linking programs combining the sectors should be developed. Considering the poor number of spin-offs compared with the high entrepreneurship in Taedok Science Town, Taejon would rather accelerate researchers' technology commercialization by developing a strong linking mechanism in advance than wait for the establishment of new business.

Notes

1) Unlike the locally-based national university, KAIST was established at the end of the 1960s in Seoul with three major objectives: encouraging scientific intellectuals to lead R&D activities in technology; educating students who are gifted in science; and promoting R&D activities through collaboration are gifted in science; and promoting R&D activities through collaboration between university and research institutes.
2) Most of the R&D centers of private firms, which have been or will be located in TST, are expected to gain from these direct and functional links with KAIST.
3) There is a site (area: 16,500㎡) for the incubation centers in the development action plan of Taejon high-tech park according to revised economic development plan by Taejon city.

References

City of Taejon, 1997, *The Annual Report of City Development Taejon*, Korea,(in Korean).

City of Taejon, 1996, *The Plan of Taejon High-Tech Centre in Economic Development Plan*, Taejon, Korea(in Korean).

Grason, L., 1993, *Science Park: An Experiment in High Technology Transfer*, the British Library, London.

Jin, Y.H. and Park, Y., 1990, "Development strategies for high-tech industrial parks in Korea," *Proceeding of Korea-UK Joint Symposium* KRSA, pp.1- 21.

Kim, Y.W., 1991, *Organization and Industrial Linkage in Developing Countries A Case Study of Less Industrialized Region in Korea*, Ph. D Dissertation, University of Sheffield.

Lee, J. Y. et al., 1990, *Taedok Science Town and its Impact on Economic Development of Taejon*, CNU (in Korea.).

Masser, I.(1990), "Technology and regional development policy: a review of Japanese technopolis programme," *Regional Studies*, 24, pp.41-53.

Most (Ministry of Science and Technology), 1992, *Taedok Science Town: Future Development plan of Technocomplex in Korea*, MOTI, Seoul, Korea, (in Korean).

TSO of (Ministry of Science and Technology), 1996, *Taedok Science Town*, Information Paper, Taejon, Korea.

Oh, D.S. and Kang B.J, 1997, "The evaluation of technopolis development in Korea," *Paper present at Techno 'Conference 97'*, St. Petersburg, Russia.

Oh, D.S. and Park, M.S., 1992, *Development Strategies of Taedok*, KOSEF, Taejon,

Korea(in Korean).

Oh, D.S., 1990, "Development of Tae-dok Science Town and the linkages between its R & D and new high-tech industry," Proceeding of Korea-U.K. Joint Symposium, *KRSA (Korean Section of Regional Science Association)*, Taejon, pp.113-125.

Oh, D.S., 1991, "Planning of high-tech industrial park," Paper to International Symposium on the Experiences of High-Tech Industrial Parks, *KRSA(Korean Section of Regional Science Association)*, Cheongju, PP. 235-238.

Oh, D.S., 1996, "The planning of science park and regional development strategy," *Proceeding of the International Symposium on Science Park and Regional Development*, CNU, Korea, pp.5-27.

Oh, D.S and Kang, B.S., 1992, "development of Tae-duk Science Town: strategies for the business incubation," *Proceedings of the International Symposium on The Development Strategies For Science Town*, Taejon, Korea.

Oh, D.S and Masser, I., 1995, "High-tech centers and regional innovation: some case studies in the UK, Germany, Japan And Korea," in C.S Bertuglia et. *al (eds.), Technological Change, Economic Development and Space*, Springer-Verlag Berlin & · Heidelberg, Germany, pp.295-333.

Oh, D.S., 1995, "High technology and regional development policy: an evaluation of Korea's technopolis programme," *Habitat International* Vol.19,No3, Pergamon, pp. 253-268.

Park, S.O., 1989, "Location of high technology industries and regional economic development," *Korean Journal of Regional Science5 (2)* pp.1-19(in Korean).

Park S. O., 1991, "Development of high-tech industrial park: strategies and policy issue," *Proceeding of International Symposium on Experiences of high-Tech Industrial Parks, KRSA*, Cheongju, pp25-47.

Park, S.O., 1991, "Science parks: problems and strategies," *Proceeding of International Symposium on the Development Strategies for Science Town*, KOSEF, Taeion, pp.235- 268.

Similor, R. et al., 1988, *Creating the Technopolis, Ballinger*, Cambridge, MA.

Wessel, K., 1991, *Raumstrukturelle Veräenderung im Entwicklungsprozess Süedkoreas*, Hoeller und Zwick, Hannover.

ABSTRACT

This study aims to identify the role of science park for technology commercialization and business promotion.

After theoretical review about science park and technology commercialization, the instruments for stimulating entrepreneurship and business in science park are described. The experience of Taedok Science Town is examined in terms of main sectors of activities, universities as base for technology transfer and the potential for technology commercialization. In conclusion, the complex model is suggested as the development strategy for business incubation in accordance with the stages of development and active technology commercialization.