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Universities, Clusters, and Innovation Systems: The Case of Seoul, Korea

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Summary. — Many policy-makers believe that strong university–industry relationships and high-technology clusters are the keys to development. The Korean experience suggests that the most important contribution of universities to economic development was not through the transfer of research results, rather it was indirect and through the preparation of high-quality graduates. Korean universities and research institutes (URIs) have contributed little to the creation of clusters with the exception of a cluster of spin-offs from government research institutes in Daeduck. The role of URIs may be changing to an entrepreneurial focus, but the strategy of concentrating on training graduates has achieved considerable success.

Key words — Korea, East Asia, universities, clusters, research and development

1. INTRODUCTION

The commercialization of university research and the establishment of clusters of entrepreneurial firms are often considered the magic seeds for driving economic growth in developed and developing countries (Miner, De Vaughn, Eesley, & Rura, 2000). [1] Korea is interesting, because its economy grew rapidly, despite limited direct interaction between industry and universities and little clustering in the vicinity of universities. Though government research centers did provide benefits to industry, they were not pivotal to the growth of the Korean economy. There are no significant technology-driven clusters beyond what might be termed "the Seoul macrocluster" that is anchored by chaebol-based research, but also includes a concentration of smaller firms in the Kangnam area, and one that may be forming around the relocated government research centers in Daejon. [2] For these reasons, the Korean experience provides an alternative perspective for evaluating the orthodoxy touting universities and research institutes (URIs) and industrial clusters as the strategy for creating economic growth in developing nations (Quandt, 1997; Schmitz & Nadvi, 1999).

First and foremost, Korea is not a developmental failure. The Korean economy is a charter member of the "Asian Miracle" Club. Korean firms such as Samsung, Hyundai, Posco, and LG are globally competitive in industrial fields including steel production, DRAM semiconductors, flat panel displays, and cell phone design and production. Given this success, the relative lack of significance of URIs and clusters of entrepreneurial firms in the national innovation system (NIS) is curious. Through an examination of Korean development, we raise questions about the prevailing wisdom that clusters and a particular style of

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university–industry relationships are an important path to economic development.

Why is Korea's record in terms of university technology transfer and the creation of high-tech startups so mixed? Not only has the contribution of university research to industry been limited, but Korea has not had any significant technology-based startup successes such as Intel or Microsoft in the United States, Huawei or Lenovo in China, or TSMC and Acer in Taiwan (Sohn, 2004). The remarkable lack of impact of university-based knowledge on Korean development and the reason that Korean high-technology clusters remain weak are the two separate, but interconnected, puzzles explored in this paper.

The first section briefly outlines the national political economy within which URI–industry collaborations are embedded. It is followed by a brief discussion of the innovation system in Korea. This sets the stage for a discussion of the role of Korean university and research institutes (URIs) in the Korean innovation system. Special consideration is given to the relocation of the research institutes (RIs) to Daeduck. It is within this context that the paper turns to a discussion of Seoul, which is the center of the Korean innovation system in terms of elite universities, corporate R&D facilities, and venture capitalists, and yet has not generated a sustainable high-technology entrepreneurial cluster. In this section, we also discuss the relative failure of the Seoul local government in sparking such development. In the concluding discussion, we point out that despite the relative weakness of Korean URI–industry relations and the inability to develop clusters, Korea has successfully industrialized and moved into high-technology industries.

2. THE GENERAL KOREAN ECONOMY

Despite many changes and frequent articles heralding the collapse of the chaebol system, the chaebols such as Samsung, Hyundai, and LG still remain at the heart of the Korean economy (Jwa, 2004; Sohn, 2002). Korean entrepreneurship has been largely confined to retail and low-technology industrial activities—the only significant exception is a cluster (discussed later) that developed in the Kangnam area of Seoul at the height of the Internet Bubble and continues to host the largest concentration of Korean IT firms (Park, 2005; Park & Nahm, 1998). Despite the debatable successes of Taejon and Kangnam, there are reasons for the relative dearth of entrepreneurship. The Korean political economy has positively discriminated against small and medium-sized enterprises (SMEs). Until the mid-1980s, the government actively encouraged the growth of the chaebols, while starving the SME sector of credit (Lim, 1998). Second, cultural and job security concerns limit the flow of personnel from large chaebol firms to smaller entrepreneurial firms. Third, the large chaebol firms can and do hire some of the most talented SME employees frustrating capability building. This makes it exceedingly difficult to assemble and retain the management and technical teams necessary to build an entrepreneurial startup (Suh, 2000, p. 18).

Not only is the capable managerial and technical labor unavailable, but also early-stage venture capital is scarce. As Kenney, Han, and Tanaka (2004) showed, Korean venture capitalists were risk averse and, more likely, to fund existing firms, than they were to fund high-technology spin-offs from either industry or university. Also, Korean banks are risk adverse except when funding their chaebol customers. For these reasons, entrepreneurs had to bootstrap their firms and there were few experienced professionals able to offer them counsel on how to build firms. The lack of capital, skilled personnel, and experienced professionals retarded the emergence of an entrepreneurial high-technology sector.

The Korean economic structure was not organized to create and commercialize new technology through entrepreneurship. Until the mid-1980s, the source of new technologies has not been internal. Rather Korea imported technologies through licenses or embodied in industrial equipment and then used them for mass production. In the mid-1980s, Korean firms shifted to a system in which, in addition to importing technologies, they began improving them through R&D (Kim, 1997). To accomplish this Korean firms allocated ever-larger resources to internal R&D. Over the next two decades, these investments were sufficiently successful to move some Korean firms to the global R&D frontier in certain sectors. Though initially certain government RIs did provide commercially useful research, after the 1980s the usefulness of their output was ultimately overshadowed by the growing corporate R&D investment (Park, 2000). In this maturation process that moved selected Korean firms to the global R&D frontier, the contributions by

startups, clusters, and technology transfer from URIs were minimal.

3. INNOVATION IN KOREA

The Korean innovation system can be separated into two periods (Kim, 1997; Park, 2000). The initial period was government led and the later period was private sector led. During the 1960s and 1970s, while the strategic focus was on creating heavy and chemical industries, innovation was neglected. Nearly all efforts were directed at establishing a basic industrial infrastructure built upon imported technology. At this stage, the government RIs played a role in assisting firms in acquiring, importing, and absorbing the foreign technologies.

Beginning in the 1980s, the locus of R&D performance and innovation shifted from the government to private firms. Private firms had grown significantly and believed it necessary to strengthen their own research capabilities to respond to competition in international markets. The organization of the Korean innovation system changed significantly as the chaebols rapidly increased their in-house R&D investment. Initially, Korean firms invested in consumer electronics R&D, but later concentrated upon the electronics components such as DRAM semiconductors, flat panel displays, and cell phones. To provide an example of the scale of the change, in 1980, 54 firms had R&D centers, while in 1995, 2,226 firms had an R&D facility (KITA, 1996). Though the giant chaebol firms were the most aggressive in establishing R&D centers, recent statistics suggest that more than two-thirds of existing firms' R&D centers are operated by SMEs (Kim, 1997). Another indicator is that Korean R&D investment increased from 1.92% of GDP in 1991 to 2.96% in 2001 (OECD, 2005). This was compounded by the fact that Korean GDP grew rapidly during this period (MOFE, 2003).

Technology acquisition was a core strategy for Korean firms. Since the 1980s, Korean firms were aggressive in obtaining technologies from abroad and using them to improve their capabilities. For example, from 1962 to 1982 there were 2,281 technical and licensing agreements, of which 533 were with the United States and 1,287 with Japan. In addition to significant royalty payments, Korean firms offered other incentives to foreign firms including funding commercialization, facilitating local market access, and providing plants and equipment. They often sent researchers to US firms to absorb advanced technology. In the 1990s, Korean corporate R&D investments began to show results. Though approved technology imports increased to over 200 in 1990, they decreased in the late 1990s, partially affected by the Asian Financial Crisis, but also by improved Korean research capabilities. This investment resulted in a rising tide of Korean patents filed at the US Patent and Trademark Office (USPTO, 2005). For example, in 1985, Korean inventors were granted 41 patents at the USPTO by 2004, this had increased to 4,428 or nearly two orders of magnitudes. To provide an indication of how important the large firms were in this increase, in 2004 Samsung Electronics Co., Ltd. received 1,604 patents in the United States, which ranked it sixth globally (USPTO, 2005).

As a legacy of the days of massive technology imports, even today in Korea, the term "technology transfer" does not refer to the flow of knowledge from the university to industry; rather to the importation of technologies from countries such as the United States and Japan. These transfers allowed Korean firms to produce new products and gave them access to a broader range of technologies than they could have developed themselves. An important side effect of this technology acquisition strategy and the subsequent evolution toward internal research was the emergence of autarkic tendency among Korean firms. This led to a lack of interest in cultivating and improving technology transfer from the URIs.

4. THE URIS IN THE KOREAN ECONOMY

In the Korean economy, universities and RIs have different roles. The RIs were established to undertake mission-oriented research for the government and for the industry. In contrast, the universities were expected to educate students, and did not have a significant research mission. In theory this created a neat division of labor mirroring Korea's needs as perceived at the different times when these two institutions were established.

(a) *Universities*

The Korean higher educational system is less than 100 years old. The first institution of

higher education in Korea was Yonhee Junior College (which later became Yonsei University) founded by the American Presbyterian minister in 1917. [3] The first university was Keijo (Japanese) and Kyungsung (Korean) Imperial University (KIU) located in Seoul, which was founded in 1924 mainly to educate Japanese settlers. KIU absorbed a technical college that had been in existence since 1916. At that time, KIU only awarded bachelor degrees, and it did not establish an engineering department until 1941. The Japanese Imperial government had little interest in providing higher education to Koreans. At the end of the occupation, Korea had an extremely weak higher education system.

The situation in 1945 was dire, because many of the skilled technicians and managers were Japanese who were repatriated. At that time, Korea did not have sufficient trained manpower to maintain the existing industrial facilities. There were only 11 Korean doctoral degree holders and approximately 200–300 science graduates (The Korean Federation of Science & Technology Societies, 1980). Korea had to build its technical manpower from this extremely small base.

After liberation, the new Korean government continued the Japanese administrative system based on a strong central government and placed the entire educational system, including universities under the jurisdiction of the Ministry of Education. Since the new Korean government was heavily influenced by the United States, the Ministry of Education launched a reorganization of the higher educational system to closely resemble the US system in form. In substance, the organization, rules, and ethics more closely resembled Japan.

The immediate mission was to increase the number of science and technology graduates. This was accomplished by increasing the number of universities and expanding enrollment in the disciplines of science and engineering. From 1945 to 1947, 6 universities and 11 (vocational and medical) colleges including Seoul National University were formed (or reformed). Despite the hiatus caused by the Korean War, by 1960 there were 85 universities. This rapid expansion resulted in a lack of qualified teaching staff and a continual shortage of financial resources leading to a serious degradation of quality. Indeed, science and engineering education was conducted with virtually no laboratory facilities. Still because of the intense desire for education, Korean students had an excellent grounding in the sciences and mathematics.

Given the conditions and the government goals, the universities were, by necessity, training institutions. Advanced research was not possible or expected. Research and inventions were neither a priority nor a goal. Put simply, stemming from the societal need, the university's primary linkage to industry was as a supplier of trained manpower and not technology transfer. Gradually, a research mission was grafted on; and communication through publication in academic journals became the technology transfer method of choice.

The institutional structure of the Korean higher educational system constrains the interaction patterns between university and industry. Korean universities are centrally controlled by the Ministry of Education. Universities, private and public, receive the bulk of their financial support from the central government. The central government charters universities, decides admissions criteria, and university size through budget allocations. There is a high degree of national uniformity in terms of rules, pay schemes, promotion and recruitment, and general working conditions, although, since the mid-1990s, greater flexibility has been introduced. The centralized allocation system meant there was substantial rigidity in research funding. Central control and the civil service-like compensation scheme effectively decoupled professional compensation from research and teaching performance.

These institutional constraints mean that Korean universities respond only slowly to changing conditions. There has been little competition between professors or universities for research support. The result is a rigid hierarchy of universities providing little opportunity for a university with an entrepreneurial or innovative administration to establish new policies and practices that over time could lead to a significant improvement in the university's standing. Until recently, there has been minimal inter-university movement of faculty because universities have an inclination to hire their own graduates or fill vacancies through old-boy networks. Further, the normal professorial workload in terms of teaching and committee work is so onerous that many professors have little time or motivation for research—much less commercializing their research.

Despite these obstacles over the last five decades the size and technical competence of Korean science and technology faculties have

improved dramatically. In 1980, there were 1,230 professors of science and engineering. Of these less than half held Ph.D.s, and of these, half were educated overseas and the other half were trained in Korea. In 2001, the number of professors had increased to 6,268 and 14,092 in science and engineering, respectively. In recent years, almost all university professorial staff have Ph.D.s, and many of these are from US research universities. As Korean students went abroad for postgraduate education, they internalized the research orientation they experienced at the foreign universities. When they returned, they imported the belief that university professors should also do research. Reflecting the improving faculty quality and desire to publish, the number of publications in SCI journals increased from 300 in 1981 to 19,279 in 2004 (MOST, 2005).

Korean universities today have highly qualified faculty trained in global-standard research. In terms of publications there has been very substantial improvement. The teaching mission, however, continues to define the university system in the overall innovation system. This definition is increasingly out-of-step with the rest of the world, where there is a growing emphasis on university research as a lever for economic development. There are obstacles. In countries such as the United States, United Kingdom, and China, where universities have enjoyed an active involvement in economic development, the universities have had substantial or total autonomy from central government control. Organizationally, the relationship of the Korean universities to the Ministry of Education is predicated upon a centrally planned approach that may not encourage entrepreneurial behavior either in terms of securing research dollars or in commercializing research.

(b) *Korean universities and industry*

The growth of any economic activity is furthered by creating proper incentives. In general, in university–industry relations it is possible to encourage institutional interaction through administrative structures or through individual professorial linkages. Traditionally, neither the university nor the professors had incentives for developing industrial linkages (Lee, 2002). It is only recently that there have been incentives for collaboration at an institutional level through technology licensing. The other new incentive is that assistance to industry has been added as a criterion of professorial evaluation.

The most common role of university researchers has been as consultants rather than as either funded researchers or even co-investigators. Industry's expectation of the university was an ample supply of well-educated graduates, not the production of commercializable knowledge. Since firms developed their own technology or imported technologies from advanced countries, they did not expect economically valuable scientific knowledge from the university. There was good reason for this. Most of the patents registered from 1990 to 2001 in Korea came from private firms (78.8%), while universities produced only 0.5% and individuals accounted for another 17% of the total patent registrations during the period (Korean Intellectual Property Office, 2003). Further, there was very little inter-institutional funding, that is, from industry to university, and research institute to university. Research was performed in institutional silos (Suh, 2000, p. 18) that were buttressed by major cultural and social differences. Corporate researchers believed, perhaps rightly, that most university faculty were more interested in publishing their research than doing work applicable to industry needs (Lee, 2002). [4]

Some have attributed the lack of interaction to a lack of trust (Kim, Seo, & Han, 2000). Though trust may be lacking, probably more significant is a belief on the part of firms that inventive activities should be performed in-house, and that universities did not conduct research that could lead to marketable inventions. Firms also criticize the direction and the pace of university R&D. Conversely, many university researchers often believe that industrial research is neither creative nor challenging and thus not attractive. There is only a minimal flow of personnel between universities and industries. Korean researchers are reluctant to leave the university to commercialize an invention. In general, it is accurate to say that university researchers and corporate decision-makers inhabit different worlds.

Given this situation it is not surprising that the R&D collaboration between the university and the industry is limited. For example, one survey with a sample of 372 firms reported that about 53% of all responding firms have never had a research collaboration with a university (Park, Um, Lee, & Hwang, 2000). The most common pattern or relationship is one in which corporations contribute money to universities, or enter into informal consulting arrangements with a professor, neither of which typically

evolves into longer-term relationships (Woo, 2002). The rules and standards governing the university and professors have not, until recently, favored the entrepreneurial exploitation of university-based research. In sum, interactions between the industry and the university have largely been informal and personal. In this respect, the university–industry relationship in Korea can be summarized in two general principles: First, there were few formal research contracts, but abundant informal linkages. Second, there were few long-term relationships (Lee, 2002).

Most university inventions were until recently owned by the inventors. The exception is if the invention was made with government research funds. In these cases, the right to file for a patent belongs to the government. Whereas one might think that ownership of the patent by individual professors would assist in commercialization, the situation in Korea makes this difficult. Where an invention might have commercial potential, professors usually transferred it to firms that in return provided them with some research funding (Lee, 2002). Anecdotally, in 2005, three engineering professors, one each from SNU, Korea, and Yonsei, told us that they were hesitant to file patents on their inventions and preferred informal avenues of technology transfer. The firms decide whether or not to file for patents, and list the university researcher as a co-inventor. Due to this circuitous procedure, the inventors did not receive a direct financial return from their inventions.

At the end of the 1980s, Korean policy-makers concluded that closer university–industry relations were desirable. To encourage cooperation, universities received government funds to establish three types of R&D centers: Science Research Centers, Engineering Research Centers, and Regional Research Centers. The centers were meant to encourage cooperative research projects combining university, corporate, and RI staff (see Table 1 for founding by year). The monies were distributed by the Ministry of Science and Technology (MOST), but were managed by the university researchers. The types of university–industry cooperation to be supported by the centers included contract R&D, technical training of technicians dispatched from private firms, and technology consulting for regional industries.

In the early 1990s, the new Young–Sam Kim government initiated yet another reorganization aimed at strengthening R&D, though there was no specific policy aimed at changing the university's role. The 1997 Asian crisis led to the reorganization of the Korean university research system and a decision to encourage entrepreneurship based on university research. An important reform legislated in 1998 was the "Special Entrepreneurship Act" that was meant to foster high-technology entrepreneurship through technology transfer from the university to the industry. In 1998, legislation was passed creating a new legal infrastructure to facilitate the exploitation of the university's inventions and patents. The Ministry of Education also liberalized the laws governing the involvement of academic researchers in business activities that did not interfere with their normal duties. Universities were urged to create technology transfer offices (TTOs) to handle patenting and manage technology transfer. The TTOs were authorized to license university inventions to the private sector. In response, many universities established new incentive systems to encourage their faculty to file patents through their TTOs. To capture these rights from professors, Korean universities created new regulations. In 1999, regulations were passed allowing universities to establish wholly owned companies to commercialize their inventions and research, though to date few universities have utilized the self-commercialization route.

In 2000, new incentives to encourage UIL activities were introduced. These incentives appear to have increased the number of startups by professors and researchers from 337 in 2000 to 1,078 at the end of 2004. The number

Table 1. *The number of SRC, ERC, and RRC granted by year*

Year	1990	1991	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
SRC	6	8	–	3	–	–	3	3	10	3	4	2
ERC	7	9	5	–	–	7	–	7	12	4	6	2
RRC	–	–	–	3	10	1	13	10	–	9	8	5

Source: MOST (2005).

of professorial patent applications also increased even more rapidly than the total number of Korean patent applications (see Table 2). Despite these changes, the number of patents filed by universities continues to be relatively small and constitutes less than 3% of all patents filed (see Table 2). Of the Korean URIs, KAIST is the most prolific patenter followed by SNU (see Table 3).

In addition to the university reforms, Korean industry also became more willing to cooperate with universities for two reasons: First, their in-house R&D operations could not alone handle all the technological paths emerging from technological evolution. Second, the role of scientific knowledge was becoming increasingly important. Korean firms experienced intense pressure to remain abreast of the new developments in science and technology, and they felt that Korean universities could help them.

In another strategy for promoting university–industry collaboration, the government created six technology parks in 1997 (Ansan, Daegu, Kyungsan, Incheon, Kwangju, and Chungnam). Interestingly, not one of these technology parks was in Seoul despite the fact that it was Korea's technological center. The performance of these technology parks has not been strong in that they have induced only minimal technology transfer between university and industry (Lee, Kim, & Sohn, 2005). Although in the future they might perform better, their current achievements appear to have been limited to providing space for 2–3 year old startups looking for new incubators.

(c) *Government research institutes in Korea*

During the 1960s, as part of an economic development plan aimed at the systematic transition from an agricultural-based economy to an industrialized economy, the government created a number of RIs. RIs functioned as gatekeepers for diffusing the government's technology plans to the industry. They provided information about technologies deemed crucial to industry needs, implemented pilot R&D programs, and transferred imported technologies to the private sector. On a parenthetical note, the existence of the RIs meant to transfer technology likely influenced by industry's low expectations for research results from universities. They were not expected to innovate. Reverse engineering complemented the strategies of large Korean chaebol that were enhancing their capabilities (Kim, 1997). From their inception to the mid-1980s, the goal was not invention, but technology absorption to close the gap between leading foreign firms and the chaebol. Given their prominence in Korea's plans for industrialization, they received the preponderance of government R&D investment.

The first RI, the Korea Institute of Science and Technology (KIST), was established in 1966 in Seoul and began operations in 1969.

Table 2. *Professorial patent applications*

Year	Professor patents applications (A)	Portion ($B = A/C$)	Total patent applications (C)	Total patents registration
1982	30	0.5	5,924	2,609
1985	147	1.3	10,587	2,268
1987	300	1.7	17,062	2,330
1988	391	1.9	20,051	2,174
1989	485	2	23,315	3,972
1990	600	2.3	25,820	7,762
1991	917	3.2	28,132	8,690
1992	965	3.1	31,073	10,502
1993	1,351	3.7	36,491	11,446
1994	1,753	3.8	45,712	11,683
1995	2,131	2.7	78,499	12,512
1996	2,252	2.4	90,326	16,516
1997	2,765	2.9	92,734	24,579
1998	3,443	4.5	75,188	52,900
1999	2,686	3.3	80,642	62,635
2000	2,810	2.7	101,782	34,894
Total	23,425	2.9	791,114	274,614

Source: The Korean Intellectual Property Office (2002).

Table 3. *Professorial patent application by university (2002)*

University	Region	Number of patent applications
KAIST	Daejon	1,751
Seoul National University	Seoul	1,666
Pohang Engineering University	Pohang	794
Hoseo University[a]	Chungnam	761
Hanyang University	Seoul	715
Yonsei University	Seoul	694
Kyongbuk National University	Daegu	618
Chungnam National University	Daejon	577
Busan National University	Busan	523
Inha University	Incheon	479
Korea University	Seoul	464
Seongkunkwan University	Seoul	456
Chonbuk National University	Chonju	423
Hankuk IT University	Daejon	396
Yoengnam University	Daegu	385
Kyungsang University	Jinju	361
Chonnam National University	Kwangju	357
Chungbuk National University	Chongju	348
Kyonghee University	Seoul	303
Bukyung National University	Busan	297
Kwangju KAIST	Kwangju	290
Aju University	Suwon	265
Kangwon National University	Chuchon	250
Total		13,173

Source: The Korean Intellectual Property Office (2002).
[a] In the case of Hoseo University, one person has over 500 patents.

It coincided with the creation of the Ministry of Science and Technology (MOST). The model for KIST was the Battelle Memorial Institute, a private self-supporting R&D institute, conducting research funded by contracts from the government and private firms. A critical difference from Battelle is that KIST was not meant to become self-supporting (Woo, 2002, p. 18). During the 1970s, about 20 more RIs sponsored by various government ministries were created as either KIST spin-offs or through the reorganization of various existing research operations. The justification for these ministry-supported R&D institutes was the creation of national technological capability.

Interministerial political struggles also played a role in motivating new RI creation (Lim, 1999). These various RIs were expected to provide justification for their ministry's policies. They also provided administrative positions for retiring bureaucrats. The result of the plethora of new RIs was wasted effort and a lack of concentration on critical technologies. They became the center of government-sponsored R&D, but bureaucratization, duplication, and sectionalism plagued them. In an effort to overcome these difficulties, they were repeatedly reorganized and consolidated in the 1980s and 1990s (Lim, 1999). In 2002, 19 RIs still existed.

Despite their problems, during the early stage of industrialization the RIs did strengthen the ability of Korean firms to absorb imported technologies. And yet, because of their inability to produce significant innovations, there are mixed opinions regarding the RIs. For example, Pack (2000) argues that the RI's produced few technological improvements, even while Korean firms significantly improved their ability to obtain knowledge from abroad. Even as late as 2001, over 85% of the government's total R&D budget went to RIs, whereas universities received only 11.3%. Initially, this was understandable because the universities had few qualified researchers. Later, it proved less justifiable as 76.2% of Korea's Ph.D. holders worked at universities. This policy of allocating the preponderance of research funds to the RIs made it difficult for university professors to remain research-oriented and meant that students received little hands-on research experience.

In 1973, the RIs were transferred at enormous cost from Seoul to Daeduk in Chungnam Province to establish Daeduk Science Town (DST). KIST was the first to move to Daeduk from Seoul, and the others soon followed. By concentrating scientists and engineers, DST was expected to become the foundation for a high-technology industrial cluster. There was an assumption that research laboratories in and of themselves would encourage the formation of an innovatory environment in the Daeduck region and attract firms to locate in the vicinity to benefit from the fruits of the RIs' research. Unfortunately, there was no plan to attract firms to commercialize the research results and few entrepreneurs emerged in the region.

In many respects, the creation of DST as a "technopolis" was simply an ad hoc solution to three other pressing problems (e.g., Oh & Kang, 1992). First, it was meant to reduce the over-concentration of the population and industrial activities in Seoul. Second, it was expected to create new first-class universities outside of Seoul, thus providing more inter-regional balance. Third, the concentration of researchers was expected to spark interactions that would lead to synergies and commercialization.

The goal set by the government in forming DST was to spawn firms and establish a dynamic cluster so as to attract more activity and unleash the positive externalities of industrial growth, thereby creating a vibrant Silicon Valley-like technology region. But the vision was not to be realized for the first 25 years, as DST faced significant obstacles. First, there was no entrepreneurial base, so that the local entrepreneurship would require outside assistance (Castells and Hall, 1994). For most of Daeduck's history, there were no local-based venture capitalists and no "star" firms that might serve as an example to others that were formed. From the outset, DST was imposed upon the region by the central government even as local governments were excluded from the planning process (Hong, 1997). In other words, the RIs were parachuted into Daeduk having no linkages to the surrounding environment.

In the last decade things may have begun to change. In 1988 the "Special Entrepreneurship Act" was promulgated to encourage new firm formation. The Act appears to have had an effect on Daeduck RI personnel and by 2004 Daeduck had 424 startups; most of which were spin-offs from RIs nearby. Despite this increase in startups, Daeduck still has not spawned a strong entrepreneurial support network, [5] diverse business services, and the financial resources to become a dynamic cluster. In 2005, Daeduck received less than 5% of total investments in venture capital.

Thus, the RIs have not sparked the formation of a dynamic high-technology cluster in Daeduck even though a significant number of researchers were relocated from Seoul. In retrospect, the decision to relocate the RIs only recently appears to have had real benefits. The Daeduck environment was unprepared and the relative lack of private sector participation meant that this experiment had little opportunity for early success. The result can probably be summarized in this way, a group of capable government researchers were relocated away from the firms that would have been most likely to benefit from their activities and no self-sustaining entrepreneurial cluster was formed until more than 20 years later.

5. SEOUL, URIS, AND THE GROWTH OF A TECHNOLOGY CLUSTER

When considering the role of Korean universities in urban development, Seoul is the obvious candidate for study. When the Korean economy grew on the basis of export-oriented light industries such as textiles and toys, labor costs were low, and small manufacturers clustered in metropolitan areas like Seoul from where it was easy to ship goods for export. By the 1990s, given the increasing land prices and environmental pollution, the Seoul metropolitan area was no longer conducive to manufacturing, and many of the factories relocated to the two neighboring provinces.

In the 1980s, Korean industry recognized that mass production of relatively low-quality commodities would no longer ensure commercial success. The industrial restructuring during the 1980s emphasized technological upgrading, production automation, and the development of high-technology industries. The manufacturing sectors also changed as the ICT sector became Seoul's leading industry. In the 1980s and 1990s, the number of manufacturing firms countrywide increased from 53,527 in 1981 to 68,395 in 1999, but Seoul's share declined from 14.9% in 1981 to 9.9% in 1999. Manufacturing employment also declined from 725,132 in 1981 to 573,189 in 1999, though total employment continued to grow.

The science and engineering RIs could not contribute to cluster formation in Seoul

because they had been relocated. In terms of universities, Seoul was well endowed but they had little interaction with industry. So despite the fact that Seoul had by far the greatest pool of promising university-based inventors and, therefore, had far greater potential than any other region, there has been minimal contribution from the URIs to the growth of local high-technology industry.

The Seoul municipal government only recently adopted policies to assist entrepreneurship (see Table 6). The first explicit policy was the opening of an Exhibit Hall in 1993 for industry fairs. In 1995, the municipal government established its first business incubator. In the aftermath of the Asian financial crisis, the municipal government became more active about encouraging the development and upgrading of local clusters. This active promotion was again strengthened during the Internet Bubble period. But because the bubble collapsed soon after, it is difficult to evaluate whether the promotion efforts of Seoul authorities have borne any noticeable fruit.

Given Seoul's centrality in the Korean economy and the enormous attraction it has for talented Koreans from around the nation, it is no surprise that it has the most high-technology startups, in general, and in the IT industry, in particular. This is evidenced by the fact that out of total 9,246 high-technology firms in 2002 in Korea, 6,824 firms were located in the Capital Region (Seoul, Incheon, and Kyunggi Province) and 4,082 firms (43%) were located in Seoul (see Tables 4 and 5). [6] Even while manufacturing has been relocated from Seoul to other cities and even abroad, corporate R&D continued to be concentrated in and around Seoul. It was only during the Internet Boom that a technology-based cluster appeared in Korea. The largest concentration of these startups was in a section of Seoul, Kangnam-gu, which was popularly referred to as "Tehran Valley" after Tehran Street, which runs through the center of the area.

Beginning in 1997, various IT and Internet firms and venture capitalists established their offices in Kangnam. In 2000, it was estimated that there were 2,133 Internet and IT startups in the area (Kyong, 2002). MNC subsidiaries such as Microsoft, Sun, Symantec, Yahoo, and eBay also established their offices there. During this time period, of the $2 billion in venture capital invested in Korea, roughly half was invested in Kangnam (Kenney et al., 2004). Many of the major IT and venture capital-related industry associations such as the Korea IT Industry Promotion Agency, Korea Association of Information and Telecommunications, Korea Software Industry Association, Korea Venture Business Association, and the Korean Intellectual Property Office were located there. During those heady days, it had a "Silicon Valley-like" environment of entrepreneurship, rapid growth, and capital gains.

Unfortunately, the Internet Bubble collapsed, even while real estate prices continued to increase forcing many of the surviving startups to relocate to lower cost locations. The startup firms relocated to places with lower real estate costs and were replaced by the headquarters for large industrial firms, foreign insurance and financial companies, and various other established organizations. By 2002, many of the Internet startups had either failed or relocated (Park, 2002). Korean venture capitalists were also seriously affected, particularly those who invested heavily in Internet firms. Despite these relocations, Kangnam still has one quarter of all of Seoul's telecommunications and IT service firms (Park, 2005). Whether Tehran Valley was a significant regional innovation

Table 4. *Number of high-tech startups in Korea*

Year	1998	1999	2000	2001	2002	2003
#	2,042	4,934	8,798	11,392	9,246	8,498

Source: The Korean Small and Medium Business Administration (2004).

Table 5. *Regional distribution of high-tech firms in Korea (2002)*

	# of High-tech startups	Ratio (%)
Seoul	4,082	43.3
Busan, Ulsan	459	4.9
Daegu, Kyungbuk	547	5.8
Kwangju, Chonnam	209	2.2
Daejon, Chungnam	670	7.1
Kyunggi	2,289	24.3
Incheon	453	4.8
Kangwon	88	0.9
Chungbuk	225	2.4
Chonbuk	103	1.1
Kyungnam	284	3
Jeju	17	0.2
Total	9,246	100

Source: The Korean Small and Medium Business Administration (2003).

Table 6. *Functions and organizations for high-tech development in Seoul*

Functions	Organizations	Founding year
General industry support	Seoul Industry Promotion Foundation	1998
	Seoul Industrial Support Center	2001
Support for a particular industry	Seoul Animation Center	1999
	Seoul Fashion Design Center	2000
	Seoul Printing Industry Support Center	2001
Support for high-tech startups	Seoul Venture Town	1999
	Seoul Business Incubator	1995
Marketing support	Exhibition and Shopping Mall (Jamsil)	1993
Financial support	Seoul Credit Foundation	1999
Attraction of foreign investments	Seoul Investment Trade Service Center	1999

Source: Seoul Metropolitan Government (2002).

system is, in some sense, unanswerable because so many of the firms failed, and those that continue have not yet established themselves on the global scene. In many ways, Tehran Valley more closely resembled New York's now defunct Silicon Alley with its emphasis on media rather than on high technology.

There was a brief moment when Kangnam experienced Silicon Valley-like growth and dynamism, but most of the firms appear to never have had sophisticated technology or good business models. Also, many did not have skilled management or first-class technologists from either industry or the URIs, local or otherwise. Whether the surviving firms will form the basis for another wave of innovation, thereby creating an evolving, self-sustaining cluster is not clear at the moment. What is clear is that even today universities or other research and educational institutions have not yet been integrated into the Kangnam entrepreneurial economy, such as it is.

6. DECENTRALIZATION POLICY—THE ANTI-CLUSTER POLICY

Beginning in the early 1980s, the decentralization policy was expanded from Seoul itself to its suburbs in the Capital Region to include Seoul, Incheon City, and Kyunggi Province. Given the drive to decentralize, although Seoul had the greatest potential for experiencing university–industry interaction and entrepreneurial cluster formation, it has received the lowest priority in national support programs. Knowledge-based firms did spontaneously gather in Seoul or the Capital Region, even as the central government invested resources in trying to establish technology clusters in the non-Capital Region area. The decentralization policy, though it may have been good for inter-regional equity, ensured that Korea's most significant efforts to encourage entrepreneurship and the development of innovative clusters were concentrated in locations that had few prerequisites for being successful.

The policy meant that second-tier universities received the greatest assistance, while the universities that had the highest probability of generating and transferring valuable knowledge were omitted from the regional innovation policy. As with the RIs that moved to Daeduck, these local universities had no entrepreneurial support infrastructure and little hope of building one. For example, the venture capital firms that provide equity finance for high-tech startups were in Seoul as were other professional service firms capable of providing assistance.

Given the control exerted by the central government, local governments were largely precluded from developing their own initiatives. [7] Compared to other regions, Seoul's local government had the greatest handicap because the decentralization policy assigned it the lowest priority. On its own initiative, the city government did establish programs aimed at connecting researchers to the region's small and medium-sized enterprises (SMEs). The most notable city government action was a 1998 decision to fund two business incubators: the Seoul Business Incubator and the Seoul Venture Town. The incubators were meant to

provide low rent space for high-technology startups. Seoul Venture Town was located in the center of Kangnam, and aimed to encourage high-tech firms in the Valley to secure benefits of clustering. The Seoul Business Incubator also assisted entrepreneurs having difficulties in commercializing technologies and/or inventions.

Decentralization itself probably had only a minimal depressing effect on the development of clusters. Perhaps, more important, it was symptomatic of deep involvement by the central government in microlevel management that discouraged individual and institutional initiative. Given the lack of encouragement, Seoul officials acted only very late to try to encourage the growth of a high-technology cluster. Kangnam continues to have some entrepreneurial activity in wireless applications, game software, and various Internet-related ventures, though very few of the firms have grown to a significant size.

7. DISCUSSION AND CONCLUSION

The Korean universities began as training institutions rather than new knowledge generators. For this reason, universities have had little significant role in new knowledge generation for commercialization. They were not research institutions. Korea overcame a general lack of technology by importing it and establishing the RIs. The rapid growth of the Korean economy meant that by the 1980s Korean chaebol had developed sufficiently to manage technology importation without government assistance. In 2005, the absence of a strong university-based research establishment means that Korea is still almost entirely dependent upon the innovations generated by industry, particularly after the 1980s when the RIs became less relevant.

Government policy regarding decentralization may also be partially responsible for the lack of any global-class, high-technology clusters in Korea. The Korean decentralization program was different from that in most nations where decentralization means the devolution of power to the regions, in Korea it simply means the central government moved functions out of Seoul—control remained centralized. Programs to encourage entrepreneurship or university–industry interaction targeted other regions, all of which had little possibility of developing significant high-technology activity. The prime example of the decentralization policy was the transfer of the RIs to Daeduck—a strategy that only recently may be having a discernable impact on the development of a high-technology cluster there. This also relocated a portion of Korea's total research from Seoul—the location of the strongest support environment for entrepreneurship in Korea. The decentralization plan was initiated for the purpose of balancing regional power and decreasing the over-concentration in Seoul, as a side effect it probably retarded the development of high-technology industries in Seoul and did not significantly improve technology development in the recipient cities.

Korean universities were and are still, to a substantial degree, embedded in a hierarchical and conservative system creating significant obstacles to inter-institutional knowledge transfer and entrepreneurship. In the late 1990s, policy-makers and university administrators changed their outlook and recognized the importance of encouraging entrepreneurship and building viable clusters. Nonetheless, bureaucratic, social, and cultural obstacles are slowing the increase in entrepreneurship based on university research. The near-term emergence of vibrant clusters based on small high-technology firms in Seoul or elsewhere in Korea is unlikely.

The nature of the university's embeddedness in the Korean political economy also affected their ability to contribute to Seoul's development. Korean URIs did not reward researchers for contributions to industry nor did they encourage entrepreneurship (Lee, 2002). But as we have seen since 2000, the new incentive schemes for enhancing academic entrepreneurship are changing. The social norms governing university faculty might change and lead to greater acceptance of academic involvement in corporate research.

There is no one unambiguously superior model for interaction between the university and the industry. Despite having weak URI–industry interaction and little entrepreneurial clustering, Korean universities and Korean society generally have experienced rapid expansion. It is useful to appreciate the strengths of the Korean system. First and foremost, the universities trained a large pool of talented scientists and engineers that became the workers upon which Korean firms have propelled themselves into the world's first rank and from whose work Korean living standards have advanced to near developed country status. They were an excellent base for Korean economic

development. Second, there are informal channels for inter-institutional information flow. Having said this, there is a growing belief among policy-makers and university administrators of the importance of encouraging URI entrepreneurship and entrepreneurial clusters. Reshaping a socio-economic system is often easier when it has failed—something that is not the case in Korea. Today, in Korea there is a general consensus that the country's challenge is to initiate an evolutionary process that will permit the current innovation system to retain the desirable characteristics while building new clusters and entrepreneurial capacity.

NOTES

1. This metaphor is borrowed from Miner et al. (2000) who referred to the widely held belief that university research was a magic seed from which Jack's beanstalk of economic development would grow.

2. There is a continuing controversy as to whether a significant cluster has emerged in Daeduk. Shin (2001) and Sung, Gibson, and Kang (2003) make the strongest argument that there is an entrepreneurial cluster.

3. Chosun Christian College was founded by Presbyterian minister H.G. Underwood without legal recognition in 1915, and changed its name to Yonhee Junior College upon certification in 1917 (Woo, 2002). It became Yonsei University after merging with Severance Medical College.

4. There was also an undercurrent of distrust of the chaebols by university faculty and students that can be traced back to the years of dictatorship.

5. On entrepreneurial support networks, see Kenney and Patton (2005).

6. In Korea a high-tech startup is defined as a firm that invests more than 5% of total sales into R&D, or if sales due to a patent account for more than 50% of total sales, or if venture capital investors control more than 10% of stockholders' equity.

7. Few local governments in Korea can actively influence their own local economies. Only recently have local governments received greater autonomy to adopt policies to improve the competitiveness of local industries.

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