Regional Innovation Systems of Tsukuba, Japan

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1. Introduction

Japan has recorded rapid economic growth since the end of the Second World War. During the early period of economic growth, Japanese economic growth was led by three major metropolitan regions: Tokyo, Osaka, and Nagoya (OECD 1996). Since the mid-1960s, however, Japan has been trying to decentralize the concentrated growth by various means, as urban congestion and rising land price in those metropolitan regions affected economic efficiency and spatial equality. One of the decentralization policies was to establish science parks in the areas where economic activities were less dynamic and land price was not very high.

In 1963, the national Cabinet approved a law to establish a new science town in Tsukuba to decentralize the growing City of Tokyo, and in the early 1980s, the former Ministry of International Trade and Industry (MITI) launched policies to develop science parks to systematically assist the lesser developed regions. With popular support from prefectural governments, MITI was successful in designating and supporting many technology intensive industrial districts (or towns) by 1985.

It has been several decades since Japanese science park policies were launched. The policies, however, seem to have been unsuccessful as the policies did not create expected outcomes. According to Castells and Hall (1994), and Bass (1998), they did not have measurable impacts on the local economies and lacked spin-off effects from R & D institutions of the newly established science parks at the end of the 20th Century. There were also insufficient synergistic effects among the institutions within the parks. Even Tsukuba Research and Academic City (TRAC), a major science park of Japan developed in the mid-1960s, was not an exception, even with enormous government investment.

In this context, this paper examines the Japanese science park policies with a specific focus on Tsukuba. It aims to find: first, how Tsukuba was built; second, to what extent the spin-off and synergistic effects and the local economic impacts affect the outcome; and third, why the expected outcome did not result. The paper does this by looking into the mechanisms of making and operating Tsukuba. In this vein, it analyzes key institutions involved in promoting Tsukuba's regional innovation, including government, research institutes, trade organizations, firms, and universities. To analyse the linkages among these actors, the concept of regional innovation systems, a popular concept of promoting high technology industrial districts, is employed. The concept is used here as it is believed to provide a useful framework of analysis in examining the complex relationships among various actors, which

are common in the promotion of high technology industrial districts.

The data presented here are from three major sources: published writings, web pages, and personal interviews. The interviews were conducted with some representatives from the prefectural and municipal governments, trade organizations, and private corporations, mainly in Tsukuba. The interviews were conducted on-site in the months of January and February, 2002. Each interview session lasted approximately one-and-half to three hours.

2. Regional Innovation Systems as an Analytical Framework

One of the major purposes of establishing Tsukuba, indicated in the earlier policy statement of the Japanese government was to advance scientific discoveries in the Japanese economy. It is also true that the process of making Tsukuba drew considerable attention from various organizations in the private and public sector, including the central government, semi-government agencies, banks, and trade organizations. There existed some aspects of "association," which pertained to "systemness," among those organizations that contributed to establishing and operating Tsukuba, as will be seen in the following section. As Tsukuba was initiated to generate scientific innovation and the operational mechanism of Tsukuba process contains the systemness, Regional Innovation Systems (RISs, Cooke 1992, 1997) could be a promising candidate of a framework analysis here. In fact, RIS is emerging as a popular research frame work used in analysing the mechanism of promoting industrial districts of the world, exemplified by Tuscany in Italy (Ottati 1998), Silicon Valley and Hollyhood in the US (Scott 1998), and Ontario in Canada (Wolfe and Gertler 1998), just to take only a few cases.

According to Cooke (1992, 1997, 1998), RIS is a system that generates regional economic clusters. It is a "system" as various elements both in the private and public sectors take part in making a particular regional economy more innovative, interacting with each other. RIS consists of elements and relationships, where the "elements" include small and large firms, research and higher education institutes, private R&D laboratories, technology transfer agencies, chambers of commerce, business associations, vocational training organizations, relevant government agencies and appropriate government departments. These constitute the basis for an integrative governance arrangement. The club, forum, working party, consortium of partnership model is what typifies this associative (Hirst 1994; Casson 1995) approach towards, enhancing the commercial community (Cooke 1997: 10).

The concept of RIS was formulated by applying core ideas of the national innovation systems approach into the debates about industrial districts (Markusen 1997; Brusco 1989;

Piore and Sabel 1984) and learning regions (Morgan 1997). Cooke (1997: 20-24) has articulated the typology of RISs into six types, according to the governance dimension and business innovation dimension. Based on the patterns of governance, three types are distinguished: Grassroots, Network, and Dirigiste RISs, while another three: Localist, Interactive, and Globalist RISs, are delineated according to the span of business activities of participating elements. In Grassroots RISs, local elements initiate actions, for example, towards technology transfer, and funding for such actions primarily comes also from local banks and governments, and local chambers of commerce. The technical specialization is assumed to be low, while the degree of supra local coordination will also be low because of the localized initiation.

In the case of Network RISs, actions are initiated by various elements at a multi-level, meaning local, regional, federal, and supranational as appropriate. Funding is more likely to be guided by agreements among banks, government agencies, and firms. System coordination is likely to be high because of the many stake holders. Specialization within such a system is likely to be flexible rather than inflexible (Cooke 1998: 20). This Network RIS is compared to a Dirigiste RIS in which technology transfer activities are animated mainly from outside and above the region itself. In a Dirigiste RIS, initiation of actions towards technology transfer is typically a product of central government policies, while funding is also largely determined by the central government. The level of coordination in such RISs is very high, since it is state run, and the level of specialization is also likely to be high (Cooke 1998: 21). Examples of Dirigiste RISs are found from the Tohuku Region of Japnan, Quebec of Canada, and Midi-Pyrenees of France.

Another three RISs that Cooke has identified based on business innovation patterns are: Localist, Interactive, and Globalized RISs. These are classified by looking at whether dominant firms of a specific region are operated locally, or internationally. If the dominant firms are either indigenous on origin, or inward investment, then localist RISs will tend to have few or no large indigenous firms and relatively few large branches of externally controlled firms. A localist start-up will probably have few major public innovation or R&D resources, but may have smaller private ones (Cooke 1998: 22). Interactive RIS is not particularly dominated by large or small firms, but rather by a reasonable balance between them. There will also be a balanced mix of public and private research institutes and laboratories (Cooke 1998: 23). In a Globalized RIS, however, there is domination by global corporations, often supported by clustered supply chains of rather independent small firms, meeting some of the requirements of indigenous or inward investor multimationals. In

California, the high-tech complexes are illustrative of this modality, with firms that have displayed rapid and high rates of growth dominating the local supply industries, and creating their own inter-firm collaborative arrangements (Cooke 1998: 23). This RIS typology, summerised by the diagram shown in Table 1 below, will be used in guiding the flow of this research in attempting to analyse the Tsukuba mechanism.

<Table 1> Regional Innovation Systems: Towards a Typology

Business innovation	Grassroots	Network	Dirigiste
Localist	Tuscany	Tampere Denmark	Tohoku (Japan)
Interactive	Catalonia	Baden-Wurttemberg	Quebec
Globalized	Ontario California Brabant	North Rhine-Westphalia	Midi-Pyrenees Singapore

Governance of enterprise Innovation support

Source: Cooke (1998: 22).

3. An Overview on Japanese Regional Innovation Policies

Japanese regional economic growth before the early 1980s was led mainly by traditional economies, such as manufacturing automobiles, household materials, and industrial equipments and machines. However, a major change has been made towards a more technology-intensive economy since then. In fact, Japan initiated strategies of technology-led development, ie., technopolis program since the mid-1980s. These Japanese policies are unique in three aspects: first, the policies were incorporated in the policies of developing less developed areas; second, the strategy was used in reducing metropolitan growth; third, the technology policies were implemented throughout most parts of the country rather than in selected areas (Edgington 1983; Masser 1990).

Main objectives of these Japanese technology policies were to create high quality

living environment, to provide the infrastructure needed in stimulating local economic development, and to assist in economic restructuring (Masser 1990: 42). Transforming national economy with new industries, such as semi-conductor, new materials, bio-technology was also an important objective.

To accomplish these objectives, in 1983, the former Ministry of International Trade and Industry (MITI) announced a call for proposals which invited prefectural governments' plans to establish a technopolis. According to the new "law for accelerating regional development based on high technology industrial complex," each prefecture seeking a designation of a technopolis was required to respond to MITI's call with a detailed plan that included a potential site of the technopolis. The sites to be designated for the technopolis were required to satisfy certain conditions: it should be in the vicinity of a "mother" city with more than 150,000 inhabitants but not overly congested so as to maintain room for further development; it should have at least one university providing courses on high technology; it should maintain local enterprises with a core technology by the plan; it must have a good access to national and international transportation networks (MITI 1988a: 13; Masser 1990: 42). This scheme and the whole program in fact was initiated by a study group chaired by professor Takemochi Ishii.

Professor Ishii's study group foresaw that two or three sites could be selected from the candidate prefectures that responded to MITI's call. However, as many as forty out of forty seven Japanese prefectures, put in bids for designation and intensive lobbying took place in competing to win the bid. The government in fact selected fourteen in the first year and twelve more in the subsequent years by 1988. It is worth noting that the majority of the sites designated as technopolis were located along the coastal areas of the Pacific and the Japan Sea, which have access to the high speed railway, Shinkansen.

In 1987, MITI also launched a program called, "Centers of Cooperative Research". It was a response to the criticism that the technopolis program focused mainly on physical infrastructure, thereby attracting only the branch plants of high technology industries, such as semiconductor fabrications. The main reason for this was seen to be the lack of "magnet" infrastructure which may attract real high technology industries. MITI's response to this was a program designed to promote university-industry linkages. While MITI's earlier policies were concerned with a balance between urban and rural areas and also between congested and lagged regions, it became more concerned with the advancement in science and technology (Bass 1998: 396).

Common facilities of the Centers included prefectural testing and research institutes,

which were established without any real estate development. They were assigned to the existing universities to generate cooperative activities among universities and corporates. According to Hashimoto (1990), there were 173 Centers being operated under this program by 1989 (Bass 1999: 396). These Centers were divided into 12 different types, based on a law call "Strengthening the Private Sector (Minkaku Law)," according to the Centers' facilities and functions. The "Type 1" Centers, "Research Cores" for example, incorporated the following four elements: open laboratories for private and cooperate R & D; advanced education and training activities; facilities for interaction and information exchange; and business incubators for high technology venture firms (Bass 1998: 396).

While there were 16 Type 1 Centers existing in Japan, these Type 1 Centers were called "the third tier of Japanese technology parks," following Tsukuba and the Technopolis program initiated in 1983. The Type I and other Centers in general were seen to be effective in promoting links between universities and local industries (Edgington 1989; Hashimoto 1990). In 1988, Japan enacted the "Law of Brain Industry" that releases stringent conditions required by the Minkaku Law.

Evaluations of these Japanese technology policies up to the mid-1990s tend to be mixed at best (Sternberg 1995: 434; Castells and Hall 1994:). Some have argued that only a few designated sites have attracted high-tech industries, or R & D activities, and these successful cases are concentrated around the Tokyo area. It has been said that there were not many spin-off effects from the major actors located in technology parks, thereby not having any impact on the local economy. Others have argued since the early 1990s that it was too early to evaluate the general progress of the policies and more specifically the impacts of the policies, since it takes a long time to see the real impacts of such policies. Tsukuba was not an exception from this evaluation in the past. Now, however, it is time to evaluate the impact of Tsukuba as more than three decades have passed since its establishment unlike many other technology parks in Japan.

4. Tsukuba Science and Academic City as a Japanese Technology Park

1) Planning Tsukuba

Tsukuba Research and Academic City (TRAC) is the earliest science park developed in Japan. In Japanese technology policies, Tsukuba project is exceptional in the sense that it was established far before the period when Japan had begun to initiate full range of the technolology park policies. It was initiated because the Japanese bureaucrats and regional

planners saw the rapidly expanding Tokyo area, benefited by the post-war Japanese economic boom, was causing serious urban congestion in the 1960s. They believed it was essential to develop new towns to disperse urban growth in other large cities. It was also a time when there was some consensus among the bureaucrats and academics who believed that Japan needed to take some measures to promote the technology-intensive economy to make Japanese national economy strong and competitive, thereby continuing economic growth.

In 1963, the Cabinet approved Tsukuba as a site for building a large scale science city. Tsukuba is located in the southern Ibaraki Prefecture, approximately 60 km northeast of Tokyo and 40 km north of Narita International Airport. The city spreads over Tsukuba city and Kukizaki town, covering approximately 28,400ha (284 km2) of rural land. It was developed for two major purposes: first, to promote science and technology by creating a major center of advanced research and higher education based in national institutes and the University of Tsukuba; second, to disperse the concentrated growth in Tokyo to its surrounding areas.

The city was planned as a new town composed of three major zones: research and education zone, commercial zone, and suburban zone, with a target population of 220,000 in total by 1990. The research and education zone covered about 2,700ha in the center of the planned city, where national research and educational institutes, urbanized areas, residential areas, and parks were planned to be located. The commercial zone, planned for the central city, was to host buildings and facilities of commercial and cultural activities. One of the major structure in this zone was Tsukuba Center, a symbolic building of the city, hosting a large-scale shopping center, a library, a museum, communication facilities, etc.

The suburban district was in the rural areas with a few scattered town centers, such as Tsujiura, covering about 25,700ha. This area was planned to promote urban expansion, but the natural and rural environment was to be preserved. Private research institutes were also planned to be located in this zone. Tsukuba is indeed a full-scale planned city, where most urban necessities were systematically planned to be located, including various arterial roads, sewage systems, parks, residences, and universities.

2) Constructing Tsukuba

To implement the plan for Tsukuba Science City, the National Land Agency (NLA) was hired, and an organization called the "Tsukuba New Town Construction Promotion Headquarter" was established. The main role of this organization was to coordinate activities of building the city, based on the guidelines formulated by the "Tsukuba Science City

Construction Act". According to the plan, the NLA had to acquire and develop the necessary land, and construct the necessary infrastructure, like the roads and power-lines.

The first Master Plan was created in July 1965. Since then, the details of the plan were revised several times, adopting inputs and suggestions from various institutions related to the Tsukuba Science City. The fourth master plan, which forms the backbone of the present project, was drawn in 1969. In fact, most of the present conditions of the city were created in accordance with this plan, although minor modifications were made. The Ministry of Education cooperated in building the new research and educational institutions and relocating the existing ones to Tsukuba. The Ministry of Finance also cooperated by providing financial resources to build residential complexes. Local governments such as Ibaraki Prefecture and other related municipalities were involved in developing public spaces and facilities, including urban parks and commercial facilities.

In 1972, the National Research Institute in Inorganic Material became the first institution relocated to the new city, and Tokyo Educational University was relocated in 1973, with a new name called, Tsukuba University. Government offices and large national research institutions moved to the city in the subsequent years. By 1980 forty-three research and educational institutions were being operated in Tsukuba. Overall the process of creating a new science city in Tsukuba was smooth. However, many of the employees of the offices and research institutions were reluctant to move to Tsukuba. Many of them in fact chose to commute from Tokyo to Tsukuba. This general tendency was seen to be a major problem for those involved in the Tsukuba project. The main reasons for this were: first, there were not sufficient opportunities for commercial and cultural activities, such as large department stores and theaters; second, the quality of educational systems for children was inferior to that of Tokyo.

The International Exposition of Science and Technology was held in 1985, which became a major turning point making Tsukuba a more attractive place for R & D activities, research activities, and as residential areas for those who work it the government laboratories. The great amount of investment in building urban infrastructure was helpful. The Tsukuba Center, a large commercial complex, consisted of a top-class hotel, various small department stores, and business offices. It was constructed as the center, promoting cultural activities and facilitating linkages among institutions and individuals of Tsukuba and those outside.

Tsukuba grew to become a city of 188,000 people by 1999, and further growth was projected according to a recent plan at the time 1998 to make the city much larger with as many as 350,000 inhabitants by the year 2030. The growth in the past was made possible by

the location and relocation of forty-six national research and educational institutions, which employed approximately 13,000 scientists and engineers. These institutions normally receive approximately 40% of the total budget and makes up a large percent of the personnel of Japanese national research institutions. Tuskuba now has 27% of the national research institutions, receives 36% of the research budget, and makes up 44% of research staffs in Japan. Many private companies also established their research institutions in the industrial parks and Tsukuba's suburban districts, consequently bringing approximately 4,500 research and engineering staff.

Since its inception in 1963, however, Tsukuba was often criticized for not having the expected outcomes. It has been said that there have not been sufficient spin-off effects from the companies and research institutes. Furthermore, institutions in Tsukuba also lack synergy effects not only among them but between them and other institutions and companies outside Tsukuba. It has also been criticized for the lack of cooperation among companies and research institutes within the city.

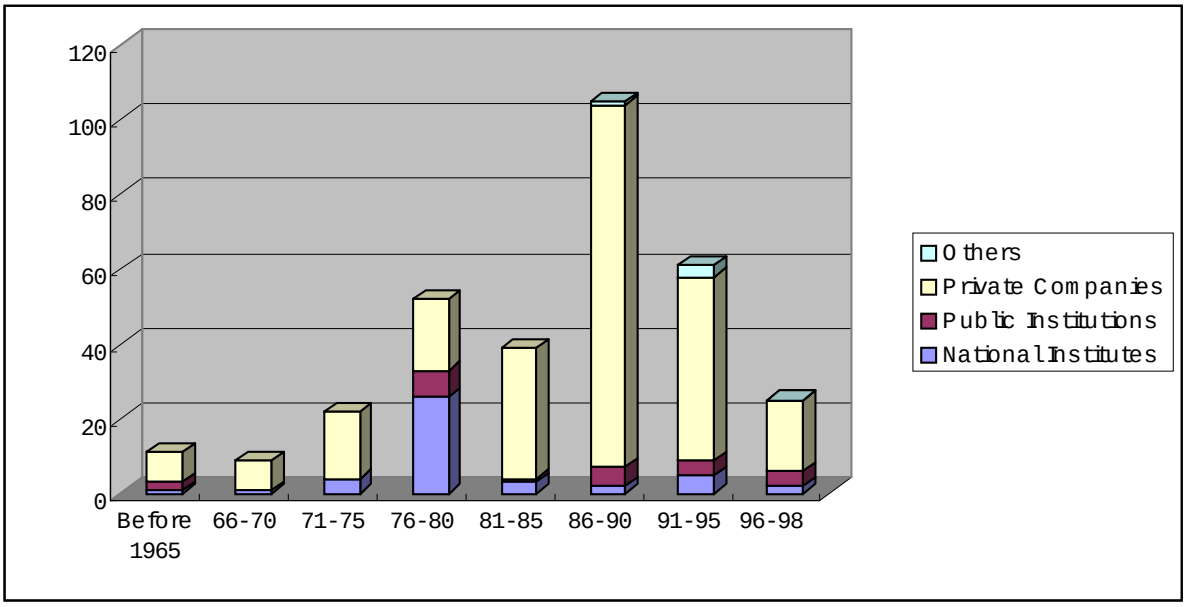
In response to these criticisms, Japanese planners and government officers tried hard to ameliorate such problems. They established new organizations to promote inter-institutional linkages, such as Tsukuba Research and Exchange Center, Tsukuba Research Assistance Center Inc. (TCI), and many science parks within Tsukuba. TCI, for example, was created as a public-private joint project to build more dynamic relationships between research scientists and local entrepreneurs and to assist in the spin-off activities from the government research institutions located in Tsukuba. It was funded by money drawn from various sources such as the prefectural government, local banks, and other corporations. It now operates four buildings to provide office space from which some 100 companies benefited in the past ten years or so.

<Table 2> Number of People Employed by Institutions of Tsukuba City : 1998

	Total	Clerical	Manufacturing	Engineers & Scientists	Others	Doctoral Degree Holders
Research Institutes	12141	3587	3	8350	202	4103
Public Institutions	725	232	7	465	40	84
Private Companies	12944	2651	3459	4498	1555	618
Others	74	18		54	1	28
Total	25884	6488	3469	13367	1798	4833

Source: Association of Tsukuba Research and Science City (ATRS), et al. (1999: 8).

<Figure 1> Number of Institutions Located in Tsukuba City: 1965-1998



Source: Association of Tsukuba Research and Science City (ATRS), et al. (1999: 5).

<Table 3> High Techology Industrial Sites of Tsukuba

Name of the Industrial Sites	Area	No of Companies
Tokodai Business and Research Park	39ha	28 & 8 Projects
Tsukuba Western Business and Research Park	102ha	14
Tsukuba Northern Business and Research Park	128ha	17
Tsukuba Research Park Hanare	5.4ha	7
Tsukuba Techno Park Toyosato	69ha	26
Tsukuba Techno Park Sakura	24.6ha	5
Tsukuba Techno Park Oho	41ha	10

Source: Association of Tsukuba Research and Science City (ATRS), et al. (1999: 11).

5. Promoting the Creation of Networks among Companies: Interviews

1) Tsukuba Research Assistance Center Inc. (TCI)

As mentioned earlier, TCI is one of the "Third Sector" projects, which was established by a consortium of governments, banks, and other local organizations. It provides spaces for various kinds of meetings related to governmental research institutes of Tsukuba. It also rents out office spaces for some small companies, most of which have some linkages with local research and manufacturing activities, such as consulting firms. One of the regular meetings that TCI hosts is a program called "Ibaraki Venture Forum" held every year.

Approximately 90 companies take part in this Forum to advertise their products and technologies and to acquire new technology. This Forum has been providing opportunities where investors, entrepreneurs, and scientists could meet together, exchange information, and make managerial and technological linkages since 1989.

TCI also hosts IRDA, which is jointly established by the Ministry of Education, the Ministry of Industry, the Ministry of Economy and Trade, and the governments of Ibaraki Prefecture and Tsukuba City. IRDA, consists of five groups, including information technology, nano technology, and food products technology. The groups assist generations of new firms with high technology and provide entrepreneurs and scientists with opportunities to establish new firms or to expand into new areas of business. Since its inception, IRDA held over 100 meetings, where 30 or more people attended each time.

TCI also runs "Ibaraki Salon," supported by the prefectural government, which provides local companies with places for managerial and technological consulting services, arranges contacts for them with national research institutes of Tuskuba, transfers technologies from local firms, and introduces companies to local professors and experienced scientists and engineers retired from universities or large corporations.

TCI runs business incubators providing office space for start-ups Tsukuba and some branch offices of large companies outside. Main purposes are to provide space for R & D activities and to transfer scientific knowledge into entrepreneural activities. This business incubator promotes start-up activities by helping entrepreneurs, maintaining good management environment for the existing companies, and nurturing information related to research institutions. In the past ten years, TCI's business incubator provided office and experimental spaces for 100 firms, most of which reached their initial goals and have graduated from the business incubator.

In addition, the Tsukuba Lecture is a program hosted by TCI, providing a place where scientists of national research institutes are invited to give explanations about their R&D activities. Other scientists and entrepreneurs are also asked to take part in such meetings. The meetings are held twice a month and the Tsukuba Lecture works as an opportunity for suppliers and consumders of technology to meet together and exchange information and technology, thereby contributing to the development of new technologies and exposing the existing technologies of the national research institutes to the outside world.

To facilitate communications between organizations of Tsukuba and those outside, TCI regularly publishes magazines advertising R & D activities, experimental equipments, facilities, and technologies of the local universities, research institutes, and companies. TCI

also creates policies of strengthening regional economy to influence the local and national governments. In order to systematically do this, it gathers data and publishes information booklets about Tsukuba.

2) Technology-intensive Companies of Tsukuba

(1) Bethel Co.

Bethel was founded in 1973 as a small family-owned company, which has grown tremendously, employing 100 staff members by 2002. The company specializes in physics, electronics, mechanics, and computer software and hardware development. Bethel integrates its technology and knowledge to produce thermal microscopes, precision plastic injection products, plastic injection moldings, and computer software. Bethel's thermal microscope is a system which measures thermo-physical property of a material or device in micro-scale, while precision plastic injection products are used as parts of digital cameras and medical equipments.

Bethel's products are sold not only to major Japanese companies and research institutes of Tsukuba, such as Sumitomo Metal company, but also to companies overseas. Main customers of this company include Japan Fine Ceramics Center, the National Institute of Advanced Industrial Science and Technology (AIST), the National Institute of Advanced Industrial Science and Technology (AIST), Tohoku University, Ibaraki University, Matsushita Electric Works, Shibasoku Co., Toso Co., and Hitachi Information Systems.

Mr Eiichi Suzuki initiated Bethel as an assembler of electrical parts. He worked for a TV station in Tokyo and also for a camera company as an engineer before he went on to build Bethel. Recently, Bethel developed an intelligence system which scans the material surface and measures the local thermo-physical property. This technology is used also in manufacturing precision products, including watches, cameras, and other thermophysical property measuring systems. The technology is based on laser beam technology, developed with some assistance from a national laboratory and local university.

Bethel often applies for financial aids from local or national government if it has a project to work on. It usually works in cooperation with other companies, universities, or national laboratories in Tsukuba. Current partners of Bethel include the National Institute of Advanced Industrial Science and Technology (AIST) and Ibaraki University. National Research Institute of Industrial Technology under MITI, operating in Tsukuba, also helps Bethel in developing new technology. Bethel currently has applied for four Japanese and one

American patents.

(2) Igaden Co.

Igaden specializes in manufacturing measurement equipments and environmental engineering. The company manufactures analog and digital circuits and automatic robots, based on electronic technology. These products are supplied to engineering and scientific laboratories of universities and research institutes in the Tsukuba area. Igaden also takes part in environmental engineering with new electrical technologies. The company purifies water contaminated by industrial and agricultural activities, such as livestock farming.

Igaden was found by Mr Igarashi Takeshi, who once worked for Sony Corp. He quit his job at Sony in 1973 and established Igaden with some technologies related to testing electronic products. His environmental engineering, however, was developed from an idea that he got from his experience in China. While he was working for Sony, he saw water flooding from Yangzu River, which destroyed many human lives. He thought that the water could be cleaned and used beneficially for people. Many years later, he developed a technology that cleaned water without using chemicals but by using electrical pulse technology. His technology has great merit in that it does not have any side-effects and is very effective in cleaning the water especially from small lakes. This technology has been developed to clean biological and industrial pollutants and Igaden sells its environmental technologies and equipments overseas as well.

For Igaden, local universities and governmental laboratories are important functioning as non-profit institutions providing objective data through scientific tests on its technology and guaranteeing the high quality of its technologies. Universities also provide technology in the process of developing Igaden's equipments. The founding father of the company, Mr. Takeshi, said during the interview that ten people from the university, including professor Matsumura of Tsukuba university, are experimenting his equipments, while using Hitachi, Maswell, and NEC as sub-contractors in manufacturing the large environmental equipments. He said his company creates work for major Japanese companies, rather than the other way around.

Igaden has also established its sales offices in Osaka and Hokkaido and linkages of cooperative research and development with universities located there. Igaden conducts experiments and field surveys there as well. In Hokkaido, for example, Igaden specifically works on developing technology to kill a special kind of bacteria that damages farm animals like cattle and pigs in Hokkaido.

(3) Tsuji Electronics Co.

Tsuji Electronics was founded in 1973 and is owned by Mr. Nobuyuki Tsuji. The company manufactures custom-made electric equipments using electronic technology. It produces signal change, controlling machines, and data acquisition facilities. It manufactures the kind of electric controllers that are able to control many machines at the same time. One of Tsuji's products can function with fifteen motors and control up to four motors at the same time. The company also produces testers that can measure electric pulses up to 500 times in a minute. These motors are used in controlling frequency, size, and color of laser beams that are used in measuring special materials, such as protein and new materials. These equipments are being used in Tsukuba's national research institutes, such as the Japanese Research Institute of High Speed Optics. The company also provides services related to such equipments.

Mr. Tsuji studied electronics at Tohoku University, located in the north of the main island of Japan. He started his career in Samyang Electronics of Osaka as an electrical engineer after graduating from the university in 1970. In 1973, he moved back to Tsukuba, his hometown, to work for a small company but ended up starting his own company. He established Tsuji in 1977. He designed and supplied electrical machines to a major electrical machinery company, Hitachi. Major products that were sold to Hitachi at the time were designing machines, operated by electronics used in producing special cables, tools, and controllers.

Mr. Tsuji believes that benefits can be gained from a program that promotes information exchange between firms and research institutions of Tsukuba. This program is called the "Society of Exchanging different Fields," which is operated by TCI. He is also active in promoting horizontal linkages under this program. He said that such program is helpful in expanding personal linkages, which have been beneficial to developing high technology products based on laser beams.

(4) Shinnetsu Industry Co.

Shinnetsu Industry Co. is located in Hitachi city, north of Mito city and the capital of Ibaraki Prefecture. It is about 70 km north-east of Tsukuba city. The city of Hitachi is the birth place of Hitachi Ltd., one of the widely known general electrical and electronic companies in Japan. Shinnetsu produces industrial heaters and heating systems which are used in industries doing research and development, manufacturing semiconductors and making medical and environmental equipments. Various kind of products include the flexible

plane heaters used for melting snows on the airplane runways and city roads driving the winter season. Another kind of heating product is an anti-dewing system attached on the surface of windows. Most of Shinnetsu's products require custom-made and highly specialized technologies.

Shinnetsu was established in 1983 by the current owner, Mr Hiroshi Ohtani. It started with three people in the beginning as a sub-contractor of Hitachi but has since grown to be a firm of 40 or so employees in 2002. The company closely works with its customers to provide them with the best service. It is known to provide its customers with the services and products at a level beyond what is expected and requested. Mr Ohtani said this has been possible only because the company maintained close and long-term relationships with its customers, which is important for maintaining work orders. In fact, the company so far has been able to maintain relationships with over 300 firms by providing such high quality services and materials.

Shinnetsu obtains advanced technologies and develops new products by training its employees in cooperation with some research institutes of Tsukuba, such as the National Research Institutes. The company also operates a research unit in cooperation with a company specializing in cosmetic materials based in Nagoya, a city far from Tsukuba. It has been conducting a joint research project, supported by the government, to explore the possibilities of using ceramic materials of cosmetics for thick film heater on the surface of flexible surface of plastic film and ceramic plate.

(5) Tsukuba Rikaseiki Co.

Tsukuba Rikaseiki is a manufacturer of specialized measuring and testing equipments, which are used in measuring direction and pressure of wind flows created from special fans. These products include cooling fans of the Central Processing Unit (CPU) of a PC (Personal Computer) and other cooling fans of automobile radiators. It sells its products to Japanese companies and exports to many other countries, including Korea, Hong Kong, and Taiwan. He said Japan produces 45% of very small fans used for cooling PC, while another 45% are produced by Korea.

Tsukuba Rikaseiki was established by Toshiaki Nakayama who studied plasma physics at a university. He loved nuclear physics and wanted to work for a nuclear power plant while he was a university student. After graduating from his university, he started his career as an engineer at Tokyo Rikaseiki, where he mastered his skills on magnetic hydro-dynamic power, a core technology of Tsukuba Rikaiseki. About 25 years ago, he quit his job

to establish his own company, Tsukuba Rikaseiki. He succeeded in developing an engineering system that precisely measured pressure and direction of wind flows in a very short time. The technology indeed was revolutionary as it could be used to reduce the time required in testing many fans within a limited time. In fact, it was able to reduce the required time from three hours to thirty minutes.

Rikaseiki's testing systems were developed along the stages of evolving personal computer systems, often in cooperation with the Japanese Institutes of Industrial Techonology stationed at Tsukuba city. The markets for its products also expanded, while other competitors were unable to catch up with the technological progress. In this way, Rikaseiki has been providing Japanese Industrial Standards with fans for a long time.

6. Regional Innovation Systems of Tsukuba

This paper so far has introduced the process of creating Tsukuba, and investigated the mechanism of running the science city. To do these the author reviewed various sources, including web pages, and conducted interviews with representatives from local governments, trade organizations, and small firms, covering some of the elements pertained in Cooke's RIS model. The interviews were intended to understand the characteristics of the elements involved in Tsukuba's RIS and their relationships with each other. Although the elements selected for interviews were not comprehensive enough to cover all of the elements contributed to Tsukuba's RIS, it is believed that they provide a reasonable amount of information essential for understanding the nature of Tsukuba.

Based on the information gathered from this research, one may conclude that Tuskuba is a genuine Dirigiste RIS, in terms of governance dimension. Planning for Tsukuba itself was initiated and directed by the central government, and funding required for the establishment of Tsukuba, including building and relocating national research institutes and higher educational institutions, was mainly from the central government, especially in the earlier stages. Although there have been increasing activities from local entities, including governments, semi-governmental agencies, and trade organizations, it is fair to state that they are far less significant than those of the central government. As Cooke envisaged (Cooke 1997: 21), research conducted in Tsukuba is found to be basic or fundamental by and large, and it may be expected to relate to the needs of larger firms in, or beyond, the region in question. (This does not mean to rule out minor research activities contributed to local small firms, however.) The level of both coordination and specialization in Tsukuba is very high as

they are run by the state.

In terms of business innovation dimension, Tsukuba seems to be a mixed RIS, showing characteristics of both Global and Local RIS. Governmental laboratories, including public universities, and R&D branch laboratories of major Japanese corporations, such as Matsushita, NEC, and Sony, dominate the landscape of Tsukuba. It is also true that the research being conducted in Tsukuba's governmental laboratories are heavily influenced by national needs, rather than local ones. In this respect, Tsukuba could be said to be a Global RIS. However, such Global characteristics are blurred by the presence of small and indigenous firms' activities, which cannot be ignored. One should not ignore the fact that some of the small and indigenous firms dynamically interact with large scale governmental laboratories, multinational corporations, and public universities, as the corporations introduced in the previous section, such as Igaden, Tsjuji, and Tsukuba Rikaseki, demonstrate. It is interesting to note that Tuskuba's indigenous industry sector is characterized by smallness. However, it tends to have a great research reach with national and international linkages, generating increasing communications with public R&D resources. This could be differentiated from the generic Localist RIS firms, as shown by Cooke (1998: 22), as they contrast to the characteristics of research reach of the Localist RIS that is primarily local and private. This is one of the reasons for arguing that Tsukuba's business innovation is characterized by a mixture of both Local and Global RIS.

7. Conclusions

This paper has attempted to identify the characteristics of Tsukuba based on information drawn from written information and interviews with representatives from the public and private sector. To do this, the author reviewed the process of establishing and operating Tsukuba, and presented the results of interviews with representatives of local governments, semi-governmental agencies, and small companies. It used the concept of Cooke's RIS as an analytical frame work to articulate characteristics of the mechanism being operated in building and managing Tuskuba. According to the typology made by Cooke, Tsukuba was found to be a typical Dirsgiste RIS, in terms of governance dimension, on the one hand. Tsukuba, however, tends to bear the characteristics of a Global RIS as well as a Local one, on the other hand.

As this research used the RIS concept as an analytical framework, the research allows one to make some comments on RIS typology. It can be said that the concept is a

useful analytical framework in general. The three types of RIS classified on the basis of governance dimension, in particular, fit well into, and are useful for the analysis of Tsukuba's mechanism. Another three types of Cooke's business innovation dimension, however, are found to be less suitable, at least, for Tsukuba. This may be because Tsukuba has developed a cluster of research and educational institutions rather than a strong business sector.

This research also allows one to make some comments on whether Tsukuba was a failure or success. As indicated in an earlier section, many writers criticised Tsukuba as it did not create significant spin-off and synergistic effects in the local economy. Overall, this research confirms such arguments. The dynamic activities made by the local elements of Tsukuba's governance mechanism and the relationships between them have to be appreciated, however. TCI, which was created by funds from various sources, such as governments, banks, and private companies, is a good example of facilitating physical and institutional infrastructures for dynamic interactions between the various elements of Tsukuba's RIS. The small and indigenous business sector is one of the other examples showing promising signs of Tsukuba's impacts on the local economic and social structures. These promising signs are believed to have contributed, and will continue, to contribute to the growth of dynamics in Tsukuba's RIS.

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