

University-Local Industry Linkages:

The Case of Tohoku University in the Sendai-Area of Japan¹

Juan JIANG

Research Fellow, Management of Science and Technology Department
Graduate School of Engineering, Tohoku University

Yuko HARAYAMA

Professor, Management of Science and Technology Department
Graduate School of Engineering, Tohoku University

Shiro ABE

Professor Emeritus, Tohoku University
Professor, Tohoku Fukushi University

Abstract

This paper focuses on Tohoku University in Sendai in the non-metropolitan area of Japan. Both a long historical and comparative perspective and a spacial perspective are essential to discuss the relevance of university-industry linkages to local-regional economic development. The conjunction of these linkages and economic development has been affected by two evolutionary processes: institutional configurations and territorial dynamics in the national innovation system. In addition, university-industry linkages have been complicated by top-down regionalization and bottom-up regionalism.

Key Words: Japan, Sendai, Tohoku University, University-Industry-Linkages, Local-economic-development

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1 Introduction

The emergence of a “knowledge-based economy” highlighted the importance of technological innovation and its underlying R&D activities as the engine of growth. This trend led the Japanese government to set the objectives of a “Nation based on Science and Technology” as the fundamental policy goal. This policy orientation has been consolidated by the Science and Technology Basic Law (1995) and the first and second Science and Technology Basic Plans (1996-2000 & 2001-2005), the latter focusing on the role that could be played by universities on economic development. Also, these last years, particular attention has been given to regional innovation systems as illustrated by the implementation of cluster related projects by the Ministry of Economy, Trade and Industry (METI) and the Ministry of Education (MEXT). As a result, there are growing expectations regarding the universities’ contributions to local-regional economic development through the creation and use of knowledge bases, intellectual property, and human resources.

However, it is not the first time in history that arguments for the need of university-industry linkages (UILs) have been raised. In the post-war period, Japan experienced three phases in which active discussions were carried out on UILs: namely, the period between the latter half of the 1950s and the first half of the 1960s, between the end of the 1970s and the first half of the 1980s, and from the latter half of the 1990s onward. The major points of argument are different in each phase:

training of engineers, the development of generic technologies, and the capitalization of knowledge.

In the second phase, the OECD countries were increasingly concerned to integrate economic and industrial policies with science and technology (S&T) policy, and their programs for advanced technology stressed the interaction between universities and industries. In Japan, on the other hand, large companies rushed to establish their own laboratories for fundamental research. Therefore, in order to better understand the essence of the concept of UILs, it is necessary to place the viewpoints of each phase into the context of the changing nature of the institutional configuration in the systems of innovation.

The term of “entrepreneurial university” is employed as an expression of a model university in the knowledge-based economy of today. However, the definitions of “entrepreneurial university” may be classed roughly into two groups. One refers to “entrepreneurship” in the economic management of capitalizing and commercializing the university’s assets and technologies in case of seeing the university entirely as an economic entity (Slaughter & Leslie 1997, Bok 2003). Another refers to “entrepreneurship” in the research management of knowledge production in case of seeing the university wholly as a knowledge institution (Rosenberg & Nelson 1996, Etzkowitz et al. 2000).

Neither was a new development. In the United States, during the 1920s and 1930s, MIT created the latter model of the entrepreneurial university which combined teaching and research with the capitalization of knowledge (Etzkowitz 2002). The subject of our study, Tohoku University, was

founded in 1907, and originated the movement toward the entrepreneurial type university in the 1920s and 1930s.

Rosenberg and Nelson raise pertinent concerns relevant to the discussions on UILs prevailing during the period between the latter half of 1980s and early 1990s, by stating that “the current debate is proceeding with surprisingly little grounding in what actually is going on now, and why and how we arrived at our present predicament” (Rosenberg & Nelson 1994: 324). Rosenberg remarks that “universities are institutions that have been shaped by the unique social and cultural histories of individual countries, and they cannot be readily transformed to conform to some foreign model” (Rosenberg 2002: 36). The paper maintains that a long-term historical and comparative approach is essential to discuss the relevance of UILs to economic development.

From a long historical and comparative perspective, the changing forms of university-industry relations can be understood in terms of “changes in the setting for the integration and differentiation of functions in the knowledge infrastructure” (Etzkowitz & Leydesdorff 1997) or “institutional changes in the science-technology system” (Freeman 1992). According to Etzkowitz and Leydesdorff, different resolutions of the university-industry relationship and internal transformation within each sphere occur in the changes in the nature of both knowledge production and economic production, and complex interactions between universities and industries and their development are strongly influenced by government actions (Etzkowitz & Leydesdorff 2000), or

according to Freeman, institutional innovations in the science-technology system occur in adjusting to a change of techno-economic paradigm (Freeman 1992) or in the process of catching up (Freeman 2002).

Modern Japan has gone through the catching up process twice in the past: first during the period between the Meiji Restoration and the end of the Second World War (WWII) and again in the post-WWII period, in which the country has organized and sustained the development, introduction, improvement and diffusion of new technologies, products and processes (Freeman 1987, 1995).

Table 1 provides an overview of the catching up processes, using and modifying the theoretical framework of Freeman.

Table 1-1 Two catching up processes in Japan

Periods	: from Meiji Restoration to the 2nd W. W.	Post 2nd WW
initial condition	: impact of the black ships	the defeat in the 2nd W. W.
changes of techno-economic paradigm	: industrial revolution to industrialization	Fordist mass and flow production to knowledge-intensive economy
policy imperative (three phases)	: 1) westernization (importing technology and institutions) 2) domestic production 3) military imperative	1) catching up with U.S. (reverse engineering) 2) autonomous innovation 3) competitive imperative
features of science-technology system (three phases)	: 1) education of scientists and engineers 2) construction of public R&D 3) contact between science and military	1) education and training in firms 2) proliferation of inhouse R&D 3) intense relationship between industries and university as agent of capitalization of knowledge

Tohoku University was established in the 2nd phase of the first period of catching up process, and originated the movement toward “entrepreneurial type university” both in the phase of the

take-off to the industrial society (2nd phase of the first catching up) and at the eve of globalizing knowledge economy (2nd phase of the 2nd catching-up).

Another major aspect found in the concept of UILs since the late 1990s onward is the need to mobilize university resources towards the achievement of local-regional economic development. In order to analyze the conjunction of the relevant UILs and local-regional economic development, a structural and actor-oriented approach (Acs 2002), or a framework is necessary to elucidate the geographical distribution of innovative activities and emergence of markedly different local-regional innovation systems within a single national institutional space (Asheim & Gertler 2005). In other words, this requires a spacial perspective on the structure of the production system and general institutional set-up.

In the U.S. in the 1980s, when economic development added an explicit university mission to teaching and research, it meant the university's contribution to the local economy as a potential source of its economic growth. This seemed to be due to two things: characteristics of the American university system – decentralization, competition, regionalism, and the coupling of research and graduate education (Feller 1999), and the federal government's retreat from the regional development which was then as a state or local responsibility, that is to say, “new economic federalism” (Fosler 1988) or “the rise of the entrepreneurial state” (Eisinger 1988), which might be seen as “regionalization” in the American context. But, in reality, the intensity of the effect of local

academic knowledge transfers on innovation is not stable over space and depends on the development level of regional innovation systems (Varga 1998).

The concept of “regionalization” and “regionalism” are considered in contrast with each other in Europe. “Regionalization refers to a process whereby national governments or the EU define regional policies for, or impose them on, regions. ...Regionalism, on the other hand, refers to an ideology and to political movements which demand greater control over the affairs of the regional territory by the people residing in that territory” (Keating 1997: 4). “Regionalization involves the imposition of organizations in order to stimulate the development of regional institutions; regionalism involves the realization of regional organizations to give active expression to regional institutions” (Cooke et al. 1998: 1574).

In the process from either direction, such a resurgence of the region as an important arena for political and economic activity brings about a shift from national state regulation to sub-national regional self-regulation in the institution which regulates economic activities. Then, universities are being asked to make an active contribution to regional institutional-capacity-building, and the regionally engaged university becomes a key local asset and a powerhouse for economic development. But, the challenge universities face is the crucible. The capacity of publicly funded university to respond to regional needs is influenced by conditions which result from the inter-relations between several geographic scales from the global to the local and also from the

historical legacy of each university and its region. It is because territoriality is an extremely complex and problematic concept for universities, and the national policy context, the characteristics of the national university system, and the characteristics of the region have much influence on the ability of universities to engage with their region (OECD 1999).

One of the arguments about the Japanese system is that “while it is extremely flexible in adapting to new knowledge over time, it retains rigidity with regard to spatial adaptation” (Malecki 2000). Another way of saying is that the Japanese system has succeeded in developing the idea of “using the factory as a laboratory” (Freeman 1987), but it might have failed to develop the idea of “the regions as a laboratory” (Cooke & Morgan 1998).

The changes of the techno-economic paradigm had a far-reaching impact on the territorial structure of national economy and the governance systems of both public and private organizations. Based on the assertion that history should never be forgotten, Freeman states that, reflecting on the recent discussions about the emergence of a mosaic of sub-national geographical agglomerations, sub-regional systems of innovation and economies of agglomeration have always underpinned national systems from the beginning of the industrial revolution, and also that a policy issue of firm, knowledge infrastructure and public sector has always been how to make social, economic and technical changes within the national economic space interacting with each other (Freeman 1995).

On the other hand, when a specific area, for example Sendai, is designated as a unit of

analysis, there exists an overlapping of multi-tiered knowledge-production-government systems which function at various scales of space. Therefore, the local-region is the systems of collective social order and such systems are positioned within a nexus of processes in the forms of organizational and institutional evolutionary processes involving emergence and transformation (Abe 1997).

Cooke and Morgan called the regional innovation system that is characteristic to unitary state, such as France, a “dirigiste” type (Cooke & Morgan 1994). In the case of Japan, these evolutionary processes are perceived in terms of dynamic tensions between regionalization and regionalism. And the reality of tensions between regionalization and regionalism is different between the first period and the second period of catching up processes, and regionalization does not necessarily accompany the devolution of function, personage and finance of government, like seen in Europe. The following is an attempt to illustrate regionalization and regionalism in the Japanese context:

Table 1-2 Regionalization and Regionalism			
Target of Strategy			
		national	local-regional
Initiative of Strategy	national	nationalism	regionalization
	(top down)		(mobilization and redistribution)
	local-regional	nationalization	regionalism or glocalism
	(bottom up)	(participation and attraction)	

Then, the modes of UILs for assisting local-regional economic development have been complicated at the crossroads of the top-down dynamics of regionalization and the bottom-up dynamics of regionalism. By focusing upon Tohoku University in the Sendai Area², this study shows how the tensions of multi-level governance have shaped the innovation systems with particular emphasis on UILs.

2 Tohoku Imperial University in the first catching up process

2-1 The establishment of Tohoku Imperial University

Tohoku University was founded by the Imperial Order of 1907 as the third Imperial University in Japan. The first, Tokyo University was founded in 1877 and Kyoto University, which was the second, in 1897. Kyoto University was founded after the Sino-Japanese War and Tohoku University was founded following Japan's victory in the Russo-Japanese War that stunned the world. At that time, Japan's industrial revolution, which started in 1886, led primarily by the textile and railway industries, was coming to a close, and Japan was about crossing the threshold into the heavy chemical industries (Okazaki 1997). This period coincided with a separation of roles between the

² Under two-tier system of local government, Sendai is the capital city of Miyagi Prefecture. According National Comprehensive Development Act, the Tohoku region comprises seven prefectures in the northern part of main land. The city area and population size of Sendai was 17.45 km² and 86,352 in 1889 and 788.09 km² and 1,025,714 in 2004.

government and market, and a proliferation of corporate entities in the private sector to take over the state-owned factories (Teranishi 2003). The progress of the industrial revolution was also concurrent with the establishment of a two-pillared system of education: namely, universities and specialized schools. Imperial University Order (1884), in conjunction with the concurrent Middle School Order (later became the Higher Middle School Order in 1894) created a career path for an elite cadre (Amano 1989). In the meantime, the creation of an education system, consisting of technical colleges, specialized technical schools, and technical schools, was prompted by the promulgation of Vocational School Order (1899) and the Specialized School Order (1903).

From the spacial perspective, two tendencies were beginning to surface. One was the establishment of a national economy through the integration of domestic markets, with local-regional economies being linked on a national basis. The other was the increasingly prominent geographic concentration of production and education. There was an incipient formation of the four modern industrial zones (Keihin, Hanshin, Kita-Kyushu, and Chukyo). With respect to educational institutions, not only the centralization of higher education institutions, but also the regional imbalances among educational institutions were becoming fairly obvious. As a result, the so-called 'local patronage systems' controlled by special-interest groups were conceived as a way to strengthen and develop the local-regional economy in view of regional competition, in which the central government was urged to promote higher education institutions in the local area, as well as

infrastructures such as roads, railways and harbors. (Teranishi 2003, Ariizumi 1985).

Amidst the backdrop of the period, the position of the City of Sendai is as described below.

When the country was roughly divided into several regional blocks in the early Meiji era, the Second Division of the military base was established in Sendai within the Tohoku region (1881). The Second Higher School was established as one of the five higher schools of the country (1887). A railway between Sendai and Ueno opened to traffic (1887). However, the population of Sendai city was 93,773 in 1903: a mere increase of 8.6% compared with that of 86,353 at the time when Sendai became a 'city' in newly organized municipal system(1889). Furthermore, Sendai Chamber of Commerce was set up in 1891, and from the view of the industrial structure, the superiority of commercial and financial sectors over industrial sector was substantial and textile-related industries dominated overwhelmingly in the industrial sector. Then, along with the decline of these industries, the consumption-oriented urban lifestyle became more emblematic of the city of Sendai. As a consequence, promotion of education and promotion of industry were designed as two major platforms of the city's policy (1903) (SCO 1908).

The process of the establishing Tohoku Imperial University started when the second Yamagata cabinet (1898-1899) planned the third and fourth Imperial Universities and the Ministry of Education issued official instructions to the Miyagi prefecture government in 1898, requesting donation of 250,000 yen in the currency of those days. This gave a boost to the campaign for the

establishment of the Imperial University. The proposal for the establishment of universities in Tohoku was passed by the parliament in 1900 and 1902, but it failed to be approved by the government at those stages. It was not before the end of the Russo-Japanese War that the Ministry of Education submitted a draft budget for the establishment of Tohoku University. However, the Ministry of Finance, caught in the post-war depression, had to implement a drastic budget cut. The budget draft for the university project was on the verge of being scrapped when Takeshi Hara (a native of Tohoku), the then Interior Minister, successfully persuaded Furukawa Mining to make a contribution, and created funds consisting of donations from Furukawa Mining and the Miyagi prefecture. The draft budget was finally approved by the Cabinet, which was followed by an issuance of Imperial Order in 1907 to establish Tohoku Imperial University (Tohoku University 1960, CHCCS 1970, PHCCM 1959).

Since imperial universities were required to comprise several colleges, a new university was to be structured in combination of a newly established college and the College of Agriculture, which was promoted from Sapporo Agricultural School. Although the people in the locality wanted a college in engineering-related fields, with an emphasis on the promotion of industry, a final decision was made to go forward with a College of Science, with due consideration to such underlying factors as striking a balance among academic areas at a national level (only Tokyo Imperial University had the Science Faculty among the two existing imperial universities and two newly planned

universities) and in accordance with the opinion of the then Minister of Education, Makino who believed that basic science was vital for the future development. The Establishment Committee was set up in 1907, in which Hantaro Nagaoka, who was then the professor of the Science Faculty of Tokyo Imperial University, played a central role. And, Masataro Sawayanagi was unofficially nominated as the first President of the University, and other professors were informally appointed as well. “Tohoku Imperial University: An Official University System” was issued in 1910 and the university was officially launched in the following year of 1911 by the Ministry of Education Order with four departments, offering two courses in mathematics, four courses in physics, three courses in chemistry, and three courses in geology.

These informally appointed professors studied individually in the United States or Europe during the period between 1907 and 1911. They, including Nagaoka, had different views on their professional positions from professors of the previous generation who had studied abroad earlier. The scholars in the previous generation had discovered their research themes while studying abroad and been given instructions accordingly, whereas this generation discovered new themes after having returned home and perfected them to challenge the world (Tohoku University 1960, Bartholomew 1989).

Hantaro Nagaoka, seeing an imitation of the developed Western World as the debt of the Japanese nation, intended to return debts by undertaking creative research activities. He was also

cognizant of the importance of the linkage of science with engineering in the realm of advanced technology of the West (Itakura, Kimura, Yagi 1973). And the first President Masataro Sawayanagi stated “the highest education in specialized education is satisfied with the provision of the highest knowledge of a given civilization, in a given time and intends to promptly apply the acquired knowledge; however, the university intends to move one step further, to devise a new development strategy, and to lead the civilization of the age” (Sawayanagi 1978: 147).

The vision of the founding fathers of Tohoku University resembled much to the aspiration of the founder of MIT, William Barton Rogers, who sought to establish an institution connecting basic with applied research and technological innovation in a period when the majority of higher education institutions were training and developing engineers who would directly contribute to the industry (Etzkowitz 2002, Jiang 2003).

2-2 A movement to “entrepreneurial type university”

Tohoku University was expanding from the late 1910s and early 1930s, reflecting the nationwide trend of increased demand for domestic production and skilled workers in the aftermath of the First World War (WWI). WWI accelerated the process of industrialization and heavy chemical industrialization. As a consequence of intensified competition with the Western companies, importation from Germany ceased, particularly that of chemical and steel products, and Japan faced

some difficulties in acquiring industrial technology. This prompted an attempt to come up with policies to protect and foster key industries for development, while keeping pace with the progress of industrial structure (Uchida 1986, Takeda 1993).

Dealing with these tasks was an adapting process which required considerable time. One way of achieving this was to increase the quantity and quality of higher education, or to increase the number of higher specialized schools and of engineering colleges of universities. Training of industrial engineer in the post-WWI period, however, underwent significant changes in its nature from the Meiji era. The demand of society for the enhanced research and development function of universities increased considerably in those days, and, in consequence, the university started to emerge as an institution to foster engineering scholars (Hoshino 1956, Yamazaki 1961, Amano 1997). Another way was to improve both quantitatively and qualitatively the research function which could then serve as the incubator of new technologies in the public and private sectors, and to organize engineering research activities (Hoshino 1956, Yamazaki 1961). The majority of research institutes established during this period were state-owned institutions, and university-affiliated institutions included Institute for Materials Research of Tohoku University, Aeronautical Research Institute and Earthquake Research Institute of Tokyo University, and the Institute for Chemical Research of Kyoto University. As a private institution, there was RIKEN (or Rikagaku Kenkyusho), with primary emphasis on basic research (Hiroshige 1973).

Rapid progress in industrialization of primarily heavy and chemical industries and the progressive modernization of the industrial structure led to the emergence of the Japan's full-scale modern industrial zones in four areas (Keihin, Hanshin, Chukyo and Kitakyushu), and the concentration of the population in metropolitan areas (Tokyo, Kanagawa, Aichi, Osaka, Hyogo and Fukuoka). For example, when looking at the changes in the industrial production output by region from 1909 to 1935, according to the Industrial Statistics of Japan, the rate of production increased steadily from 54% to 62% in the four industrial zones but that in the Tohoku region (six prefectures) was consistently less than mere 3% in all years studied (Ikeguchi 1967). In addition, the poor harvest of 1913 caused by spells of intense cold, following the lean years of 1902 and 1905, afflicted Tohoku (Iwamoto 1994).

At that time, the population of Sendai City was relatively stable, largely comprising government officers, school teachers, company employees, students, military personnel and self-employed individuals, etc., and "it exhibited much of the characteristics indicative of a city with such specific functions as public services and self-employed businesses" (CHCCs 1954a). This characteristics could be found in the statistics of enrolled students at Sendai Higher Technical School, which was established in 1906 under the Ministry of Education; in 1925, 43.5% of entering students were natives of the Miyagi prefecture, but only 8.3% of graduates found employment in Miyagi and 20.3% were employed in Tokyo, mostly as government engineers rather than engineers of private

companies (Amano 1997).

The expansion of Tohoku University is described in Table 2-1 (increase in the number of colleges before the promulgation of the University Order of 1918 and increase in the number of faculties after the promulgation).

Table 2-1 Chronology

	<i>Faculties</i>	<i>Institutes</i>
1907	• College of Agriculture	
1911	• College of Science	
1915	• College of Medicine	
	• Faculty of Science	
1919	• Faculty of Medicine	• Steel Research Institute
	• School of Engineering	
1922	• Faculty of Law and Literature	• Institute for Materials Research
1935		• Research Institute of Electrical Communication

During this period of expansion, out of earnest desire for the establishment of the School of Engineering and continuation of the specialized engineering schools, Miyagi prefecture and Sendai city donated a considerable amount of money for establishing of the School of Engineering in response to the request made by the Ministry of Education. As a research-oriented university, Tohoku University's contribution was aimed mainly at the national level rather than towards the region (Tohoku University 1960). It is particularly worth of noting that the initial stages of the University finally came to an end during this period and the academic seeds that had been planted by the founding fathers began to blossom with the invention of K.S. Magnet Steel (1917) by Kotaro

Honda and Yagi Antenna (1926) by Hidetsugu Yagi, and the establishment of engineering research organizations (such as Institute for Materials Research and Research Institute of Electrical Communication), which would generate such creative outcomes.

Financed with contributions from private companies, Institute for Materials Research started out in 1915 as Provisional Institute of Physical and Chemical Research, an affiliation of the Physics Department of the College of Science. It acquired the status of a public research institution and became Steel Research Institute affiliated to Tohoku University in 1919. It was a pioneer institution established as an affiliation of the Imperial University, in anticipation of academic research achievements of the University. After receiving contributions from Sumitomo zaibatsu conglomerate as well as from Kobe Steel, Mitsubishi Shipping, Mitsubishi Steel, and Mitsubishi Mining, it was transformed into Institute for Materials Research (hereinafter refereed as 'Materials Research') in 1922 by official institutionalization to grant the equivalent status as a faculty of the University. Despite the economy suffering from periodic depressions between the latter half of the 1920's and the first half of the 1930's, Materials Research achieved an exceptional development, particularly during the period of stagnant university growth due to budget constraints. This owed to a number of research achievements: for example, patenting and commercializing of innovations born from research, and rendering of research funds in the form of contributions from the industrial sector (Tohoku University 1960, Tohoku University 1966, Yamazaki 1961).

Research Institute of Electrical Communication, another affiliate of Tohoku University was established in 1935 and it was officially granted the same independent university status as Materials Research in 1944. In large part, this was a direct consequence of the research achievements of the Electric Engineering Department of the School of Engineering (established in 1919). In those days in Japan, most electric engineering departments of universities laid stress on the strong electric field regime, whereas the weak electric field in the realm of electrical communication was being considered periphery. However, Hidetsugu Yagi, the leading figure of the department, took an initiative in the research of electrical communication. After the 1920s, a large amount of money was donated from Saito Gratitude Association in Sendai. Most of the articles published in the periodicals of Japanese Association of Electrical Engineering were written by Yagi and his students during the latter half of the 1920s. Following the success of Materials Research, a plan was made to establish a large scale research institution, and it embarked on its way to achieve its vision of becoming a leading center of electronic engineering in Japan (Tohoku University 1960, Research Institute of Electrical Communication, Tohoku University 1985, Yagi 1953).

The marked successes of Materials Research and Research Institute of Electrical Communication depended on the fact that Faculty of Science and School of Engineering were established in a non-industrial city of Sendai, which brought about remarkable research achievements by pursuing and satisfying their academic interests without resorting to the popular

trend, and that large corporations had opportunity to utilize advanced research achievements, thus greatly contributing to the development of Japan's materials and electronic industries. This was an embodiment of the ideas of Honda and Yagi. The former asserted that no real industrial development could be attained unless basic research was conducted on technology application issues together with the fundamental and basic research on basic issues (Tohoku University 1966). The latter claimed that nothing but a pursuit of creative research without imitating others would lead to the development of industrial technologies. Nonetheless, it was not that no benefits were brought to the industrial activities of the local community of Sendai. Although the emphasis was on basic research, the local spillovers were significant and resulted in the formation of business such as Toyo Blades (1921), Japan Heat Wire Limited Partnership (1926), Tohoku Metal Industry (1933), and Tohoku Steel (1937) (Tohoku University 1960, CCMH 1968).

2-3 Under the military imperative

Ensuring of mobilization of supplies had always occurred during wartime, but the mobilization system was more thoroughly reorganized in the latter half of the 1930s, covering the areas of S&T research and higher education, in addition to the transformation of industrial structure to meet anticipated military needs. It was under such historical background that Tohoku University acquired a number of new research institutions during the short period from 1939 and 1945, which

includes the Institute for Agricultural Research (1939), the Research Institute of Mineral Dressing and Metallurgy (1939), the Research Institute for Tuberculosis and Leprosy (1941), the Research Institute for Scientific Measurements (1941), the Institute of Aero-Medicine (1943), the Institute of High Speed Mechanics (1943), the Chemical Research Institute of Non-Aqueous Solutions (1944), the Research Institute for Glass (1945) (Tohoku University 1960).

On the other hand, since the growing disparities between existing industrial zones and other regions were caused by the transition to a wartime economy, the so-called ‘regional policy’ was set forth by the central government. The Tohoku region experienced a series of depressions at the end of the 1920’s and frequent famines in the early 1930’s, which gave birth to the Second Tohoku Promotion Association (1933), to promote the development of Tohoku as part of national policy. As specific measures, the Tohoku Kogyo and the Tohoku Promotion Electric Power were established as statutory companies (1936).

When the Tohoku region was in crisis due to cold weather damage and famines, Sendai City government established the City Promotion Research Committee (1936); at the same time, invested in the creation of Tohoku Kogyo and Tohoku Promotion Electric Power. In 1939, the City government formed a Committee for the Expansion and Renovation of the Shiogama Port in industry-government partnership, involving the port towns and villages around Sendai and Shiogama, and the Sendai Office of the Ministry of Internal Affairs formulated the plan of the Great Sendai

Industrial Zone stretching from Sendai to Shiogama.

This grand plan failed to materialize in the intensified war period. The number of factories which located in Miyagi prefecture was ten before 1930, rose to six between 1931 and 1940, and jumped to 29 between 1941 and 1945. There were three types of factories located in Sendai City: rubber production factories established along with the Tohoku Promotion measure, arsenals and munitions plants, and factories built on the seeds planted by Tohoku University. However, unfortunately, much of the infrastructure created was hit by a massive air-raid in July 1945, just before the end of the war in August, which destroyed the central part of Sendai, where the research institutions and government agencies were located (Sato 1963, CHCCS 1954b, Fujii & Okuda 2002, CCMH 1968).

3 Tohoku University in the second catching up process

3-1 “The Vannevar Bush of Japan”

When Karl T. Compton (the former MIT President), who was then the Director of Scientific and Technical Advisory Section (U.S. Army Forces, Pacific, GHQ), visited Japan to conduct the Scientific Intelligence Survey in September 1945, just a month after the end of the war, he said, “Our first business with a Japanese scientist was to locate Hidetsugu Yagi, the Vannevar Bush of Japan, a former student at Harvard” (Compton 1945: 102). This was presumably because Yagi was the

President of the Board of Technology, which was the counterpart organization to the Office of Scientific Research and Development (ORSD) in which Compton assumed the key post. In the early days of electronics when technological competition was becoming intense, Yagi, someone from the Far East and the then Assistant Professor of Tohoku Imperial University, was invited by the Institute of Radio Engineers (IRE) of the U.S. to give a lecture in 1928. His lecture on directional antenna and split-anode magnetron stirred and impressed the audience. Furthermore, it was perhaps because Compton found a similarity in Yagi's concept regarding the mission of engineering and technology institute: making the impossible possible by integrating basic research into technological innovation (in contemporary terms, it may be referred to as 'entrepreneurial university').

However, there was a sharp contrast between the circumstances of Tohoku University and MIT in the post-war period and between situations of the urban regions where these universities were located. The high volume of research and development (R&D) funding provided to MIT by the federal government during the War persisted throughout the Cold-War, and catalyzed the formation of a high-tech cluster along Route 128 in the 1980s (Dorfman 1983, Matkin 1990, Castells & Hall 1994).

On the other hand, there were debates within the GHQ over higher education policies in Japan under Occupation Forces. Civil Information and Education Section (CIE) compiled a report highlighting the demilitarization and democratization; in contrast, the report of Economic and

Science Section (ESS) laid stress on S&T for the sake of the economic reconstruction. The former had dominance in the first half of the occupation period, and it was during these time when a new university system was created (Haneda 1995). “The Eells Incident”, a student protest against the address by W.C. Eells (a consultant to CIE) took place at Tohoku University and “UILs” and “militarism” were almost taken as synonymous in that period (Tohoku University 1960). In immediate post-war Sendai, military facilities and centers of administration, education, commerce, military, finance and transportation were mostly burned down, leaving paralyzing damage to the whole city functions. Moreover, strict liability for compensation was imposed on the city; three factories were chosen to be closed down as compensation and some machinery and equipment of 19 factories were subject to confiscation (CHCCS 1969).

In addition to the differences in the situations of the two universities and regions, there was a contrast in their fates between Vannevar Bush and the Vanner Bush of Japan. Bush’s report titled “Science: The Endless Frontier” made a profound impact on the direction of S&T policies of post-war U.S., most prominently on the setting up of the National Science Foundation (NSF), which led to the expansion of research of universities in the 1950s. Meanwhile, Yagi delivered a speech of similar ideas as Bush’s at the session hosted by “Comrades for S&T Policy” (established in June 1946 with similar vision as NSF), while referring to Bush, who had worked on the military mobilization of S&T as Yagi did and who had advocated the importance of promoting S&T even in

the post-war period (Yagi 1946). However, Yagi was purged from public positions by the GHQ because he had attended War Cabinet meetings as the President of the Board of Technology.

During the ten years after the war, particularly until 1952, reform towards democratization of social, political and economic structures and demilitarization has been designated as a priority issue, and it was the time when Japan addressed to achieve economic stability and reconstruction (Yamazaki 1961, Kosai 1984, Koasai & Teranishi 1963). During this period, Japan also created a framework for the post-war system including industrial, S&T, educational, and regional policies. It was after the restoration of independence that the so-called “industrial policy” and full-fledged S&T policies were implemented. The informal mode, which has been regarded as characteristics of the nature of UILs of post-war Japan, was built upon these initial conditions of the second catching up process (Hane 1999, Etzkowitz et al. 2000b).

3-2 Supporting the high economic growth

In 1952, the advisory board of American Society Engineering Education visited Japan at the request of ESS of the GHQ to hold engineering education study conferences throughout the country and urged to reconstruct industries through UILs (Japan Society for Engineering Education (JSEE) was established latter on, followed by the establishment of its regional offices) (Haneda 1995). However, it was in the latter half of the 1950s that an explicit endorsement of the importance of

UILs was noted in the policy documents of the Japanese government and in petitions submitted to the government by economic organizations. This was because the high economic growth policy and the “sputnik shock” made policymakers realized that technological advancement underpinned growth and that an increase in the enrolment of science and engineering students was vital to maintain the technological edge.

In those days, the expectation was mounting for the development of autonomous technologies, and the first report from the Council for S&T (established in 1959) initiated a boom of S&T promotion. Human resources development, improvement and enhancement of research activities, strengthening of S&T information activities and reinforcement of comprehensive administrative systems were the four policy items upheld by the report. It was thirty years later in 1995, however, that the fourth policy item, that was the proposal for the enactment of the S&T Basic Law, was finally put into effect (Hiroshige 1973).

In the private sector, prompted by the enactment of the Law for Acceleration of Rationalization of Enterprises of 1952, foreign technologies were introduced on a large scale, domestic investment activities were activated, and rapid economic development was achieved by effectively utilizing introduced technologies (in other words, creating a construction boom of new industrial plants by concentrating on development and production (Goto & Wakasugi 1984, Goto 1993)). The 1960s saw a further round of investment in central research institutions by individual

enterprises, triggered by the enactment of the Law on Technological Research Associations in Mining and Manufacturing (1961) to promote collaborative research activities among corporations aimed at strengthening the capacity to develop autonomous technologies. This was followed by the introduction of the government subsidy scheme for Large-Scale Project Programme (1966). The establishment of central research institutions to develop new autonomous technologies, however, has brought some issues to the surface: including the issue of capabilities of researchers and poor research ability of Japanese universities (criticized as depending heavily on the imported scientific ideas and as lack of ingenuity within universities) (Hoshino 1966).

During the period of high economic growth, new plant location became an issue from two perspectives: 1) developing the infrastructure to support industrial activities accompanied by the industrialization of heavy and chemical industries, and 2) controlling the continuous expansion of regional disparities caused by the concentration of corporations affected by variables in plant sitting and by the prioritization of public funds to support the industrial development. And later, when formulating the industrial location policies and the national land development policies, measures based on these two perspectives were implemented in a tie-in manner; the “Pacific Belt Zone Plan” and the Law on the Promotion of Industrial Development of Under-developed Regions, the “Comprehensive National Development (CND) Plan” and the Act for the Development of New Industrial Cities. (Sato 1963, Sogo Seisaku Kenkyukai 1963). This was because the industrial

development had a marked tendency for regional concentration rather than regional dispersal (Shinohara 1965), and in consequence, fiscal and financial centralization gave the region strong incentives to attract factories. Although local autonomy increased functionally by the post-war reform, the central government enhanced rather much control over the fiscal management, placing constraints on local initiatives (Teranishi 2003).

In post-war Sendai, conversion of military industries to civil production was not easy. Most of the industries consisted of small family-run factories, with the exception of rubber and metal industries. Therefore, in 1954 the city government drew up an ordinance to encourage the establishment of factories in Sendai, with a goal to achieve transformation from a consumption city to a production city. At the same time, Sendai hosted the regional offices of central government, and branch offices of Tohoku Development Corporation and Hokkaido Tohoku Development Finance Public Corporation were established in Sendai and leading trading firms started operating in Sendai. These led the city of Sendai to aim for the administrative center of the whole Tohoku region, as well as for establishing a regional core city intending to function as a control center of economic activities (CHCCS 1969).

In 1960, Sendai City Comprehensive Planning Conference comprising representatives of various fields was set up and submitted a report titled “The Plan for the Great City of Sendai in the Future” in 1963, and its key concept was “The Great City of Sendai/the Hub City”. Some of the

measures to achieve this goal included the enactment of the Factory Attraction Ordinance (1961) and the developing of residential district in preparation for new factories. When the New Industrial City Development Promotion Law was promulgated in the following year, Miyagi prefecture government, Sendai city government and the business community exerted much concerted efforts to gain the designation and succeeded in realizing it in 1963.

At this period, there were two major initiatives which were launched with regards to universities of the Sendai area: one, derived from the policies of the central government, and the other, the movement initiated in this area. In accordance with the central government plan to increase the number of students in the field of the science and engineering capacities, science and engineering faculties of Tohoku University were expanded and Engineering Departments of Tohoku Gakuin University (1962) and Tohoku Institute of Technology (1964) were established. In the early 1960s, the S&T Agency launched the Regional Science Promotion Conferences in each regional block in 1963 in order to disseminate its policy messages throughout the country. In Tohoku, the conferences were held six times (in 1965, 68, 70, 73, 77, and 80) hosted by the Tohoku Regional Head Office of Productivity, Tohoku Economic Development Center, Tohoku Society for Engineering Education, and Chambers of Commerce of the six Tohoku prefectures, and the professors of the Faculty of Engineering of Tohoku University participated in the discussions of the conferences. Partly due to such activities, Tohoku Industrial Technology Development Society was established within the

campus of Tohoku University primarily led by the Tohoku Society for Engineering Education with full cooperation of Miyagi prefecture government and Faculty of Engineering. It was the first incubator established in Japan based on the American model (Japan Development Bank 1989). In the meantime, the establishment of Industrial Technology Center of Miyagi prefecture itself (1968) fell behind the other prefectures, and it was finally established after the establishment of the Tohoku Engineering Technology Laboratory of the National Engineering Agency (1967).

In response to mounting demands for applied research and for the development of engineers as a new post-war university, Tohoku University needed to address the issues as to how to inherit and reconstruct the creative tradition of the pre-war period. One of the witnesses of the reemergence of the tradition was the establishment of Semi-Conductor Research Promotion Association (1961), which was built on the patented co-invention by professors Yasushi Watanabe and Junichi Nishizawa, and which was supported by the major electronics companies in Japan. Professor Nishizawa, while studying in the United States, was strongly impressed by the Science Park program of Fredrick Terman and Stanford Research Institute, and dreamed of establishing its Japanese version in Sendai, but the actual research institute that he established was “the School of Discipline to repeat experiments until you are absolutely sure without compromises” and it inherited Honda’s philosophy of, “verification through experiments and re-verification through university-industry cooperation” (Nishizawa 1992).

3-3 Technopolis and “Intelligent Cosmos”

By the 1970s, Japan faced the challenge of transition from post-war policies in every area of industrial, S&T and regional policy. By then, the post-war objectives had been achieved to some extent. And some negative aspects of success had emerged and Japan faced the challenge of ‘boomerang effect’ against the impact on international society. However, the defining and implementing of specific measures had to wait until the 1980s when Japan achieved enduring cost competitiveness after overcoming the shock of the two oil crises in the 1970s after the wave of the global-scale university disputes in the latter half of the 1960s, which also swept across Japan.

The most notorious of these measures were STA’s ERATO (Exploratory Research for Advanced Technology), MITI’s Fifth-Generation Computer Project, and MITI’s Technopolis Project. The first two signaled Japanese’s transition from imitator to innovator, the third signaled strategic change in the industrial policies sent shock waves through Europe and the US (Arnold & Guy 1986, Hilpert 1991). Relating to the last one, the competent officer of MITI boasted that this concept could solve both the issue of regional economy and the task of becoming a high-technology-based nation (Kobayashi 1982), and the responsible director of Japan Industrial Location Center remarked that there were three significances in this program in terms of national economy, industrial policy and regional policy (Kaneko 1982).

In retrospect, however, the perception of these significances seemed overestimation. At an

initial stage, as the instrument for building a technology-based nation, it was a pioneering model in the country to develop an infrastructure of high-tech industry, by borrowing from the experience of the Silicon Valley. But when this idea was made public by MITI, it provoked the unwanted attention from local governments; 40 of Japan's 47 prefectures immediately volunteered to host such high-tech cities. In the end, 26 districts were designated. However, most of these were not areas that satisfied the initial requirements conducive to the realization of the government's vision (Yamazaki 1992).

When turning the attention to Tohoku University, Professor Nishizawa of the Research Institute of Electrical Communication and Professor Masumoto of the Institute for Materials Research were assigned as the research directors of two of the four programs in the first phase of ERATO, which started in 1981. Also in 1985, the Faculty of Engineering founded the Aoba Engineering Promotion Society as an organization to serve as bridge between the faculty members and local industries.

However, Miyagi prefecture was late to launch the Technopolis program, and was not included among the 15 districts in the first designation order, and the program was eventually launched in 1986 by following the additional designation. One of the reasons of the delay in start of the program might be such that the bitterness of failure in attracting the U.N. University was still felt among concerned parties of universities, industries and governments, at the time of the Second CND

Plan (1969). The delay, from the viewpoint of industrial location, was perhaps because many high-tech factories were already present in Tohoku, accounting for more than 30% of new factory location in Japan, due to the opening of the Tohoku Shinkansen (high-speed train) and the Tohoku Expressway. However, since almost of new factories were parts-producing ones without R&D functions, Tohoku Industrial Technology Development Society established in 1966 was evaluated as not being sufficiently utilized for regional development (TEF 1984).

The latter half of the 1980s was the period in which Japan was getting swallowed up in the political and economic changes on a global scale. Trade frictions were escalating even more than in the 1970s and the pressure on opening of market and expanding of domestic demand were getting heavier. And meanwhile, the yen appreciation depression accelerated by the financial liberalization and the industrial hollowing-out in regions were causing serious concerns. MITI's proposal entitled "Basic Vision of Industrial Structure in the 21st Century" (1986) and the Fourth CND Plan (1987) were prepared to implement the solution to two issues: dealing with globalization and strengthening of self-sustaining development of regional economy. Along with the implementation of the Fourth CND Plan, establishment of cooperative research centers was started by the Ministry of Education (1987), and Basic Study on Promotion of S&T in Regions (1988) was implemented by the S&T Agency.

The Fourth CND Plan identified "Multi-Polar Pattern of National Land Use" as policy

rationale, but its concept was interpreted differently between the center and the other regions. On the one hand, the plan advocated strengthening the international financial and information functions of Tokyo as a hub city of the world, in response to rapidly advancing globalization. To that end, the plan stated the need to split the functions of the capital city and to strengthen Osaka's center function of culture and Nagoya's center function of industrial technology, thus creating "National Capital Belt" (Sazanami 1991). On the other hand, the interpretation on the part of other regions referred to decentralization from the center, accompanied with the devolution of central government functions. After the end of the 1970's, an increase in the population took place mainly in Tokyo and there was the formation of a governance structure comprising Tokyo metropolitan area at the top, other metropolitan areas and regional core cities at the middle, and local central cities at the bottom (equivalent to the private sector's headquarters / branch offices / sales representative offices) (Abe 1991, Hatta & Tabuchi 1994). There was such intrinsic conflict within the "Multi-Polar" concept of the Fourth CND Plan formulated in 1987. As a solution to the conflict, the plan advocated the promotion of regional deployment of high-level functions, such as, exploration, R&D activities in the new industrial areas: that is to say, regionalization in the Japanese context.

Several proposals were made during the implementation of the Fourth CND Plan, one of which was the proposal for "the ideal state of what new UILs should be in the third technological innovation era in which basics, application, and development, or science, technology and industry

are intertwined and closely related” (JERC 1988). Also proposed was the conversion from the “adaptable S&T” of transferring existing technological seeds to local-regions to the “creativity-oriented S&T” toward innovative and autonomous technology development (Japan Techno-Economic Society 1990). Such a shift from hitherto approach emerged partly because the concept of the Tohoku Intelligent Cosmos (TIC) Plan, which signified the resurgence of the tradition of Tohoku University, was successfully incorporated into the Fourth CND Plan. (The subtitle of the first version of the TIC Plan was “Plan for Academic, Technology and Information Capital” as self assertions to “National Capital Belt”).

Leaders of business community involved in promoting the regional development of Tohoku had aspired to achieve a “10% economy” to obtain 10% share in major economic indices in accordance with the share of population of Tohoku. However, the instrument to achieve this goal relied on the exogenous way. Miyagi prefecture was awarded a Technopolis designation in 1984 and its project included the establishment of an industrial development organization. But the major strategy adopted was to promote the campaign to attract corporations by developing core industrial districts in the north Sendai area. The terms ‘knowledge-based regional industry’ and ‘promotion of the development of R&D-oriented industry’ were mentioned in the “Basic Plan of Sendai: Aiming for Healthy City in the 21st Century” (1981); however, those terms were mere catch phrases, a self-developed industrial plan had yet to be formulated. The first plan of such kind was formulated in

1994 after becoming the “designated city”.

The interim report leaked during the plan making process of the Fourth CND failed to offer favorable prospects for the future of Tohoku, by providing nothing beyond the conventional description that Tohoku was Japan’s major supply base of food and timber and the station of tourism and recreation. On the other hand, from the viewpoint of concerns over a progressing hollowing-out of Japan’s manufacturing industry along with the shift to overseas production, it was the problem that the Tohoku region remained at a very low concentration of R&D functions in the private sector and a very high rate of outflow of S&T university graduates. Therefore, the major task of Sendai was to invite and foster R&D functions (TRRDC 1987, HTDFPC 1987).

Professors at Tohoku University, who had been conducting comparative regional studies, perceived a huge gap between the current status of the Tohoku region and the pursuit of the regional level adaptation that took place in the Western nations in response to structural changes after the 1970’s: specifically, the shift from the conventional exogenous strategy to the endogenous regional innovation strategy. Bearing the slogans: ‘The Tohoku in The World’ and ‘The Construction of The Future-oriented Industrial Society’, the TIC Plan, a bottom-up and innovation-oriented regional development project for the Tohoku region, was derived from the international symposium entitled “Tohoku in the World of the 21st Century” (Sep. 1986), which was the first occasion on which over 2000 people gathered from industries, universities and governments around seven prefectures. The

symposium was the brainchild of two social scientists and the then President, N. Ishida (microbiologist) and Prof. J. Nishizawa (electronics, and later, president). In those days, NHK's Special TV Program described the project as "Reviving Tohoku by Professors".

It differed from other regional plans in three respects³. First, this plan was not a "top down" one dictated by government ministries: it adopted a "bottom up" approach aimed at promoting innovative scientific and technological R&D. Although the conceptions of their plan were different from the national plan, they worked with the national government in order to acquire resources and realize their objectives, and they succeeded in the attempt to incorporate the aims of their plan into the national plan. Second, it was not the sum of conventional prefectural plans seeking budgetary support, but a regional plan in which seven prefectures were linked laterally with each other⁴. In the Japanese government system, there are some regional bureaus of central government but no political entity of the regional level between central and prefectural governments. Also prefectural governments were used to compete with each other in seeking subsidies and benefits from the central government. Third, it was a plan initiated by academics, who played decisive roles as go-betweens, bringing together seven prefectural governments, seven federations of chambers of commerce and industry, and ten national universities in Tohoku, and also convincing the business world, members of parliament and the central government.

³ The following description of TIC plan depends on Abe (1990, 1998, 2002, 2004) and Jiang (2003).

⁴ M. I. Luger, who was co-author of *Technology in the Garden*, gave the attention to TIC plan as the grandest regional development plan (Luger 1994).

The implementation of the plan has entailed developing a systematic institutional structure as well as the design of a research-friendly environment. One element of this structure is ICR (Intelligent Cosmos Research Co. Ltd.), an organization specifically designed to support strategic R&D efforts and to facilitate industrial applications of R&D. Fourteen R&D corporations based on academic seeds have been established through joint investments by the national government⁵ and private companies. ICR has worked to initiate 12 research projects under the Regional Consortium R&D System of MITI. Another element is the Academic Society, which seeks to establish creative academic activities in a comprehensive manner, and to serve as a guide for the future development of the region (the number of universities and members affiliated were 70 and 890 in 1995). In parallel with implementation efforts inside the region, the TIC group worked to persuade the central government to focus its policy on the region, eventually leading to support and encouragement for regional initiatives, since carrying their plan into effect would require both radical policy changes at the national level and regional institutional innovation. They won government approval to make a comprehensive survey of measures to promote the TIC plan, and survey committees made up of members of the academic, industrial and governmental communities were formed by eight ministries and agencies (NLA, ME, STA, MAFF, MITI, MC, MPT, and MT⁶) respectively. It was unusual for

⁵ Three investors of quasi-governmental special corporation were Japan Key Technology Center, Bio-oriented Technology Research Advancement Institution and Drug Fund Advance Reaction-Relief and Research Promotion.

⁶ Abbreviations: name of ministries and agencies.

ME and STA to figure on the list at that time because neither ministry nor the Agency had the concept of “region” in their policy thinking. The TIC plan group made a then radical proposal to both ministries to position the concept of a “regional innovation system” in their national policy promotion. It was the first time that a regional framework was adopted for the promotion of national S&T promotion policies. It was promulgated in the White Paper of STA of 1991. And, in 1995, the S&T Council issued Recommendation 22, entitled “Regional S&T Promotion”, which was incorporated into the Basic Law for S&T (1995).

TIC plan has been a sort of experiment of the meso-level region in the age of globalization and knowledge economy. It intended to shift from exogenous development to endogenous development by enhancing capabilities to formulate and implement its own development policies. At the same time, it urged the structural reform projects from within. In the development of TIC plan, the Creating Cosmos Commission of Tohoku University – although it was not a formal organization of the University – played a critical role. Members included successive presidents, the deans of Faculties except Law and Economics, directors of Institutes and leading professors, all stood together for a resurgence of the scientific tradition of the University so that it could contribute both to the region and the nation.

NLA: National Land Agency, ME: Ministry of Education, Culture and Sports, STA: Science and Technology Agency, MAFF: Ministry of Agriculture, Forestry and Fisheries, MITI: Ministry of International Trade and Industry, MC: Ministry of Construction, MPT: Ministry of Posts and Telecommunications, MT: Ministry of Transport.

Their philosophy was that the mission of university was to pursue ‘socialization of the university’ to enhance region’s capabilities and ‘creation of collective intelligence in the region’ to forge new regional-based industrial dynamics. It was, in effect, a renaissance movement to revive a tradition of exploring new disciplines, which would connect the scientific training and research to practical application in a globalized knowledge economy. Although the reinterpretation of the tradition of the University by the Commission was not explicitly expressed in terms of innovation theory, its essence was very similar to the contemporary theory of innovation systems (Lundvall 1992). And, although the chairman of Tohoku Economic Federation, the governor of the Miyagi prefecture, the mayor of Sendai city, and the president of Tohoku University were all the heads of formal organizations, they played a role as ‘social entrepreneurs’ (Henton et al. state (1997)) beyond the boundary of their formal positions.

3-4 Under the competitive imperative

In the confusion after the economic bubble burst in 1991-93, the Basic Law for S&T of 1995 seemed to be a saving grace to the nation which was in the situation of soul searching, in that it laid down the basic framework for Japan’s S&T policy and aimed to be an advanced S&T-oriented nation for the 21st century (Omi 1996). The Law and its first S&T Basic Plan of 1996 called for the promotion of S&T as a whole and of UILs in particular.

Furthermore, some signs of changes in the Japanese economy emerged at the end of the 1990s. Such signs included negative economic growth, increase in unemployment rate, increase in fiscal deficits, and loss in Japan's competitiveness. Learning from the U.S. experience in dealing with the twin deficits, which led to the set up of The President's Commission on Industrial Competitiveness in the early 1980s, the Prime Minister formed in haste the Economic Strategy Council (1998) and the Industrial Competitiveness Council (1999). The following five years from 1998 was marked by various policy developments, having in mind the measures taken by the U.S. and U.K. since the early 1980s with the purpose of strengthening competitiveness and fostering new industries. The policy measures adopted included the development of various legal frameworks to promote further UILs and a number of policy programs propelled by these linkages, such as 'the Japanese version of TLO', 'the Japanese version of Bayh Dole Act', 'the Japanese version of SBIR', 'the Japanese version of COE' and 'making independent agency of National University' (Jiang & Harayama 2005b).

The Second S&T Basic Plan (2001-2005) was formulated under such circumstances, and a number of reports on the nature of university-industry partnership were presented successively by various ministerial commissions around this period (Omi 2003). The case for UILs in these documents emphasized the need for transfer of university technologies to industrial use, on patenting of intellectual property of universities, and on the commercialization of university research results.

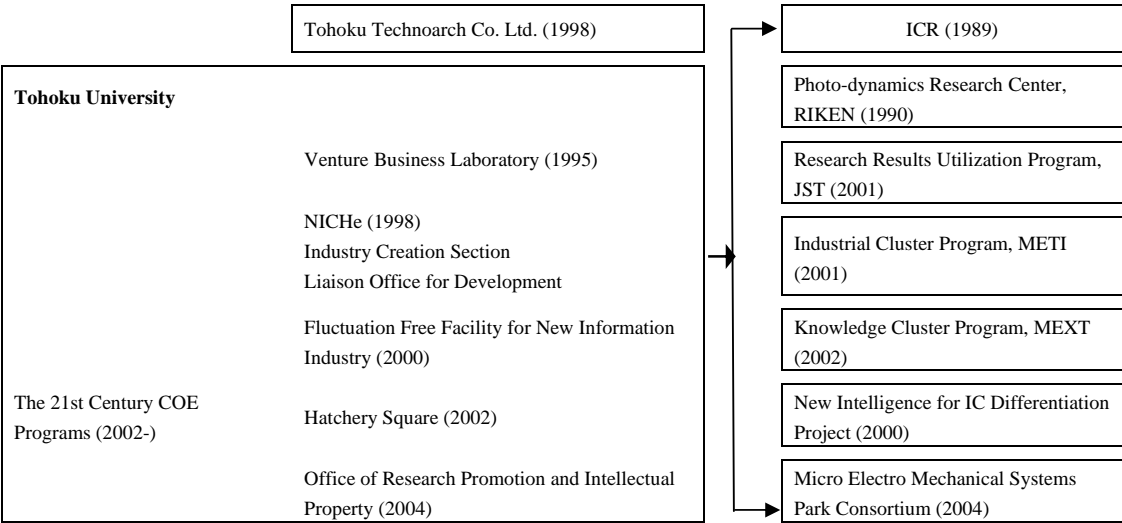
Under the circumstances where industries and ministerial agencies have unanimously regarded 'strengthening of industrial technology, leading to the creation of new industries' and 'reviving strong international competitiveness' as imperative, they helped promote such measures as 'Fostering University-Launched Ventures' (2001), 'Industrial Cluster (IC) Project' (2001), and 'Intellectual Cluster Creation (ICC) Project' (2002) (Jiang & Harayama 2005a).

Based on these new policy lines, new frameworks for UILs have been constructed and programs for promoting R&D and creating of new enterprises have been put forward. At Tohoku University, the New Industry Creation Hatchery (NICHe) was established in April 1998, to spur domestic industries by leveraging the intellectual resources accumulated at the University. NICHe has two functions: a research function that drives technological development activities, and a liaison function as a bridge between industries and university. As related facilities, the Fluctuation Free Facility (FFF) for New Information Industry and the Hatchery Square were dedicated in 2000 and 2002 respectively, and Tohoku Technoarch Co., Ltd (the technology licensing office) was established in 1998.

In 2004 when Tohoku University become an independent legal entity, the University established the Office of Research Promotion and Intellectual Property with an aim of contributing to development of the society by promoting wide range of academic research, creation of wisdom and scientific knowledge as well as by managing, utilizing and protecting intellectual properties

created as the achievements of university researchers.

Figure 3-1 The present structure for collaboration with industry and main projects

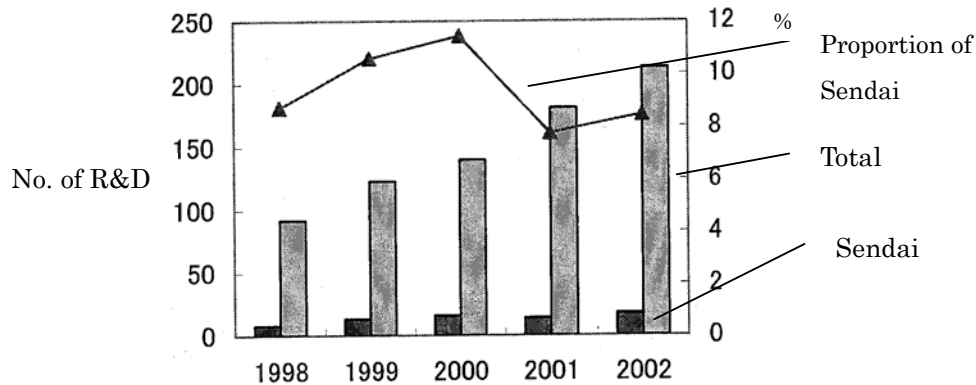


Under the competitive imperative, the numbers of patents, collaborative R&D, and spin-off companies are the criteria by which the university is evaluated. The number of collaborative R&D projects between Tohoku University and companies throughout Japan has been growing since the late 1990s, and almost doubled between 1998 and 2002. But the vast majority of collaboration partners are large enterprises and the number of collaborative projects with companies in the Sendai area remain limited amounting to around 10% of the total.

Similarly, the University has generated plenty of university spin-off companies so far, and ranks among the top five universities with regard to the number of spin-off companies (METI 2005). But those firms do not always set up their headquarters in the Sendai area (Nishiyama 2004,

Research corporation section, Tohoku University 2004).

Figure 3-2 Locations of collaborative R&D partners with Tohoku University



Source: Tohoku University, 2004

In 2002, Sendai City government formulated “The New Industry Creation (NIC) Plan, that underscores the decline in its centrality as a core regional city. It also underscores the fact that the rate of business closures surpassing the rate of openings, the decrease in the number of business establishments, the hollowing out of the branch office economy, and deteriorating employment situation. On the other hand, the current situation is analyzed in such a way that the comparative advantage lies in the concentration of universities as a center for human resources development and for research and development and in the concentration of various industry support organizations. The Plan identifies the ICC Project of MEXT as one prime strategy among numerous strategies for creation of new industries.

The formulation of the “NIC Plan” itself was partly to show the enthusiasm of the local government in the hope that their proposal would be designated as one of the ICC Project. Under the

economic circumstances of the latter half of the 1990s, the creation of new industries became the most important goal for local regions. However, with an unexpected consequence of public works projects, which had been implemented to ease pressure on Japan to expand domestic demand since the mid 1980s, the collapse of bubble economy, and public works projects designed as an economic stimulus, the local fiscal conditions deteriorated severely. It put the financial restrictions on challenging activities initiated by the local community, and led to more local governments' reliance on the central government (Abe 2004). The ICC Project, although it carries the name "Cluster" Project, is in essence similar to the Research Center Program of the NSF of the U.S. as admitted by a committee member who formulated the Project (Study Group on Measures to Return Research Results to Society 2001). When "Sendai Cyber Forest Cluster" with a focus on the intelligent electronics was adopted, it was still difficult to find appropriate corporations that could attend to the research seeds of universities at the development and commercialization stage (Jiang, Harayama, Abe 2003). At the time of interim assessment, the performance of Sendai project was ranked 9th among 12 blocks of the nation, and many substantive issues had yet to be resolved (S&T Policy Bureau, MEXT 2005).

Similarly, the Industrial Cluster Project of METI may be characterized as the approach in which the various measures, which had previously been undertaken by METI, were put together by regional blocks and then crowned with the word 'Cluster'. With respect to 'Measures for an Aging

Society’ and ‘Measures for a Recycle-oriented Society’ of Tohoku Bureau of METI, a responsible officer admitted that there was no choice other than to select themes that might anticipate demand in the future because of a low level of the accumulation of particular industries in the Tohoku region (Jiang, Harayama, Abe 2003, Tohoku Bureau of Economy 2001).

During the recent decade, universities face with triple identity conflicts: namely, acquiring the status of COE and global fame, contributing to the enhancement of national competitiveness, and contributing to the development of local region (Yonezawa 2003, Motohashi 2005, Tabata 2005).

When two professors⁷, who have inherited an academic attitude of Nishizawa and based on the philosophy of glocalism (extending local initiatives to global endeavors), try to proceed with New Intelligence for IC Differentiation Project and Micro Electro Mechanical Systems Project, they face intense pressure to mobilize their projects into the scheme of central government’s initiative as essential resources to improve the national competitiveness. In the meantime, a strange scene has unfolded in a series of symposiums held by university-industry-government cooperation with a theme of Regional Contribution of Universities, in preparation for making national universities into independent administrative entities. Tohoku University is an integral component of the identity of Sendai in the opinions of those involved in industries and governments of the Sendai area; however, Sendai is not necessarily an integral component of the identity of Tohoku University in the opinions

⁷ Both were ranked top in 2002 and 2003 respectively, as the researcher having the most promising ability to create new industry according to the Questionnaire on Excellent Universities of Choice of Companies conducted by Nikkei Shimbun.

of high-ranked professors (Jiang 2003).

Under the competitive imperatives of nation state, the progress of two processes, namely achieving regionalization of top-down innovation policies and exploring and mobilizing individual seeds for the improvement of competitiveness of the country, may sometimes facilitate formation of a new domestic network or partnership between and among regions and organizations. However, on the other side of the coin, it could induce the re-emergence of traditional and parochial zero-sum games over investments and market shares. In preparation for the next CND Plan, the need for the establishment of meso-level strategic activity unit beyond prefectural boundaries is being discussed in the wake of the highly globalized era (the report of the Advisory Committee on Research and Reform, National Land Development Council, 2004). This was the issue presented by the Cosmos Plan to the central and local governments. In somewhat of a historical paradox, the Tohoku region, which was supposed to be running ahead, decided to dissolve a promotional organization consisting of universities, industries and governments of the seven Tohoku prefectures (July 2005), just as when an awareness was growing at the central government level.

4 Conclusion

It requires both a birds-eye view and an insects-eye view to grasp the reality of university-local industry linkages; it takes an eye to see from a broad perspective what forces are

working and an eye to penetrate from a field-oriented perspective the motivation and capabilities of the people and organizations involved in their activities. It is because a region which encompasses certain geographic spaces is often conceived as a kind of collective personality as a unit of activity when assigned a proper name, but historically, its outline and boundary undergo various vicissitudes. It is also because there are multi-layers of several social and functional spaces which either cross the boundary or fractionize the boundary within the geographic space, and the directions of influencing forces are different.

In this study, we have examined the role of Tohoku University in the Sendai area from the perspective of university-local industry linkages. We have attempted to argue that not only a long historical and comparative perspective but also a spacial perspective are essential to discussing the relevance of UILs to local-regional economic development. Indeed, the conjunction of UILs and local-regional economic development have been affected by two evolutionary processes: the institutional configurations in the national innovation system, which can be understood as the techno-economic-social system in terms of the creation, application, transfer and capitalization of knowledge, has been changed at different stages of catching-up process; and the local-regional innovation systems have been forced to restructure due to territorial dynamics in the national innovation system. Thus, the modes of UILs for assisting local-regional economic development have been complicated at the crossroads of the top-down dynamics of regionalization and the bottom-up

dynamics of regionalism.

After the 1970s, the central government of Japan (perhaps governments of other nations too, to some extent) has swayed back and forth in dealing with the impacts of changes of the time. In the past, a long-term policy was replaced every 10 years or so in most cases, but the time span has been shortened to less than half of the previous length and now there are some ironic consequences; for example, emergency measures are extended whereas long-term strategic and structural reforms are dealt with on an ad hoc basis. This is evident in the mountainously accumulated policy documents and a number of policy schemes and policy cliché that have been drawn up successively. However, it takes a considerable time to foster innovations at the attitude and action level which are appropriate for and which will ensure the intended objectives of the newly adopted policy concepts and frameworks.

The volume of the sound of discussions on UILs is amplified when changes are necessary in role patterns in production, application and capitalization of knowledge, and the emphasis placed on the content of the role of universities varies in accordance with the situations in which the counterpart industries are placed. Nonetheless, radical innovation in the production of knowledge requires a clear and consistent commitment to its own missions, rather than flexibility to meet temporary and complementary needs. Therefore, those who aspire for radical innovation in knowledge production would contribute more to the region which requires change and reform in

social system to adapt to the changing times.

The term “national innovation system” was introduced as an official policy vocabulary in the policy documents issued in 2002 by the METI and the MEXT, and the term “local regional innovation system” is also used when implementing measures for regional development programs of the ministries. This term refers to the analytical concept from the perspective as to how innovation processes should be organized by identifying a specific spatial area as a unit of strategic behavior, and at the same time, it refers to the normative concept to specify the objectives to be achieved. Nevertheless, a local-regional innovation system is not simply a reduced version of a national innovation system. There are in fact two aspects in the local-regional innovation system: one, solution to the problems of a given region, and two, solution to the issues of the time that are not confined to a particular region. There are complementary and conflicting aspects between the local-regional innovation system and the national innovation system. The same applies to the relationship between the national economy and regional economies and between industrial policies and regional policies.

When tracing back the history of Tohoku University, its establishment was made possible through donations from the private sector and local governments, but what was actually established was a national imperial university. Since the University was not bound by the requests of the local community for direct contribution, the founding fathers had innovative ideas on the mission of

university. When achievements as the fruition of their mission were recognized around the world, Tohoku Imperial University has become the pride and symbol of the City of Sendai as the “Capital of Academia”.

Some implications assumed from the historical study of the case of Tohoku University in Sendai area are as follows. Tohoku University had originated a movement towards an entrepreneurial-type university that is a effective and creative inventor and transfer agent of both knowledge and technologies through the alignment of industrial development with research and teaching as academic mission, both in the period of the take-off to the industrial society in the early twentieth century and more recently in the dawn of global and knowledge-based economy. However, in marked contrast to the greater Boston area in which MIT is located, the Sendai area in which Tohoku University is located has not become Marshallian-type area nor a Hub-type one. It remains a satellite-type one.

The technologically oriented, research-intensive university had not insulated the local region from not only the vicissitudes of the business cycle or the inherent uncertainty of technological development but also the territorial dynamics of the industrial development. University efforts to promote linkages with local-regional industries would not function without some kind of involvement from industries, financial institutions and other supporting activities, and those locations are largely defined by the territorial dynamics in the national innovation system. The

project of interlinking less-favoured region such as Tohoku to future process of innovation could be realized only within a long-range planning time-frame that aims at changing the current spatial pattern of innovation; that is a transition from the vertically integrated model of innovation to the horizontal integrated regional model in the Japanese production system. Although it is not easy for the local regions to set up their independent and long-term ventures when it is unclear what tangible results will follow, a step out of the dilemma for the local-regions seems to lie nowhere other than achieving the right balance between regionalization and regionalism, participating actively in the national innovation process and devoting endogenous efforts to induce self-sustaining development on the local-regional level.

Propelled by the competitive imperatives of today, Tohoku University is strongly encouraged to play an active role in R&D concerning new technologies and in capitalization of knowledge and there is also a rising expectation from the local community of Sendai on the University as the most profound resource to lead the development of local-regional economy. However, in such situation, the spiritual attachment between the University and local-regional communities tend to be rather loose.

It is a matter of course that Tohoku Imperial University not only created a basis for several areas of industries, but also left the footprints on the development of regional industries and industrial culture. Although the number of companies established on the basis of the research

activities of the Tohoku Imperial University is a lot fewer than the spin-off companies of today, they have survived the waves of difficulties, such as exhaustive wars, defeat in the Second World War, emerging technologies, and globalization of economy, while undergoing many metabolic changes. The secret of its survival may lie in the spirit of the Honda's lesson, "the industry is the disciplinary place for bushi" (warriors of feudal Japan), which is framed and hanged on the wall of Honda Memorial Hall of the Institute of Materials Research. This practical philosophy was shared by industrialists who established the companies and has been inherited through the generations and renewed the synergism between entrepreneurships of industrialists and professors. Today, compared with the past, the legal framework to promote UILs has been more minutely developed and policy schemes and projects have been more actively promoted. Nevertheless a question still remains as to how it is possible to construct, pass on and extend communities in which both universities and industries share the spirit and ambition as practical entities.

Reference:

- Abe, K., Study on Japanese Urban System, Tokyo : Chijin Shobo, 1991.
- Abe, S., "Rationale of Tohoku Intelligent Cosmos Plan" Technology and Economy, 279, 1990: 27-35.
- Abe, S., "Regional policies and the re-interpretation of local-regional culture and history" in N. Watanabe ed., The Recovery of Histories in Tohoku, Tokyo : Kawade Shobo, Shinsha, 1997.(in Japanese)
- Abe, S., "Regional Innovation Systems in Japan: the Case of Tohoku" Braczyk et al. eds., Regional Innovation Systems, London : UCR Press, 1998: 286-318.
- Abe, S., "Tohoku Intelligent Cosmos Plan in the Middle Milepost" Intelligent Cosmos, 35, Spring, 2002.
- Abe, S., "Regional Innovation Systems in the Less-favoured Region of Japan: the Case of Tohoku" P. Cooke et al. eds., Regional Innovation Systems, 2nd ed., London : Routledge, 2004: 261-290.
- Acs, Z. J., Innovation and the Growth of Cities, Cheltenham, UK : E. Elgar, 2002.
- Amano, I., Study on Higher Education in Modern Japan, Tokyo : Tamagawa University Press, 1989.
- Amano, I., Education and Modernization, Tokyo : Tamagawa University Press, 1997.
- Ariizumi, S., "The Local and the Center in Political History of Modern Japan" Japanese Society for Historical Studies, Study of Japanese History, Vol.271, 1985: 139-158.
- Arnold, E., K. Guy, Parallel Convergence, London : F. Pinter, 1986.
- Asheim, B. T., M. S. Gertler, "The geography of innovation: regional innovation systems" in I. Fagerberg et al. eds., The Oxford Handbook of Innovation, Oxford : Oxford University Press, 2005.
- Bartholonew, J. R., The Formation of Science in Japan: building a research tradition, New Haven : Yale University Press, 1989.
- Bok, D., Universities in the Marketplace : the commercialization of higher education, Princeton : Princeton University Press, 2003.
- Branscomb, L. M. et al. eds., Industrializing Knowledge : UIEs in Japan and the United States, Cambridge, Mass. : MIT Press, 1999.
- Bush, V., Science: the Endless Frontier, reprinted ed., New York : Aron Press, 1980.
- Castells, M., P. Hall, Technopoles of the World, London : Routledge, 1994.
- CCMH (Compilation Committee of Miyagi's History), History of Miyagi Prefecture: Vol.9 Industry, Miyagi Prefecture Press, 1968.
- CHCCS (City History Compilation Committee of Sendai) ed., History of Sendai: Vol. 1, Main Edition 1, Sendai City Office, 1954a.
- History of Sendai: Vol. 4: Separate Edition 2, Sendai City Office, 1954b.
- History of Sendai, Sequel 1: Administration and Construction, Sendai City Office, 1969.
- History of Sendai, Sequel 2: Economy and Culture, Sendai City Office, 1969.
- History of Sendai, Kobun-do, 1970.
- Compton, K. T. "Mission to Tokyo", The Technology Review, Vol. 48, No. 2, Dec. 1945.

- Cooke, P., K. Morgan, "The creative milieu: a regional perspective on innovation" in M. Dodgson, R. Rothwell eds., *The Handbook of Industrial Innovation*, Vermont, USA : Edward Elgar, 1994.
- Cooke, P. et al., "Regional systems of innovation: an evolutionary perspective" in *Environment and Planning A*, Vol. 30, 1998: 1563-1584.s
- Cooke, P., K. Morgan, *The Associational Economy*, Oxford : Oxford University Press, 1998.
- Dorfman, N. S., "Route 128: The development of a regional high technology economy", *Research Policy* 12, 1983: 299-316.
- Eisinger, P. K., *The Rise of the Entrepreneurial State: state and local economic development policy in the United States*, Madison : University of Wisconsin Press, 1988.
- Etzkowitz H., L. Leydesdorff, "Introduction: universities in the global knowledge economy" in Etzkowitz H., L. Leydesdorff eds., *Universities and the global knowledge economy: a triple helix of university-industry-government relations*, London and Washington : Pinter, 1997.
- Etzkowitz, H., A. Webster, C. Gebhardt, B. Terra, "The future of the university and the university of the future: evolution of ivory tower to entrepreneurial paradigm" in *Research Policy* 29, 2000: 313-330.
- Etzkowitz, H., L. Leydesdorff, "The dynamics of innovation: from National Systems and "Mode 2" to a Triple Helix of university-industry-government relations" in *Research Policy* 29, 2000: 109-123.
- Etzkowitz, H., *MIT and the Rise of Entrepreneurial Science*, London ; New York : Routledge, 2002.
- Feller, I., "The American university system as a performer of basic and applied research" in Branscomb et al., 1999.
- Fosler, R. S., *The New Economic Role of American States: strategies in a competitive world economy*, Oxford University Press, 1988.
- Freeman, C., *Technology Policy and Economic Performance: lesson from Japan*, London : Pinter, 1987.
- Freeman, C., "Formal scientific and technical institutions in the national system of innovation" in B-A. Lundvall ed., *National Systems of Innovation*, London : Pinter, 1992.
- Freeman, C., "The 'national system of innovation' in historical perspective" in *Cambridge Journal of Economics*, 19, 1995: 5-24.
- Freeman, C., "Continental, national and sub-national innovation systems: complementarity and economic growth" in *Research Policy*, 31, 2002: 191-211.
- Fujii, N., and Okuda, M., "Industrialization in Region and Its Consequences in Wartime Japan" Nakamura, T. and Fujii, N., eds., *Urbanization and Existing Industries*, Tokyo : Nihon Keizai Hyoron-sha, 2002.
- Goto, A., and Wakasugi R., "Technology Policies" Komiya, R., Okuno M., and Suzumura K., eds., *Industrial Policies of Japan*, Tokyo : Tokyo University Press, 1984.
- Goto, A., "Technology Policies: The Experience of Post-War Japan" Kosai, Y. and Teranishi J. eds., *The Economic Reform of Post-War Japan*, Tokyo : Tokyo University Press, 1993.

- Hane, G., "Comparing university-industry linkages in the United States and Japan" in L. M. Branscomb et al. eds., 1999.
- Hatta, T., and Tabuchi, T., "Contributing Factors to and Measures for Unipolar Concentration in Tokyo" Hatta, T. ed., Economic Analysis of Unipolar Concentration in Tokyo, Nihon Keizai Shimbun, 1994.
- Haneda, T., "New University System and Science and Engineering Education" Nakayama, S., Gogo, K., and Yoshioka, H. eds., General History: Japan's Science and Technology 1, Tokyo : Gakuyo Shobo, 1995.
- Henton, D. et al., Grassroots Leaders for a New Economy, San Francisco : Jossey-Bass, 1997.
- Hilpert, U., ed., Regional Innovation and Decentralization, London ; New York : Routledge, 1991.
- Hiroshige, T., Social History of Science, Tokyo : Chuokoron-sha, 1973.
- Hoshino, Y., A Short History of Technology of Modern Japan, Tokyo : Dainihon Tosho-sha, 1956.
- Hoshino, Y., Technological Innovation in Japan, Tokyo : Keisoshobo, 1966.
- HTDFPC (Hokkaido Tohoku Development Finance Public Corporation), "Survey on Regional Development of Research and Development Functions" March 1987.
- Ikeguchi, K., Regional Structure in Japan: Regional Development and Reconstruction of Oval Structure, Tokyo : Toyo Keizai Shimpō, 1967.
- Itakura, K., Kimura, T., and Yagi, E., The Life of Hantaro Nagaoka, Tokyo : Asahi Shimbun, 1973.
- Iwamoto, Y., 120 Years of the Development of Tohoku, Tokyo : Tosui Shobo, 1994.
- Japan Development Bank, Chosa: Special Issue: The Trend of Science Park Building and Regional Vitalization, No. 136, 1989.
- Japan Techno-Economic Society, Basic Research on Science and Technology Promotion in Regional Community (II) Research on Measures to Promote Science and Technology by Utilizing Human Resources in Tohoku, (a report commissioned by Science and Technology Agency FY1989), March 1990.
- JERC (Japan Economic Research Council), For the Establishment of Arena for Truly International and Creative Activities in Science and Technology—The Way Industry-Academics-Government Cooperation should be, 1988.
- Jiang, J., "Entrepreneurial University and Regional Development" in Development Bank of Japan, Tohoku Branch, Cluster Research-Greater Sendai Area, Sendai, Dec. 2003.
- Jiang, J., Y. Harayama, S. Abe, "'Cluster Project' and 'University-Industry Linkages': Case of Sendai Area" A collection of excerpts from research reports of the 26th Annual Conference of Japan Association for Planning Administration, 2003.
- Jiang, J., Y. Harayama, "Cluster programs and university-industry partnership " in The Journal of Science Policy and Research Management , Vol. 20, No. 1, 2005a: 4-11.
- Jiang, J., Y. Harayama, "The development of regional science & Technology policy in Japan, in contrast

- with the US and EU" in *The Journal of Science Policy and Research Management*, Vol. 20, No. 1, 2005b: 63-77.
- Kaneko, M., "Today's Significance of Technopolis Plan" *Industrial Location*, Vol. 21, 7th ed., 1982:22-33.
- Keating, M., "The political economy of regionalism" in M. Keating, J. Loughlin eds., *The Political Economy of Regionalism*, London : Frank Cass, 1997.
- Kobayashi, M., "Technopolis: new concept of regional development" in Sakata, T. ed., *Creation of New Regional Community*, Tokyo : Gyosei, 1982.
- Kosai, Y., "Reconstruction Period" in Komiya, R., Okuno M., and Suzumura K., eds., *Industrial Policies of Japan*, Tokyo : Tokyo University Press, 1984.
- Kosai, Y. and Teranishi, J., "Economic Reform and Stabilization in Post-War Japan" in Kosai, Y. and Teranishi, J. eds., *Economic Reform of Post-War Japan*, Tokyo : Tokyo University Press, 1993.
- Luger, M. I., "Science and Technology in Regional Economic Development: the Role of Policy in Europe, Japan and the United States", *Technology in Society*, 16(1): 9-33, 1994.
- Lundvall, B-A. ed., *National Systems of Innovation*, London : Pinter, 1992.
- Malecki, E. J., "Network models for technology-based growth" in Z. Acs ed., *Regional Innovation, Knowledge and Global Change*, London : Pinter, 2000.
- Matkin, G. W., *Technology Transfer and the University*, New York : National University Continuing Education Association : American Council on Education : Macmillan, 1990.
- METI, "Results of Basic Research on University Spin-off Companies, FY2004", 2005, <http://www.meti.go.jp/press/200504250>.
- Motohashi, K., "University-Industry collaborations in Japan: The role of new technology-based firms in transforming the National Innovation System" in *Research Policy*. Vol.34, 2005: 583-594.
- Nishiyama, E., "The Roles of the Influencer for the Formation and the Development of High-Tech Industrial Cluster in Sendai Region", *Kenkyu Nenpo Keizaigaku*, (Tohoku University), [Economics], 66(1): 105-123, October 2004.
- Nishizawa, J., *NHK Ningen Daigaku : a Genealogy of Originality*, Tokyo : NHK shuppan, 1992.
- OECD, *The Response of Higher Education Institutions to Regional Needs*, Paris : OECD, 1999.
- Okazaki, T., *Trace of Industrialization*, Tokyo : Yomiuri Shimbun, 1997.
- Omi, K., *Science and Technology-Based Nation*, Tokyo : Yomiuri Shimbun, 1996.
- Omi, K., *Build Japan on Science and Technology*, Tokyo : Keizai Shinppo Sya, 2003.
- PHCCM (Prefectural History Compilation Committee of Miyagi), *History Compilation Committee of Miyagi Prefecture ed., History of Miyagi Prefecture: Vol. 11 Education*, Miyagi Prefecture Press, 1959.
- Report by Research and Reform Section, National Land Development Council, *Comprehensive Review of National Land*, May 2004.
- Research corporation section, Tohoku University, *Research on situation in university spin-off companies*,

- 2002, Tohoku University, 2004.
- Rosenberg N., R. R. Nelson, "American universities and technical advance in industry" in *Research Policy* 23, 1994: 323-348.
- Rosenberg, N., R. R. Nelson, "The role of universities in the advance of industrial technology" in R. S. Rosenbloom, W. J. Spencer eds., *Engines of Innovations*, Boston : Harvard Business School Press, 1996.
- Rosenberg, N., "Knowledge and innovation for economic development: should universities be economic institutions?" in P. Conceicao et al., *Knowledge for Inclusive Development*, Westport, Conn. : Quorum Books, 2002.
- Sato, M., *Industrial Location Policies of Japan*, Tokyo : Kobundo, 1963.
- Sawayanagi M., *Nation and Education* (a complete collection of Masataro Sawayanagi/ Masataro Sawayanagi Corpus Press of Seijo Gakuen ed. No.3), Tokyo : Kokudo-sha, 1978.
- Sazanami H., "Structural Transformation in Japan: Issues and Prospects of Regional Development in the Coming Years" in L. Rodwin & H. Sazanami eds., *Industrial Change and Regional Economic Transformation: the Experience of Western Europe*, London : Harper Collins Academic, 1991.
- Tabata, H., "The incorporation and economic structural reform of Japan's national universities" in *Social Science Japan Journal*, vol. 8, No. 1, 2005: 91-102.
- Science and Technology Policy Bureau of MEXT, *Interim Report on the Intellectual Cluster Projects- FY 2004*, March 2005.
- SCO (Sendai City Office) ed., *History of Sendai*, 1908.
- Shinohara., M., *Quantitative Analysis of Regional Economic Structure*, Tokyo : Iwanami Shoten, 1965.
- Slaughter S., L. L. Leslie, *Academic Capitalism : politics, policies, and the entrepreneurial university*, Baltimore : Johns Hopkins University Press, 1997.
- Sogo Seisaku Kenkyukai ed., *Regional Development of Japan*, Tokyo : Diamond, 1963.
- Study Group for Transfer of Research Results to Society, *The Report*, MEXT, 2001.
- Takeda, H., "Heavy and Chemical Industrialization and Economic Policy" Banno, J. ed., *Transformation to Modern Society*, 1993: 110-144.
- TEF (Tohoku Economic Federation), "Survey Results of University-Industry Linkage in the Tohoku Region" September 1984.
- Teranishi, J., *Japan's Economic System*, Tokyo : Iwanami Shoten, 2003.
- Tohoku Bureau of Economy, *Creation of Competitive and Self-sustainable Region*, 2001.
- Tohoku University, Research Institute of Electrical Communication, *Record of Electrical and Communication Engineering Conversazione: Special Edition for the 50-Year Anniversary of the University: Research on Electrical and Communication Engineering*, 1985.
- Tohoku University, *The 50 Years History of Tohoku University*, 1960.
- Tohoku University, *The 50 Years History of Institute for Materials Research*, 1966.

- TRRDC (Tohoku Regional Research and Development Center), "Survey Results of the Development of Academic and Research Functions in Tohoku", March 1987.
- Uchida, H., History of Technology Policies, in Nakaoka, T., et al., Technologies and Technology Policies of Modern Japan, Tokyo : United National University, 1986 : 163-247.
- Varga, A., University Research and Regional Innovation, Boston, Kluwer Academic Publishers, 1998.
- Yagi, T., "Scientists and Engineers, Be Politically Minded", 1946, in Japanese Science and Technology Series No.5: General History 5: 84-87.
- Yagi, T., Night Tales of Engineers, Tokyo : Kawade Shobo, 1953.
- Yamazaki, A., Network-based Distribution and Decentralization Policy, Tokyo : Taikei-do, 1992.
- Yamazaki, T., General History of Modern Japan: History of Engineering, Tokyo : Toyo Keizai Shimpou-sha, 1961.
- Yonezawa, A., "Making 'World Class Universities': Japan's Experiment" Higher Education Management and Policy, Vol. 15, No. 2, 2003: 9-24.