Experiences of Technopolis Development in Republic of Korea: Policy and Recent Trends

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1. Introduction

Technopolis is a regional innovation strategy that generates sustained and propulsive economic activity through the creation and commercialization of new knowledge(Preer, 1992). A technopolis is not merely a concentration of high-technology firms or research and development organizations. At the center of the technopolis is the creative process of developing new technologies and translating them into commercial products or processes. But, a frequently raised question so far has been how to measure the effectiveness of technopolis as an instrument of regional innovation policy to stimulate technology-led economic development.

Korean experience is interesting in this respect not only because of the extent to which it reflects regional innovation and economic growth but also because of the way in which policy trends have been incorporated into regional conditions and tasks of national development(Ko, 1998). Recently, regional innovation policy based on technopolis in Korea is one of critical instruments to achieve regional economic growth and sustainable development through networked collaboration between HEI's, research institutes and industries. It is expected that technopark can be regional platform for comprehensive approach of technology-based regional development. This is particularly apparent in Daedeok Valley (hereafter referred to DV) which utilizes technology led development as a means of promoting the regional innovation for sustainable development in Daejeon city(Oh, 2004). Daedeok Valley is also the good examples of explaining these impacts of regional development through the creation of the technopolis. Particularly, there are clear evidences of strong expansion of high tech venture businesses due to successful development of DV shift from pure science city to technopolis.

This paper reviews the policy trends of technopolis in Korea with particular reference to Daedeok Valley. The paper is in four parts. The first of these outlines the policy and recent trend of technopolis in Korea. It describes the context within which this policy has developed. The second examines the experience of one of the successful sites, DV in more depth. This highlights the ways in which DV has been in the shift from science city to technopolis. The major research interest is focused on the question "what kinds of shift have been made on the changing process from pure science city(DST) to technopolis(DV) for 30 years in terms of three aspects like structure, activities and network. The third section evaluates its impact on regional development. The last part of the paper evaluates the effectiveness of technopolis policy and discusses some of key issues for sustainable development.

2. Policy and Recent Trend of Technopolis in Republic of Korea

Three clear phases of technopolis development are evident in Republic of Korea : the National Science Town at Daedeok in the 1970s and 1980s ; the technopolis programme and local technoparks from 1989 to 2000 ; and Regional Innovation System(RIS) started from the National Balanced Development Plan (NBDP) and Innovation City planned competitive strategy transferred from countries to cities by National Balanced Development Plan since 2003. The key features of Technopolis development in Republic of Korea show us changes of the policy following three phase (see Table 1.).

Development	Features	Examples
First Phase 1973-1989	**Science City** - basic research orientation - Central Government initiative	**Daedeok Science Town(DST)** **Daedeok Valley(DV)** : DST and its vicinity(DTV) designated in 2002 (National R&D Special Zone)
Second Phase 1990-2000	**Technopolis** : early stage of Development - 9 sites designated (only one being built) - research and production focus - Central Government initiative (very little participation of local authorities) **Technopark** : mature stage of development - focused on production by high-tech firms - public and private sector collaboration	*Initial stage* **Gwangju Technopolis** **6 pilot projects of technopark** : Daegu, Kyonbuk, Chungnam, Gyeonggi, Songdo, Gwangju
Third Phase 2000-	**Innovation City Project** **in Regional Innovation System**(RIS) : - emphasizing the role of local authorities based on National Balanced Development Plan - regional innovation and economic development based on the Technoparks - platform between sectors of industry, academia and government	**10 cities (in 11 regions)** - Jeonju, Ulsan, Naju, Gimcheon, Busan, Jinju, Daegue, Wonju, Jincheon-Umseong, Seogwipo - Population : 20,000~50,000

Source: Author, 2006.

Table 1. Key features of Technopolis development in Korea

2.1 First Development Phase : Daedeok Science Town(DST)

The first development phase began in the 1970s when the National Science Town was established at Daedeok, in Daejeon. Daedeok Science Town(hereafter DST) were intentionally created as an engine of enhancing national competitiveness of high technology and economic prosperity through the agglomeration of research institutes bring together many national and regional development policy efforts from the last 30 years. The plan represents a concreted attempt by central government to create a science city(Technopolis) outside the capital region. Especially, it was expected that DST can enhance research efficiency through a systematic and comprehensive R&D investment to each institute, create an optimal research environment by mutual exchange and application of a variety of information, knowledge and know-how, and promote investment effectiveness by the shared use of facilities, manpower and projects. In order to achieve aims, the development of DST in the initial stage was centered on public sector research institutes and nationally funded universities (Oh, 1995). The main objective of this first development phase was to establish a strategic science and research center for the development of high technology since the government sought to raise its technological trajectory of future industrial development. Thus, DST is located in Daejeon, approximately 150km south of Seoul, the capital of Korea. Daejeon is itself located in the center of South Korea, which received strategic projects such as new government office complex and 1993 Daejeon Expo to promote balanced regional development. The construction of DST was also a project to realize the national objective of decentralization of population and industries from the Capital Region where continued concentration was occurring. The plan and construction of DST started in the 1980s and was completed in 1989 with most of the science facilities and research institutes established. DST encompasses 6860 acres of land, which is similar size as the central research and education district in Tsukuba Science City in Japan (6669 acres). Initially, the development was centred on public sector research institutes and nationally funded universities, but by the late 1980s private sector research institutes began to relocate from the Capital Region, which is continuing to the present day.

DST brings together many national and regional development policy efforts from the last 20 years. The plan represents a concerted attempt by the central government to create a technopolis outside the capital

region. The objectives of DST development include: (1) creating a foundation for joining the ranks of the advanced countries. The 21st century based on science and technology development, (2) fostering closer links among research institutes, academia and industry through the effective placement of government-supported research institutes, universities and private research institutes, and (3) establishing a pollution-free science garden city with cultural facilities. Especially, it is expected that DST can enhance its research efficiency through a systematic and comprehensive R&D among each institute, create an optimal research environment by mutual exchange and application of a variety of information, knowledge and know-how, and promote investment effectiveness by shared use of facilities, manpower and projects. Establishing DST has been regarded as a way of maximizing the use of limited R&D resources. However, the development of technopolis program is closely tied to central government priorities. The dominant role of the government is particularly evident in the first phases of DST development, which were established by a central government initiative; local authorities were excluded from the initial planning of the technopolis program particularly that of DST. Because of such exclusion, there seems to be a lack of closer linkage between technopolis and regional industrial development.

In the 1980s at the initial stage of development, the function of DST was to establish a R&D center for government supported institutes and industries through the relocation policy of central government. In the early 1990s, the completion of construction of DST became a priority. There was a change in the expectations of the role of DST due to changing economic and social climate. In the original plan, DST was envisaged to play a role as a center for pure scientific research in Korea. However, recently applied research and development that are directly applicable to commercialization has become an expectation. Therefore, DST has been criticized for being unable to fulfill such needs (Shin and Sul 1999). Since the mid 1990s, efforts are being made to enable high-tech venture firms to be established in DST with mechanisms to support the commercialization of R&D results achieved in DST. The main components of this mechanism are TBI (Technological Business Incubator), Post-TBI and venture park where start-up firms can direct their efforts in commercializing their new technology.

In 2000, central government has designated DST and its vicinity as Daedeok Valley(hereafter DV) for the further development of technology commercialization based on R&D. This variety of high-technology based development activities enable the Daedeok Valley(DV) to be re-designated the first National R&D Special Zone[1] to carry out the pilot project of regional innovation and technology-led economic development with strong support from central government. According to the report of the DV Managing Office, DV is a place where people, technology, and nature harmoniously coexist as well as where business and research activities are conducted efficiently and conveniently. But much more than that, it's a world-class innovation cluster where creativity openly blossoms and breathes.

2.2 Second Development Phase : Technopolis, Technopark

The second development phase occurred in the late 1980s. There were technopolis development drew heavily upon the development experience of US and Japanese technopolis. They were intended to be more production-oriented and to promote regional economic development. Korea's basic plan for technopois development was conceived in 1989 as an adjunct to national economic growth and physical planning of the country as a whole. The Korean technopolis programme aims to promote industrial development by raising the technological level of local business and establishing high-tech industries in peripheral areas, to encourage R&D to ensure sustained regional development and to create attractive local communities where people can live and work(MOST, 1989). Nine sites had originally been designed as technopolis, but only one of them, Gwangju, is being built. Six had been subsequently re-designed as local high-tech industrial parks or technoparks. In selecting appropriate locations for technoparks, the central government took into consideration similar factors to those applied in the designation of technopolis. These included proximity to a major city(the mother city), proximity to universities and research institutions, the current agglomeration of industries and national policies for balanced regional development and good access to highways(Kang & Oh, 2002). The possibility of

[1] National R&D Special Zone : all accommodating within the Daejeon Metropolitan City - Daedeok Science Town(DST), Daedeok Techno-Valley(DTV), Industrial Complex, Yuseong Tourist zone

collaboration between university and industry, however, had been confirmed through the development of collaboration center between university and industry leading by some universities in Korea. On basis of these experiences, Ministry of Industry and Resources (hereinafter referred to MIR) had promoted the development of technoparks leading by local governments and local universities in 6 regions of Korea since 1997. At the same time, incoming private sector companies are regarded as key actors in the technological innovation process. Central government supported these 6 pilot projects technoparks in providing facilities and equipments and local governments gave support in management and other expenditures. These projects were completed in year 2002 and the 6 above mentioned technoparks are expected to be sited down as platforms of region innovation, which can facilitate technology-based development through close collaboration between local universities and industries (see table 2.).

	Case	Location	Development Year	Area of the Site	Central Operating Body
National Pilot Projects	Daegu Technopark	Daegu	1997	130,081㎡	Incorporated Foundation of Daegu Technopark
	Kyongbuk Technopark	Kyungsan	1997	463,000㎡	Incorporated Foundation of Kyongbuk Technopark
	Chungnam Technopark	Asan Chonan	1997	208,873㎡	Incorporated Foundation of Chungnam Technopark
	Gyeonggi Technopark	Ansan	1997	90,900㎡	Incorporated Foundation of Gyeonggi Technopark
	Songdo Technopark	Incheon	1997	55,000㎡	Incorporated Foundation of Songdo Technopark
	Gwanju Technopark	Gwanju	1997	60,600㎡	Incorporated Foundation of Songdo Technopark
MCIE approved Technopark	Busan Technopark	Busan	1999	42,420	Incorporated Foundation of Busan Technopark
	Pohang Technopark	Pohang	1999	187,324	Incorporated Foundation of Pohang Technopark

※ MCIE : Ministry of Commerce, Industry and Energy, Republic of Korea

Source: Presidential Committee of NBDP(National Balanced Development Plan) 2004.

Table 2. Technoparks in Korea

2.3 Third development phase : Innovation City based on Regional Innovation System(RIS)

The third development phase has been emphasizing the role of local authorities in the settlement of the Regional Innovation System(RIS) in their regions. The central government called 'Participatory Government', which started in 2003, established the goal of national balanced economic development to solve the huge con-centralization of business and industries in Seoul metropolitan area. In presenting its national vision, the central government encourage every regional government to establish a unique strategy of regional economic growth, based on their specific characteristics and competitive advantages. Whilst developing the third stage of development of the technopolis programme, the government realised that local initiatives are indispensable for technology-led regional development. Hereby technoparks represent a new process of development as a basic tool of regional innovation. At present technoparks are located in 15 cities within 7 provinces. There are 12 technoparks under operation in Korea, now (pilot-technoparks in 6 region in 1997, 2 technoparks that was started in 1999, and 4 technoparks began to operate newly in 2003). For the purpose of enhancing regional competitiveness local governments are preparing 'Five-year Regional Innovation Plan' by utilizing technoparks based on 'Five-year Plan of National Development Plan' which was established by the central government. In this local plan, technoprk can be used as platform where sectors of industry, academia and government work together towards the technology-based development. It is expected that the regional development policy based on these successful technopark programs strongly lead to the regional innovation and local competitiveness.

• Concept of Regional Innovation System (RIS)

Regional Innovation System can be defined as systemic networks, which are established by an active interaction between various elements present through the process of creation, and diffusion of new knowledge and technology. The roles of regional innovation system are to maintain an internal institutional consistency by controlling functional redundancy and to organize local innovation to make infrastructure run more effectively. Regional innovation systems connect local innovative actors to their supporting organizations, such as industries, research institutes, universities, and transfer centers of technical know-how, with regional clusters. This process builds a close cooperative system and contributes to the development of innovation. In this process, local government try to activate the connection between organizations and enhancing their effectiveness, while the central government needs to mediate, facilitate, and support regional technical innovation systems.

The regional innovation system is based upon the experiences of developed regions and differs from technology innovation theories that espouse industry zones or innovation environments, therefore; it is possible to apply this system to structurally weak regions. Moreover, because the system has an evolutionary characteristic, it can advise local policy decision makers to move towards effective development by investigating local routes to development (Cook et al. 1998).

Consequently, regional innovation systems integrate the efforts of the components of technology innovation, specifically medium and small-sized business, large enterprises, research organizations, universities, and technology transfer centers, within an innovative regional cluster. This process establishes a close cooperative system, and more readily facilitates the successful incidence of innovation(Kang, 2004).

• Technopark in the Model of Regional Innovation System (RIS)

The regional innovation system can develop an environment which can encourage local industry with the formation of a technology cluster and the networks which are necessary for the process. With the focus on the production system, the basic model of the regional innovation system coordinates human resources and technology in the area of technology development and provides financial resources and know-how (management and information) to facilitate business support. The basic resource, which is necessary for the building of regional innovation systems, is the ability to network and collaborate among resources of human capital, technologies, financial sources, know-how and infrastructure (Kang, 2004).

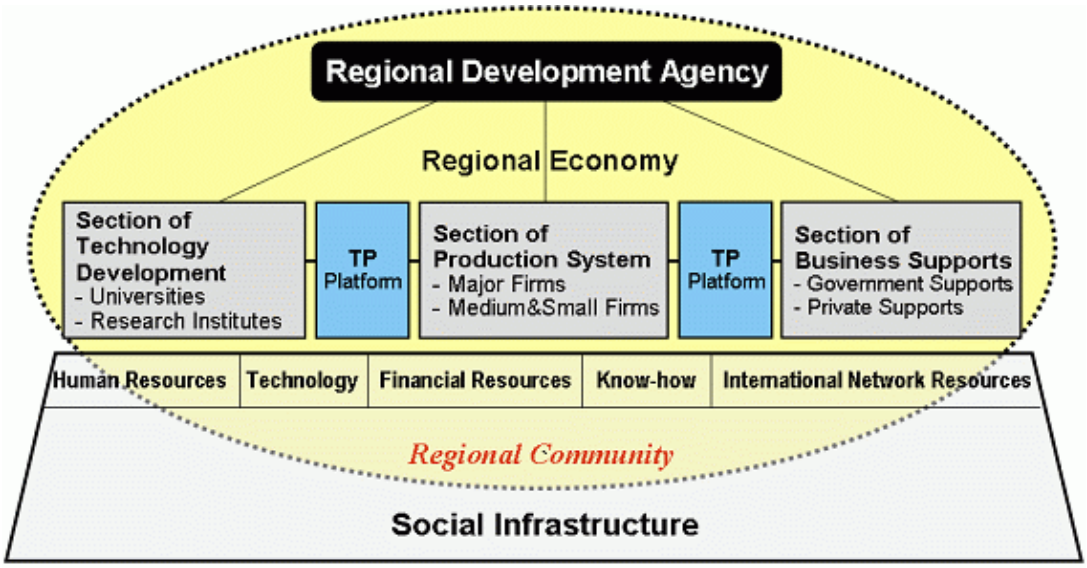


Figure 1. Model for the Building of the Regional Innovation System

Note: RCC(Regional Research Center, source: PCNBD,2004

Technopark is the main elements to let the section of technology development, section of production system and section of business supports. Technopark is the platform between industry, academia and government. Therefore technopark play the main components to let RIS model operated in reality. The basic RIS model emphasizes the operational framework of the organic growth of regional innovation systems as well as expanding the availability of necessary resources for local industrial development as it focuses on the development of local industry to maximize the potential of the region. The RIS model stresses indirect support to the business environment including the formation of networks and emphasizes an institutional framework for planning and coordinating extensive systematic industrial development by the economic agents in the region(Kwon, 2000). As a coordinating organization for the development of local industry, the Regional Development Agency(RDA) assembles the core components of the region and coordinates the development of the network. The regional innovation system pulls together community resources such as human capital, technologies, financial resources, know-how, and the international network to increase the frequency of innovation by narrowing the barriers between technology development production systems and business support. The centre of the regional innovation systems is the strategy of using technology commercialization to connect innovation with commercialization rapidly(Kang,B.S, 2004). From this perspective, the regional innovation system (RIS) as a basic strategy in promoting regional innovation and technology-led economic development can have an impact on the structure(function), activities and networking in the technopark development through the significant and mutual linkage.

• Construction of Innovative Cities

Local cities, in general, cannot satisfy the necessary conditions to be a core of regional innovation. So, central government construct some innovative cities or innovation districts in the local areas to foster them as centers of regional innovation. An innovative city means 'a geographic concentration where innovation is created, diffused and utilized by cooperation among relocated public organization, industry, academia, research institute and government in region.' Especially, the relocation of some public organizations from Seoul to localities is expected to be a catalyst to stimulate the construction of innovation city, which consists of innovative actors, support environments for innovation activities and basic infrastructure.

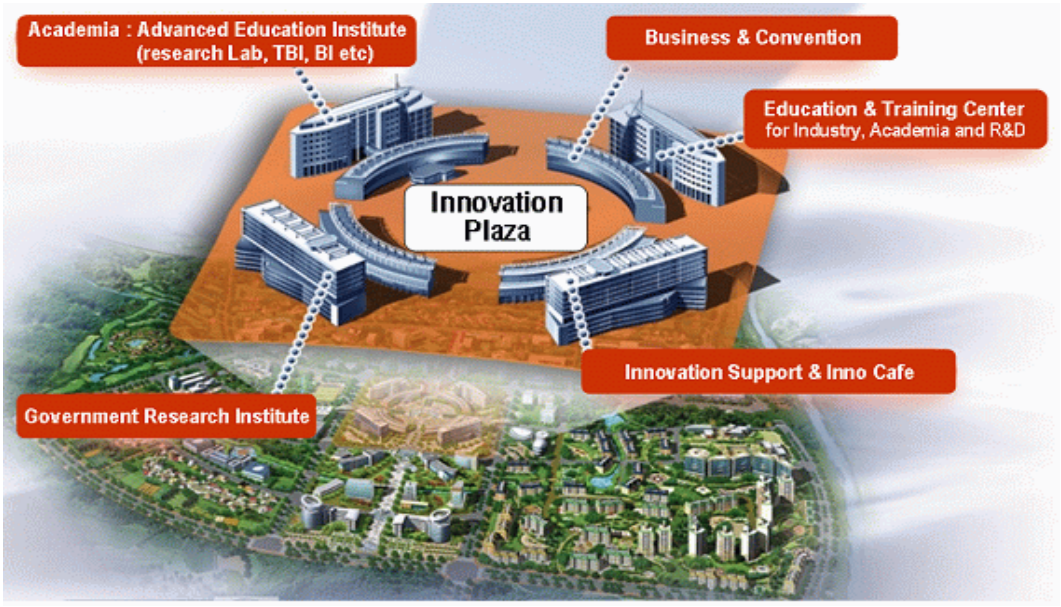


Figure 2. Concept of Innovation city : Innovation Community

Source : Innovation City, the Future for the Region, Presidential Committee of NBDP(National Balanced Development Plan), Ministry of Construction & Transportation, Korea Land Corporation, 2006

To succeed RIS in innovative cities, the critical question is how to create and sustain regional innovation. Because regional innovation is made come true with close network of networks among various actors in government does its best to build RIS nationwide and concentrates on three key strategies for it: organizing of Regional Innovation Association, fostering the capabilities of local academia and vitalizing new cooperation between industry and academia.

Regional Innovation Association (RIA) is a delegation of all innovative actors in region and plays the role of coordinator and facilitator for regional innovation. RIA formulates the vision, strategy, major tasks for regional innovation and facilitates the network building among innovative actors. RIA, in addition, plays the roll as a bridge of the communication between the platform of RIA and locality and an innovator of strengthening regional competence for innovation and diffuse innovative atmosphere in regional community. At present, there are 14 RIAs which are working nationwide.

Local academia plays very important roll in the building-up of RIS because academia produces knowledge-based businesses in the basis of its technology in addition of its basic role of education. Local academia, moreover, has also to accelerate R&D and technology transfer as a regional R&D center. Central government plans to concrete the system for human resources development, with the good excellent educational environment in advanced technologies. University-based RIS projects called NURI were designated by the Ministry of Education in cooperation with local governments to carry on above mentioned objectives. For example, NURI project aims to strengthen the innovative competence of local academia and propel the capacity restructuring of local academia. It develops various incentives for the improvement of working competitiveness of local academia. New pattern of the cooperation between industry and academia is centred on technology, commercialization and business. NURI project will foster some local universities as hub universities for the close cooperation between industry and academia.

	Regions	Roles and Features
Local Technoparks	• Jeonnam Technopark(2003) : 60,600㎡ • Gangwon Technopark(2003) - Chuncheon: 35,602㎡, Wonju: 33,580㎡ - Gangneung : 66,000㎡ • Chungbuk Technopark(2003) : 233,310㎡ • Jeonbuk Technopark(2003) : 66,000㎡	• **Plat form** for the sectors of industry, academia, and government work together towards the technology-based development
Innovation City Projects (10 cities in 11 region)	• Jeonju (Jeonbuk) • Naju (Jeonnam, Gwangju) • Gimcheon (Gyeongbuk) • Jinju (Gyeongnam) • Wonju (Gangwon) • Jincheon-Umseong (Chungbuk) • Seogwipo (Jeju) • Ulsan (Ulsan Metropolitan City) • Busan (Busan Metropolitan City) • Daegu (Daegu Metropolitan City)	• **Summary of Project** - based on National Balanced Development Plan(NBDP, 2004) - Period : 2005-2010 - Population : 20,000~50,000 - Size : about 1,650,000~8,250,000㎡ • **Innovation Community** - Collaboration between Industry, Academia, R&D, and Government etc.

Table 3. Features of Local Technoparks and Innovation City Projects

Source : Innovation City, the Future for the Region, Presidential Committee of NBDP(National Balanced Development Plan), Ministry of Construction & Transportation, Korea Land Corporation, 2006

3. Case Study

: Technopolis Development from Daedeok Science Town(DST) Daedeok Valley(DV)

3.1 Analysis Framework

This study offers an analyzing framework to examine the experience of DV in depth. This highlights the ways in which the technopolis policy has provided a framework for local efforts to promote regional innovation and economic growth. In the first part, we describe the background, development features of the Daedeok Valley. The second section development of DV is analyzed and evaluated in terms of structure, activities, network which are major factors of technopolis development.

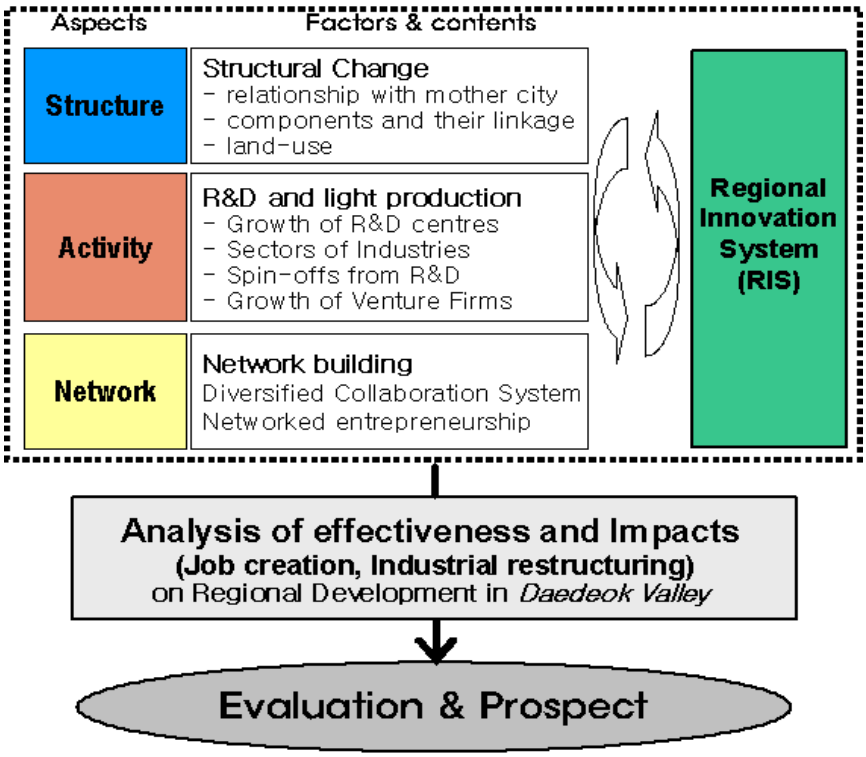


Figure 3. Analysis Framework : major aspects of technopolis development

The detailed factors and contents of analysis is as follows : As for structure, there are four factors of analysis related with technopolis development such as the relationship with mother city, land use, major components and their linkage. In the part of activity, growth of R&D centers, sectors of industries, spin-offs from R&D, growth of venture firms are analyzed in detail. Because significant value of the technopolis lies in its potential for achieving a synergistic rate of technological innovation through assist the development of dense communication networks among heterogeneous R&D activities (Rogers and Dearing, 1990).

Research interests are focused on network, which is a strategic linkage among the R&D centers, entrepreneurs and universities for regional development. In this respects, we analyse network building in terms of diversified collaboration system and the process of the networked entrepreneurship in DV. In the last part, the effectiveness of technopolis policy in DV is analyzed with respect to impacts on regional development including job creation, industrial restructuring etc.

3.2 Overview of the Daedeok Valley(DV)

Daedeok Science Town (hereafter DST) within Daedeok Valley is the unique science town in Korea which has been developed as a Mecca of science and technology with strong research workforce. It has been built with the investment of KRW 30 trillion for the past 3 decades. It also possesses the mixture of next generation technologies such as IT, BT and NT. As mentioned before, it has been well developed with the balance amongst research institutes, academic institutes, industries and public sectors where they possess the model of next “Silicon Valley” in Korea.

From the late 1980s, private sector research institutes began to relocate from the Capital Region into DST, which resulted from the changed objective of government that promoted applied research by private R&D centers. In the late 1990s, another new change began to rise in DST. Through spontaneous entrepreneurship of venture industries, the industrial activities of DST have been activated. Since then, the whole industry structure in Daejeon has been modified to "high-tech production venture." This has been continuously developed with supportive policies. In 2000 central government has designated DST and its vicinity as Daedeok Valley for the further development of technology commercialization based on R&D. At the present, there are 824 ventures accommodating in Daedeok Valley. This will lead to a unique venture valley in the country as the high-tech city. These high-tech firms and private research institutes made R&D and industrial activities more varied. This variety of high-technology based development activities enable the Daedeok Valley(DV) to be re-designated the first National R&D Special Zone[2] to carry out the pilot project of regional innovation and technology-led economic development with strong support from central government. As the cooperation between industry, universities, research institutes and government organizations has improved, Daedeok Valley has developed into a cluster of high-technology firms.

Since 2000, DST faced a new turning point in terms of urban structure and functional change. Daejeon City Administration mapped out a scheme to develop a high-tech industrial district, so-called 'Daedeok Valley'. DV links DST to several critical areas in Daejeon City. DV is a regional innovation strategy to generate a maximum synergy effect by linking these critical areas functionally and spatially. In terms of functional change, DST in the initial stage functioned as a science city, which modelled after Tsukuba Science City in Japan. It focused on R&D and education to enhance the capability of high technology development. Above all, it concentrated on pure R&D stressing on basic research and restricting production and other industrial activities. Since manufacturing was allowed with restrictions in DST, this model was not appropriate for the regional industry and economy. As a result, DST as a model of science city was subject to criticisms.

However, as many private R&D centers moved into DST, DST began to function gradually as a multifunctional technopolis. Private R&D center has an aptitude to directly link R&D to industrial activities because it has an attribute to pursue profits like an enterprise. Accordingly, it caused the acceleration of technology commercialization in DST. From the late 1990s, venture incubation had begun to grow remarkably in DST. Under these circumstances, a demand for industrial function was raised not from outside but inside of DST. Moreover, because Daejeon Science-industrial Park will be created near DST, the development of DST as a multifunctional technopolis will be accelerated (See Figure 4).

1973-1977 Infrastructure Construction	May 1972 : Elementary plans for town construction decide March 1974 : Construction commences for facilities and institutes
1978-1989 R&D Capacity Expansion	April 1978 : Research institutes start moving in (Standard/Chemical/Shipping Institute) August 1981 : "Fundamental Construction Plan for Daedeok Industrial Base"
1990-1999 Innovative Creation	Nov. 1992 : Daedeok Science Town completed, private research institutes moved in Dec. 1993 : Daedeok Science Town Administration Law enacted Jan. 1997 : "Daedeok Science Town Management Plan" was announced
2000-2004 Cluster Formation	March 2000 : High-tech start-ups started moving in, DST renamed as Daedeok Valley(DV) Nov. 2004 : Daedeok R&D Special Zone Law enacted
2005- DAEDEOK INNOPOLIS Launched	Jan. 2005 : Daedeok Science Town/Daedeok Valley/Special Zone redesigned as "DAEDEOK INNOPOLIS" Sep. 2005 : DAEDEOK INNOPOLIS HQ was founded Nov. 2005 : Creation Brand Identify logo

[2] National R&D Special Zone : all accommodating within the Daejeon Metropolitan City - Daedeok Science Town(DST), Daedeok Techno-Valley(DTV), Industrial Complex, Yuseong Tourist zone etc.

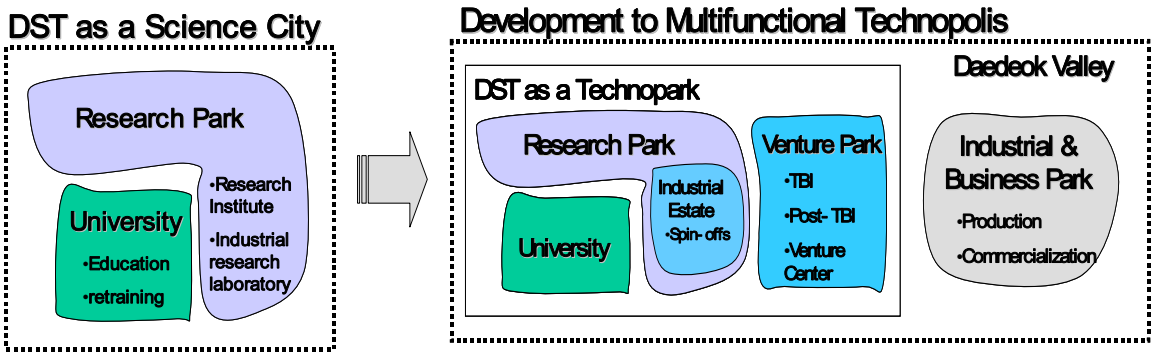


Figure 4. History and Functional Change from Science City to Technopolis

Daedeok Valley is now becoming the high-technology clusters where the applications of intellectual property based on R&D are made very actively. It is, also, the only place for highly educated workforce of R&D with 10% of Ph.Ds in entire Korea. It consists of the most convenient facilities for the technology commercialization of specialized industrial sectors like IT, BT and NT with the research institutes and universities together.

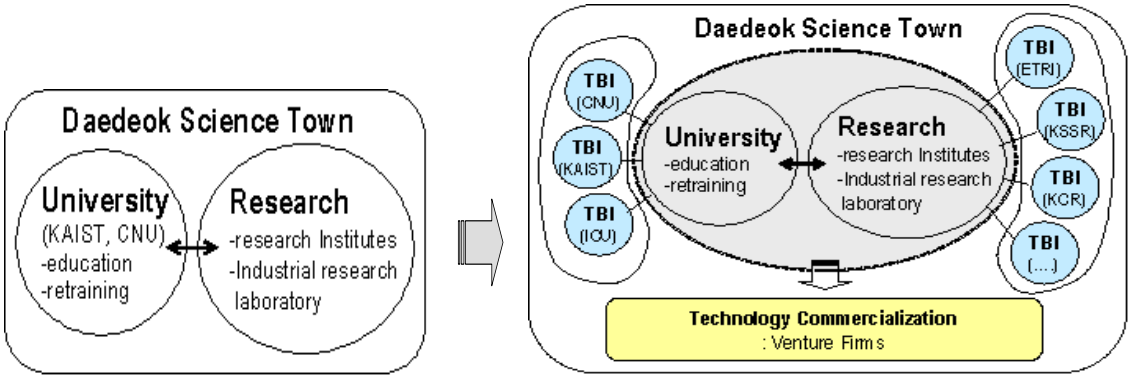
3.3 Analysis of Development Features

3.3.1 Structure

DST was planned as a satellite city at the initial stage. Even though DST is close to it's mother city Daejeon, the relationship between DST and regional economy in Daejeon was not positive. The location of DST was only important in terms of national goals. When DST was incorporated administratively into Daejeon in 1983, DST was merely a secondary urban center.

From the end of 2000, DST is faced a new turning point in terms of its role for urban structure. Daejeon Metropolitan City Administration mapped out a scheme to develop a high-tech industrial district, Daedeok Techno Valley(DTV). DTV links DST to several other critical areas in Daejeon Metropolitan City. DTV is a bridge between pure science city and technopolis towards regional innovation strategy to generate a maximum synergy effect by linking these critical areas functionally and spatially. DV can be understood as the comprehensive approaching policy to contain DST's R&D function, technology commercialization of DTV and mass production by local industry.

In terms of functional change, DST functioned as a pure science city in the initial stage. It focused on R&D and education to enhance the capability of high technology development. Above all, it concentrated on pure R&D stressing on basic research and restricting production and other industrial activities. Since manufacturing was allowed with restrictions in DST, this model was not appropriate for the regional innovation on the basis of technology transfer.



Basic Research + Education **Basic Research+Education+Technology Commercialization**

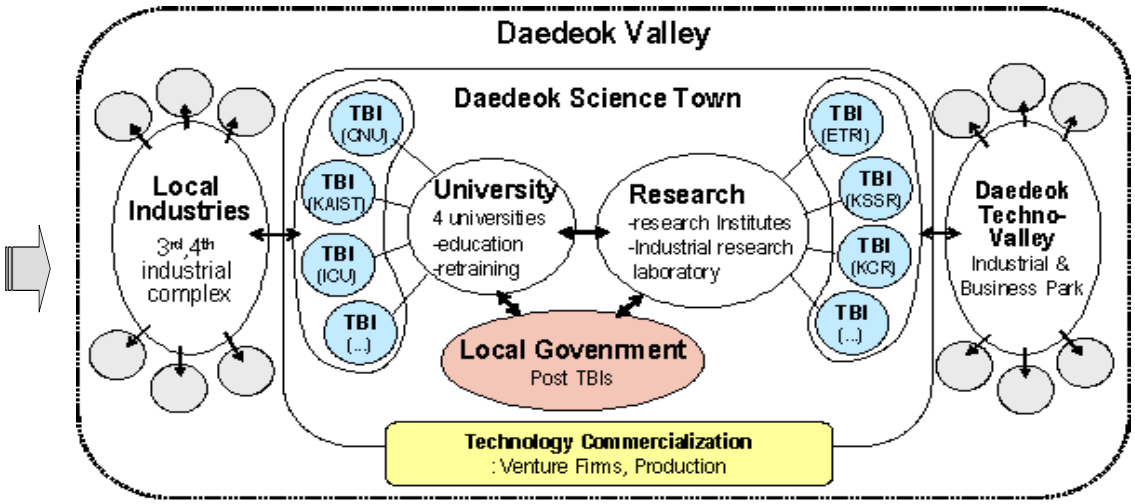


Figure 5. Change of Function; from Science City to Technopolis

However, as many private R&D centers settled down in DST, DST began to have other function gradually developed to a multifunctional technopolis. Private R&D centers had aptitudes to directly link R&D to industrial activities because they had their attributes to pursue profits like an enterprise. Accordingly, they caused the acceleration of technology commercialization in DV. From the late 1990s, venture incubation began to grow remarkably in DV. Under these circumstances, a demand for industrial function was raised not from outside but inside of DV. It was Daedeok Techno-Valley project created near DST in 2003. Since then, the development process of DV, as a multifunctional technopolis, has been accelerated to mature stage (See Figure 5).

The functional change of DST brought about the change of land use in three times(Oh, 2001). In the initial stage, land use of DST focused on the site for R&D and education. Then, the total area of 6,618 acres consisted of academic and research area, residential area, green belt area, and area for other uses. The academic and research area occupied 16% of the present area, it was designated to a few public institutions which were moved into DST by the central government. In 1981, the master plan of DST was changed for the first time. About 38.5% of the site was designated for research and education purposes so that research und universities facilities could be built there. Thereafter, central government promoted public institutions to move into DST development concept were changed from pursuit of self-sufficiency city to conurbation with its mother city(satellite town). The second change on DST's land use was also occurred in the R&D area and other uses area. The site of research and education was increased to 46.6% of the whole site. The expansion of academic and research area was for public institutes and private R&D centers moving into DST. Other uses area was also expanded for the provision of `93 Expo site development. In the late 1990s, a significant change occurred in the land use of DV caused by feverous of venture inauguration in DV. The land uses for light production and venture business increased in DV because the spin-offs from many research institutions in DV secured their site within the area to keep in close proximity with their mother organizations. In fact, most spin-offs in DV at an initial stage used existing space of their mother organizations. Several institutions launched their own TBI business. There after, Daejeon City established the project of Daedeok Techno-Valley(DTV) as science industrial park near the DST. Because R&D and manufacturing activities of industries and venture firms are inseparably related to each other, industrial site for light production are designated here in DTV comprehensively (Oh, 2005).

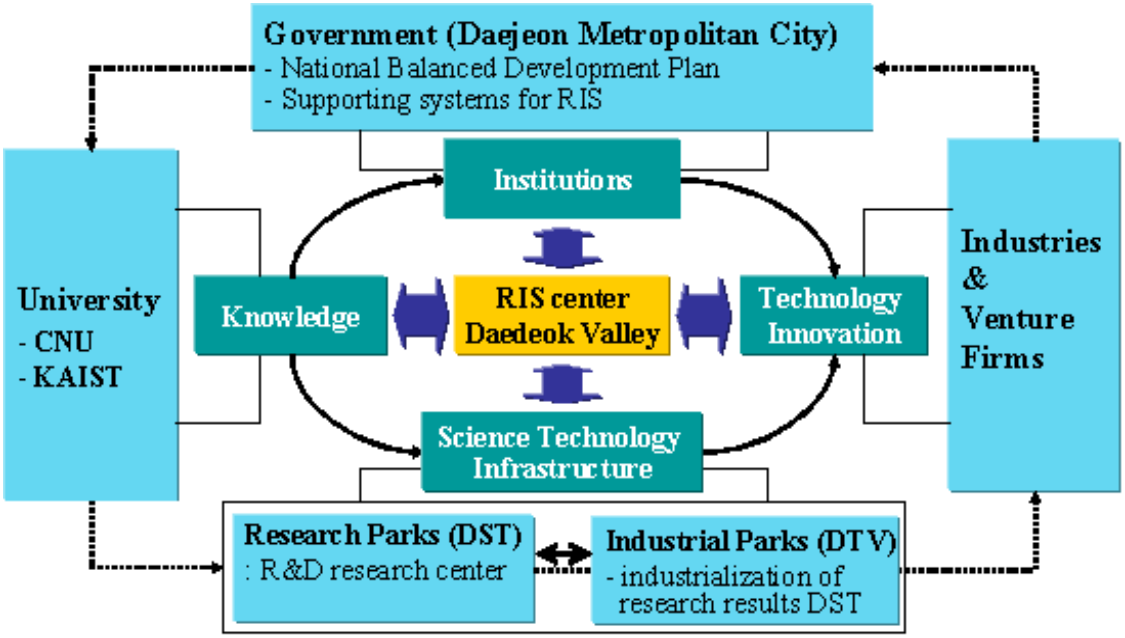


Figure 6. Structure of RIS in Daejeon, Korea

In particular, we can see the critical change of functional structure from pure science city to technopolis for complex model of Regional Innovation System(RIS). Since the start of Daedeok Valley in 2000, the role of Daedeok Valley for performing RIS in the region is activity in connection with the promotion of regional innovation activities based on the collaboration among universities, research institutes and industries. In addition, new functional structure has been made on the basic of 5 years local innovation masterplan. It consists of four components which will be worked together for technology-based regional development. The main concerns of RIS center in DV put on the technology-based regional development through the support of the organization of production system, management support, and the commercialization of technology by R&D activities. RIS center manages the collarboration among the sector of university, industry based on the DV's development(DST plus DTV). Moreover, the role of the local authorities varies substantially between these three major components of technopolis development. As the collaborative research among industry, universities and research institutes becomes increasingly critical and the support role of local government within the Daedeok Valley responds by extending their roles. Accordingly, the structure of pure science city has developed into that of techopolis of regional innovation cluster among the agents of innovation in RIS(see Figure 6).

3.3.2 Activities

• R&D

DV is host to a concentration of 21 Government Research Institutes including ETRI, 10 Government Invested Institutes, and 40 Enterprise Research Institutes. ETRI led the world's first ever commercialization of CDMA and has been instrumental in developing DRAM technologies. More recently, ETRI successfully developed WiBro(Wireless Broadband Internet) and DMB(Digital Mobile Broadcasting) which are fast proving to be next generation IT industries. Other prominent research institutes including the Korea Atomic Energy Research Institute, which successfully produced localized atomic fuel, are part of our complex as well. DV is also home to the Korea Aerospace Research Institute which developed KITSAT satellites 1-4 which are widely recognized as embodying globally advanced technologies. (DAEDEOK INNOPOLIS Management Office, 2006)

There are typically two levels of R&D activities in DV. One is corporate R&D labs, which are engaged in basic research; the other is division-level labs, which are used for research directly related to the business and manufacturing needs of their particular division-level activities and also focus on the

commercialization of their products for their business. The characteristics of R&D activities in DV have changed according to the changes in the main body of R&D activities. For example, the research institutes of private firms in Daedeok are varied in their sectoral pattern of activities, while many government institutes are biased towards basic research and development rather than for production and commercialization.

At an initial stage, DV focused mainly on pure basic research, because most of the institutes in DST were public organizations. But, in terms of technology-led economic development, this policy predicted development isolated from the regional economy. It is because long-range investigation of a basic research could make little economic impacts on the region. In 1988, about 42% of all government research institutes were located in DST and this percentage had increased until year 2004. From the late 1980s, private sector research institutes began to relocate from the Capital Region into DV, which resulted from the changed objective of government that promoted applied research by private R&D center. Private sector substantially has been higher than public sector in the R&D centers since 1992. Table 3 shows the increasing development of R&D centers and their employees.

Institution	1979	1985	1990	2000	2004
Government and Public institute	5 (3,879)	8 (6,229)	19 (7,020)	30 (8,319)	28 (10,803)
Private institute (including venture firms)	3 (719)	-	8 (1,432)	62 (3,832)	204 (7,446)
Branch offices of Government	-	-	3 (244)	9 (451)	11 (690)
University	1 (1,146)	2 (1,157)	3 (1,984)	4 (2,311)	5 (3,394)
Supporting Institute					7 (62)
Total	9 (5,744)	10 (7,386)	33 (10,680)	105 (14,913)	255 (22,395)

Table 3. Growth of R&D Centers and Related Institutions in DV

Note : ( ) : **No. of Employee**
*Source; DAEDEOK INNOPOLIS Management Office, 1979-2004 (*http://ddinnopolis.or.kr/)

From 1990 onward, many private firms began to construct their research facilities in DST. Because of huge government projects such as Expo`93 in Daejeon and the relocation of the third government headquarter of central government from Seoul, the investment of private R&D has been aggressively increased(Oh, 2003). These private R&D labs differed in both activity and focus from the government institutes. Since private institutes carried out R&D for their mother enterprise, they had more interests in the technological innovation and profits of mother enterprise than public benefit. These attributes of private institutes made R&D activities in DST more subdivided and varied. This variety of activities is important, because it suggests the potential for future development in DST as well Daejeon, as it can be attractive to a wide range of research-focused technologically advanced and innovative organizations. For example, the R&D fields which carried out on private R&D labs in 2005 was more subdivided than those of 1992. There are 32 private labs in 12 fields related with particular industrial sectors like IT, BT, NT etc. As R&D activities of private institutes became subdivided and varied, the potentiality of DV for technology commercialization has increased[3].

[3] The number of international patent registrations will increase from 1,659 in 2004 to 5,000 in 2010, and to 16,000 in 2015

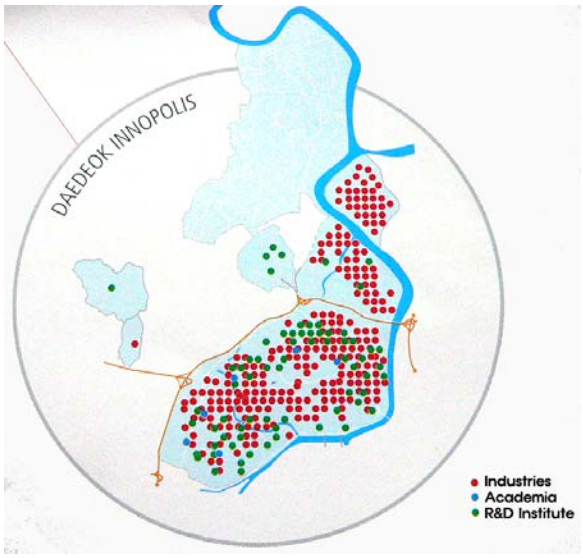


Figure 7. Occupation of Industries, Academia and R&D Institutes in DV

Description	Public Sector	Private Sector	Total
Comprehensive R&D	4 (1,230)	1 (83)	5 (1,313)
Bio technology	4 (482)	5 (455)	9 (937)
Information technology	3 (2,655)	5 (848)	8 (3,503)
Precision chemical	1 (403)	9 (1,672)	10 (2,075)
New material (including high molecule)		5 (549)	5 (549)
Meccatronics (including marine science)	2 (571)	2 (305)	4 (876)
Resource, Energy development	5 (2,173)	2 (76)	7 (2,249)
Astronomy, Aerospace, Astronautics	3 (806)	1 (109)	4 (915)
The others	6 (2,483)	2 (112)	8 (2,595)
Total	**28 (10,803)**	**32 (4,209)**	**60 (15,012)**

Table 4. Sectoral Comparison of R&D Centers ; Number (employee)

*Source; DAEDEOK INNOPOLIS Management Office, 2004 (*http://ddinnopolis.or.kr/

Given the abundance of R&D institutes operating in our complex, it is hardly surprising that we carry out large amount information exchanges. Its members get outstanding results through sharing resources and the joint utilization of advanced equipment. Further, there are always a wide number technological transfers, and joint amalgamated research project, on the go between our R&D institutes.

• Industrial Activities in DV

The industrial activities of DV have focused on venture business from spin-off firms. The features of industrial activities in DV are divided into three stages. At the initial stage, there were a few venture start-up activities in DV. Several public institutes permitted venture inauguration to their researchers in the existing space of their facilities. It was not remarkable in terms of number of spin-offs or economic impacts on the regional economy. There is a concentration of highly educated and skilled research manpower in public and private R&D centers in Daedok Science Town. This means that there is a high

possibility of commercialization of research results from Daedok Science Town. It is argued that the high potentiality is because there are about 2000 doctorate degree holders. Recently, active spin-offs are inceasing in the research institutes and universities in Daedok Science Town. Although several previous assessments indicated that the mere concentration of public and private research organizations in a space could not generate the inertia for high technology spin-offs, Daedok Science Town is a case where this is not so significant sources of technology-oriented new ventures are being generated. Actually, 7.1% of total venture firms in Korea is located in Daejeon /Chungnam Province(6% in Daejeon, 1.1% in Chungnam Province). It is the highest concentration outside the Capital Region(Seoul's and Gyonggi's). The start-up activities in DV began to be observed from the time when institutions in DV launched their TBIs. As research institutes and universities including ETRI, KAIST and CNU participated in TBI business, the number of venture firms in DV suddenly increased, and this made the venture start-up in DST to be accepted by an essential aspect and activity area rather than be understood as a mere part of R&D activity. When venture firms from the major 10 R&D centers in DV were surveyed until 2004, there were 2 firms in DV in 1990, 20 firms in 1996, but it grew up to 172 firms in 2004. If job creation is analyzed for the same years, 35 persons were employed in 19, grew up to 187 employees in 1996, 2,212 persons in 2002, and 3,237 persons were employed in 2004 (See Table 5).

Year	1990	1992	1994	1996	1999	2002	2004 (DV total)
No. of firms	2	6	7	20	154	130	219 (824)
Job Creation	35	84	96	187	924	2,212	3,237 (22,395)

Table 5. Growth of Venture firms from major R&D centers in DV

*Source; DAEDEOK INNOPOLIS Management Office, 2006 (*http://ddinnopolis.or.kr/)

The total firms of 219 companies were created from 10 public research institutes in DV by 2004. ETRI , KAIST and Korea Standard Science Research Institute are the main bodies, which actively contributed to technology commercialization. And, the venture start-ups extended to all area of Daejeon since late 1990's. The venture inauguration set out from DV began a full-scale relation with regional territory not only to Daejeon but also to its vicinity.

Name of research Institute	No. of Spin-off Firms
Electric and Telecommunication Research Institute (ETRI)	57
Korea Standard Science Research Institute	19
Korea Advanced Institute of Science and Technology (KAIST)	117
Total of major R&D spin-offs	**193** *(**88.1%** of total R&D spin offs)*

Table 6. Major Research Institutes in DST and their Spin-offs

Source; Oh, 2005; Kim, 2000

We enable many venture enterprises to find a fresh start and conduct business at DV through our solid support policies. We maintain a high level of contact with the its members and are always on the lookout for venture enterprises or corporations with abundant growth potential. We make good firms better by providing management services. To support the enterprises in DV, we offer various tax benefits including the exemption or reduction in acquisition taxes, registration taxes, and property taxes. Besides this, a DAEDEOK Special Fund has been formed to support stable venture capital investments. And full efforts are being exerted in the expansion of occupancy areas & facilities. We offer further support in the form of marketing activities so that product development can be transformed into profits.

3.3.3 Network

Networking activities in DV has been made on the basis of the close relationships between research institutes, universities and industrial sectors including venture businesses. It has been developed in three steps; network building for the collaboration between research institutes, diversified collaboration and networked entrepreneurship of venture businesses. There three different ways of network has been aided by self-help meeting information exchanges at initial stage and networked community building with the indirect support by local government for RIS system. The features of networking in DV are as follows;

• Network Building for the Collaboration

At the initial stage of DST's development, research institutions felt the necessity of collaboration activities among them for the information exchange. So, they formed an organization, what is called 'Daedeok Science Town Association (DSTA)'. DSTA is an organization of promoting the mutual friendship and contributing to the development of DV through regular meeting of chief personals of research institutes. The chief managers of 52 institutions in DST are its members, of which about 84% are public institutions. DSTA has major jobs such as activation of DV, policy formulation for DV development, formation of research atmosphere, building up international cooperation. Enhancing cooperation among member institutions, and building ties with local communities are also its major tasks. But the collaboration activities of DSTA were limited the public interest for the development of DV. Of course, it is difficult to find common interest among member institutions. These activities of DSTA, which have little relations with the interest of its members, could not promote the collaboration among its members. In conclusion, DSTA can be said to be an organization only for friendship. But, by holding regular meetings, DSTA could make network building the collaboration project and opened the possibility of collaboration among research institutions in DV.

• Diversified Collaboration System

The collaborative activities among research institutions in DV was gradually increased and subdivided as time progressed. KAIST, CNU and ETRI individually began to match the collaborating project with industrial sectors. The different way of collaboration between R&D institution and industrial sector in DST can be made in technology transfer activities. They were initiated by universities. Three national universities and one private college are located in DST. They have played a pivotal role in cultivating a highly specialized workforce, as well as pursuing the close linkage between research and education (MOST, 1996). In particular, it was KAIST and CNU that have led this collaboration since the initial time. They facilitated knowledge creation, human capital formation, technology transfer provision of regional leadership and knowledge infrastructure etc. KAIST concentrates its efforts in the field of new technology, particularly in the R&D of high-tech industry, and supporting venture start-ups so that it could create a base for international competition in DST. KAIST has a Technology Innovation Center (TIC) and a Consulting Center for Technology Transfer which is to accelerate technology innovation by providing research results from KAIST to opening firms and support venture business firms by the establishment of the national technology utilization system. Furthermore, regarding collaboration between university and industry, there are also BI (Business Incubator), Regional Research Center (RRC) and Rental Research Institutes (RRI) managed by above mentioned universities in DV. ETRI has been also active in the collaboration with the industrial sector as a research institute in DV. It has two major roles in the collaboration with the industrial sector: one is venture incubation through TBI; the other is the management of higher education institution called ICU. ETRI is the second research institution which launched its own TBI business in DST. The TBI of ETRI is the core venture incubator in DST, as it has been playing a critical role in incubating many venture firms in the field of IT. Moreover, ETRI established Information and Communication University (ICU) to provide bachelor, master and doctorate courses for training professional manpower in the field of IT.

Figure 5 explains how the collaborative network in DV has changed in the initial time. As mentioned before, networking among institutions in DV was simple just for friendship and somewhat formal co-operations. However, as activities of and subdivision of collaboration in DV increased, thus diversified collaboration of DV emerged by individual collaborative activity of research institutions in DV.

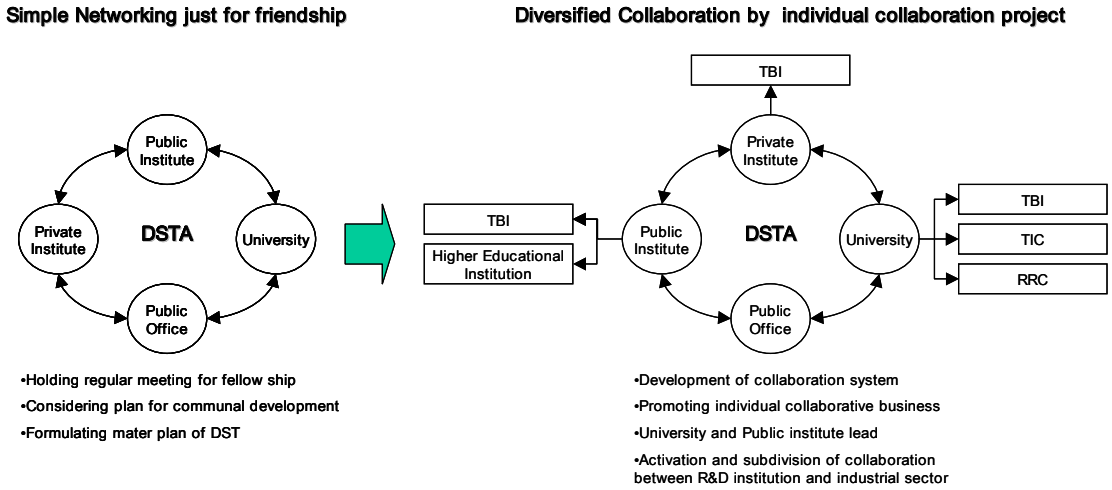


Figure 8. Change of Collaborative Network in DV

• Regional Cluster with the Networked Entrepreneurship

Venture firms in DV hesitated to keep company with one another for security reasons fearing leakage of their business information. As venture inauguration is gradually increasing in DV they realized that mutual and cooperation for growing venture businesses is essential to promote the business success in the age of infinite competition. The collaboration among venture businesses has accelerated to make successful technology commercialization and also overcome their lack of capability. Networking among venture firms in DV can be classified into two types. One is an active and direct networking by organizing community and the other is a passive and indirect networking by information infrastructure.

'Daedeok 21C Venture Family' is an example of networking by organizing community. It is an early model, in which venture firms in DST were networked and confined to organizations which were made up of spin-offs only from DST's institutions. The aim of 'Daedeok 21C Venture Family' is to accelerate information exchange and technology innovation among venture firms in DST and to develop a venture 'ecosystem'. It had changed its name to '21C Venture Family' in 2000 and expanded its number up to 280 firms from Daejeon and Chungnam province. However, networking alone is not enough to make organizations keep in close relationships for active technology commercialization and project building. Therefore it is needed to develop cooperative projects for members to keep them in close cooperation with particular project.

Recently, venture firms in the similar business fields began to establish venture communities in DV zone. The idea is that firms are not doing M&A or investing capital but establishing network and establishing practical collaboration to cover essential needs of entrepreneurs. The technologies emerged from a period of laboratory-based R&D in the 1980' and 1990' into an application and diffusion phase since the end of 1990'. The relationships between high-tech firms and infrastructure elements such as universities, R&D centers and agencies are likely to be more critical in DV'case, as R&D activity and skills are externalized into markets, rather than hierarchies. The industry becomes characterized by the presence of many SME's, often in close networks around the original players, most of which are R&D centers and universities. Following this pattern, the several specialized industries in DV like IT, BT are now characterized by many high-tech SME's concentrated in regional clusters and engaged in symbolic relationship with multi international firms. The networked communities consisted of the firms of these specialized industries are present at mature stage of DV's development. A survey of these patterns(Oh,2002) in detail has indeed confirmed that life-style reasons are the main factor in the initial location decision, while this might suggest some magnetic effect as the basis for all part of DV and Daejeon area. In other words, high-tech cluster start by accident through the presence of focal organizations(R&D centers universities in DV) which generate spin-offs. These Spin-offs, lead to continuous links, which sustain clusters of several specialized sectors of industry in the long turn. There are several good examples such as 'Semi-conductor Assembly Daedeok IT-net', and 'Daedeok Bio

Community'. For example, Semi-conductor Assembly in Daedeok Valley is a venture community, whose purpose is to create a new business model in the field of semi-conductor, Daedeok IT-net is a cluster that promotes joint ownerships for gathering market information and know-how and does marketing by members together in the field of IT and software. Especially, this cluster keeps on doing the closer collaboration with the mother-organizations of spin-offs like ETRI and KAIST.

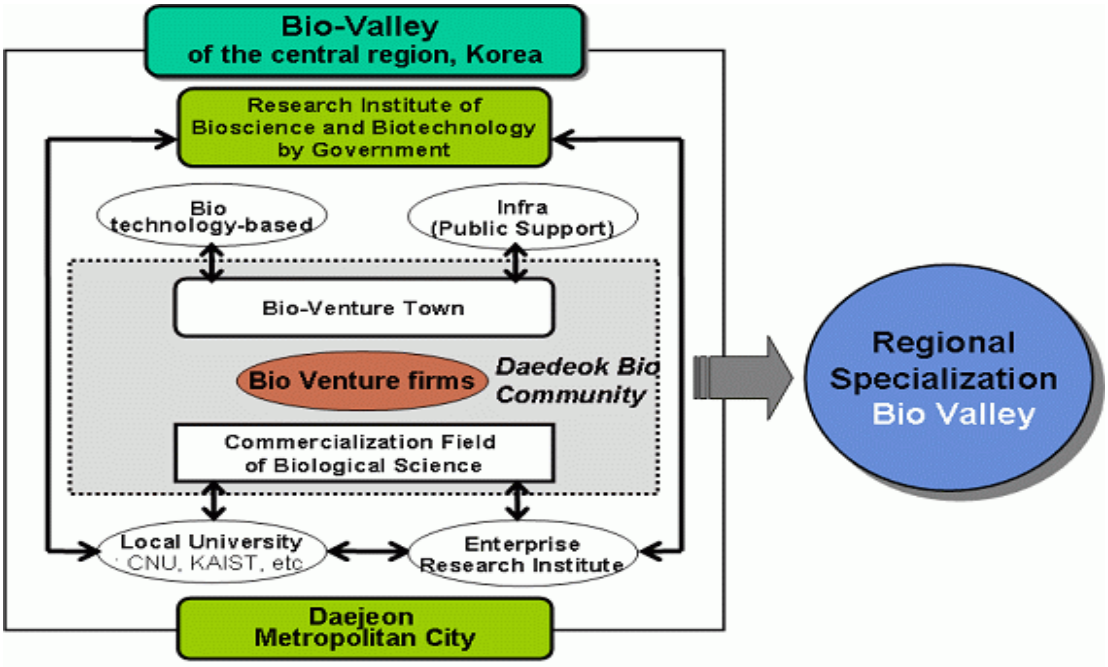


Figure 9. Daedeok Bio-Valley Cluster

Daedeok Bio-Community consisted of 14 venture firms is a group with a purpose of developing competitiveness through co-work, information exchange, and joint marketing. The local agency of regional innovation gave its full support for the establishment of Bio-cluster with the close collaboration of national Biotech Institute in DV, because this sector of industry is the driving force for future development of DV in the 21stcentury. This pattern of clustered development, through which venture firms is collaborating with one another, is very meaningful in terms of an alternative business model. It can facilitate the SME's competitiveness at the market of specialized industrial sectors. The other networking type among venture firms in DV is the collaboration based on the information infrastructure. It is networking that utilizes cyber space offered by Internet. For instance, there are two firms which manage online collaboration system such as Hallow DD and DVI News in DV. These are included serve information, DB for business, publicity (information) activities and consulting through online network. Collaboration by information infrastructure has some advantages. Because it is not restricted by space and is able to connect in real time.

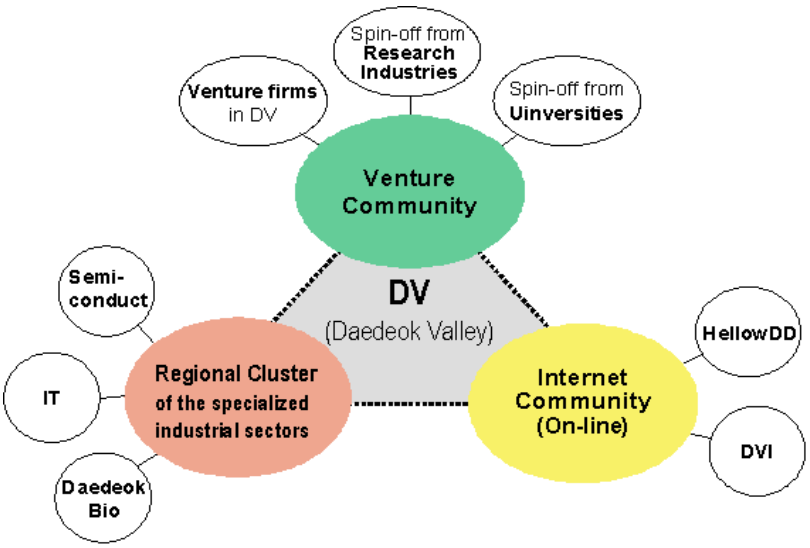


Figure 10. Regional cluster and Networked Entreprenurship

After DV has been designated as national R&D Special Zone, Daejeon is preparing comprehensive collaboration network for regional innovation to integrate above mentioned networks for the close collaboration. DV office establish by National R&D special Zone plays the role of platform, which will facilitate the networked cooperation among universities, research institutes industries and local government. The main body, which will manage this collaboration networking is the regional innovation council. It is consisted of representatives from those four sectors. This council will make decision of major projects of RIS and give continuous financial support for them during five years. It is expected that endogenous development of local industry will be facilitated by close cooperation within the network based on the support of local universities and research institutes.

Moreover, DV is conducting a diverse range of project that will cement its reputation as a successful innovation cluster within ten years. DV is focused on promoting research that is geared towards technology commercialization. The formation of venture ecosystems that connect its members with other regions is another one of our primary goals. Moreover, we wish to facilitate the sharing of knowledge from within our walls to the far corners of the earth, wherever new talents or ideas may lie. DV will remain dogged in our pursuit of becoming a top-tier cluster.

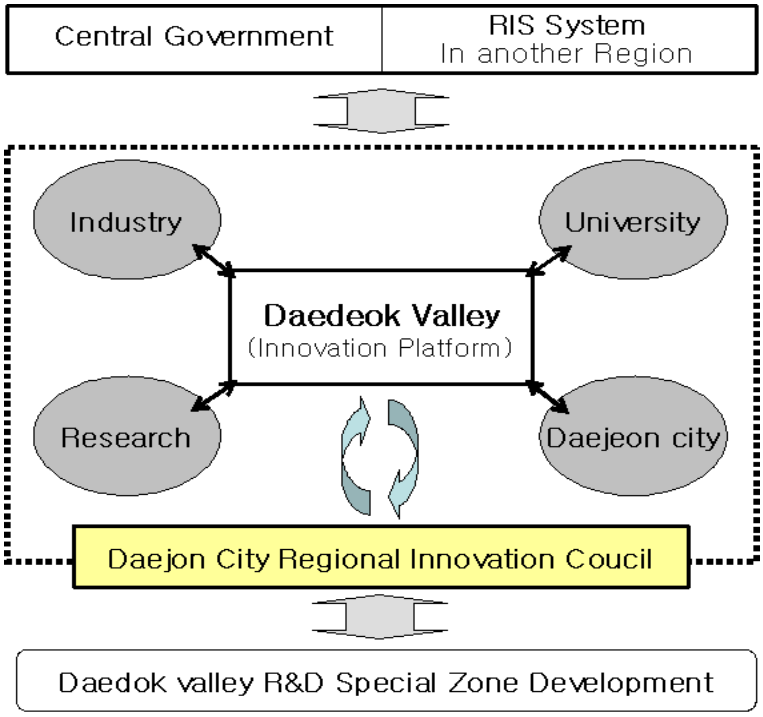


Figure 11. Collaboration Networking for Regional Innovation

3.4 Impacts on Regional Development

3.4.1 Job Creation & Growth of Venture Firms in DV

The volume of employment created by the development of DV is relatively small by international standards. The employment in DV itself is 14,913 persons from total 105 institutions. It is not a large number in comparison to the employment in the region. However, taking into account that DV's employment consists of professional manpower which is the center of knowledge and technology, DV's employment is more meaningful in terms of high-tech development, because highly qualified research manpower in public and private R&D centers has been highly concentrated here. There are about 2,000 Ph.D degree holders who work in DV. It can be argued that there is a high possibility of commercialization of research results or high-tech commodity from high-tech research in DST. Although several previous assessments indicated that the mere concentration of public and private research organizations in one location couldn't generate the incidence of high technology spin-offs, research organizations in DV have been significant source of technology-oriented new ventures, and DV's fervour for venture start-ups had spread into whole of Daejeon area from the late 1990s. There are 644 venture firms in whole area of Daejeon in June 2005. 219 venture firms out of those are located in DV, which represent a 34% of venture firms in Daejeon. Even though they are not located in DST, all venture firms in Daejeon area have some relations with DV in terms of their R&D or have set here especially to establish connections with DST (See Table 7).

Classification	No. of Institution	No. of Employee
Public Institute	28	10,803
Private Institute	32	4,209
Public Agency	11	690
University	5	3,394
***Venture Firm**	172	3,237
Supporting Institutes	7	62
Total	**255**	**22,395**

**Number of Venture firms and their employments are limited only to venture firms that are active in DST now. Source; DAEDEOK INNOPOLIS Management Office , 2004*

Table 7. No. of Institutions and Employee in DV, Korea

The growth of venture business influences job creation. Survey from Daejeon Metropolitan City indicates that the total employment by venture firm in Daejeon area is about 13,300 persons in 2001, which is about 20% of total employments in manufacturing industries. It is meaningful if we consider that venture business is not labor-intensive but technology-intensive industry. Also, according to the survey result from Daejeon Metropolitan City Small & Medium Business Support Center (TSSC), which was conducted against 698 firms in Daejeon in February 2001, venture firms employing 1 ~ 5 persons showed the highest ratio by taking a 59% share of whole venture firms in 1999. In 2001, however, venture firms that employed 6~10 persons show the highest ratio of 31%. It can be said that the employment by venture firms in Daejeon area is growing fast. Accordingly, Daejeon Metropolitan City expects big employment extension than current employment scale in 2001 and plans to support 3,000 venture firms until 2010, and creation of about 75,000 jobs by 2005 (See Table 8).

Classification	Present Condition			Transition in the Near Future			
	1999	**2000**	**2001***	**2002**	**2003**	**2004**	**2005**
No. of Firms	300	500	698	1,050	1,580	2,200	3,000
Sum of Sales (billion Won)	180	382.5	731.5	1,470	2,607	4,224	6,000
No. of Employee	5,100	8,500	13,300	21,000	34,760	52,800	75,000

**Data of 2001 has been investigated until February 2001.*
Source; Daejeon Metropolitan City, 2005

Table 8. Transition of the Job & Sales Creation by Venture Firms in Daejeon

Growth of venture Business is shown in sales increases. According to the investigation of Daejeon Metropolitan City (2002), the amount of turnover by venture businesses in Daejeon area was 382.5 billion won (375 million us dollar) in 2000. It is about double that of 1999, and corresponds to about 5.6% of all output of manufacturing industries in Daejeon area. If those figures are classified by scale, venture firms which had less than 30 million won showed the highest ratio by 38% of all firms in 1998. However in year 2000, venture firms which had sale over 500 million won showed the highest ratio of 35%. Venture firms in Daejeon made great strides. Average sales value per company was shown to have grown 36 times, from 25.9 million won in 1998 to 928 million won in 2000 in relative terms. Daejeon Metropolitan City expects that the scale of venture firms will be increased up to 6 trillion won in 2005 if sales of venture businesses in Daejeon grow at current trend. It corresponds to about 56% of whole sales from manufacturing industries in Daejeon and 33% of GRDP from the region.
According to the report of Daedeok Valley Management Office(DVMO) in 2006, within 10 years DV will have obtained immense growth as well as the number of our occupant companies and R&D

institutes and the number of international patent registrations will rise. Especially, the companies in DV is estimated 3,000 units in 2015 and the number of foreign R&D institute is expected to 20 in 2015 from 2 in 2004. In addition, DVMO is predicting the international patent registration will be increased about 10 times more than the number in 2004 and the sales by technology commercialization are expected to reach 31,296 million in 2015.(see Table 9)

Year	Companies(units)	Foreign R&D Institutes	International Patent Registrations	Sales (USD in million)
2015	3,000	20	16,000	31,296
2004	824	2	1,659	3,547

Source ; DAEDEOK INNOPOLIS Management Office, 2006

Table 9. Estimation for the Growth of DV from 2004 to 2015

3.4.2 Industrial restructuring

Another impact of DV on regional economy could be industrial restructuring. In fact, impacts on regional economy did not appear until late 1990s. Until 1993, the industrial structure of Daejeon city did not change much in spite of the establishment of DST. However, since its function was changed in 1993, Daejeon Metropolitan City has made efforts to enable high tech venture firms to move into DST by providing support mechanism for the commercialization and production of R&D results in DST. The main components of these mechanisms are TBI, post-TBI and venture industrial parks where start-up firms can concentrate on commercialization of their technology. As a result, venture businesses grew rapidly in Daejeon area since then - emphasis given to new types of business in the field of high technology, which are different from existing industries in Daejeon area.

The development of high-tech industry due to the growth of venture business gave rise to changes in the industrial structure of Daejeon. According to the data of National Statistical Office(2002), the industrial structure of Daejeon shows that the ratio of manufacturing industry has increased from 12.9% in 1999 to 13.6% in 2000. The changes in industrial structure appear in the business feature of the transferred firms. Venture businesses that moved into Daejeon area from the late 1990s number 41 firms in total. Only 4 firms moved into city's territory in 1999, but in 2000, it increased to 26 firms. Moreover, about 11 high venture firms have moved into Daejeon as of June 2001. Daejeon Metropolitan City has gained pride by this. It is expected that the industrial structure of Daejeon will be changed by the active growth venture business. According to the city's estimation(2000), the industrial structure of Daejeon will consist of 2.8% by agriculture and forestry, 17.6% by mining and manufacturing, and 79.6% by service in 2005. It is expected that the ratio of mining and manufacturing industries will increase and that of service business will decrease than that of 2000. In addition, Daejeon City expects to change the composition rate of industries between traditional industries and IT industries from current 70: 30 to 40: 60 in the near future. It is desirable for Daejeon City if she could have an initiative to support IT industries in the central area of Korea (See Table 10).

Classification		1995	2000	2005
Population (unit; thousand persons)		1,268	1,390	1,770
Population in economic activities		458	588	790
Industrial Structure	**Agriculture & forestry**	10.5(2.3%)	21.0(3.6%)	22.1(2.8%)
	Mining & manufacturing	71.0(15.5%)	80.0(13.6%)	139.2(17.6%)
	Service	376.5(82.1%)	487.0(82.2%)	628.7(79.6%)

Source; Daejeon Metropolitan City, 2006

Table 10. Change of industrial structure of Daejeon

4. Conclusion : Evaluation and Prospect

This paper has been evaluated with respect to the experiences of Technopolis development in Republic of Korea. Different approaches to Technopolis development like science city, and technopark in RIS have been found to have particular strengths in particular circumstances. An initial conclusion of this review is that Technopolis can be valuable instruments of regional innovation policy as well of technology-led economic development in Korea. Evidence considered in this paper suggests that Technopolis support spin-offs and their development after the incubation stage, that they add value to the local economy. There are important strengths in the Technopolis concept in terms of value added to local economy. Economic circumstances have encouraged higher education institutions and R&D centers to strengthen their links with local communities and seek ways to facilitate technology transfer.

In particular, this paper tries to identify the effectiveness of technopolis policy to regional innovation through reviewing the trends of regional technology based regional development policy in Korea with particular reference to Daedeok Valley(DV). The research interest, is focused on the analysis of three major factors of technopolis development(structure, activity and network) and impact on regional innovation. Through the case study, it is identified that development from pure science town(DST) to technopolis(DV) have had good impacts on regional development based on the policy of Regional Innovation System(RIS). The results show us positive changes for regional innovation into following three aspects.

Firstly, structure of DV has been changed from science city to multifunctional technopolis which can facilitate technology commercialization and production. A model of pure science city that DST took in the beginning stage is not easy to get a synergy effects for technology-based regional development, because it is very limited for a planned science city to have all the functions to cover R&D and production in a short period of time. In order to play a role for a driving force for regional innovation, it was necessary to have a shifting development from science city to technopolis to be set in organic relationships with regional demands of technology commercialization. The structural change through the designation of DV gave the further potential of facilitating the growth of high-tech venture business based on DST's R&D. Establishment of the industrial park of DTV as well as other post-TBI sites hereafter were the adequate policy-making to cover this huge growth of high-tech venture firms.

The new projects of National special R&D Zone, in particular, can accelerate the future development of technopolis in Daejeon area. There is interesting give and take strategy between DV and mother city. While DV provides city with the potential of high-tech industrial growth, mother city provides DV the city amenities such as good residence and cultural services. It means that DV and other city area can benefit each other for the sustainable development in the region.

Secondly, there are a change of activities from pure R&D to industrial development through huge growth of venture business in DV, which enable to technology commercialization. Private research institutes and venture businesses, started from spin-offs from DV, are driving force of this change. If DST persisted in pure R&D and ignored commercializing its R&D results, it might not be so active such an active expansion of technology commercialization. Spontaneous entrepreneurship of venture firms in DV are also very important factors that can make DV actually contribute to the regional innovation of Daejeon Metropolitan City, Korea. DV is also a good example to show us that private R&D centers can lead the technopolis development through their profit-oriented projects and also subdivided researches on technology transfer. They are another potential for endogenous development. Technopolis should be preceded by the construction of comprehensive support system that can facilitate research to develop into technology commercialization based on the mixed activities of private and public R&D centers.

Thirdly, network building for the collaboration among universities, research institutes and industries is a critical factor that makes technopolis have a capacity of sustainable development. Since most R&D institutions in DST were operated individually and managed by centeral government. It was impossible to expect any synergy effects through their collaboration. However, in the late 1990s, R&D organizations, universities, and industrial sectors began to collaborate with each other actively. Above all, venture firms in DV propelled active collaboration by various sets of networking and provided an opportunity for DV to have networked entrepreneurship.

The changing process from formal network to regional clustering is meaningful for the regional innovation. The network building called DSTA was a formal association only to play a limited role for public interest, it opened a possibility of collaboration among research institutes in DST at the first stage. The second stage of development initiated by major research university(KAIST) and research institute(ETRI) in 90's was the starting point for the close cooperation of technology transfer and commercialization. The regional cluster of specialized industrial sectors at third stage is the most important development. It can accelerate the regional capability of technology-based development and regional innovation through closer collaboration among high-tech SME's which were spin-off from universities and research institutes and keep on the close linkage with them. This kinds of process enables the city to form RIS system to integrated these three stages of the sustainable development for regional innovation. The functional changes the growth of high-tech firms and their networked collaborations, which has been made on the shifting process from DST to DV, enables the technopolis development to give a positive impact on regional development in terms of job creation and industrial restructuring etc. The impact of DST's change began to appear gradually in job creation, sales increase, and innovation of industrial structure. High-tech venture businesses located in DST has grown based on DV's R&D capacity accumulated for the last 30 years. The shift from pure science city to technopolis was not made by top-down approach of central government policy, but by the continuous efforts of local government which understood the effectiveness of technopolis for regional innovation and prepared several policy instruments in regional context. Inevitably the findings of such a study raise more question than they answer about DV's experience in this field. Nevertheless, they demonstrate some of the insights into the relationship between technology and regional innovation policy that can be obtained by these means and also Point out the importance of good policy making for sustainable development of technopolis.

<table>
<tr><th rowspan="2">Aspect</th><th rowspan="2">Factors & contents</th><th colspan="3">Development Features shifted from DST to DV</th><th rowspan="2">Evaluation</th></tr>
<tr><th>DST</th><th colspan="2">DV</th></tr>
<tr><td rowspan="3">Structure</td><td>Relationship with mother city</td><td>Satellite Town
(unique Science City)</td><td colspan="2">- Integration with its Mother City
(Multi-functional Technopolis as RIS center)</td><td rowspan="3">Positive effect for
-high-tech potential industries growth
-Sustainable development in the region
(environmental, Social and economic aspects)</td></tr>
<tr><td>Component and their Linkage</td><td>Basic Research + Education(Univ.)
- pure R&D
: High-tech development oriented
: restricting production</td><td>Basic Research + Education(Univ.) + Technology Commercialization
(venture firms)</td><td>Basic Research + Education(Univ.) + Technology Commercialization
(local industries, industrial & business park)
→ Regional Innovation System(RIS)</td></tr>
<tr><td>Land use</td><td>R&D use area
(38.5%)
: for Public Institutes</td><td>R&D use area
Expansion (46.6%)
: for Public institutes and Private R&D centers</td><td>National R&D Special Zone (70.2㎢)
- DST, DV, DTV
- R&D, TBI business, Industrial & Venture business, manufacturing etc.</td></tr>
</table>

Activities	Growth of R&D center	**Pure Basic Research** (5 public institutes, 3 private sectors, 1 national university) - focused on public R&D and education	**Applied R&D** (30 public institutes, 4 universities) : Private sector(62) increased and varied	**Comprehensive development of high-tech industry** (71 R&D institutes, 6 Universities)	Positive effect for - active spin-offs & their settlement in the region (Daejeon, Korea)
	Industrial Activities (spin-offs and growth of high-tech SME's	None	**Spin-offs from Public R&D center** (launched by their TBIs only) : KAIST,ETRI,KSSRI (Total 255 including 219 spin-offs firms)	Spin-offs from **varied sector of private and public R&D centers (TBIs, BIs)** : active & strong growth of venture firms and their settlement in the city (219 in DV, 824 in Daejeon)	
Network		**simple Network** among research institutions for minor communication (DSTA)	**Network building** for the collaboration among universities, research institutes and industries (total 255 including 219 spin-off firms)	**Regional cluster and Networked Entreprenurship** - venture community - Regional cluster of the specialized industrial sectors - Internet community - **clustered development**	Positive effect for - sound entrepreneurship of SME's - closer linkage between academia and industry - formation of high-tech cluster

Table 11. Evaluation of Technopolis Development in DV

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