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The Mechanism of High-tech Industrial Cluster Formation: An Empirical Study on the Process of ICT Cluster Formation in Oulu, Finland

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The Mechanism of High-tech Industrial Cluster Formation:

An Empirical Study on the Process of ICT Cluster Formation in Oulu, Finland[1] [2]

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CONTENTS

Introduction

The concept of the industrial cluster is a familiar one to regional development workers, policy formulators for industry, science and technology, and researchers in these fields throughout the world.[3] In Japan, the central government implements cluster policies[4] developed since the beginning of this century by the Ministry of Economy and Industry (METI) and the Ministry of Education, Culture, Sports, Science and Technology (MEXT). Regional governments may use central government measures to augment policies they already have in place; those with no measures of their own may use the government's as starting points for new initiatives.

The development of an industrial cluster takes time. This may be one reason why Japanese communities planning to create a cluster tend to wait for the results of existing initiatives to come in before exploring future strategies.[5] Similar approaches are taken throughout much of Europe, North America and Asia. Even regions where clusters are up and working make ongoing efforts to ensure that they produce stable or better results.

As an idea, the industrial cluster has drawn steady interest from a wide range of people across the world and from regional development specialists in particular. This is because it is seen as a valuable methodology for producing stable growth and employment in regional economies, one which helps a region's leading industries to maintain and strengthen their competitiveness while creating new local firms and sectors. For individual companies, the concept can have important relevance for site location and innovation strategies. Companies with global operations, especially in knowledge-intensive or science-based fields, find numerous advantages in locating in an industrial cluster: not only do they enjoy superior access to materials and components, but they also have a better chance to differentiate their goods and services

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[3] Michael E. Porter, in *The Comparative Advantage of Nations* (1990), points out that the more competitive of a country's industries tend locate in clusters. He uses the term frequently throughout the book.

[4] METI initiated an industrial cluster project in FY2001. MEXT began an intellectual cluster development project in FY2002.

[5] Some regions, such as Kyoto and Hamamatsu, are regarded as home to developed industrial clusters. Even here, however, efforts are ongoing to support the creation of new businesses and industries.

from those of other firms. Clusters provide a favorable environment for innovation, which is a difficult factor to overestimate. Entrepreneurs, meanwhile, benefit greatly from starting up in a region supportive of their needs. It would hardly be surprising to find that regions which are supportive turn out disproportionate numbers of entrepreneurs.

Research on industrial clusters took off in earnest in the 1990s, when both national and local government policymakers showed increasing interest in the subject. From the start, there has been some confusion as to what, exactly, is meant by the term "industrial cluster," and proponents tend to differ in their definitions. Some, moreover, refer simply to "clusters," others to "industrial clusters" or "regional clusters."[6] Still others, emphasizing the role of clusters in fostering venture business, use the term "innovation clusters."[7] In a similar vein are the "industrial district" and "innovative milieu" concepts.[8] "Regional innovation systems"[9] also have many features in common with industrial clusters. Terms and definitions may vary, but all of these concepts are closely connected with how regional development strategy, national and regional science and technology policy, and innovation policy are designed.

"Industrial cluster" is the term I use in this paper. It refers to a type of regional industrial strategy aimed at achieving sustainable development of the local economy, or, more specifically, ensuring stable employment and maintaining or increasing local exports. Thus I stress the word "industrial" in "industrial cluster."

Suitable businesses for an industrial cluster are by no means limited to those in high-tech or even the manufacturing industry. Local measures to promote the tourism industry may result in "tourism clusters," for example. Of the many types of industrial

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[6] METI and MEXT use the term "regional cluster" in linking the Industrial Cluster Plan with the Intellectual Cluster Creation Project (MEXT Science and Technology Research Center Research Group No. 3 (2004), p. 4).

[7] Nishizawa (2005), p. 31.

[8] The former concept is described in Piore and Sabel, *The Second Industrial Divide* (1984), as a regional industrial community characterized by flexible division of labor, as opposed to a shift of production to a country where the mass-production method is relatively underdeveloped. The latter expression focuses on the community's cultural and institutional environment: an "innovative milieu" policy aims at creating a local culture that is amenable to innovation (Matsubara (1999), pp. 92-93).

[9] Regarded as a counterpart for a national innovation system. Deriving from a perspective that focused on the concept's limitations, the term is also a product of modern regional economic theory and regional industrial policy theory (Mitsui (2005), p. 215).

cluster, I have chosen to examine the high-tech variety and particularly the mechanisms by which it is formed. This is a subject of great interest to regions that may not possess the full range of resources of a major urban center, but may be home to respected research universities or existing industrial clusters in need of technological upgrading. Some regions with top-notch research facilities have tried to draw in headquarters of high-tech firms, but were unable to attract them in sufficient numbers to form a cluster. In the end they lost a good proportion of their graduates to other regions. For almost a decade, several such communities have been working hard to remedy this situation, and now, with improved physical and institutional infrastructure, are beginning to reap solid results. But since clustering begets further clustering, communities will need to take stronger measures in order to benefit from the true lock-in effect[10] that is an industrial cluster's primary characteristic. This brings us to an important motivation for undertaking this study: The formation of high-tech clusters is an important issue, and not only for individual regions. Progress in this area will affect how Japan as a nation maintains its industrial competitiveness and promotes regional self-reliance. The two types of high-tech clusters considered most typical are IT (or ICT) clusters and bioclusters. I focus on the former in examining the mechanism of cluster formation for this report.

Chapter 1 differentiates the concepts of "industrial agglomeration" and "industrial cluster" and defines what is meant by an industrial cluster in this report. Chapter 2 reviews the findings of existing studies of industrial agglomeration and industrial clustering. Chapter 3 addresses the question of why industrial agglomeration continues, as examined in prior studies on industrial agglomeration, as a starting point for constructing a working hypothesis for the mechanism of high-tech cluster formation. Chapter 4 examines this hypothesis in light of the formative process of the ICT cluster in Oulu, Finland. Finally, Chapter 5 discusses the conclusions reached through this analysis and considers future issues. In the Appendix I examine what these findings may mean to regions in Japan hoping to create high-tech industrial clusters of their own.

[10] Fujita and Hisatake（1999）

Chapter 1 Differentiating the Concepts of Industrial Agglomeration and Industrial Clustering

In this chapter I compare the concepts of industrial agglomeration and industrial clustering, and describe what is meant by "industrial cluster" in this paper.

A simple explanation of the industrial agglomeration is a useful place to start.[11] Economic geographers and business historians have made numerous studies of centers in Japan for the production of such traditional products as textiles, and also of the clusters of small and medium-sized manufacturing firms that have formed in the larger cities. Much of this research actually deals with industrial agglomeration, as it examines the economic mechanisms at work when numerous companies (often SMEs) in a given industry concentrate in a particular area.[12]

In the definitive book on modern industrial agglomeration, *The Essence of Industrial Agglomeration*, by Hiroyuki Itami, Shigeru Matsushima, and Takeo Kikkawa, Itami (1998) defines an industrial agglomeration as "a concentration within a relatively small region of numerous, deeply connected firms."[13] As I will make clear, the fact that companies are the only actors is one point that distinguishes industrial agglomerations from industrial clusters. Explicitly excluded from agglomerations are universities, public research centers and other knowledge-creating institutions, as well as trade organizations and other groups that promote partnership.

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[11] Hashimoto (1997) classified industrial agglomerations in Japan into a total of four categories: two which developed around large-scale firms and two which developed around small and medium-scale firms. Category 1 agglomerations are "company towns" such as Niihama or Mizushima, which are dependent on large corporations with integrated production systems. Category 2 agglomerations are also company towns, but complement large-scale processing and assembly companies in, for example, the automobile and electrical industries. Toyota and Hitachi exemplify this type. Category 3 agglomerations develop around production areas, and include Sabae, Tsubame and Tokoname. Category 4 agglomerations consist of networks of firms, typically in machinery and metals processing, that develop in large cities. Examples are Ota-ku in Tokyo and the city of Higashi Osaka. The form in which labor is divided among firms in an agglomeration is clearly the major consideration in this method of categorization.

[12] Kikkawa, Takeo, et al. *Shijo torihiki o koeru keizai gorisei* [Economic rationalization exceeding market forces] (2001): p.102.

[13] Ibid., p.2.

To describe industrial clusters[14], we might look to the definition given by Michael E. Porter in 1990 in *The Competitive Advantage of Nations* and repeated in his 1998 work *On Competition*. Porter defines clusters as "geographic concentrations of interconnected companies, specialized suppliers, service providers, firms in related industries, and associated institutions (for example, universities, standards agencies, and trade associations) in particular fields that compete but also cooperate."[15] This definition thus differs from Itami's in several respects, the most important being that Porter explicitly includes related organizations, such as universities and standards associations, in his definition, and that he makes reference to the actors' behavior towards one another, namely their competition and cooperation. Since Porter uses the presence of universities as an example, it would be easy to infer that business-academic partnership is a requirement for an industrial cluster, or that clusters are by definition composed of high-tech companies. Porter, however, believes differently:

> Some clusters center on research universities, while others draw little on the resources of formal technological institutions. Clusters occur both in high tech and traditional industries, in manufacturing as well as in service industries. Indeed, clusters often mix high tech, low tech, manufacturing, and services. (Porter, *On Competition*, p.207)

METI, which has had an industrial cluster project in progress since 2001, defines a cluster as "an industrial agglomeration consistently producing new businesses which are not only world-class but also serve to support the local economy."[16] Here, METI expresses the policy objective of creating new business, while, with "world-class new businesses," it emphasizes the transfer, or export, of products or technologies to other regions or overseas. One important element of Porter's conception is that a cluster be outward-looking.[17] In this sense his idea fits neatly within METI's definition.

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[14] Porter himself uses the term "cluster." He does not say "industrial cluster," but prefaces the word "cluster" with the name of a place or product: e.g., Italian, shoe, fashion, or California wine cluster; Massachusetts cluster, forestry products cluster, and so on (Porter, 1998), pp.199-206. Any of these can reasonably be considered as an industrial cluster.

[15] Porter, Michael. *On Competition*. Harvard Business Review Press (1998): pp.197-198.

[16] The METI website (e.g. http://www.meti.go.jp/policy/local_economy/main_02.html). In presentation materials of the Economic and Industrial Policy Bureau and elsewhere, METI gives Porter's definition in addition to this one, apparently adding to Porter's definition to emphasize policy objectives.

[17] "The outward-oriented clusters based in a geographic area constitute the area's primary *long-run* source of economic growth and prosperity." (Porter, *On Competition*, p.228.)

In this paper, I attempt to explore the mechanism by which industrial clusters are formed. "Activity groups" play a vital role in cluster formation. I give them special attention and seek to incorporate them into the definition of an industrial cluster.[18] For our purposes here, an "activity group" may be taken to mean a flexible group, composed of local individuals or organizations, which works steadily for the creation, continuation or development of an industrial cluster. Such flexible groups exist to one degree or another in any place regarded as an industrial cluster. I emphasize their existence, therefore, and seek a place for them within the definition.

Building on Porter's definition, I describe "industrial cluster" as "a value chain, and a social system supporting it, existing in a coherent geographical area against a backdrop of initiatives carried out by loose-knit, flexible activity groups composed of local actors and aimed at the agglomeration of related companies and the generation of value in a given field." Porter, in defining clusters as "geographic concentrations of interconnected companies … and associated institutions (for example, universities, standards agencies, and trade associations) in particular fields that compete but also cooperate," does not make an issue of the intentions or promotional efforts of local actors; as long as the situation described in the definition exists, the presence of activity groups is irrelevant. If we go by Porter's definition, a conurbation like Tokyo is composed of diverse industrial clusters. While this is significant in itself, more important for Japan's future is how regions which, like Tokyo, do not possess a full range of necessary resources, can promote sustained development while making the most of the resources (like top-rate research universities) which they do have[19], and, by

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[18] One way in which industrial clusters are held to differ from industrial agglomerations is that the former involve the participation of related entities, such as universities, standards associations and trade groups, and the cooperation of related firms and organizations. These local actors must, to some extent, have the development of local industries – or the formation and continuation of the industrial cluster – as a common objective. This is especially true when local universities are included in these related groups. Since universities are driven by very different imperatives than private companies, the two must have a sense of common purpose above and beyond their normal mission if they are to work as close partners within a cluster. In this paper, groups with a relatively strong sense of common purpose are called "activity groups" and are described in the definition of *industrial cluster*.

[19] From the perspective of regional economic promotion, Matsushima (2005) proposed the concept of the "hardiness of regional economies," which differs somewhat from the idea of sustainable development. In Matsushima's view, a hardy region experiences no sudden or large-scale decline in area-wide employment over the long-term, even while exposed to all sorts of adversity. Even if a decline occurs, employment quickly recovers to a level near the original.

extension, whether such regions will recognize the value of industrial clusters in pursuing that goal. Activity groups would seem to be a prerequisite for the formation of an industrial cluster in areas like these. I make the presence of activity groups a part of my definition on the basis of this view, and also because people known collectively as "activity groups" exist to one extent or another in the places we regard as industrial clusters. I describe these activity groups as "loose" because local actors clearly differ in their degree of participation, and as "flexible" because changes in a cluster's environment will inevitably affect the behavior of related activity groups. Interestingly, many of the processes in the development of Silicon Valley – the original industrial cluster, in Porter's sense – are thought to have occurred naturally, regardless of their initial catalyst[20]; "activity group" might be an inappropriate term under the circumstances. But it seems clear that underlying the motivations of the entrepreneurs, academics and others involved in the formation and development of Silicon Valley was an anti-East Coast competitive urge, as well as a latent desire to create a new business paradigm.[21] Silicon Valley has seen little growth since the late 1980s. Joint Venture: Silicon Valley Network (JV:SVN) took off in 1992 as a spontaneous attempt to counteract the loss of both firms and people; its efforts to revitalize the area are well known. Initiatives like these suggest that Silicon Valley as a whole can be viewed as a "loose activity group whose members have certain objectives in common." And while Silicon Valley may be an exception, any number of areas have used it as a model for research as they labored to form high-tech industrial clusters of their own. While they may vary in the extent of their undertakings, there is no question that activity groups of some form have existed, and have put enormous effort into the formation of industrial clusters, in each of these regions.

He analyzes Tōmō, in Gunma Prefecture, as an example of a hardy region.

[20] It is well known that Frederick Terman, who harbored a sense of rivalry towards the East Coast, worked tirelessly to get Stanford graduates to remain in the West. Thanks to his efforts, former students Bill Hewlett and Dave Packard stayed in Palo Alto, where in 1939, working out of a small garage, they created the company that was to grow into the global giant bearing their names. Terman was also in part responsible for the establishment in 1951 of the Stanford Research Park on the grounds of the university. In 1955, he induced the world-renowned semiconductor researcher William Shockley to open the Shockley Semiconductor Laboratory in the area; in 1957, eight researchers left Shockley to set up Fairchild Semiconductors. The numerous spinoffs which followed included Intel in 1968.

[21] This kind of nuance can be found throughout AnnaLee Saxenian (1994), for example on pages p.p.63-76 of the Japanese translation.

In the following I use the term “industrial agglomeration” in Itami’s sense: “a concentration within a relatively small region of numerous, deeply connected firms,” and “industrial cluster” as defined above.

Chapter 2　A Review of Research Findings on the Economic Mechanisms At Work within Industrial Agglomerations and Industrial Clusters

In this chapter I review the findings of research to date on the economic mechanisms found in industrial agglomerations and industrial clusters.[22] Since innovation is one of the more important aspects from which I consider high-tech cluster formation mechanisms in Chapter 3, I look first at how the relationship between industrial agglomerations (or industrial clusters) and innovation is treated in existing research.

Most research on the economic effects of industrial agglomerations starts with Alfred Marshall(1920)'s analysis of "localized industries". Marshall made the analysis to help explain the subject of external economics, and it deserves discussion here.

Marshall said that "localized industries," or "agglomerations of specific industries in specific regions," form for a variety of reasons – natural conditions, royal sponsorship, or a ruler's forced relocation of artisans, for example – and that once formed, they tend to be maintained.

In Marshall's view, some examples of the advantages of industrial agglomerations are that they:

① Perform traditional functions, such as enabling "success secrets" to spread from firm to firm, which indicate how technology accumulates or proliferates within a region.
② Promote the growth of subsidiary industries by, for example, supplying tools and raw materials, systemizing distribution, and putting expensive machinery to economical use.
③ Create regional markets for localized industries, to the benefit of users and specialist workers alike.

The first of these advantages is usually defined as "technology and information spillover," but it actually is more than that. We can also find room for "innovation" within the definition. To paraphrase Marshall, when one person comes out with a new

[22] A detailed discussion of Itami's "Ongoing Mechanisms in Industrial Agglomerations" in Itami(1998) is given in Chapter 3.

idea, others pick it up and add their own inventions, thus producing the basis for another new idea. This behavior is not mere imitation, but what Schumpeter (1926) called "carrying out new combinations"[23] – innovation, in other words. Marshall, too, noticed the innovation-promoting effect of industrial agglomerations.

By creating new regional markets for localized industries (the third advantage), industrial agglomerations make it easier for workers to change jobs. Marshall says that labor-management relations in agglomerations are generally good, but the occasional unpleasant situation cannot be allowed to degenerate into repeated friction. When a long-standing relationship goes sour, both parties benefit if it can easily be nullified. Yamamoto (2000) says that these conditions "create the basis for the active diffusion of knowledge and technology."[24] In this respect, they also promote innovation. Thus, while he may not articulate it explicitly, Marshall does include the promotion of innovation among industrial agglomeration's advantages.

Of the various forms of economics of agglomeration, Marshall seems to have explained the "economics of specification." It is urban economists, on the other hand, who explain the "economics of urbanization." Henderson et al (1995) use city-specific and industry-specific data for the United States to show that rising industries, such as computers, electronic devices, and medical equipment, grow faster in conditions of urban diversification (Jacobs's externality) and industrial specialization within a region (Marshall, Arrow, and Romer's externality), and that mature industries, such as metals, general machinery, electrical machinery, transportation machinery, and precision machinery, maintain high growth rates under conditions of intra-region specification (Marshall, Arrow, and Romer's externality). These findings confirm the "economics of

[23] Schumpeter (1926) gave five examples of new combinations: ① The production of a new good, meaning one not yet known among consumers, or a good with new quality. ② The introduction of a new production method, meaning one which is, for all practical purposes, unknown in the industrial sector in question. This includes new methods for the commercial handling of products, and need not be based on a new scientific discovery. ③ The opening of a new market, meaning one as yet uninvolved in that particular industrial sector in that particular country. Whether the market exists or not is irrelevant. ④ The acquisition of a new source of supply for raw materials or semi-finished goods. In this case as well, it is irrelevant whether the supply source is an existing one, one which has been previously overlooked, or one which has been regarded as impossible to acquire – or, one which must be created from the beginning. ⑤ The reorganization of the industry, meaning the formation of a dominant position (for example, by forming a trust), or the breaking of a monopoly.

[24] Yamamoto (2000), p. 22.

agglomeration" in individual industries in the manufacturing sectors of industrialized countries, and indicate as well that the growth of rising industries in industrialized countries is hugely affected by the "economics of urbanization."

Sonobe and Otsuka (2004), who argue in *Roots and Strategies of Industrial Development: Lessons from the East Asian Experience* that "an environment conducive to the generation of devices and mechanisms to effectively supplement the market – and especially, 'industrial clusters' – is vital to the development of industries (in developing countries)," are looking into the importance of industrial agglomerations. Focusing on industrial agglomerations in Japan, Taiwan, and China, the researchers analyze their data on the assumption that factors influencing corporate profit differ according to the stage of an industry's development and whether that development is driven by merchants or engineers.

We can draw a number of conclusions from their findings. When development is fueled by engineers, important factors are ① at the initial stage, the scale of technical knowledge and industrial diversity and the proximity of the area to a large city; ② at the quantitative expansion stage, the scale of agglomeration in the industry concerned and the amount of technical knowledge (at startup); and ③ at the qualitative improvement stage, the scale of innovation: technological, institutional, logistical and so on; proximity to a large city; and the scale of agglomeration in the industry concerned (although this brings negative effects through external diseconomies). Proximity to a large city produces opposite effects in the case of merchant-driven development. In merchant-driven agglomerations, distance from a large city correlates with higher profits at each stage.

If we substitute high-tech industrial clusters in developed countries for "engineer-driven agglomerations at the qualitative improvement stage," we are left with no doubt about the importance of innovation and the "economics of urbanization."

In *The Future of Japanese Industrial Agglomerations*, Hashimoto (1997) analyzes existing industrial agglomerations. As one of their economic advantages, he describes how individual industries taking part in the division of labor profit from the benefits of

scale and economies of scope already existing for the agglomeration as a whole. For those advantages to be generated, conditions must be present that will reduce the costs of adjusting the division of labor. In Hashimoto's view, these conditions – the "merits of contact" among companies – are important[25], if hard to explain in economic terms.

"Merits of contact" is a collective term coined many years ago by Alfred Weber, referring to cost reductions and other advantages resulting from benefits of scale within a cluster, ease of access to labor markets and subcontracting firms specializing in a particular industry, reduced production and distribution times, access to important information, and so on[26]. While each of these may be, as Weber put it, an "agglomeration-derived cost reduction," "access to important information (available only in the region concerned)" brings companies benefits exceeding that of lower costs. These are probably what Takaoka (1997) calls "absolute rationality[27]." "Absolute rationality resulting from the merits of contact" also has significance as an innovation-producing environment in the sense that Schumpeter meant it (the pursuit of new combinations).

The above is the substance of existing studies in the field of economics. Other research – primarily by Porter, who expanded the concept of the cluster – has been undertaken from the standpoint of business administration. Here I shall summarize the main points of Porter's analysis of industrial clusters.

Porter mentions three effects of industrial clusters: ① improved productivity, ② inducement of innovation, and ③ new business ventures. He repeatedly emphasizes the importance of "improved productivity" as an outcome and also as the ultimate objective. On occasion, however, he places greatest emphasis on innovation as an outcome. For example: "Some of the most important agglomeration economies represent dynamic rather than static efficiencies and revolve around innovation and the rate of learning" (Porter, 1998, p. 208).

Porter proposes a "diamond model" (Figure 2-1) to illustrate the environment required

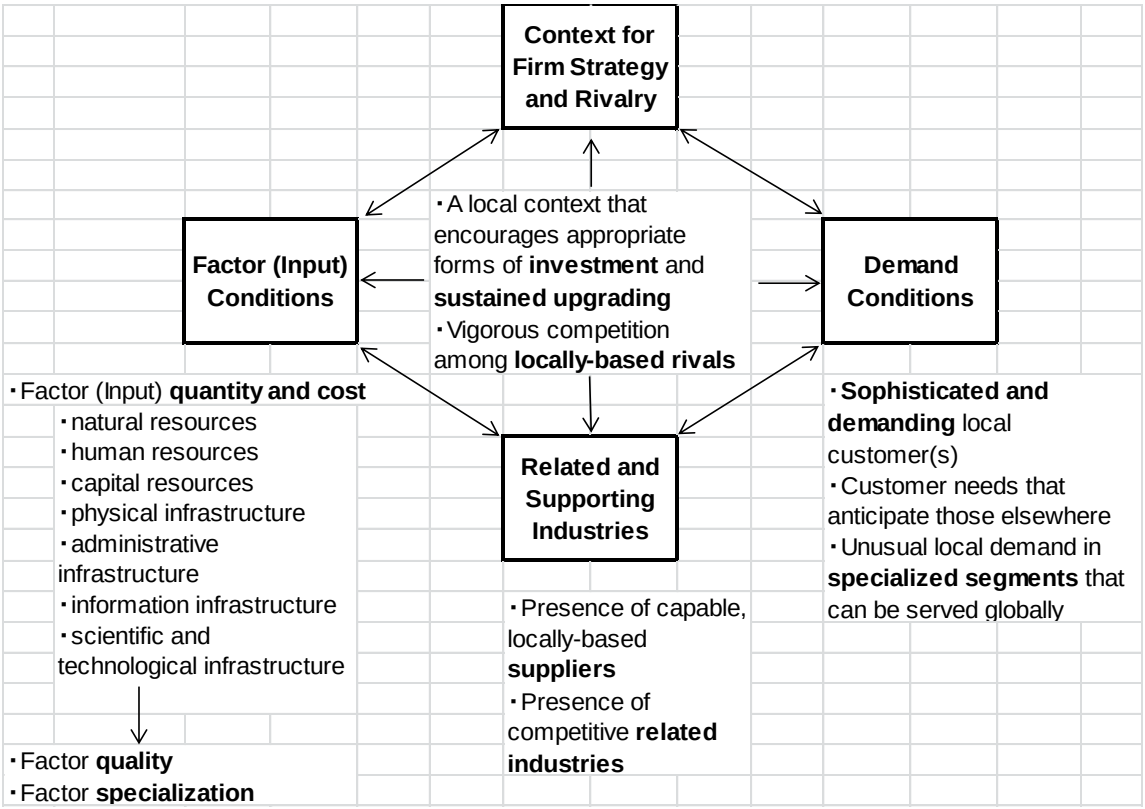
[25] *The Future of Japanese Industrial Agglomerations*, pp. 163-164.

[26] Yanai (2002), p. 22.

[27] Takaoka (1997) uses the term "absolute rationality" to mean the benefits arising from input resources unavailable in other regions (regardless of cost), as opposed to "relative rationality," meaning cost reduction.

for a cluster. He states that the sources of location advantage are ① factor, or input, conditions (the quantity and cost of input resources), ② demand conditions (such as sophisticated and demanding customers), ③ the context for firm strategy and rivalry, and ④ related and supporting industries.

Figure 2-1 Sources of Location Advantage, according to Porter



Source: Porter, *On Competition*, p.325

In the context of firm strategy and rivalry, Porter sees competitive relationships among local firms as "rivalry among neighbors," a pressure that points firms toward creative differentiation, regardless of their will: in other words, a force driving innovation. It is one of the reasons why "rivalry" plays such a central role in Porter's definition. Here is Porter on the significance of rivalry:

> Rivalry with locally based competitors has particularly strong incentive effects because of the ease of constant comparison and because local rivals have similar general circumstances (for example, labor costs and local market access),

> so that competition must take place on other things. In addition, peer pressure amplifies competitive pressure within a cluster, even among indirectly competing or non-competing firms. Pride and the desire to look good in the local community motivate firms in their attempts to outdo each other. (Porter, *On Competition*, p.219)

Porter(1998) states that "the geographic scope of a cluster can range from a single city or state to a country or even a network of neighboring countries."[28] "Drawing cluster boundaries," he points out, "is often a matter of degree, and involves a creative process informed by understanding the most important linkages and complementarities across industries and institutions to competition. The strength of these 'spillovers' and their importance to productivity and innovation determine the ultimate boundaries."[29] Kanai (2003) explains the boundaries of spillovers by means of the "stickiness of information" concept: how much it costs to transmit locally generated information and knowledge to other areas. Information is "stickiest" when, as in the case of embedded information, it is not easily transferable. When sticky information is fundamental to a cluster's success, the cluster may have geographical boundaries which allow for face-to-face exchange. Porter thus sets the geographical boundaries of a cluster at from 100 to 200 miles.[30]

Porter (2001) also stresses the necessity of economic and social policies within the cluster and the local economy. A productive economy, he says, requires well-educated workers with a sense of opportunity, who are healthy, have adequate housing, and who are willing to invest in upgrading their capabilities.[31] Here Porter seems to be emphasizing the importance of a living environment appealing enough to attract the intelligent workers the cluster needs. Porter (1998) delivers a rather biting criticism of the overconcentration of business, politics and many other aspects of life in and around Tokyo.[32] Crowding, with its adverse effect on efficiency, is not the only the only thing that bothers Porter about the current situation; his criticism also appears to stem from a worldview that sets great store in the quality of life.

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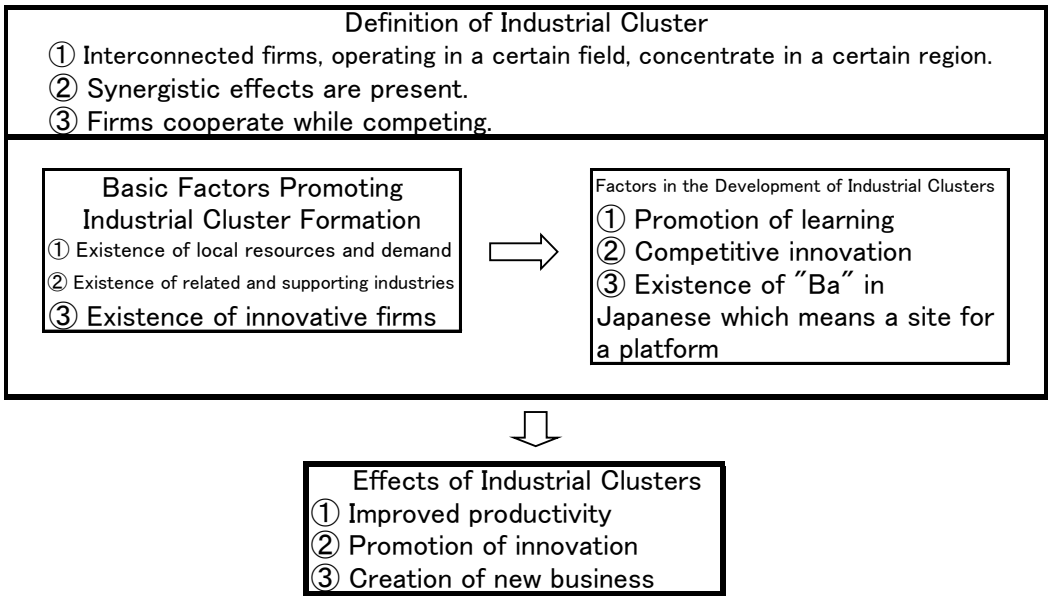
[28] Ibid., p.199.
[29] Ibid., p.202.
[30] Discussion between Porter and Kanai. Kanai (2003), p.49.
[31] Ibid., p.154.
[32] Ibid., pp.235-236.

Japanese business economists also have produced a great deal of research on industrial clusters. Researchers studying the formation and development mechanisms of industrial agglomerations and clusters include Itami (1998) et al, whose work on sustaining mechanisms is discussed in detail in the next chapter, as well as Kanai (2003), Maeda (2003) and others. Drawing on various theories proposed in existing research on industrial agglomerations and clusters and in business economics, Kanai (2003) schematizes the relationship between the variable constituents of an industrial cluster. As basic factors promoting cluster formation, he points to the existence of ① local resources and demand, ② related and supporting industries, and ③ innovative firms in the region. As factors promoting cluster development, he names ① the promotion of learning, ② competitive innovations, and ③ the existence of "*Ba*" in Japanese which means a site for a platform.

Figure 2-2　Relationships between the Variable Constituents of Industrial Clusters, according to Kanai (2003)



Source: Kanai (2003), p.69.

From on-site analyses of eight advanced clusters in Europe and North America, Maeda (2003) recursively extracted factors required for the forming and development of a cluster. He found eight factors necessary to a cluster's *foundation*: ① a specific locality

(travel distance of from one to two hours), ② a specific industry (specialization in one industry), ③ locally obtainable resources, ④ a focus on response (e.g. to economic crises), ⑤ a core firm, ⑥ research and development facilities, ⑦ public institutions, and ⑧ visionaries. As *development* factors, he mentioned: ⑨ contact and interaction among industry, academia and government, ⑩ opportunities to interact (official and non-official occasions), ⑪ local competition, ⑫ venture capital and angel investors, ⑬ business support (taxation and management experts, technology specialists, incubators), ⑭ cross-fertilization with other industries, ⑮ international operations, ⑯ spinoff ventures, ⑰ partnership with large firms, ⑱ IPOs, ⑲ nationwide recognition, and ⑳ a certain standard of living and culture.

These studies, based on wide-ranging theoretical research and numerous on-site analyses, offer many lessons to anyone thinking about cluster formation. They do not, however, include a probing analysis of the time relationships or reciprocal alliances at work between the different factors in the formative stages. In this paper, therefore, I analyze the process by which each formative factor starts to operate, the time relationships between the various formative factors, and the mutually enhancing causal correlations between them. By doing so, I attempt to examine the formative mechanism of high-tech clusters from a more dynamic perspective.

Chapter 3 Constructing a Working Hypothesis for the Formative Mechanism of High-tech Industrial Clusters

In this chapter I shall clarify the information set down by Itami(1998) in *Sustaining Mechanisms of Industrial Agglomerations* (*Sangyo Shuseki ga Keizoku Suru Mekanizumu*), and, on that basis, construct a working hypothesis[33] for the formative mechanism of high-tech industrial clusters.

3.1 Sustaining Mechanisms of Industrial Agglomerations

Itami (1998), working from the perspective of business economics, names two factors necessary for sustainability in industrial agglomerations. The first is that the agglomeration have a continuous inflow of external demand through firms (or groups of firms) having direct contact with external markets ("demand-channeling firms"[34]). The second is that the entire agglomeration maintain flexibility as a specializing integrated group. In other words, it must be capable of responding to constant changes in external demand.

Itami gives three conditions necessary for demand-channeling firms to grow up within an agglomeration: a rich store of technology; ease of starting up in business; and deep involvement in the agglomeration by people in frequent contact with external market information.

For an agglomeration to have sustained flexibility as an integrated group with a division of labor, Itami cites three conditions: a rich store of technology; low inter-business adjustment costs; and ease of starting up in business. For division of labor and agglomeration to take place in a manner which meets the flexibility

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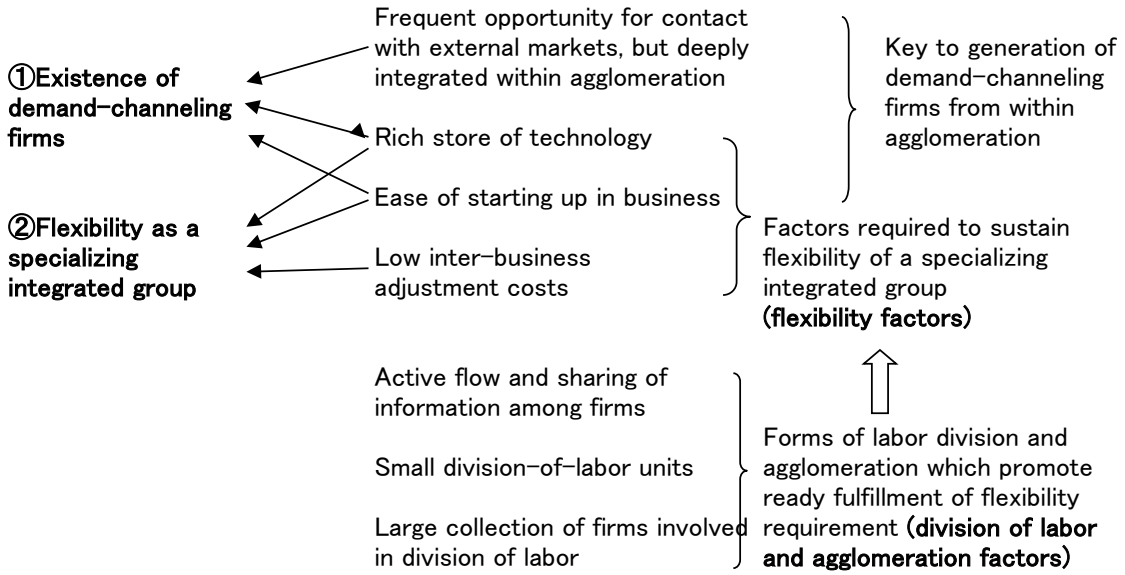
[33] In this paper I use the term "working hypothesis" as defined in the *Kojien*: "A hypothesis, established not with the objective of providing an ultimate explanation for a given phenomenon, but as an effective means of controlling or facilitating research or experimentation currently under way." I do not attempt to offer a uniform theory for the formative mechanism of high-tech industrial clusters. Instead, I assume a case in which a high-tech cluster is formed in a region without an existing industrial agglomeration. To construct a formative mechanism, I call this a "working hypothesis for the formative mechanism for a high-tech industrial cluster."

[34] Takaoka(1998) calls these "linkage firms."

requirement, he names three further conditions ("division of labor and agglomeration factors"): that the units of labor division be small; that the collection of firms involved in the division of labor be large; and that there be an active flow and sharing of information among firms. This mechanism is illustrated in Figure 3-1.

Figure 3-1 The Sustaining Mechanism for Industrial Agglomerations, according to Itami (1998)



Source: Created from Itami (1998)

Industrial agglomerations analyzed for their sustaining mechanisms tend to be those in large cities, such as the cluster of machinery and metal processing SMEs in Tokyo's Ota Ward. Perhaps for that reason, the agglomerations treated in this breakdown are "technological agglomerations" in a relatively static sense; they do not necessarily show a specific relationship between industrial agglomerations and innovation.

In her analysis of the formation and variation mechanisms of industrial agglomerations, Takaoka (1997) treats agglomerations as "transaction systems." By this she means a system in which supply and demand are linked through cross-interactions occurring in every process involving an economic entity: the search for business partners,

negotiations, coordination and so on. More specifically, she uses two qualities to organize the mechanisms peculiar to industrial agglomerations: utility of division of labor within the agglomeration, and linkage between the agglomeration and its markets. She holds that industrial agglomerations take root because of their self-preserving functions: The sustained generation of new companies is self-preserving in quantitative terms, while the accumulation of technology and building of reputation[35] serve self-preservation in the qualitative sense. She cites rising land prices and technological sophistication as among the external variation factors affecting the utility of labor-sharing within the agglomeration (resulting in fewer start-ups), and pursuit of the economics of speed as among those affecting linkage between agglomerations and markets (resulting in further promotion of reputation). As an example of internal variation factors (strategic corporate actions) relating to the utility of labor-sharing within an agglomeration, Takaoka points to the generation of companies within the agglomeration; as one relating to linkage between agglomerations and markets, she cites technological innovation by companies within the agglomeration (resulting in the enhancement of both technology and reputation) (Figure 3-2).

Figure 3-2　Formation and Variation Mechanisms of Industrial Agglomerations, according to Takaoka (1997)

Agglomeration's "genesis": Ease of obtaining labor force, raw materials; national or local government measures to attract production facilities, etc.

↓

Agglomeration's "taking root": Formation of agglomeration's systems → Variation in agglomeration's systems

	[Formation of agglomeration systems]	[Variation of agglomeration systems]	
(Mechanisms peculiar to agglomerations)	Agglomeration's self-preservation	External factors	Internal factors (note 1)
① Utility of division of labor within the agglomeration	Continuing business creation	Fewer start-ups, due to rising land prices, technological sophistication and other factors	Generation of linkage firms within the agglomeration
② Important role of linkage between the agglomeration and the market (linkage firms; note 2)	Accumulation of technology and building of reputation (note 3)	Enhancement of reputation, due to demands for economies of speed and other factors	Acquiring of new orientations due to technological advances within the agglomeration

Source: Takaoka (1997), with additions.

Notes:1) Internal factors in system variation: strategic actions by member firms and linkage firms.
Notes:2) Takaoka (1998) describes the role played by linkage firms in ②.
Notes:3) In Takaoka (1998), the term used is "accumulation of technology to a level befitting reputation."

[35] Takaoka (1998) puts this as "accumulation of technology to a level befitting reputation."

In ①, "utility of division of labor within the agglomeration," Takaoka sees new business creation as the key to an agglomeration's maintenance (self-preservation) in quantitative terms and also as an external factor in the logic of change, taking the existence of a division-of-labor system as a given condition.

In ②, Takaoka examines the role of reputation in the "linkage between the agglomeration and the market," regarding linkage firms as the main players. She views the accumulation of technology as a key factor in creating reputation. Takaoka treats innovation as a factor in changing reputation, although this is not specifically expressed.

Kikkawa (2001) uses five keywords to summarize the theories of Itami(1998), Takaoka(1997) and others on the mechanisms peculiar to industrial agglomerations. Three of these concern mechanisms that work within an agglomeration: ① division of labor, ② technology accumulation, and ③ new business creation; two concern mechanisms that link the interior of an agglomeration with the outside: ① linkage firms, and ② reputation.

Kikkawa summarizes the four keywords mentioned by Itami (1998) in grouping the sustaining mechanisms of industrial agglomerations into three that concern mechanisms working within an agglomeration (division of labor, technology accumulation, and new business creation), and one that concerns mechanisms linking the interior of an agglomeration with the outside (demand-channeling firms).

Of the five keywords mentioned by Takaoka (1997) in discussing the formation and change mechanisms of industrial agglomeration systems, Kikkawa lists three that work within an agglomeration (division of labor, technology accumulation[36], and new business creation), and two that link the interior of an agglomeration with the outside (linkage firms[37] and reputation).

[36] Takaoka herself sees a relationship between technology accumulation and reputation, discussing it in the section on "mechanisms linking the inside and outside of agglomerations."
[37] In discussing the connection between agglomerations and markets, Takaoka (1998) defines firms which perform (demand-supply) linkage functions as "linkage firms."

Figure 3-3 shows industrial agglomeration mechanisms as summarized by Itami (1998) and Takaoka (1997) and their relationship to the summary by Kikkawa (2001).

Figure 3-3 Industrial Agglomeration Mechanisms as Summarized by Itami (1998) and Takaoka (1997) and Their Relationship to the Summary by Kikkawa (2001)

	Kikkawa (2001)		Itami (1998)	Takaoka (1997), Takaoka (1998)
① Mechanisms that work within an agglomeration	"Division of labor"	←	(Flexible) division of labor (agglomeration groups)	(Utility of) division of labor (within agglomeration)
	"Technology accumulation"	←	(Depth of) technology accumulation	Technology accumulatio
	"New business creation"	←	(Ease of) new business creation	(Sustained) new business
② Mechanisms that link the interior of an agglomeration with the outside	"Linkage firms"	←	(Existence of) demand-channeling firms	Linkage of agglomeration and markets (linkage firms link demand and supply)
	"Reputation"	←		(Building of)

Sources: Created from Itami (1998), Takaoka (1997), Takaoka (1998), and Kikkawa (2001).

Although I cite technology accumulation here as an internal mechanism of an agglomeration, I do not treat innovation directly.

3.2 Summarizing the Breakdown Mechanisms of Industrial Agglomerations

I should now like to summarize the mechanisms which contribute to the breakdown of an industrial agglomeration. Of the "lock-in effects" described by Arthur (1994), it is the "negative effect" which has the potential to bring about an agglomeration's decline. The lock-in effect is thought to possess "positive effects" which, during the formation process or other early stage of an agglomeration's existence, work by means of the "economies of agglomeration" to promote the agglomeration's growth by keeping individual companies within the site or attracting new ones to it. Once an agglomeration is formed, however, the lock-in effect can work to impede reform and other necessary change. If member firms become overly attached to certain values, ideas, or methods, they may fail to keep up with innovation. Thus the lock-in effect has its negative aspects as well.

These negative effects may be the flipside to the positive lock-in effects possessed by industrial agglomerations during the formative period. By clinging to past successes, firms in an agglomeration may come to lag behind the general trend of innovation.

According to Yamashita (1998), the economies achieved by industrial agglomeration ultimately amount to those of scale and of scope. While the individual phases of planning and design, trial, and volume production tend to differ in terms of the principal economies they achieve, the overall balance of these two types of economies is established through the mutually limiting relationship of product variation to production scale. This balance allows for an interplay linking the market factors and technological factors to be maintained within an agglomeration. The logic of agglomeration breakdown can be summarized in this way: Product variation may be either too small or too large. In the former case, overdependence on economies of scale during the volume production phase may cause economies of scope to perform inefficiently during the planning and design phases, resulting in further reductions in product variation. In the latter case, the region may not be able to fill all functions required during the trial and volume production phases, resulting in work being sent out of the agglomeration into the surrounding area and impeding the efficient performance of economies of scale during the volume production phase. The latter case can be seen as the transformation of an industrial agglomeration into a commercial agglomeration. In the former case, however, the agglomeration's survival would be in jeopardy should there be, for example, any drastic change in demand for a small variety of products[38].

Common to these two types of logic is a decline in the innovative capacity of the industrial agglomeration as a whole. This refers primarily to a decline in the capacity for making innovative products, but, in Yamashita's two examples, breakdowns during the shift to volume production can be read as declines in process innovation capacity. In this sense, maintaining an industrial agglomeration raises the important question of how one can maintain innovative capacity by using a logic opposite to that which governs an agglomeration's breakdown.

3.3 The Formative Mechanisms of High-tech Industrial Clusters

[38] Yamashita calls a phenomenon of this kind an "unintentional effect."

In this section I use the formative mechanisms of industrial agglomerations examined by Itami, Takaoka, and Kikkawa as starting points in constructing a working hypothesis[39] for the formative mechanisms of high-tech industrial clusters. I have already explained the differences between industrial agglomerations and industrial clusters in Chapter 1. Here, I first consider the sustaining mechanisms of industrial agglomerations composed of firms in high-tech fields. Next I examine the mechanisms by which high-tech industrial agglomerations are formed, assuming the "formative process for high-tech industrial agglomerations" to be the process leading up to the point where the sustaining mechanisms of high-tech industrial agglomerations begin to function. I assume the existence of principal entities which drive the formative process – which prompt, in other words, the initial functioning of the sustaining mechanisms. These are the "activity groups" included in the definition of "industrial cluster" in this paper. In this paper I assume the existence of pressure or encouragement by activity groups (or cooperation or alliances that may occur among local actors as a result) because I believe them to be features of industrial clusters which aid in distinguishing them from industrial agglomerations. It is for this reason that I make high-tech industrial clusters, rather than high-tech industrial agglomerations, the subject of my discussion.

As I have mentioned, I focus here on the formation of high-tech industrial clusters in areas that had no previous agglomerations related to high-tech industry[40], rather than those that developed from existing agglomerations of machinery or similar industries. I do this so that we may think about formative mechanisms under the most easily understood initial conditions. I also wished to grasp the implications of attempts to form high-tech industrial clusters by areas not in possession of a full set of local resources – utilizing, for example, the local resources of a research university.

Innovation is thought to play a greater role in high-tech industrial agglomerations (or

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[39] As I noted earlier, here it is assumed that a high-tech industrial cluster forms in an area having no existing industrial agglomeration. As "high-tech industries," one thinks primarily of IT (or ICT) regarded as typical of the field.

[40] An example of an existing industry related to high-tech industry is machinery, assuming that the high-tech industry aspired to is in the IT field. In some urban areas, it is usual for there to be a certain level of industrial and technological infrastructure. Here, however, such urban areas cannot be considered as agglomerations of "related" industries.

clusters)[41] than in groupings of traditional industries. As I noted earlier, innovation in traditional industries is not treated specifically in the logic of continuation. It appears instead in the logic of breakdown, in the observation that certain factors, such as a negative lock-in effect, can produce a breakdown-inducing decline in the innovative capacity of an industrial agglomeration.

The situation is different for high-tech industrial agglomerations, even setting aside cases in which attempts have been made to attract production functions. Innovation appears to be deeply involved in the very process by which a branch factory (for example) develops into a home base[42] for a certain area, takes root there, and expands its sales and scale of operation. For a high-tech agglomeration, the *logic of formation* and *logic of development* seem closely linked with innovation.

Thus, in constructing a working hypothesis for the formative mechanisms of high-tech clusters, I explicitly introduce innovation as a factor.

As a first step in putting together the hypothesis, prior to discussing the sustaining mechanisms of high-tech industrial agglomerations, I examine the relationship between industrial agglomerations and innovation as it concerns high-tech industry.

3.3.1 Innovation and Its Relationship to Industrial Agglomerations

Kikkawa (2001), while agreeing with Yamasaki (2000) that "research conducted in Japan … has failed to present any framework that provided a profound insight into the relationship between industrial agglomerations and innovation[43]," argues that "the

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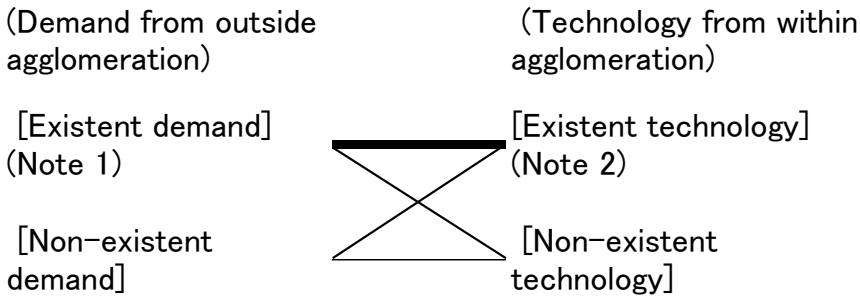
[41] Through 3.3.2 I use the term "industrial agglomerations" in reference to situations classifiable as either an industrial agglomerations or an industrial cluster.

[42] By "home base," I mean a base of operations at which a firm performs the kinds of activities Porter refers to as "home base activities": "those involved in the creation and renewal of the firm's product, processes, and services." (Porter (1998), p.261)

[43] Yamasaki (2000), p.84. In the same book, Yamasaki himself says: "The innovative capability of an industrial agglomeration does not derive from the drawing force of the factories' location, or from cost advantages, as discussed in the study of industrial location. Rather, what drives innovation is the location of talented people to take charge of future technological innovation" (p. 78). He goes on to say: "The factors that enhance innovative potential are found in agglomeration of workers, scientists, and managers capable of promoting innovation, and local organizations and leaders who can efficiently turn these factors into innovation" (p. 85). Vital to

theory presented by Takaoka (1998) on the dynamic mechanisms of industrial agglomerations could serve as a starting point"[44] for creating such a framework." According to this theory, linkage firms promote innovation by uniting existent or non-existent demand (non-manifest demand) and existent or non-existent technology (latent technology) (Figure 3-4).

Figure 3-4 How Linkage Firms Unite Technology and Demand, according to Takaoka (1998)



Source: Created from Takaoka (1998)
Notes:1) Includes demand currently latent due to relations with the agglomeration.
Notes:2) Includes technology currently latent within the agglomeration.
Notes:3) Boldness of line (added by author) indicates frequency of linkage through linkage firms. Linkages of this kind (excluding those of manifest demand and manifest technology) can be seen as a form of innovation.

Compared with other environments, innovation occurs more easily within an agglomeration, resulting in the higher productivity and product differentiation that sustains the agglomeration. I now wish to consider the extent to which such sustaining mechanisms of an agglomeration, including the innovation-stimulating functions of linkage firms, can be seen as factors in this process.

There are a variety of causal correlations among Kikkawa's five keywords regarding the sustaining mechanisms of industrial agglomerations. I shall therefore attempt to clarify which factors promote innovation, not only in the context of "technology

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both industrial agglomerations and innovation are a concentration of corporate workers and scientists, and the right ways of coordinating them.

[44] Kikkawa (2001), p.111

accumulation" and "linkage firms," but in relationship to each of the five keywords.

First, *division of labor*: ① In industrial agglomerations with a developed division of labor system, the range of materials and related services required by the industry concerned is relatively diverse. This can be regarded as favoring the "carrying out (of) new combinations," Schumpeter's term for innovation. This range of choice exists in regard not only to type but also to things such as cost and speed. Information on parts or services suppliers – their technology, behavior, and so on – is readily available. Since all are members of the same community, firms benefit from a containment of opportunistic behavior. (This is also true in relation to the procuring of general intermediate goods.)

Next, *technology accumulation*: ② Industrial agglomerations are home to large stocks of technology and skills involving products, services, manufacturing processes, raw materials, sales routes and other resources. A plentiful supply of existing technology and skills forms the basis for new combinations, and is thus likely to favor innovation. This situation is similar to that described in ①. Another factor favoring innovation is the presence in industrial agglomerations of large numbers of people skilled in such technologies.[45] Needless to say, the development of elemental technologies, for example, requires scientific knowledge or other resources unobtainable by merely combining technologies or skills that already exist. In such cases, industrial agglomerations may not always offer the most favorable environment for development. Viewed from the perspective of the individual firm, there may be problems in getting access to (existing) technologies or skills, as well as in utilizing them. For the agglomeration as a whole, however, the availability of such large volumes of technology and know-how is an undiluted advantage.

Not all aspects of technology accumulation, however, are advantageous at all times. Industrial agglomerations tend to foster the accumulation of technologies that suit the agglomeration's existing reputation, thus favoring innovation that does so as well. Excessive concern over one's existing reputation, however, can produce the negative lock-in effect of penalizing firms whose innovation takes a new or different path. Care

[45] According to Keijiro Otsuka (2005), the spillover of information (imitation) that precedes innovation "is inseparably related to the development of the labor market and the movement of skilled workers which that entails." (pp. 85-86)

should be taken that such firms are not left behind.[46]

Third is *linkage firms*. As noted by Takaoka (1998), these have the function of uniting (external) demand and (internal) technology. Linkage firms have been called the "gatekeepers" uniting demand and supply. By definition, they are key players in linking a cluster's internal entities with those outside. Takaoka (1998) examines the ways in which they join existent or non-existent (non-manifest) demand with existent or non-existent (latent) technology. The creation of non-existent (non-manifest) demand and the drawing out of non-existent (latent) technology are clearly "new combinations," or innovation. In this sense, ③ linkage firms are in the position to perform or promote innovation. Thus, industrial agglomerations with linkage firms have more opportunities to innovate.

Fourth is *reputation*. While much depends on the extent to which an agglomeration can gather demand and attention from the outside, ④ by facilitating the inflow of trial production and diverse types of demand, reputation promotes "innovation through linkage firms." Reputation also encourages person-to-person interchange; this is the source of much information, and increased opportunities for innovation, within an agglomeration.

At the same time, because the flow of demand and information into an agglomeration tends to be consistent with its existing reputation, there is, as I mentioned in discussing technology accumulation, the potential for a negative lock-in effect under which certain types of innovation will be restricted. This, too, is an important issue.

Fifth is *business creation*. With plentiful human resources and both volume and diversity of demand, industrial agglomerations provide a favorable environment for business start-ups. ⑤ Start-up firms tend to occupy niche positions. Compared with large firms, they are adept at dealing with changes in technological paradigms and may even be the instigators of such change. Thus, industrial agglomerations with large numbers of start-ups are more likely to carry out radical or disruptive innovation[47].

[46] This is believed to be one of the reasons why the relationship between industrial agglomerations and innovation can be difficult to understand.

[47] According to Christensen (1997), radical innovation means the most pioneering innovation, representing comparatively important departures from existing technologies, and is antithetical to incremental innovation. Disruptive innovation is antithetical to sustaining innovation; it brings to the market values and standards that differ completely from conventional ones, and

More start-ups will increase the total number of firms in an agglomeration, giving new depth to its division of labor or accumulation of technology. Innovation thus progresses via the logic of *division of labor* and *technology accumulation*.

In addition to these five points, there is another of crucial importance. This is that ⑥ innovation is nurtured by the keen competition that exists within an agglomeration. As Porter emphasized, it is the fierce competition that exists between a cluster's rival firms that makes them more likely (than others located elsewhere) to work seriously at differentiating their products and services and at achieving the innovation required to do so. Porter warned, however, that any cluster is susceptible to the suppression of competition through sweetheart agreements, cartels, or other dubious ties,[48] and that these will suppress innovation as well.

Thus, each of the above is an advantage for innovation to some degree or another. Points ② and ④, however, have the potential to depress innovation by means of the negative lock-in effect if too much is attached to an established reputation. Viewed as a whole, industrial agglomerations offer fundamentally favorable conditions for innovation.

Kanai (2003) says that a "double-loop study" (Argyris and Schön, 1978), as used in organizational theory, is important to preventing this negative lock-in effect.[49] This is opposed to the "single-loop study." Conducted within an existing framework, the single-loop study may, in certain circumstances, encourage a negative lock-in effect and thereby weaken the agglomeration. In contrast, the double-loop study goes beyond existing frameworks to transform conventional values. Bringers of different types of knowledge into an organization (in this case, an industrial agglomeration) play an important role in a double-loop study. In double-loop studies on industrial agglomerations, the greatest attention is paid to the roles played by universities, public

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therefore undermines the competitive advantage of the existing products of promising firms. Firms with proven track records are assumed to apply their resources to sustaining innovation and to excel at incremental innovation as well. To put it another way, we can view new entrants to a market, including start-ups, as being more suited to disruptive or radical innovation.

[48] Porter (1998), p.243.

[49] Kanai(2003), p.63.

research institutions, and individual visionaries[50], rather than affiliated firms in a given field.[51]

3.3.2 Sustaining Mechanisms of High-tech Industrial Agglomerations

Next, I examine the sustaining mechanisms of high-tech industrial agglomerations. Because of the importance of innovation to high-tech-tech agglomerations, I shall make reference to the relationships between agglomerations and innovation we examined above.[52] To the two mechanisms suggested by Itami (1998) – ① the diversity and flexibility of an agglomeration with a cooperative structure, and ② the presence of demand-channeling firms (linkage firms) – I should like to add another: ③ ease of innovation. As I discussed earlier, industrial agglomerations generally present very favorable conditions for innovation, and innovation is regarded as a key factor in the continuance of industrial agglomerations, particularly those of the high-tech variety. We might also add another mechanism – ④ an environment that fosters the creation and growth of start-ups – primarily for its role in enhancing ① and ②. As we saw in 3.3.1, industrial agglomerations provide a comparatively favorable environment for entrepreneurship; an actual increase in the number of new firms gives new depth to an agglomeration's division of labor and increases the likelihood of radical and disruptive innovation. Serving to support all four of these sustaining mechanisms is a fifth, ⑤ promotion of reputation. Places known as industrial agglomerations tend to have relatively established reputations. Reputation helps demand-channeling firms bring in demand, promotes innovation[53], and draws in new firms and entrepreneurs. A summarization of the sustaining mechanisms of high-tech industrial agglomerations,

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[50] In the context of industrial clusters, a "visionary" is a key person in the region or agglomeration, capable of instilling in it a well-conceived vision for its development. Other terms for such a person include "champion" and "first-level influencer." (Leaders who support and carry out the visions of first-level influencers are called "second-level influencers.")

[51] I have focused here on the importance of universities and other local actors in promoting double-loop studies within industrial agglomerations. But for these actors to give of their best, they must have a shared conception of their goals – something the efforts of activity groups can help develop. Thus there is growing appreciation for activity groups and the clusters in which they work.

[52] In summarizing the sustaining mechanisms of high-tech industrial clusters, I draw upon the five keywords proposed by Kikkawa(2001).

[53] I have previously mentioned that over-adherence to existing reputation carries the possibility of suppressing innovation through a negative lock-in effect.

therefore, would look like this[54]:

① Diversity and flexibility of agglomeration with cooperative structure
② Presence of demand-channeling firms
③ Ease of innovation
④ Environment fostering creation and growth of start-ups
⑤ Promotion of reputation

3.3.3 Working Hypothesis for the Formative Mechanisms of High-tech Industrial Clusters

Based on the five sustaining mechanisms summarized above, I shall now look at the formative process of high-tech industrial agglomerations. I regard the process by which these five sustaining mechanisms begin to work as the "formative process." Assuming the presence of the activity groups included in this paper's definition of industrial clusters, the process will advance by means of the efforts of those groups as well as various other factors. In the following, therefore, I speak of the formative process of industrial *clusters* rather than that of industrial *agglomerations*.[55]

In order for the first mechanism – diversity and flexibility of an agglomeration with a cooperative structure – to begin to work, the first and most important requirement is a concentration of a variety of firms in a particular field in a particular geographic area. Leaving aside for a moment the matter of flexibility, the first necessity is a growing agglomeration of firms.

For mechanism two – the presence of demand-channeling firms – to take effect, such firms must begin to emerge within the agglomeration. The "appearance of demand-channeling firms" is thus an appropriate term for the formative process. From

[54] I examined "keen competition within the agglomeration" as a factor favoring innovation in connection with the relationship between high-tech agglomerations and innovation. I did not, however, treat it as a sustaining mechanism of high-tech agglomerations. Since many aspects of it are subsumed within ③, I chose to eliminate it here.

[55] In this paper, the feature that most distinguishes industrial clusters from industrial agglomerations is the presence of activity groups and their influence on the formation (or continuation) of clusters.

this point on, I will refer to demand-channeling firms as "anchor firms[56]." In this report, I use the term "anchor firm" to mean "a firm that brings into an agglomeration a sizeable level of demand originating outside it, and contracts work of some kind from other firms within it." There is little difference, therefore, between this term and "demand-channeling firm." "Anchor" seems preferable in this case because the word, in both its literal and figurative sense, more accurately describes the crucial role of such firms in an industrial cluster and their final position in the (local) value chain. In the following discussions, therefore, I refer to the "emergence of anchor firms" as a factor in the formative process.

To activate the third mechanism – ease of innovation – there must be changes that improve the environment for innovation. This can be regarded as a formative process.

Similarly, the fourth mechanism – an environment fostering the creation and growth of start-ups – calls for improvements in the entrepreneurial environment. This, too, is considered a formative process.

The prerequisite for the fifth mechanism – promotion of reputation – is *establishment* of reputation. This is a formative process.

We should make note of one point in regard to the "flexibility" mentioned in mechanism ①. Of the three requirements for flexibility given by Itami (a rich store of technology, low inter-business adjustment costs, and ease of starting up in business), two are thought to be achievable after the fact: "a rich store of technology" during the process of mechanism ③ (ease of innovation), and "ease of starting up in business," during the process of mechanism ④ (an environment fostering the creation and growth of start-ups). As for the remaining flexibility requirement (low inter-business adjustment costs), although the flow and sharing of information (requirements for division of labor and agglomeration according to Itami) are important to its achievement, I assume that the presence of activity groups and adjustment capabilities, considered prerequisites for industrial clusters in this paper, produce a certain level of exchange and information-sharing among companies and other local actors. Therefore, for ①, I do not specify the process by which flexibility is achieved as a discrete formative process.

[56] These are also referred to as "anchor companies."

The above can be summarized as follows:

Sustaining mechanisms of high-tech industrial clusters		**Formative processes of high-tech industrial clusters**
① Diversity and flexibility of a specializing integrated group	→	① Growth in the agglomeration of firms
② Presence of demand-channeling firms	→	② Emergence of anchor firms
③ Ease of innovation	→	③ Improvement of the environment for innovation
④ Environment fostering creation and growth of start-ups	→	④ Improvement of the entrepreneurial environment
⑤ Promotion of reputation	→	⑤ Establishment of reputation

As we saw in section 3.3.1, "Industrial Agglomerations and Innovation," there are mutually enhancing causal correlations at work among the mechanisms sustaining industrial agglomerations. Similar relationships can be seen among the five formative processes listed above. The advancement of one formative process will boost the advancement of other formative processes.

The mutually enhancing causal correlations among the five formative processes are shown in graphic form in Figure 3-5 (p. 38). Considering the degree of strength of the mutually enhancing causal correlations at work among the various formative processes, the point at which each formative process begins, and the possibility of activity groups influencing the formative processes, I assume that the five formative processes will advance in order of probability. I therefore rearrange the processes in the following order, which is how they appear in Figure 3-5:

I. Improvement of the environment for innovation
II. Growth in the agglomeration of firms
III. Emergence of anchor firms

IV. Improvement of the entrepreneurial environment
V. Establishment of reputation

Among the five formative processes, those in which the influence of activity groups is possible, and in that sense are more or less controllable[57], are I (improvement of the environment for innovation), II (growth in the agglomeration of firms) and IV (improvement of the entrepreneurial environment). Processes III (emergence of anchor firms) and V (establishment of reputation), however, in many ways represent the outcome of other processes, and their advancement is not likely to be promoted in any direct way by activity groups. First, therefore, I look at the mutually enhancing causal correlations between I, II and IV: I → II (improvement of environment for innovation → growth in agglomeration of firms), II → IV (growth in agglomeration of firms → improvement of entrepreneurial environment), and I → IV (improvement of environment for innovation → improvement of entrepreneurial environment). Because these begin to work more strongly, and/or sooner, than causal correlations moving in the opposite direction, I position them between II and IV. V is placed last because it largely represents outcomes of other processes. By placing "promotion of reputation" at the end, I do not mean to suggest that it has little effect in advancing the other processes; instead, I am pointing out it requires more time than the others to move forward – that is, for a certain level of reputation to be achieved.

The mutually enhancing causal correlations between the various formative processes are as indicated in Figure 3-5. Starting with process I, "improvement of the environment for innovation," I would like to add some brief comments.

① *Places with good universities and public research and development institutions are more attractive to high-tech firms.* Areas with high-quality universities and other higher learning institutions and public research bodies (including national research and development projects; same below) produce research and technology professionals who draw the interest of high-tech firms. The result is an upswing in interest in districts possessing these assets.

[57] The "control" referred to here does not mean total control over every aspect of the process, but a certain measure of influence over, or encouragement of, even some aspects. The entities exerting this control are the "activity groups" mentioned in this paper's definition of industrial clusters, composed of specific key organizations or persons from the region.

② *An environment supporting innovation promotes the growth of existing firms, encouraging them to make the district their home base and facilitating the emergence of anchor firms.* The idea behind this causal correlation is that innovation is the most important factor in the growth of firms operating in high-tech industries.

③ *As the presence of universities and public research and development institutions produces more innovative "seed" technologies and workers familiar with them, opportunities for start-ups increase.* The results of work conducted at universities and other institutions of higher learning, public research institutions, and so on serve as "seeds" for path-breaking technological breakthroughs. With more of these institutions, there are more such "seeds" and more opportunity to form the start-up companies that offer one route to their commercialization.

④ *Places with good universities and public research and development institutions enjoy enhanced reputations as research meccas.* When an area can claim more and better research universities and public research institutions in a certain field of industry, it can attain a reputation as a center of research in that field. While this may not lead directly to a reputation as an industrial cluster, it does have an indirect effect.

⑤ *As firms grow in number, they serve as leaders in facilitating innovation.* Although there are many actors that influence the process of innovation in a district, firms naturally play a vital role. We can assume that growth in the agglomeration of firms will provide a favorable environment for innovation.

⑥ *As firms grow in number, the probability of anchor firms emerging increases as well.* This causal correlation, rooted in the theory of probability, derives from the assumption that as the number of firms in a local agglomeration grows, the probability that firms that will grow into anchor firms will grow in proportion.

⑦ *As firms grow in number, the district's industrial ecosystem deepens, increasing the opportunities for new business creation.* Even if the emergence of an anchor firm has no impact on the entrepreneurial environment, an increase in the number and diversity of firms will enrich what Yamasaki (2002) calls the "industrial ecosystem,"[58] thereby

[58] Yamazaki(2002) uses the term "industrial ecosystem" to describe the value chain in an industrial agglomeration, likening it to the food chain in a biological ecosystem (Ibid., p.p.4-5).

increasing the opportunities for business creation.

⑧ *As firms grow in number, the district enjoys a rising reputation as an industrial agglomeration.* This is based on the idea that growth in the number of firms in an agglomeration is fundamental to the establishment of its reputation as an industrial cluster.

⑨ *Anchor firms link demand to technology, facilitating innovation.* This is based on an idea I discussed earlier, that anchor firms (linkage firms) promote innovation by linking demand from outside an agglomeration with technology inside it. But in addition to performing this linkage function, anchor firms themselves possess large stores of technological information and the capacity to carry out important innovations. They thus promote innovation via both routes.

⑩ *As anchor firms emerge, they produce increased business opportunities which attract outside firms to the area.* This correlation is based on the idea that the appearance of anchor firms enriches a district's "industrial ecosystem," causing outside firms to become more interested in locating there as subcontractors. The cause-and-effect relationship is rather weaker here than in ⑪, where the emergence of anchor firms directly increases local opportunities for new business creation.

⑪ *As anchor firms emerge, business opportunities increase, providing more opportunities for the creation of new subcontracting firms.* The logic here is that the emergence of anchor firms enriches the local "industrial ecosystem," enhancing the possibility of new high-tech firms appearing as subcontractors.

⑫ *The reputation of a district benefits when it becomes known as the "home base" of an anchor firm.* Most firms regarded as "anchor firms" are either well-known or growing. Since this fame extends to the place where they are headquartered, the home district also enjoys an enhanced reputation.

⑬ *Improvement of the entrepreneurial environment results in more new firms, thus facilitating radical and disruptive innovation.* High-tech start-ups are well-positioned to carry out innovation, either radical or disruptive; many are founded precisely for that purpose. According to this logic, innovation of these types will flourish in places that support the creation of new business. The strength of the causal correlation depends on

how much of a role start-ups play in innovation as a whole.

⑭ *Improvement of the entrepreneurial environment leads to more new firms and a deepening of the corporate agglomeration.* This can be taken as a matter of course, provided that the number of businesses created is not smaller than the number of those that close down.

⑮ *An improved entrepreneurial environment leads to more new firms, thereby enhancing the district's reputation as a home for rising industries.* The causal correlation here holds that places offering a good environment for new business creation and their resulting outcomes – a suitable environment for starting a business; growing numbers of start-ups actually benefiting from such an environment; the emergence of rapidly-growing, listed firms from the overall number, and so on – can enjoy a growing reputation as centers of rising industry, and, consequently, as high-tech clusters.

⑯ *An established reputation facilitates the inflow of information on markets and technology, thus encouraging innovation.* In certain ways, the establishment of a reputation is itself an outcome of other processes, and therefore occurs after the other processes are to some extent under way. Once something of a reputation has been achieved, however, transactions, inquiries, meetings, academic conferences and so on provide inbound routes for information on the market for the industry involved, as well as for information on related technology. This has the potential to trigger innovation in the region.

⑰ *Districts with an established reputation are more appealing to firms considering location sites.* Once a district achieves a certain reputation, it attracts greater interest from high-tech firms from other regions, including those overseas. By extension, these firms may have more interest in locating in the district. Their interest would include setting up small-scale centers for acquiring technological information.

⑱ *Districts with an established reputation hold more interest for potential supporting businesses.* Once a district achieves a certain reputation, it draws the interest of venture capitalists, business angels, and other individual and corporate experts providing support services to start-up firms. This serves to further improve the entrepreneurial environment.

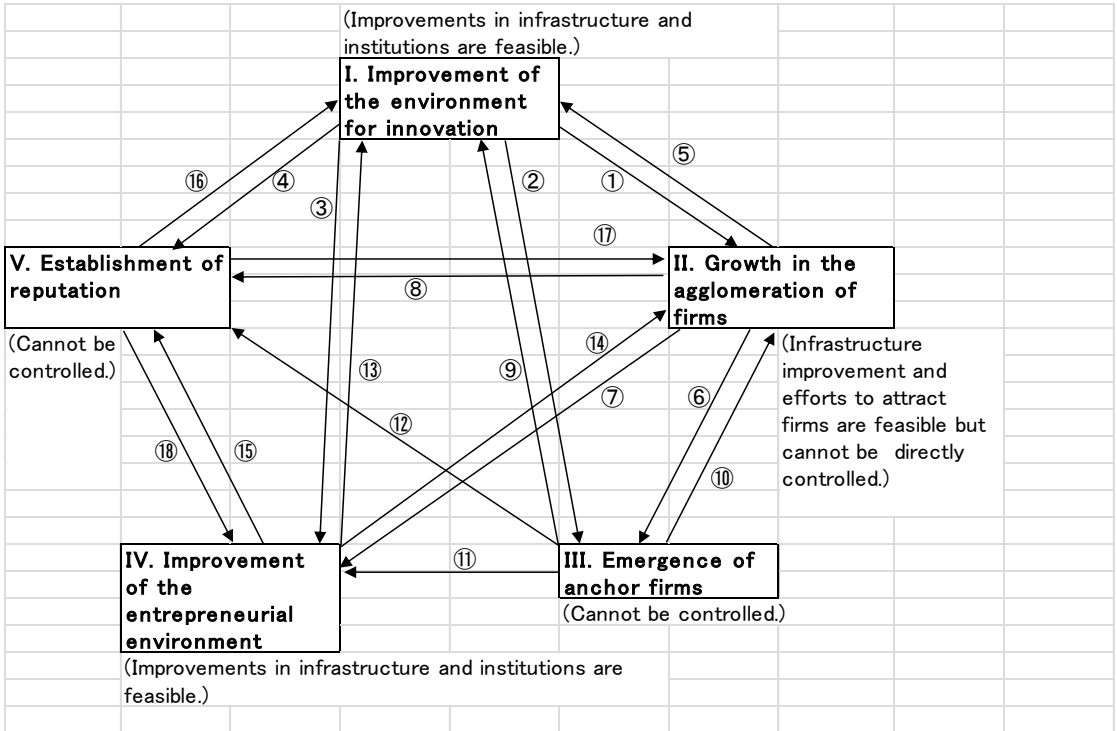
Direct causal correlations for the directions IV → III (improvement of entrepreneurial

environment → emergence of anchor firms) and V → III (establishment of reputation → emergence of anchor firms), are difficult to conceive. Therefore, these are not included in the correlations listed above.

In the initial stages of cluster formation these five formative processes can be expected to advance rather slowly in roughly the above order. Subsequently, through processes I through V, mutually enhancing causal correlations begin to link the various formative processes, giving momentum to the cluster's formation. I therefore break the formative period for industrial clusters into two parts: the *foundation period*, during which there is considerable advancement in the five formative processes and a fairly cohesive agglomeration of firms, and a *development period*, during which mutually enhancing causal correlations go to work among the different formative processes, spurring their progress and enlarging the scale of the corporate agglomeration. In the following discussion I refer to the five formative processes (and the probability of their order of advancement[59]), the mutually enhancing causal correlations among the formative processes, and the entirety of the two periods, the foundation period and the development period, as the working hypothesis for the *formative mechanism of high-tech industrial clusters.*

[59] Probability regarding the order of the five formative processes is assumed mainly for the foundation period. During the development period, the start of mutually enhancing causal correlations among all processes means there is less disparity between the probability of each process's advancement than during the foundation period.

Figure 3-5 The Formative Mechanism of High-tech Industrial Clusters (Five Formative Processes and Their Mutually Enhancing Causal Correlations)



① Places with good universities and public research and development institutions are more attractive to high-tech firms.

② An environment supporting innovation promotes the growth of existing firms, encouraging them to make the district their home base and facilitating the emergence of anchor firms.

③ As the presence of universities and public research and development institutions produces more innovative "seed" technologies and workers familiar with them, opportunities for start-ups increase.

④ Places with good universities and public research and development institutions enjoy good reputations as research meccas.

⑤ As firms grow in number, they serve as leaders in facilitating innovation.

⑥ As firms grow in number, the probability of anchor firms emerging increases as well.

⑦ As firms grow in number, the district's industrial ecosystem deepens, increasing the opportunities for new business creation.

⑧ As firms grow in number, the district enjoys a rising reputation as an industrial agglomeration.

⑨ Anchor firms link demand to technology, facilitating innovation.

⑩ As anchor firms emerge, they produce increased business opportunities which attract outside firms to the area.

⑪ As anchor firms emerge, business opportunities increase, providing more opportunities for the creation of new subcontracting firms.

⑫ The reputation of a district benefits when it becomes known as the "home base" of an anchor firm.

⑬ Improvement of the entrepreneurial environment results in more new firms, thus facilitating radical and disruptive innovation.

⑭ Improvement of the entrepreneurial environment leads to more new firms and a deepening of the corporate agglomeration.

⑮ An improved entrepreneurial environment leads to more new firms, thereby enhancing the district's reputation as a home for rising industries.

⑯ An established reputation facilitates the inflow of information on markets and technology, thus encouraging innovation.

⑰ Districts with an established reputation are more appealing to firms considering location sites.

⑱ Districts with an established reputation hold more interest for potential supporting businesses.

Note: For processes IV→III (improvement of the entrepreneurial environment → emergence of anchor firms) and V → III (establishment of reputation → emergence of anchor firms), direct causal correlations are difficult to conceive and therefore are not included in the above.

3.4 Verifying the Working Hypothesis: Selection of a Region for Analysis

In the next chapter I attempt to verify my working hypothesis for the formative mechanisms of existing high-tech industrial clusters by examining the formation of the ICT cluster in Oulu, Finland. Oulu is northern Finland's principal urban center, and, while it has a relatively developed industrial base, its long history revolves around politics, commerce and trade rather than industry. The industries that existed until the 1950's – paper and pulp, chemical fertilizers, leather goods and others – were not the sort that form the groundwork for IT industries. But the opening of the University of Oulu, and especially its electrical engineering department, proved the springboard for gradual but sustained efforts by activity groups interested in forming a high-tech industrial cluster. Ultimately they succeeded in creating one of the leading ICT clusters in northern Europe.

There were three reasons for choosing Oulu as my subject for analysis. The first was that before the formation of its ICT cluster, Oulu was not a center of the kind of industry – machinery, for example – on which ICT industries are normally based. In other words, it presented initial conditions that would be comparatively easy to understand when analyzing the formative processes of industrial clusters. The second reason was that Oulu clearly had "activity groups interested in forming a high-tech industrial cluster," the presence of which is part of this paper's definition of industrial clusters. The third reason was that the level of labor mobility, and the possibility of interregional shifting of corporate headquarters and other facilities, was relatively low in Finland.[60] Oulu, therefore, was an appropriate case study for anyone wishing to analyze the processes and mechanisms involved in the formatting of a high-tech cluster under the most easily understandable conditions.

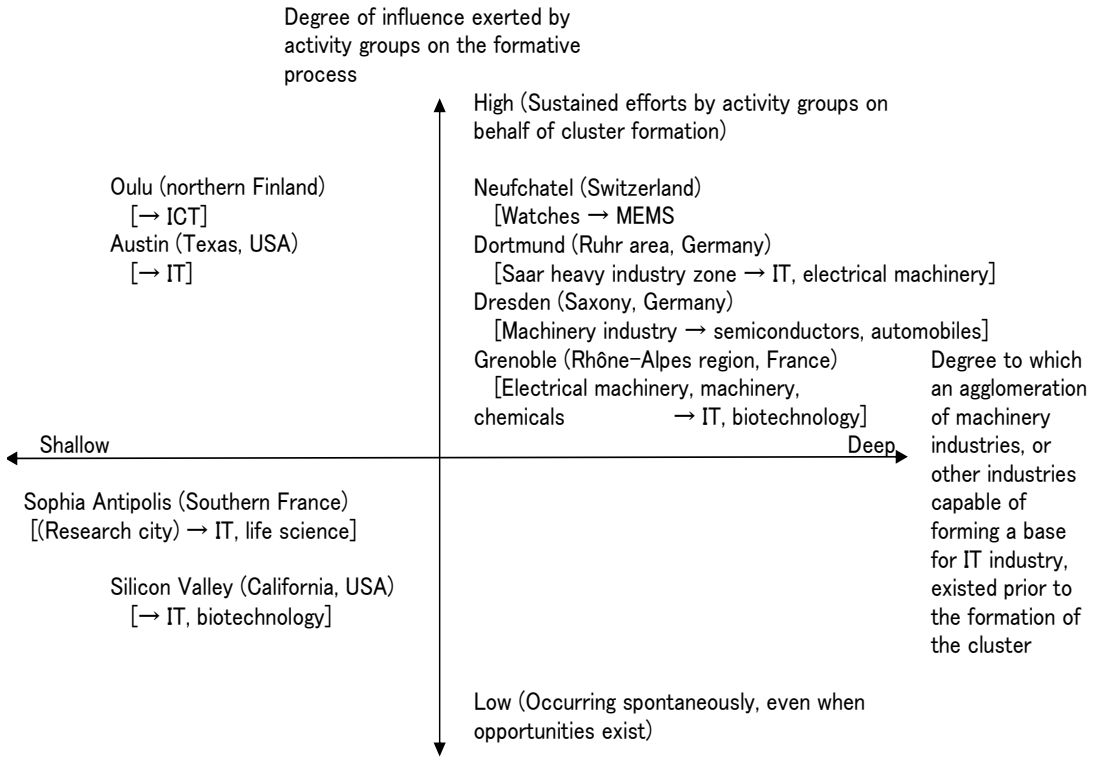
In Figure 3-6, major IT clusters in Europe and North America are organized according to two considerations: on the horizontal axis, the degree to which there existed, prior to the formation of the cluster, an industrial agglomeration of the kind capable of forming a base for IT industry; on the vertical axis, the degree of influence exerted by activity groups on the formative process. Oulu is the only one of these IT clusters which satisfies the three conditions set down in the paragraph above.

Oulu is a northern city even by Finnish standards, and though it is the capital of its

[60] The comparison here is with the United States.

region of Northern Ostrobothnia, it can hardly be called an urban center in global terms. Another matter of interest, therefore, is how a city and region of this sort managed to build an ICT cluster and acquire, within the global economy, an industrial and technological centrality as a mecca of mobile communications technology.

Figure 3-6 Classification of IT Clusters in Europe and North America



Chapter 4 Development of the Oulu ICT Cluster and Verification of the Working Hypothesis

In this chapter I examine the background to the Oulu ICT cluster and broadly trace its development over time. Keeping in mind the five formative processes discussed in Chapter 3, I focus on the efforts of principal regional actors to promote each process and the degree to which the processes moved forward as a result. Finally I verify my working hypothesis on the formative mechanism of high-tech industrial clusters, focusing on the five formative processes, causal correlations at work among the formative processes, and classification of the periods of foundation and development.

4.1 Oulu Before Development

Oulu's path toward development as an ICT cluster began in earnest with the founding in 1958 of the University of Oulu. Before examining that event, let us quickly survey the major industries that existed prior to that time.[61]

① The Founding of Oulu

Oulu was founded in 1605 by King Carl IX of Sweden. Facing the Gulf of Bothnia and the Oulu River delta, it had long been a center of regional trade, and at the time of its founding was the principal city of northern Finland. Its location at 65°01' north latitude places it less than 200 km from the Arctic Circle (66°33'). Oulu[62] is a Finnish word, but at the time of the city's founding all of Finland was under the rule of the Swedes,[63] who called it Ureaborg. But whatever its name, its wealth of resources earned it a reputation as "Stockholm's storehouse." Its economy was supported by a thriving export trade, most notably of salmon and other foodstuffs. A salmon features prominently on Oulu's

[61] Descriptions of historical facts in section 4.1 are based on material from the Oulu website (http://www.oulu.ouka.fi/) and Wikipedia homepage (http://en.wikipedia.org/wiki/Oulu).

[62] In the Sami language, used in the northernmost areas of Finland, Sweden, and Norway and in Russia's Kola Peninsula, "Oulu" is rooted in the word for "flood." Located in the Oulu River delta, the town is said to have been a center of trade for many centuries. (Based on material from the Oulu website: http://www.ouka.fi/city/english)

[63] Finns have lived permanently in Finland since about the 1st century. With the establishment of the border between Sweden and Russia in 1323, Finland became part of Sweden. In 1809, Sweden ceded Finland to Russia, putting it under Czarist rule as an autonomous grand duchy. Finland finally gained its independence in 1917 in the aftermath of World War I and the Russian Revolution. The Republic of Finland was established in 1919.

coat of arms.

② Tar Exports and International Trade

The forests surrounding Oulu provided it with abundant lumber, the raw material for tar. Tar was one of Oulu's chief exports from the 17th through the 19th century, as it was used to coat the wooden ships produced at the time. It was such an important source of foreign capital that it became known as the "black gold of the North."

In the plaza outside the Oulu city hall stands a superbly decorated lamppost, given in 1886 to the Oulu Tar Makers' Association by the Glasgow Chamber of Commerce and Industry in appreciation of Oulu's longstanding tar exports to the city.[64] The advent of steel ships brought an end to the tar trade in the early years of the twentieth century.

The eighteenth and nineteenth centuries, however, were a time of expanding maritime transport. Scheduled trade with Stockholm and Central Europe was thriving, firmly establishing Oulu as a center of trade and an international city.

③ The Industrial Revolution and the Flourishing of the Lumber Industry

The Industrial Revolution began in Britain in the late eighteenth century, and by the start of the nineteenth century its effects were being felt in northern Finland. That was when automotive vehicles came into general use, and the lumber industry, reaping the benefits, began to flourish. Lumber exports continued until about 1930, after which they gradually fell off. However, products made from the region's abundant lumber resources are important exports even today.

④ The First Industrial Miracle: Tanneries

In 1863, Karl Robert Åström opened a tannery which proceeded to develop into Oulu's first "industrial miracle" (the second being the ICT cluster). The firm achieved enormous success exporting harnesses, straps and other leather goods to Imperial Russia, Northern Europe and the Baltic countries.[65] Åström's company, called Weljekset Åström Oy in Finnish, was located need the city center. It was one of Oulu's largest export factories for over a century before finally closing its doors in 1974. In its place now stands one of Finland's three National Science Centers, with exhibits designed for children and the general public.

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[64] Interview with Seppo Mäki.

[65] Mika Kulju (2002), pp. 24-25.

⑤ The Appearance of Pulp and Paper Mills and Chemical Fertilizer Plants

In the 1930s, when Finland had been independent from Russia for over a decade, the opening of Oulu's first paper and pulp mills signaled the birth of the city's first major industry of the twentieth century. The British paper manufacturer Peter Dixon & Son Ltd. opened the paper and pulp mill Toppila Oy in 1931 in the city's Toppila district; the Nokia affiliate Oulu Oy started another in 1937 in the Nuottasaari district.[66] While the former closed in 1980[67], the latter remains in operation today as a plant of the major papermaking group Stora Enso Oy, turning out glossy paper and other high-quality paper goods.

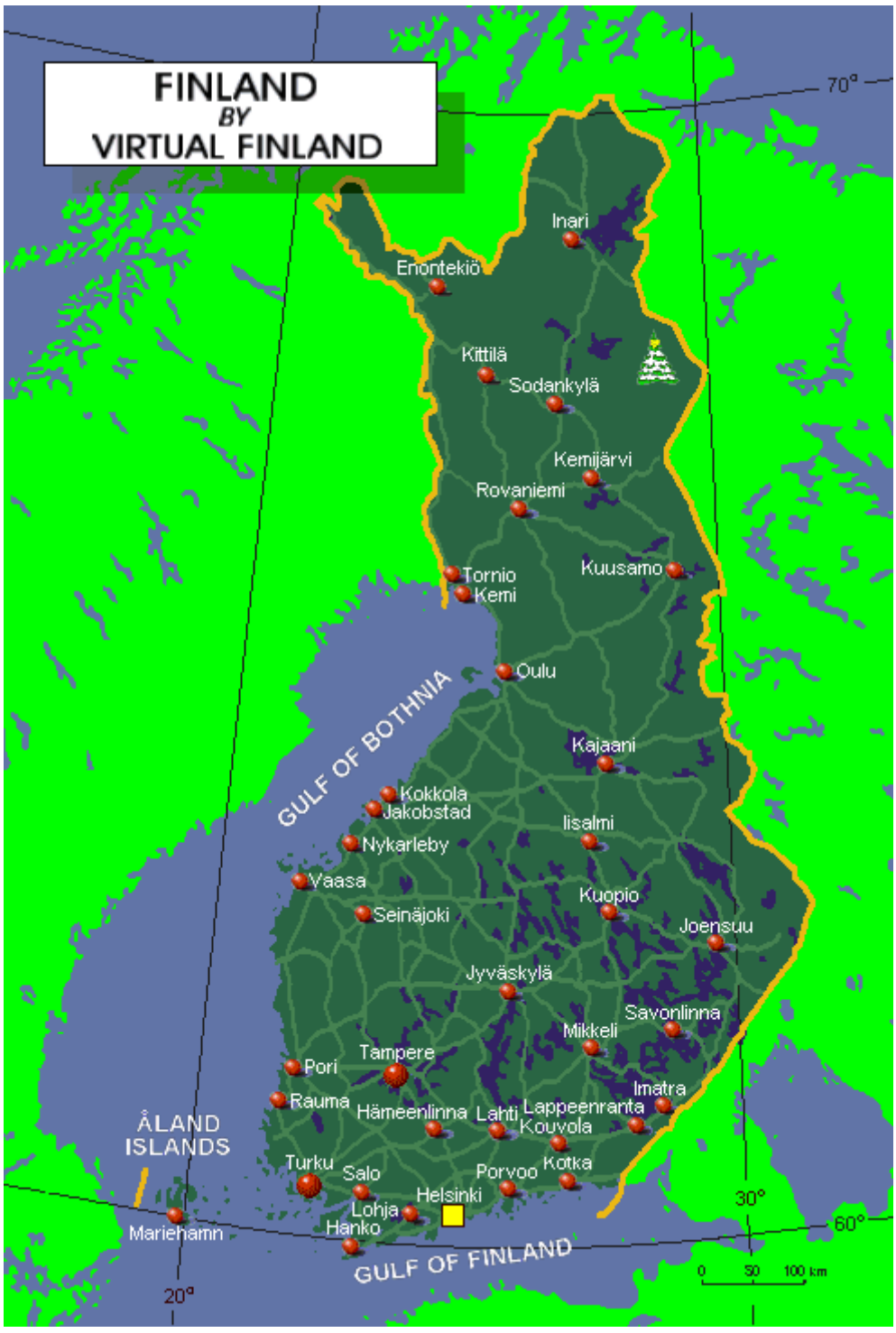
In the 1950s, a time of postwar reconstruction, Typpi Oy opened a chemical fertilizer plant in Oulu's Laalina district.[68] The plant is run today by Kemira Chemicals Oy and manufactures formic acid (used as a synthetic raw material in the production of organic chemicals and in leather tanning) and hydrogen peroxide (for bleaching agents and disinfectants), among other products.

⑥ Construction of Electric Cable Plants

In the 1960s, two firms constructed electric cable plants in Oulu: Northern Cable (Pohjolan Kaapeli Oy), a member of the Nokia group, and Tim Vilmin Kaapeli.[69] The former was a prelude to the transfer by Nokia of its entire wireless telephone division from the Helsinki region, in southern Finland, to Oulu. This plant later broke off from the Nokia group to become the nucleus of PKC Group Oy, a commissioned assembler of wire harness and electronic devices which in 1997 became the Oulu region's first listed company.

[66] Mika Kulju (2002), p. 24.
[67] Interview with Seppo Mäki.
[68] Mika Kulju (2002), p. 26.
[69] Mika Kulju (2002), p. 27.

Figure 4-1 Map of Finland



Source: *Virtual Finland* website.
(http://virtual.finland.fi/netcomm/news/showarticle.asp?intNWSAID=27068

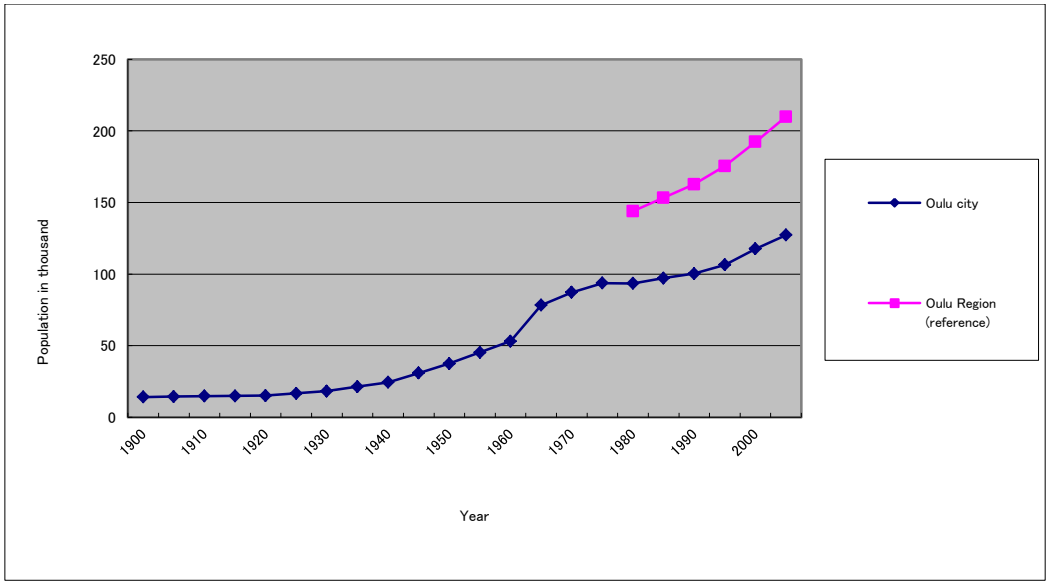
4.2 Summary of the Development of Oulu and the Oulu Region

In the following I summarize the development of the Oulu metropolitan area and the Oulu ICT cluster, based on changes in population and the number of employed in various industries in the city of Oulu and the Oulu region as a whole.

① Population Trends in Oulu City

Figure 4-2 shows long-term changes in the population of the city of Oulu. The city's population stayed relatively stable, at about 15,000, from the turn of the twentieth century until about 1920. Tar exports had already ended, and the city's commercial life centered on comparatively small-scale trade in lumber products and tanneries.

Figure 4-2 Long-term Population Changes in the City of Oulu



Data for Figure 4-2

Year	1900	1910	1920	1930	1940	1950	1960	1965
Population	14,174	14,777	15,119	18,287	24,398	37,449	53,080	78,270
Year	1970	1975	1980	1985	1990	1995	2000	2005
Population	87,244	93,707	93,454	97,200	100,350	106,448	117,670	127,213
Oulu region population (reference)			143,888	153,265	162,644	175,466	192,263	209,908

Note: The Oulu region includes, in addition to the city of Oulu, the following ten municipalities: Hailuoto, Haukipudas, Kempele, Kiiminki, Liminka, Lumijoki, Muhos, Oulunsalo, Tyrnava, and Ylikiiminki.
Sources: Yearly editions of the Oulu City Statistical Yearbook (Oulun kaupungin tilastollinen vuosi-kirja); Statistics Finland.

From 1930 to 1950, a period encompassing World War II, the population increased from

18,000 to 37,000; continued growth was seen in 1960 (53,000) and 1970 (87,000). The increase in population during these years seems related to the dramatic rise of the paper and pulp industry in the 1930s and the development of chemical fertilizer and electric cable production in the 1950s and 1960s respectively. Growth was particularly striking in the five years from 1960 to 1965, when the population rose 47.5% from 25,000 to 78,000. The large number of new factories in operation, coupled with the opening in 1958 of the University of Oulu, clearly set the stage for rapid population growth.

This trend ended abruptly, however, when the population actually fell, from 93,707 to 93,454, over the five-year period from 1975 to 1980. Growth picked up again, although gradually at first: The population reached the 100,000 mark in 1990 and has continued growing at a quickening pace, to 106,000 in 1995, 117,000 in 2000, and 127,000[70] in 2005. Contributing factors included, in the late 1970s, declining employment in what had been until then the leading manufacturing industries, and, in the 1990s, the region's growing ICT cluster. I would like to examine these trends in light of changes in the numbers of people employed in different industries.

② Number of People Employed in the City of Oulu, by Industry

Figure 4-3 shows the number of people employed in various industries in the City of Oulu since 1975. From 1975 to 1980 there was almost no change, the number holding steady at approximately 43,000. The number of manufacturing workers fell by 12,000, but declines were greater in construction (down 18,000) and in wholesaling, retailing, hotels, and restaurants (down 13,000). In the field of community, social, and welfare services, however, employment grew by 28,000. It is unclear just why these changes took place, but the big decline in manufacturing employment[71] may have produced a spillover effect responsible for at least some of the declines seen in other industries. The employment situation also played a role in the drop in the city of Oulu's population during this period.

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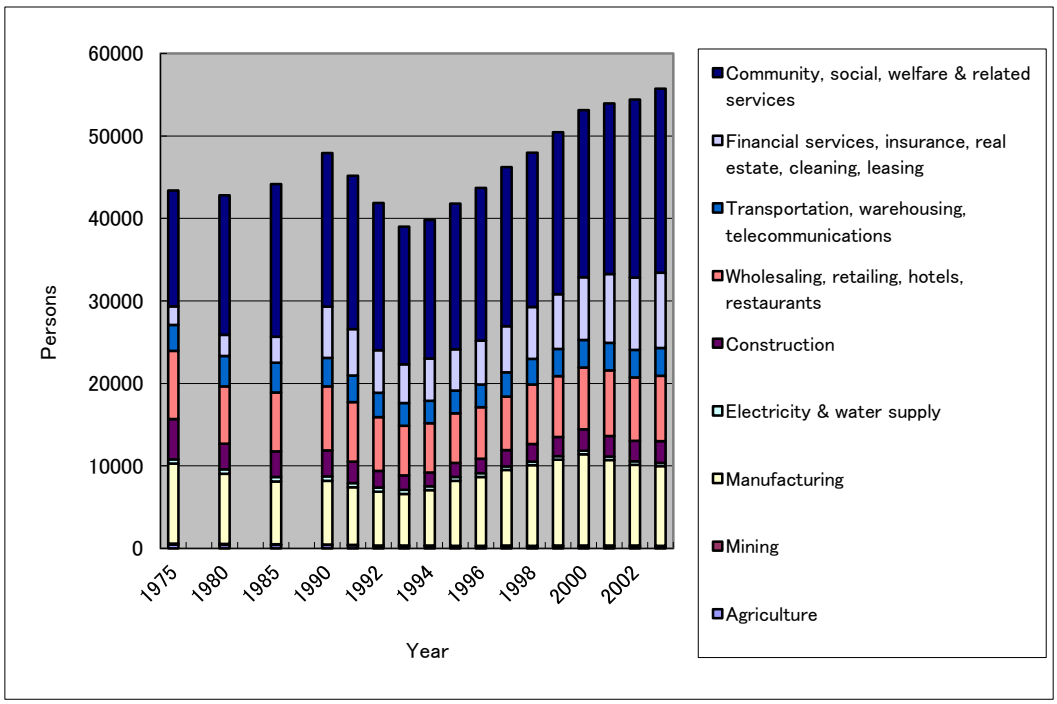
[70] With 128,000 people, Oulu is Finland's sixth most populous city after Helsinki (562,000), Espoo (232,000), Tampere (204,000), Vantaa (188,000), and Turku (174,000). (Helsinki, Espoo, and Vantaa fall within the Helsinki metropolitan area. Population figures are as of June 2006.)

[71] Parvo Simila, former director of the Economics Division of the Oulu City Government, said in an interview that the downturn in employment, particularly in manufacturing, that took place in the late 1970s created a sense of crisis within the city government that "something had to be done."

During the decade of the 1980s, the total working population grew by more than 5,000 to slightly less than 48,000; much of the growth derived from an increase of 3,657 in the fields of finance and real estate (including financial services, insurance, real estate, cleaning, and leasing). Employment also grew in community, social, and welfare services (up 1,721) and wholesaling, retailing, hotels, and restaurants (up 834). Notably, however, employment in the manufacturing industry fell throughout the 1980s, from 8,486 at the start of the decade to 7,728 at its close, a decline of 758 people. Although construction of the Oulu ICT cluster began during this period, it did not create enough new jobs to make up for those lost in the manufacturing industry.

Figure 4-3 Changes in Oulu City Employment, by Industry



Data for Figure 4-3

	1975	1980	1985	1990	1991	1992	1993	1994
1.Agriculture	467	434	419	409	370	317	297	298
2.Mining	96	109	65	36	42	37	33	44
3.Manufacturing	9,712	8,486	7,635	7,728	6,986	6,512	6,275	6,720
4.Electricity & water supply	512	571	517	545	527	500	498	467
5.Construction	4,888	3,095	3,138	3,146	2,600	2,031	1,751	1,667
6.Wholesaling, retailing, hotels, restaurants	8,255	6,936	7,108	7,770	7,215	6,528	6,012	5,959
7.Transportation, warehousing, telecommunications	3,162	3,691	3,631	3,437	3,207	2,919	2,760	2,747
8.Financial services, insurance, real estate, cleaning, leasing	2,238	2,569	3,146	6,226	5,635	5,190	4,695	5,091
9.Community, social, welfare & related services	14,070	16,902	18,519	18,623	18,593	17,833	16,693	16,820
Total	43,400	42,793	44,178	47,920	45,175	41,867	39,014	39,813

	1995	1996	1997	1998	1999	2000	2001	2002	2003*
1.	274	254	262	243	272	268	267	260	229
2.	46	60	62	65	66	68	75	78	82
3.	7,874	8,354	9,184	9,775	10,425	11,086	10,378	9,805	9,650
4.	452	439	418	433	427	405	415	396	388
5.	1,708	1,774	2,000	2,132	2,319	2,600	2,502	2,485	2,643
6.	6,032	6,227	6,480	7,210	7,358	7,513	7,921	7,683	7,933
7.	2,750	2,775	2,951	3,105	3,297	3,313	3,346	3,349	3,382
8.	4,986	5,288	5,574	6,299	6,655	7,610	8,372	8,774	9,097
9.	17,690	18,515	19,299	18,717	19,648	20,265	20,666	21,585	22,340
Total	41,812	43,686	46,230	47,979	50,467	53,128	53,942	54,415	55,744

Source: Statistics Finland

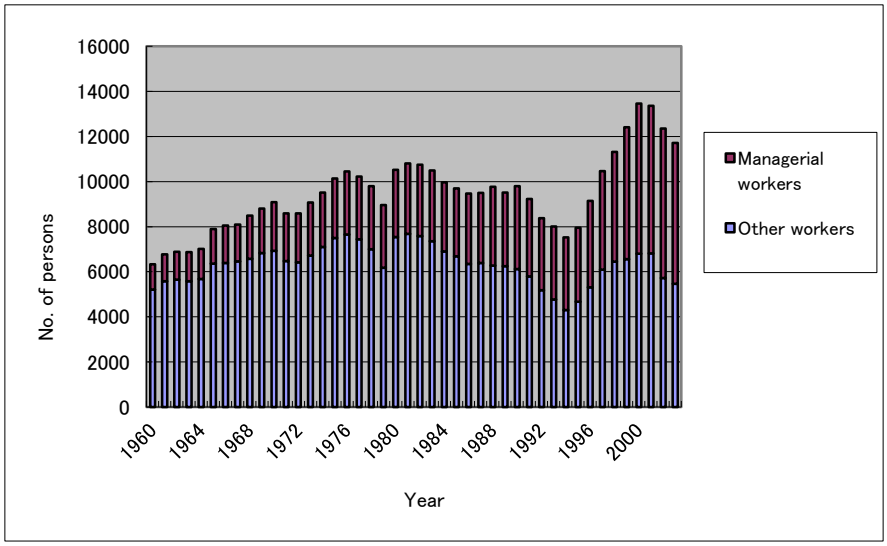
Notes: 1. Provisional figures

Notes: 2. Data for 1975, 1980 and 1985 are from Standard Industrial Classification 1988 (TOL 88).
Data for 1990 and afterward are from Standard Industrial Classification 2002 (TOL 2002).

The breakup of the Soviet Union cut sharply into Finland's exports during the period from 1990 through 1993, throwing the nation's entire economy into a deep slump and causing employment in Oulu to fall across the board, from 48,000 to 39,000. This was followed by a period of dramatic growth through 2000 (to about 53,000); employment continued to grow through 2003 (to about 56,000). During the ten years starting in 1993, employment gains were seen in community, social, and welfare services (up 5,647), financial services, insurance, real estate, cleaning, and leasing (up 4,402), and manufacturing (up 3,375). To a great extent, growth in manufacturing – particularly in the high-tech sector – is believed to have been the economy's driving force throughout this period. The real increase was largely achieved in third-sector industries including corporate services.

Figure 4-4 analyzes the number of workers in the manufacturing industry according to two groups: those in the managerial class (directors, managers, researchers and so on), and other workers. Employment has grown steadily in the managerial class.

Figure 4-4 Numbers of Employed in Oulu Manufacturing Industry (Managerial Workers; Other Workers)



Data for Figure 4-4 Unit: No. of pers

Year	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
Managerial worker	1,131	1,183	1,228	1,295	1,330	1,529	1,661	1,628	1,914	1,963	2,152	2,108	2,168	2,360	2,402
Other workers	5,207	5,583	5,659	5,583	5,678	6,360	6,392	6,459	6,576	6,834	6,930	6,477	6,416	6,714	7,105
Total	6,338	6,766	6,887	6,878	7,008	7,889	8,053	8,087	8,490	8,797	9,082	8,585	8,584	9,074	9,507

Year	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Managerial worker	2,638	2,793	2,777	2,796	2,786	2,976	3,116	3,170	3,140	3,072	3,000	3,127	3,112	3,484	3,259
Other workers	7,497	7,655	7,447	6,999	6,178	7,541	7,688	7,578	7,357	6,898	6,690	6,342	6,386	6,279	6,248
Total	10,135	10,448	10,224	9,795	8,964	10,517	10,804	10,748	10,497	9,970	9,690	9,469	9,498	9,763	9,507

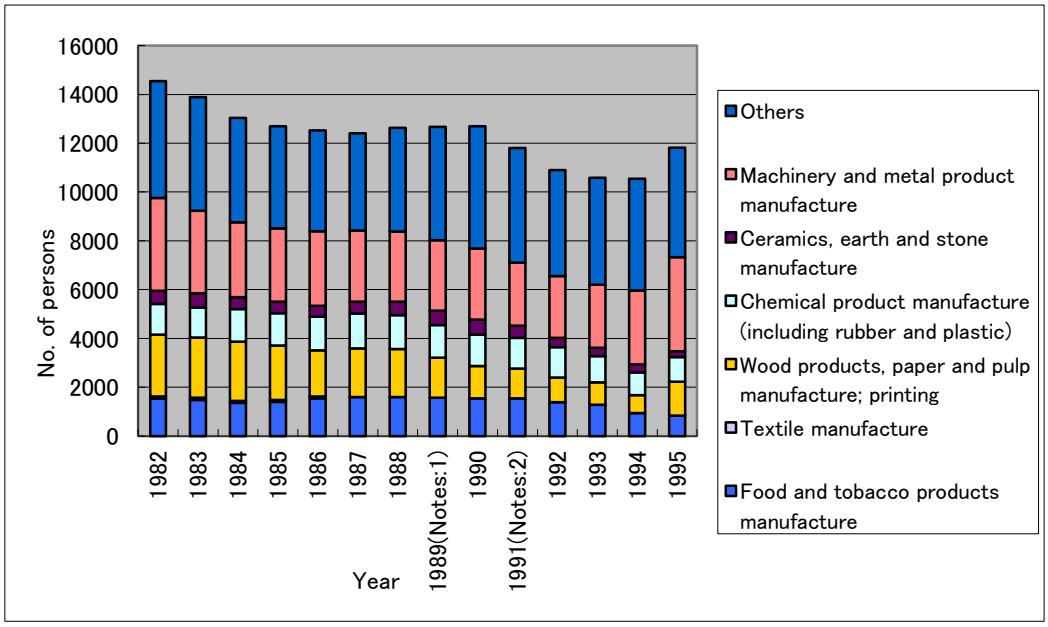
Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Managerial worker	3,681	3,433	3,182	3,234	3,218	3,277	3,827	4,379	4,879	5,839	6,656	6,547	6,626	6,245
Other workers	6,115	5,793	5,188	4,770	4,303	4,678	5,315	6,089	6,440	6,567	6,800	6,814	5,725	5,465
Total	9,796	9,226	8,370	8,004	7,521	7,955	9,142	10,468	11,319	12,406	13,456	13,361	12,351	11,710

Sources: *Oulu City Statistical Yearbook*, Oulu City Economic Bureau

Employment growth was especially rapid from 1995 through 2000, the number of employed rising by a yearly average of 15.2% from 3,277 to 6,656 persons. While the pace slowed somewhat from 2000 through 2003 (6,245), it remained over 6,000. The dramatic rise in managerial-class employment appears to have owed a lot to an increase in researchers and technicians. The number of "other workers," meanwhile, having bottomed in 1994 at 4,303, rose to 6,814 in 2001; this still fell below the levels achieved during the peak years of 1976 (7,655) and 1981 (7,688). The number increased substantially, however, in 2003, to 5,465. The robustness of the research and development and technology sectors of Oulu's manufacturing industry is evident from this analysis.

Figure 4-5 analyzes employment in Oulu's manufacturing sector from 1982 to 1995 according to type of business. (Data were unobtainable in some instances.) The early 1980s saw a drop in employment, chiefly in the fields of machinery and metal products, wood products, paper, and pulp, and printing. The overall trend stabilized later in the decade, although the decline continued in the hundreds in the wood products, paper and pulp, and printing industries. Employment in the machinery and metal products industry was generally stable throughout this period but failed to show an increase. Declines were seen in virtually every field from 1991 to 1994, resulting in an aggregate loss of over 2,000 jobs. Machinery and metal products was the only industry that posted gains, which were particularly dramatic from 1994 to 1995 (27.7%).

Figure 4-5 Industry-specific Employment in the Oulu Manufacturing Sector



Data for Figure 4-5

	Food and tobacco products manufacture	Textile manufacture	Wood products, paper and pulp manufacture; printing	Chemical product manufacture (including rubber and plastic)	Ceramics, earth and stone manufacture	Machinery and metal product manufacture	Other	Total
1982	1,539	89	2,527	1,266	530	3,802	4,797	10,748
1983	1,484	92	2,457	1,243	569	3,390	4,652	10,497
1984	1,360	81	2,425	1,341	483	3,067	4,280	9,970
1985	1,405	81	2,224	1,321	470	3,009	4,189	9,690
1986	1,547	75	1,893	1,376	450	3,058	4,128	9,469
1987	1,605	0	1,992	1,428	488	2,903	3,985	9,498
1988	1,596	0	1,965	1,396	548	2,873	4,258	9,763
1989(Notes1)	1,569	0	1,648	1,338	586	2,889	4,640	9,780
1990	1,542	0	1,330	1,279	624	2,905	5,021	9,796
1991(Notes2)	1,549	0	1,213	1,260	504	2,583	4,700	9,226
1992	1,391	0	1,014	1,241	378	2,530	4,346	8,370
1993	1,290	0	918	1,074	341	2,579	4,381	8,004
1994	939	0	733	941	327	3,024	4,581	7,521
1995	835	9	1,382	1,017	232	3,862	4,480	7,955

Notes: 1. As data for 1989 were unavailable, averages of the 1988 and 1990 figures were used for the purpose of this chart.
Note2. As there were no clear data available for chemical product manufacture for 1991, an average of the 1990 and 1992 figures was used for the purpose of this chart.

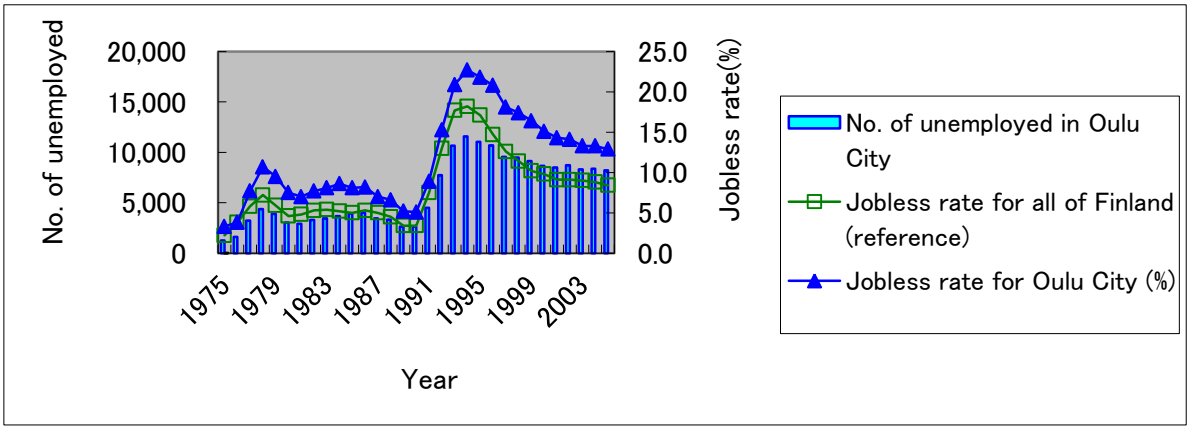
Source: *Oulu City Statistical Yearbook*.

③ Numbers of Unemployed in Oulu City

As shown in Figure 4-6, the number of Oulu's unemployed increased throughout the late 1970s, the jobless rate reaching a peak of 10.7% in 1978. Job declines in the manufacturing and construction sectors are thought to have been behind the trend. The 1980s brought an initial period of stabilization followed by a steep ascent beginning in 1991, the year of the collapse of the Soviet Union. The jobless rate climbed to a high of 22.7% in 1994. Although the development of the ICT cluster helped to usher in a period of overall improvement, since the 1990s both the numbers of unemployed and the jobless rate have been markedly higher than they were during the 1980s. Comparatively high levels of unemployment affected not only Oulu, but Finland as a whole, during these years. (See Figure 4-6. Oulu's rates were 2% to 5% higher than the average for Finland.) High unemployment casts a troubling shadow on the Finnish economy, which since the mid-1990s has been notable for the success of its high-tech industries and high growth rates of real GDP.[72]

[72] During the period from 1994 to 2000, Finland's real GDP growth rate ranged between 3% and 6% - one of the highest rates in Europe. Thanks to the development of the ICT cluster, per capita real GDP for the Oulu region surpassed that of Finland as a whole by 15.8%. (See Figure 4-12.)

Figure 4-6 Trends in the Number of Unemployed and the Jobless Rate in Oulu City



(Data for Figure 4-6)

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
No. of unemployed in Oulu City	1,251	1,602	3,235	4,354	3,877	3,037	2,909	3,298	3,461	3,662	3,926	4,008	3,442	3,334	2,617	2,621
Jobless rate for Oulu City (%)	3.3	3.8	7.7	10.7	9.5	7.5	7	7.7	8.1	8.6	8.1	8.2	7	6.6	5.2	5.1
Jobless rate for Finland (reference)	2.2	3.8	5.8	7.2	5.9	4.6	4.8	5.3	5.4	5.2	5.0	5.3	5.0	4.5	3.4	3.4

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
No. of unemployed in Oulu City	4,484	7,730	10,666	11,581	11,039	10,678	9,554	9,474	9,146	8,669	8,512	8,711	8,316	8,375	8,208
Jobless rate for Oulu City (%)	8.9	15.3	20.9	22.7	21.8	20.8	18.1	17.4	16.4	15.1	14.3	14.1	13.3	13.3	12.9
Jobless rate for Finland (reference)	7.5	13.0	17.7	18.2	17.1	14.7	12.6	11.4	10.2	9.8	9.1	9.1	9.0	8.8	8.4

Source: *Oulu City Statistical Yearbook*, Oulu City Economic Bureau, *Statistics Finland*.

There are several reasons why the city of Oulu has a high unemployment rate compared with the rate for Finland as a whole. For one thing, the nationwide figure is strongly affected by the situation in populous southern Finland, which includes the capital Helsinki and its environs. Figures for regions not in the South are worse – that is, higher – than that for Finland as a whole. Another factor is the greater proportion of young people in Oulu City's population.[73] Since higher rates of joblessness are associated with younger demographics[74], the city's relative youth pushes up its jobless rate proportionately. As one more reason, we can cite the ongoing influx into Oulu of people from other municipalities, mainly in northern Finland, from the mid-1990s onwards.[75] These new arrivals, who have spurred the development of the ICT cluster,

[73] People between the ages of 15 and 24 accounted for 17.0% of Oulu City's population, 4.5 percentage points higher than the figure for Finland as a whole (12.5%).

[74] In 2004, the jobless rate for young Finns (between the ages of 15 and 24) was 20.8%, more than twice the rate for all ages.

[75] During the seven years from 1994 through 2000, the population of the city of Oulu increased by 16,000. About 9,300 of this figure, however, represented a "social increase;" that is, the net increase obtained by subtracting the number of people who had moved out of Oulu from the number of those who moved into the city from other regions or countries.

include a sizeable number of non-working spouses and other members of the newly unemployed. Their presence appears to raise the jobless rate in proportion.[76] These are just a few of the contributing factors.[77]

Over the past forty years, Finland has become a welfare state whose policies have provided its citizens with a high level of welfare at a high cost. Finns enjoy free education from kindergarten through university, health care at nominal cost at public hospitals, ample retirement benefits and a well-working unemployment insurance system.[78] This welfare system appears to have functioned well, helping to maintain social stability in the face of a troubling income disparity which has widened since the 1990s.[79]

④ Unemployment in the Oulu Region, by Industry

This analysis has relied so far on data for the city of Oulu. The geographical limits of the Oulu ICT cluster, however, extend to the city's neighboring municipalities. The analysis will now focus on data for the Oulu region, which includes Oulu City itself and ten neighboring municipalities – Kempele, Oulunsalo, Hailuoto, Haukipudas, Kiiminki, Liminka, Muhos, Tyrnävä, and Ylikiiminik – which, since 2000, have carried out regional industrial policies in concert with Oulu City (see Figure 4-7).

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[76] For example, if a family moved to Oulu because one member found work in the city's vicinity, there was no guarantee that the person's spouse or other dependent would also immediately find work. The social increase in population would be accompanied by growth in the number of newly unemployed persons like these, potentially pushing up the unemployment rate. (This is regarded as a real problem in the Oulu region. The Oulu Region Business Agency supports the establishment of small businesses and carries out policies for that purpose.) Also in this regard, the jobless rate for Finnish women differs is only a few percentage points from that for men. As of April 2006, males accounted for 74.0% of the total number of unemployed in Finland (aged 15 to 64); females accounted for 69.5%.

[77] An article by the Oulu City Government for the July 13, 2005 issue of Technology News said that since Oulu was the largest city in northern Finland, some structural long-term unemployment was natural in the region, but that the amount was a mere 2.5% of Oulu's total labor force. Unemployment, it added, was steadily declining.

[78] Castells, Manuel and Pekka Himanen (2002), p. 12 of Japanese version.

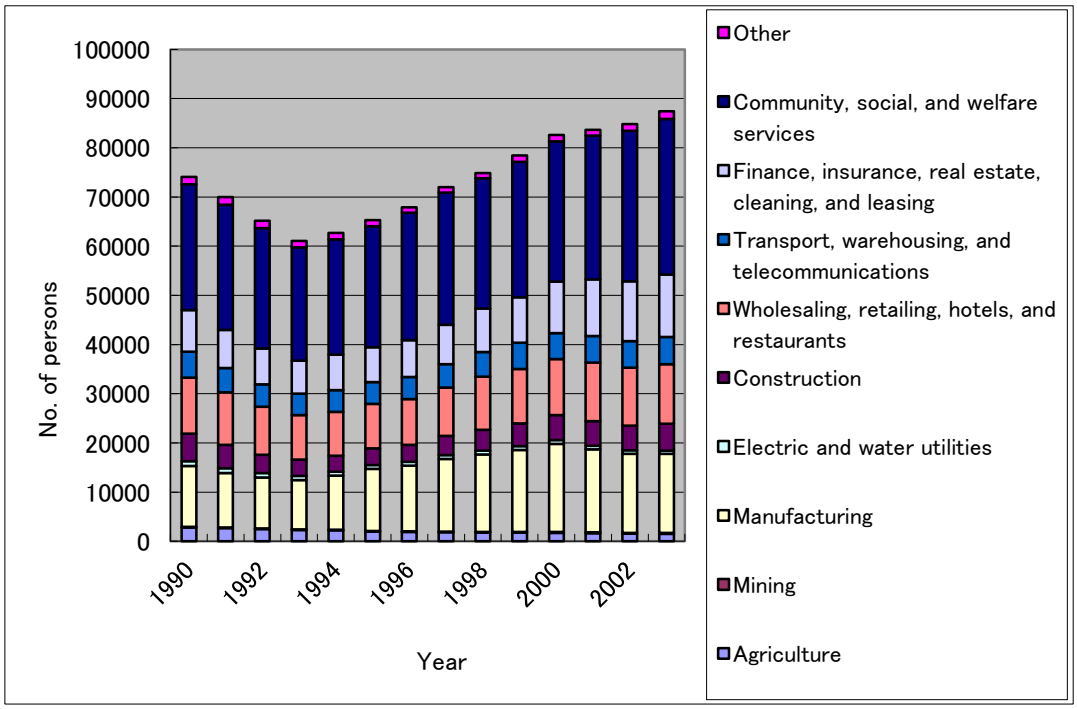
[79] According to Manuel Castells and Pekka Himanen (2002), Finland's Gini coefficient (a coefficient which measures the inequality of income distribution) rose dramatically from 1990 (0.204) to 1998 (0.295), indicating a rise in inequality. Nevertheless, the incarceration rate, an indication of social exclusion, has fallen consistently since 1950 (per 100 thousand, the figure was 187 in 1950, 69 in 1990, and 62 in 2000.)

Figure 4-7 The Oulu Region (11 Municipalities)

Source: Website of the Oulu Regional Business Agency
(http://www.ouka.fi/ouluseutu/yrityspalvelut/suomi/intra_esitteet.htm)

Figure 4-8 shows transitions in employment in various industries (because of limited availability of statistics, data start in 1990, or, in some cases, 1993). Between 1990 and 1993, total employment in the industries shown fell by a yearly average of 6.2%. From that point to 2000, however, the figure rose steeply by an average of 4.4% per year. Growth between 2000 and 2003 was somewhat slower at annual average of 1.9%. The decline that took place between 1990 and 1993 was common to all industries. By contrast, the rapid growth that characterized the period from 1993 through 2000 centered on manufacturing and on finance, insurance, cleaning and leasing, which recorded average annual growth of 8.6% and 6.7% respectively. Manufacturing employment peaked in 2000, posting an overall decline for the period from 2000 to 2003. Jobs in finance, insurance, cleaning and leasing grew during the same period by a yearly average of 6.6%. In community, social, and welfare services, employment grew by 3.6% annually on average. While the drop in manufacturing employment owes something to labor intensity, the steady growth in employment in the service sector appears to have been spurred by the momentum created by the opening of the ICT cluster in the 1990s.

Figure 4-8 Trends in Employment in the Oulu Region, by Industry



(Data for Figure 4-8)

	1990	1991	1992	1993	1994	1995	1996
Agriculture	2810	2666	2483	2323	2237	1989	1902
Mining	136	156	127	119	157	142	138
Manufacturing	12373	11086	10348	10038	10955	12629	13329
Electric and water utilities	965	947	909	851	805	774	763
Construction	5626	4729	3743	3320	3268	3353	3486
Wholesaling, retailing, hotels, and restaurants	11353	10692	9762	9014	8880	9045	9306
Transport, warehousing, and telecommunications	5286	4925	4560	4354	4434	4460	4484
Finance, insurance, real estate, cleaning, and leasing	8435	7761	7255	6691	7218	7062	7467
Community, social, and welfare services	25584	25489	24479	23061	23451	24612	25920
Other	1543	1530	1500	1299	1312	1256	1111
Total	74111	69981	65166	61070	62717	65322	67906

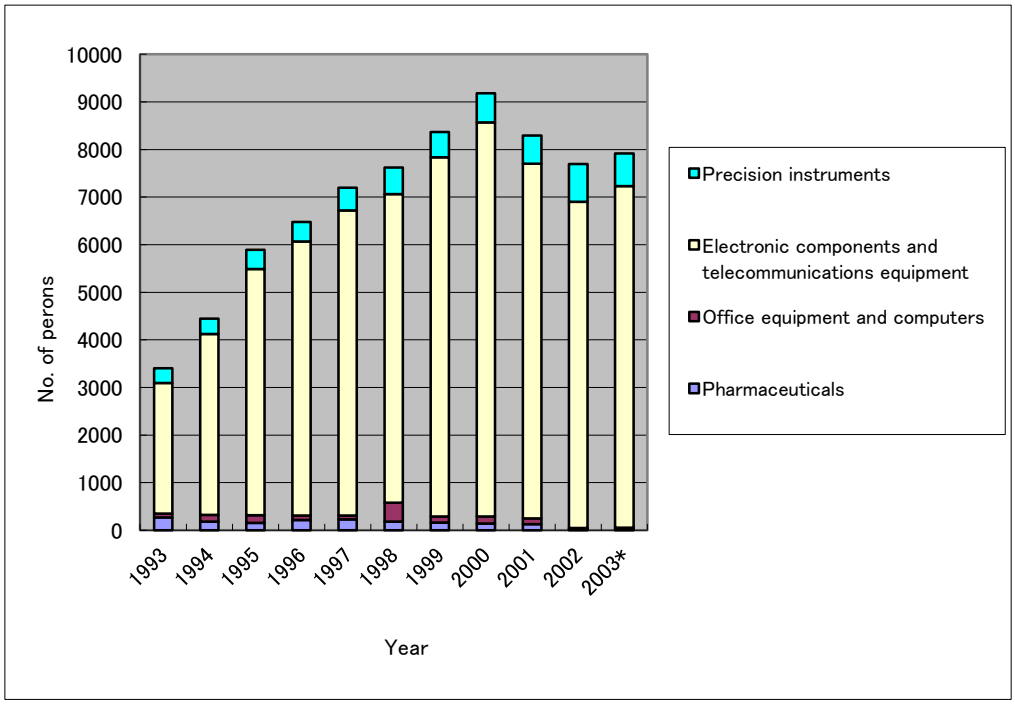
	1997	1998	1999	2000	2001	2002	2003*
Agriculture	1834	1773	1776	1733	1653	1575	1510
Mining	158	161	168	166	172	166	204
Manufacturing	14764	15729	16654	17918	16909	16075	16097
Electric and water utilities	757	769	772	740	699	662	640
Construction	3954	4259	4606	5139	5003	5067	5431
Wholesaling, retailing, hotels, and restaurants	9805	10797	11085	11329	11921	11735	12120
Transport, warehousing, and telecommunications	4764	5027	5284	5302	5372	5427	5519
Finance, insurance, real estate, cleaning, and leasing	7952	8844	9278	10504	11544	12187	12725
Community, social, and welfare services	26896	26471	27528	28499	29188	30560	31645
Other	1110	1045	1290	1246	1186	1337	1541
Total	71994	74875	78441	82576	83647	84791	87432

Source: Employment Statistics, Statistics Finland.
Notes: 1. Industrial classification is according to Standard Industrial Classification 2002 (TOL 2002).
Notes: 2. Data for 2003 are provisional.

⑤ Numbers of Employed in High-tech Manufacturing in the Oulu Region

Figure 4-9 shows transitions in the number of persons employed in those manufacturing industries in the Oulu region that are counted as "high-tech" fields: electronic components and telecommunications equipment manufacturing, precision equipment manufacturing, office equipment and computer manufacturing, and pharmaceutical manufacturing. From 1993 to 2000, these industries as a whole experienced rapid growth in employment, the number of employed rising from 3,401 to 9,181 for an annual average of 15.2%. These figures support the view that the growth in manufacturing employment as a whole during this period (up 7,880 persons, from 10,038 to 17,918) was driven by an increase in high-tech jobs. The greatest contribution by far was made by electronic components and telecommunications equipment manufacturing, where employment grew by 5,537 persons, from 2,744 to 8,281, for a contribution rate of 95.8%. The figure slipped somewhat from 2001 onward, a result of the worldwide slump in the IT industry and redistribution of production centers; nevertheless, it remained above pre-1998 levels.

Figure 4-9 Trends in the Number of Employed in High-tech Manufacturing in the Oulu Region



(Data for Figure 4-9) Unit: Persons

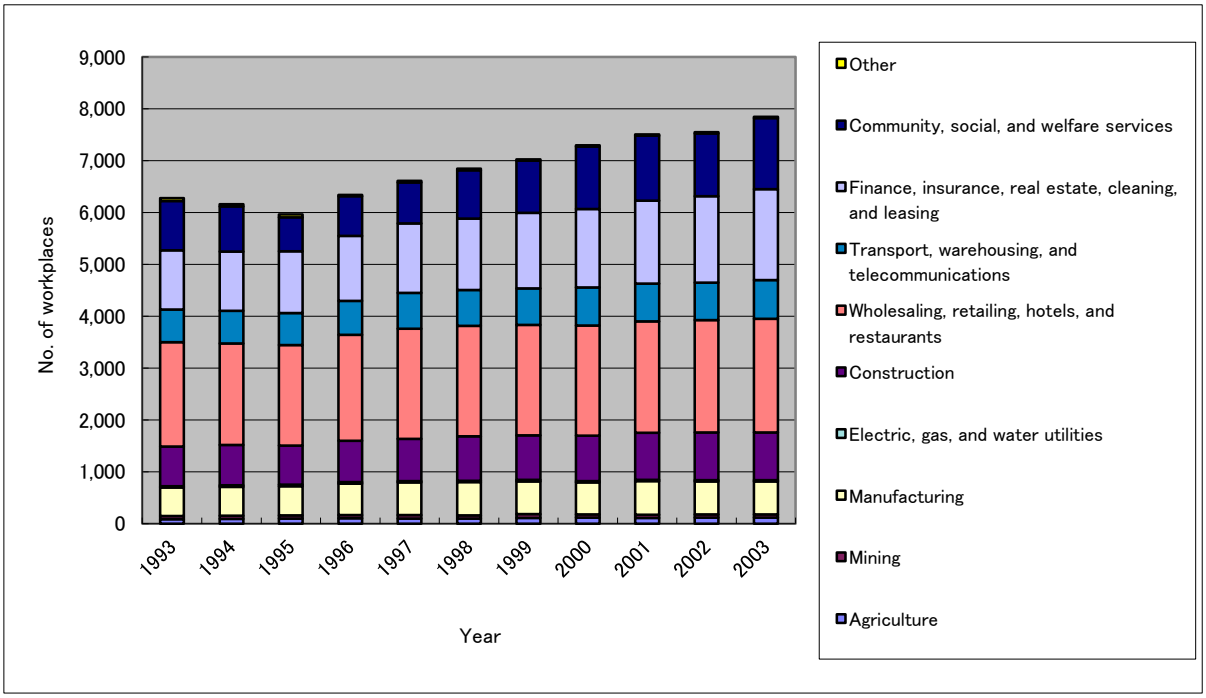
Year	Pharmaceuticals	Office equipment and computers	Electronic components and telecommunications equipment	Precision instruments	Total
1993	266	85	2,744	307	3,402
1994	184	137	3,799	328	4,448
1995	157	157	5,174	401	5,889
1996	216	95	5,754	410	6,475
1997	228	81	6,413	476	7,198
1998	179	400	6,483	557	7,619
1999	164	122	7,547	536	8,369
2000	139	151	8,281	610	9,181
2001	127	125	7,449	591	8,292
2002	26	22	6,850	794	7,692
2003	27	24	7,181	684	7,916

Source: Statistics Finland.
Notes: 1. Data for 2003 are provisional.
Notes: 2. Classified in accordance with Standard Industrial Classification 2002 (TOL 2002).

⑥ Numbers of Workplaces in the Oulu Region

Figure 4-10 shows that after hitting a low point in 1995, the number of workplaces in the Oulu region rose consistently both up to and after the turn of the century. In the manufacturing sector, the number rose 17.3% from 550 in 1993 to 645 in 2001. The number of job holders rose 73.2% during the same period, from 10,348 in 1993 to 17,918 in 2000, indicating a substantial increase in the number of people employed at each workplace. Behind the rising trend was the striking growth of Nokia, to be discussed later in this paper, and the tendency of firms which established operating bases as subcontractors for Nokia to expand their operations to include not only business aimed at Nokia but also emigration and export to other regions.

Figure 4-10　Trends in the Number of Workplaces in the Oulu Region, by Industry



(Data for Figure 4-10)

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Agriculture	82	90	96	102	99	96	112	114	110	118	117
Mining	61	64	65	65	66	60	70	62	61	58	62
Manufacturing	550	556	557	602	628	643	633	619	645	638	633
Electric, gas, and water utilities	27	30	31	30	26	29	29	26	27	25	25
Construction	767	776	757	795	813	854	855	873	906	919	922
Wholesaling, retailing, hotels, and restaurants	2,012	1,958	1,936	2,048	2,125	2,134	2134	2,126	2,148	2,166	2,191
Transport, warehousing, and telecommunications	628	628	620	651	690	688	700	733	729	724	746
Finance, insurance, real estate, cleaning, and leasing	1,145	1,142	1,188	1,256	1,341	1,376	1457	1,512	1,602	1,666	1,751
Community, social, and welfare services	950	874	659	765	792	936	1007	1,207	1,252	1,211	1,371
Other	55	44	54	23	31	30	26	26	27	25	29
Total	**6,277**	**6,162**	**5,963**	**6,337**	**6,611**	**6,846**	**7,023**	**7,298**	**7,507**	**7,550**	**7,847**

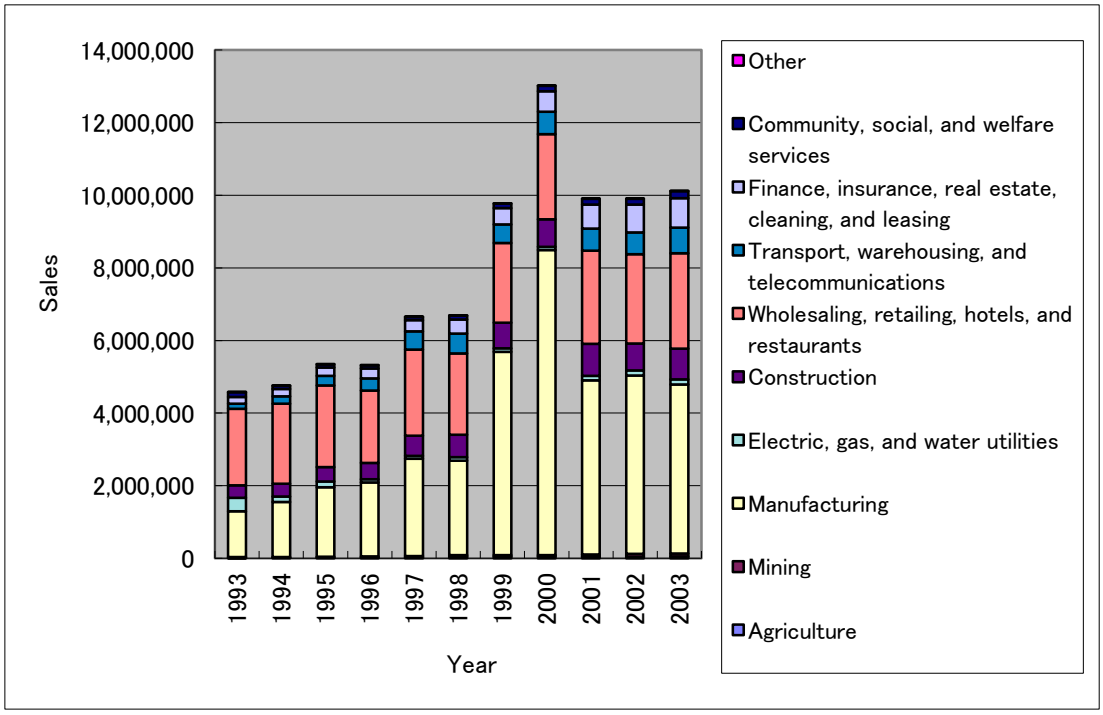
Source: Statistics Finland.

⑦ Sales Figures for Industries in the Oulu Region

Sales figures for industries in the Oulu region are shown in Figure 4-11. Having climbed steadily from 1993 to 2000 – particularly for manufacturing in 1999 and 2000 – sales fell off in 2001 to the 1999 level, where they have stayed. The size of the increase in 2000 was so great that the subsequent margin of decline was all the more

conspicuous. Still, recent levels have been twice that of 1995 or 1996 (about 10 billion euro in total; somewhat less than 5 billion euro for the manufacturing sector).

Figure 4-11　Trends in Sales Figures in the Oulu Region, by Industry



(Data for Figure 4-11)　Unit: Thousand Euro

年	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Agriculture	13,647	16,240	16,683	19,267	18,276	46,701	45,178	52,711	45,073	43,317	49,034
Mining	19,670	16,120	25,393	30,073	41,690	39,158	39,886	35,972	62,447	76,261	83,492
Manufacturing	1,266,717	1,518,601	1,919,735	2,036,463	2,679,757	2,601,795	5,602,627	8,401,700	4,799,826	4,916,046	4,654,852
Electric, gas, and water utilities	366,478	154,682	157,938	91,005	81,592	98,872	93,662	88,269	119,316	136,400	139,808
Construction	347,816	347,995	397,898	447,309	555,377	614,143	708,609	755,716	882,490	743,714	852,980
Wholesaling, retailing, hotels, and restaurants	2,105,924	2,202,021	2,240,058	2,000,905	2,372,320	2,245,949	2,191,408	2,350,552	2,565,299	2,457,738	2,621,859
Transport, warehousing, and telecommunications	142,151	205,276	269,548	330,177	500,097	545,395	516,318	613,266	609,020	606,705	709,433
Finance, insurance, real estate, cleaning, and	186,011	199,848	227,010	274,665	311,830	384,339	447,216	568,488	656,192	759,166	809,212
Community, social, and welfare services	124,207	91,075	88,587	88,517	89,850	104,614	121,992	145,671	158,791	166,760	197,605
Other	2,563	2,704	2,350	1,409	2,051	2,221	1,282	1,755	2,117	1,978	1,903
Total	4,575,184	4,754,562	5,345,200	5,319,790	6,652,840	6,683,187	9,768,178	13,014,100	9,900,571	9,908,085	10,120,178

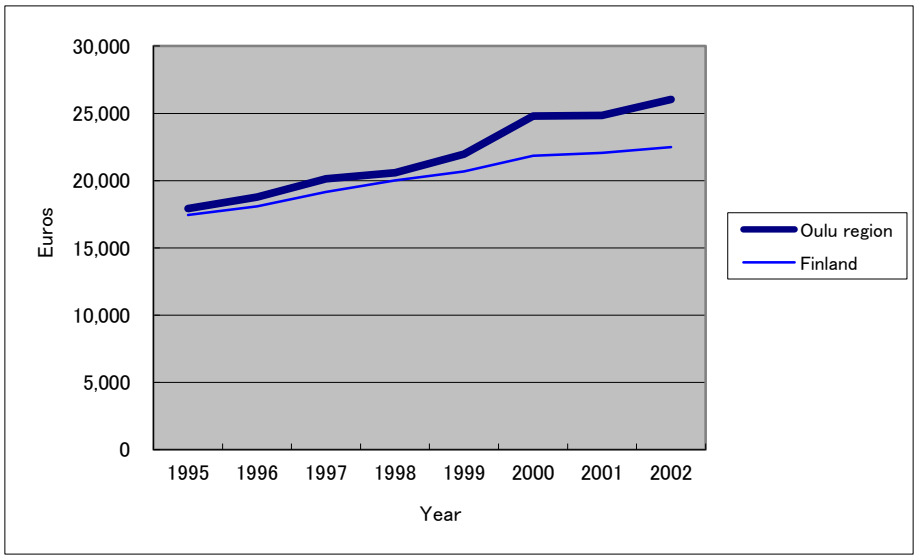
Source: Statistics Finland.

⑧ Per-capita Added Value for Residents of the Oulu Region

Sales growth in the manufacturing and service industries, particularly those involving high technology, was supported from the late 1990s to 2000 by strong growth in

per-capita added value for residents of the Oulu region (Figure 4-12). In 2002, the figure for Finland as a whole exceeded 15.8%, indicating how the ICT cluster has contributed to the growth of the entire Oulu region.

Figure 4-12　Trends in Per-capita Added Value for Residents of the Oulu Region (2000 prices)



(Data for Figure 4-12)　　Unit: Euros

Year	1995	1996	1997	1998	1999	2000	2001	2002
Oulu region	17,916	18,791	20,142	20,577	21,962	24,812	24,853	26,047
Finland	17,441	18,084	19,154	20,024	20,687	21,841	22,059	22,487

Source: Oulu Region Business Agency (Oulu Region Quick Facts)
Notes: 1. Figures for 2002 are provisional.
Notes: 2. Data for Ylikiiminki are not included.

4.3　Moves Taken by Local Actors in the Forming of the Oulu ICT Cluster, by Decade

Following is a decade-by-decade analysis of the steps leading up to the ICT cluster's formation, focusing on the moves taken by local actors.

4.3.1　Principal Initiatives from 1958 through the 1970s

① Founding of the University of Oulu and Its Department of Electrical Engineering

The University of Oulu was the first university in northern Finland and the second general university in Finland as a whole. When it opened in 1958, it included schools of

philosophy, engineering, and medicine, and, as associated facilities, the Northern Finland Research Institute and Teacher Training Institute. According to Mika Kulju (2002), the idea of establishing a research institute for technology and economics in northern Finland was proposed in 1949 a local politician, Pentti Kaitera. Fending off criticism by those who favored locating the institute in the South, proponents, led by people who were themselves from the North, finally won approval after a vigorous inducement campaign lasting almost ten years. Having come into being in large part thanks to this determined effort, the University of Oulu has been strongly committed from the start to the promotion of northern Finland. As will become clear later on, the University of Oulu has been central to the Oulu ICT cluster in terms of both research activity and training. Against this background, Pertti Huuskonen, current president of Technopolis Oyl, the firm which operates the Oulu Science Park, calls the university's establishment "the most logical regional policy taken in the last hundred years."[80] Clearly it was a giant step forward in the development of the northern regions[81], as young people from the North had previously to move south if they wanted a higher education.

Establishment of the Department of Electrical Engineering and installation of Juhani Oksman as its head

The university's School of Engineering was established at the school's inception, while the Department of Electrical Engineering[82], which would play the central role in research and training for the ICT cluster, was founded in 1965 as the Department of Electrical Engineers.[83] At the outset the department focused on the training of electrical engineers for Northern Finland. Juhani Oksman[84], a graduate of the Helsinki University of Technology who was a researcher at Helsinki University's radio astronomy station and studied the ionosphere at an observatory in the Arctic town of Sodankylä, was invited to serve as both professor and department chair. Though born in southern Finland, Dr. Oksman had strong ties with the North, having lived in the Arctic town of Rovaniemi through high school in connection with his father's work.

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[80] Mika Kulju (2002), p. 193.

[81] In the following pages I describe how, for years after the university's founding, graduates of its Department of Electrical Engineering had to seek work in the South.

[82] The department today is not only the largest in the Faculty of Engineering but in the University of Oulu as a whole, with over 3,000 students and teachers combined.

[83] The name was changed to the "Department of Electrical Engineering" in 1975 and to the "Department of Electrical and Information Engineering" in 2002.

[84] The description of Dr. Oksman was taken from Mika Kulju (2002), pp. 35-49.

His experiences in Rovaniemi, and the outlook[85] he developed there, left him with a strong sense of mission regarding the economic development of northern Finland. In a speech given in 1966 at a ceremony marking his installation as department chair, he revealed the importance he attached to the field of electronics and promptly changed the goal of the department – which had been the training of electricians for northern Finland – to reflect this interest. This, more than anything else, was the first step towards the creation of a high-tech industrial cluster in Oulu.

Invitation of Professor Otala

In line with his focus on electronics, Dr. Oksman invited Matti Otala[86] to teach at the school. Dr. Otala was head of the wireless telecommunications department of Finland Cable Factory, then a subordinate of Nokia. Mika Kulju (2002) describes Dr. Otala as a gifted technician who built a vacuum-tube radio at the age of seven and a cathode ray tube television at fifteen. Born in Oulu[87], he worked at Helval, a television manufacturer, after graduating from the Helsinki University of Technology. He then joined Finland Cable Factory, becoming a Nokia researcher when that firm was absorbed by Nokia in 1966. His having been born in Oulu was what brought him to the attention of Dr. Oksman, who invited him to join the University of Oulu as a professor in charge of electronics research. Dr. Otala agreed on condition that he be allowed to commute to work as a "suitcase professor."[88] Not everyone at the university was pleased at this accommodation, but Dr. Oksman, as chair of the department, overrode any opposition.

Dr. Otala officially began teaching at Oulu in 1968. As head of the Department of Applied Electronics (now the Electronics Laboratory), he led research projects incorporating the actual needs of the electronics industry. In the process, he developed a keen interest in the future of the electronics industry in northern Finland. The

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[85] In an interview, Dr. Oksman said that his father was an artist who found work in Rovaniemi, the capital of Finland's northernmost state of Lapland, after losing his job in the South. Dr. Oksman said he wanted to repay the region for the kindness his father had received in Rovaniemi, which had needed workers to help rebuild after Soviet bombing. His father's difficulty in maintaining employment sparked a keen interest in the problem of unemployment in northern Finland, to the extent that he chose it as the topic for a high school research paper.

[86] See Mika Kulju (2002), pp. 51-62, for information on Professor Otala.

[87] According to Mika Kulju (2002), wartime air raids caused Dr. Otala's mother to flee from Helsinki to Oulu, where Dr. Otala was born. (Ibid., p.53).

[88] The term is used for professors who stay in the vicinity of the university only when they have classes to teach.

professor himself[89] describes how this came to be:

> Dr. Oksman and I held sauna meetings at which we defined out shared goals. We agreed to work to curb the outflow of people from northern Finland and to promote the region's development. There would be no meaning in training engineers in Oulu if they all moved to the South after finishing their studies. The North needed industry and the jobs it would provide. We would consider the field a blank slate and start working in areas where it would really make a difference.

Dr. Oksman and Dr. Otala coined the term *EEI* to refer to the electrical and electronics industry. Through opinion articles, lectures, and other channels, Dr. Otala avowed that within a few years, EEI in northern Finland would be in the position to provide thousands of jobs.[90] At first there were few who believed such predictions, but by 1975 some 2,000 jobs had been created and the professors were (narrowly) able to save face.[91]

Dr. Otala was a key catalyst in getting the firm Kajaani, an important actor in the construction phase of the Oulu ICT cluster, to invest in the electronics industry. Located in a town of the same name about 180 km southeast of Oulu, Kajaani is a manufacturer of paper, pulp, and papermaking machinery. Dr. Otala's ideas on the future of the electronics industry drew the interest of Kajaani's president, Mikko Tähtinen. In 1968, after meeting Dr. Otala, an enthusiastic Mikko Tähtinen promptly launched Kajaani Electronics (*Kayaani Oy Elektroniikka*).[92] Its first products, measurement instruments for the pulp bleaching process, were developed in cooperation with Dr. Otala's research lab. In later years the collaboration turned out a number of electronic products for use in areas unrelated to papermaking. (More information on Kajaani is given later.)

In 1971 Dr. Otala was named chair of the department. In his acceptance speech, he pointed to information technology as a new and promising area deserving of the school's attention. This led to expanded research in IC and software and shows that of

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[89] Matti Otala, *Uskalla olla visas* ("Dare to be smart"), Ajatus Kirjat, Jyväsklä, 2001. Quoted from Mika Kulji (2002), p. 56.

[90] Dr. Oksman has said this estimate was for jobs mainly in the production sphere.

[91] Interview with Dr. Oksman.

[92] At the time of its establishment, the new company was given the name Jänkä Electronics (*Oy Jänkä Electronics Ab*), concealing its connection with Kajaani. (Mika Kulju (2002), p. 61.)

the three fields[93] important to Nokia when it began to increase its research activity in Oulu in 1985 – electronics, software, and wireless communications – the university had already started taking steps to build up the first two. The department's move into telecommunications, meanwhile, started with research into radio waves conducted for Dr. Okman's Aurora project. A telecommunications lab was opened in 1973, leading to the founding of the Center for Wireless Communication (CWC) in 1995.

In 1974, Dr. Otala was named the first director of the government-affiliated VTT Technical Research Center of Finland (details on which are given later). He proved a strong leader in advancing the center's practical research. By 1983, when he moved to the elevator manufacturer Kone[94], he was one of the most active visionaries involved in the Oulu ICT cluster.

Transformation of the Electrical Engineering Department at the University of Oulu

With the contributions of Dr. Oksman and Dr. Otala, the Department of Electrical Engineering underwent important changes over the course of its development. The evolution of its research areas is traced in Figure 4-13.[95]

As mentioned earlier, the department's original name was the Department of Electrical Engineers. In reality, however, it provided a full range of courses that qualified it as an engineering department. At its start, the department included the Department of Measurement Techniques, Department of Applied Electronics, and Department of Theoretical Electrical Engineering.

The Department of Measurement Techniques was established as Dr. Oksman's research lab. It later added courses in photoelectrical engineering and is now known as the Optoelectronics and Measurement Technology Laboratory.

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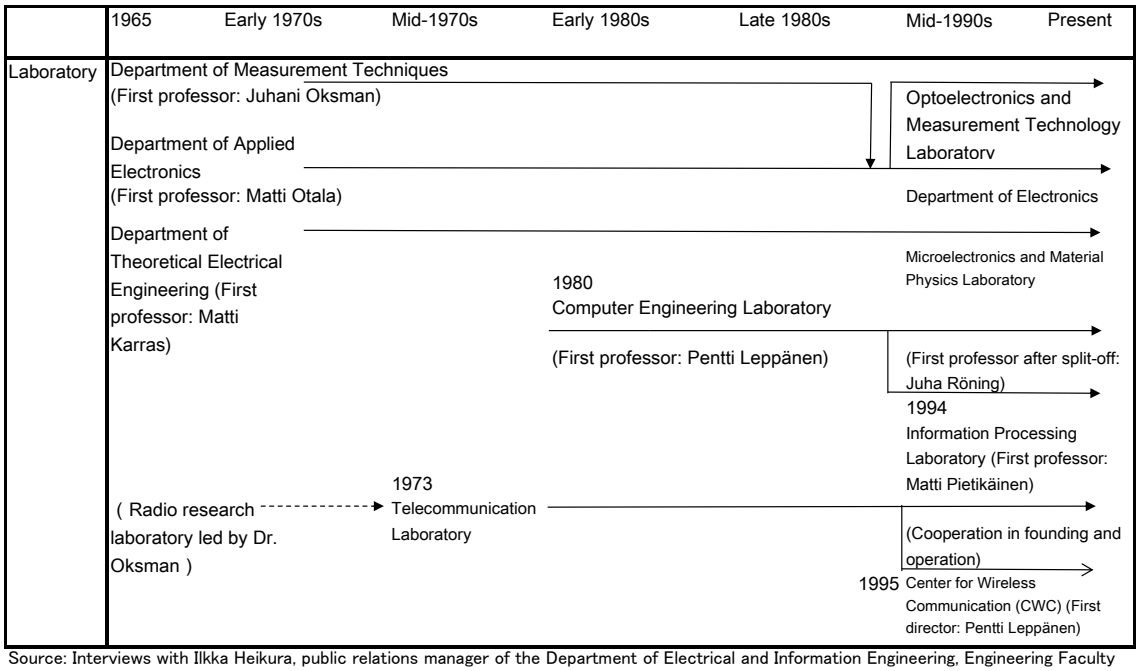
[93] Interview with the director of Tekes Oulu (Finnish Funding Agency for Technology and Innovation). Established in 1983 as an umbrella organization of the Finnish Ministry of Trade and Industry, Tekes extends economic support for surveys, research and development in science and technology.

[94] Dr. Otala went on to executive positions at Nokia and other leading Finnish companies.

[95] I turned to the website of the University of Oulu Department of Electrical Engineering (http://www.ee.oulu.fi/) for much of the information I sought on the department. Other valuable information was provided by Ilkka Heikura, public relations manager of the Department of Electrical and Information Engineering, Engineering Faculty of the University of Oulu.

Figure 4-13 Evolution of Research Laboratories in the Department of Electrical Engineering, Faculty of Engineering, the University of Oulu



Source: Interviews with Ilkka Heikura, public relations manager of the Department of Electrical and Information Engineering, Engineering Faculty of the University of Oulu.
Notes:1. In 1965, the time of its establishment, the department was called the Department of Electrical Engineers. In 1975 it became the Department of Electrical Engineering, and in 2002 it was given its current name, the Department of Electrical and Info

Notes:2. In addition, the Department of Information Processing Science was created within the Faculty of Science. This department is now the second largest in the university (the largest is the Department of Electrical and Information Engineering).

Having begun as Dr. Otala's research laboratory, the Department of Applied Electronics (now the Electronics Laboratory), went on to conduct broad-ranging practical research that included the cooperative project with Kajaani. With Seppo Leppävuori as acting professor, the department worked with Aspo, a firm based in southern Finland, on the development of electronic circuitry utilizing thick film hybrid technology – a project which contributed to the evolution of IC circuitry design in Oulu and mounting technology for electronic parts.[96] Dr. Leppävuori worked somewhat in the shadow of his colleagues Drs. Oksman and Otala, but he played a vital role in the cluster's formative process in terms of technology, training, and strategy; it was he wrote the proposal to invite the government-affiliated VTT Electronics Research Laboratory to Oulu.[97]

The very first graduate of the Department of Electrical Engineering, the earner of its first doctorate, and the first of its graduates to become a professor, was Seppo

[96] Interview with Jouko Möttönen, vice president of Polar Electro.
[97] Mika Kulju (2002), p. 68.

Säynäjäkangas, a graduate of the Department of Applied Electronics. In 1977 Dr. Säynäjäkangas founded what was to grow into the first global business to come out of Oulu. This was Polar Electro Oy, a producer of wristband heart rate monitors for athletes such as cross-country skiers. By the early 1980s he was focusing all of his energies on the business. Even so, he retained for many years the title of Founding Professor and served as a role model for entrepreneurs building start-ups from the products of university research.

The Department of Theoretical Electrical Engineering was led by the physicist Dr. Matti Karras, who focused on using theoretical physics to delve deeper into the various aspects of electrical engineering. The department later underwent of change of name to become the Microelectronics and Material Physics Laboratory. It dealt mainly with the miniaturization of IC circuitry, the downsizing of electronics components, and similar issues from a materials standpoint.

In 1973 Dr. Oksman created a fourth laboratory, the Telecommunication Laboratory. As a geophysicist specializing in the ionosphere, Dr. Oksman explored the field of radio waves, focusing on spread spectrum technology. The technologies developed in this field were used in the production of military radar. But some promised to be applicable to civil telecommunications as well in products such as automobile phones and mobile phones. The industrial community was quick to notice this potential, especially the television manufacturer Salora, Nokia, and their shared subsidiary, Mobira, which saw an excellent opportunity for Nokia to achieve global success in both mobile phones and base systems. As a participant in academic conferences, Dr. Oksman was one of the first to recognize its future promise. In 1973 he opened the Telecommunication Laboratory with the aim of pursuing research in this field. Playing an important role here was Pentti Leppänen, who had worked with Dr. Oksman on ionosphere studies in the Arctic town of Sodankylä.[98] The Center for Wireless Communication, opened in 1995, cemented the university's reputation as a mecca for telecommunications research.

A fifth laboratory, the Computer Engineering Laboratory, was established in 1980; a branch of this, the Information Processing Laboratory, opened in 1994 and continues in operation today. As early as 1969 the Department of Information Processing Science[99],

[98] Mika Kulju (2002), p. 46.

[99] With a total of almost 2,000 students and teachers, this is now the second largest department

part of the Faculty of Science, was already offering courses in information processing. However, the relatively early stage at which the Department of Electrical Engineering introduced its computer engineering program seems to have had a lot to do with Nokia's move, starting in the late 1980s, to expand its research activity in Oulu.

The Department of Electrical Engineering has thus been concerned with more than electronics ever since its founding in 1965. It was a pioneer in introducing full-fledged programs in telecommunications (particularly wireless communications) in 1973 and in computer engineering in 1980. In 1978, Nokia chose it for the development of base station systems for NMT.[100] The department has also been instrumental in the development of embedded software[101] for mobile phones (since 1985) and, with the support of the Finnish Ministry of Defense, in the research and development of CDMA , a third-generation mobile phone technology (since 1980).

Erkki Veikkolainen was a 1980 graduate of the Department of Electrical Engineering who worked for private firms in the western part of Finland, at the VTT Technical Research Center of Finland, and for Nokia Mobile Phone (now Nokia Mobira) as chief of embedded software development. In the following paragraphs he describes the University of Oulu's early start the ICT field and how that influenced the decision to invite Nokia to locate its research functions in Oulu.

> Oulu was earlier than other regions to focus on information technology. When Dr. Oksman joined the Department of Electrical Engineering at the University of Oulu's Faculty of Engineering, he lost no time in shifting the focus from electrician training to electronics. Envisioning the future of microprocessors, the university began introducing information technology programs as early as the 1970s. It was quick to initiate change and flexible as to its content.
>
> One reason for Mobira's choice of Oulu as its center for (mobile phone) software development was the leading-edge research in (embedded) software being conducted at the University of Oulu and VTT Electronics. Oulu was

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in the University of Oulu, exceeded only by the Department of Electrical and Information Engineering.

[100] Abbreviation for Nordic Mobile Telecommunication System. This was a first-generation analog mobile phone system developed in 1981, principally in Sweden, Finland, and other Scandinavian countries.

[101] Microcomputer control software embedded in electronic components.

> already the site of the most advanced work in Finland.[102] Another attraction was a talented workforce in the form of the university's graduates. People involved with the university worked hard to attract (the research functions of) Mobira to the region. (Additions in parentheses are the author's.)

In their selection of priority areas for research, Dr. Oksman and his colleagues succeeded in drawing to Oulu the research functions of Nokia, thereby contributing in no small way to the region's goal of promoting high-tech industry. In the environment of the day, however, this was by no means an obvious choice. In fact, people who were actually involved tend to emphasize the astuteness it required. One such is Jorma Terentjeff, a 1974 graduate of the Engineering School's Department of Applied Electronics. Mr. Terentjeff served as plant manager and president of numerous corporations before becoming CEO of JOT Automation, a prototypical electronics firm originating in Oulu. (JOT was listed in 1998; in 2002 it merged with Elektrobit, another Oulu-based company.) In Mr. Teretjeff's words,

> Oulu's development would not have happened without the existence of the University of Oulu's Department of Engineering and the smart choices of those who set its direction. Drs. Oksman and Otala acted wisely in rolling out programs in wireless research and IC research at an early stage. In those days, such courses of study were far from clearly cut.

Another view on the subject was voiced by Ilkka Heikura, a public relations manager, graduate of the Department of Electrical and Information Engineering, and author of a book on the forty-year history of the Department of Electrical Engineering (Heikura, 2005). Mr. Heikura spoke of the University of Oulu's concentration on specific fields at a time when Finland lagged behind the United States and other countries in electronics research.

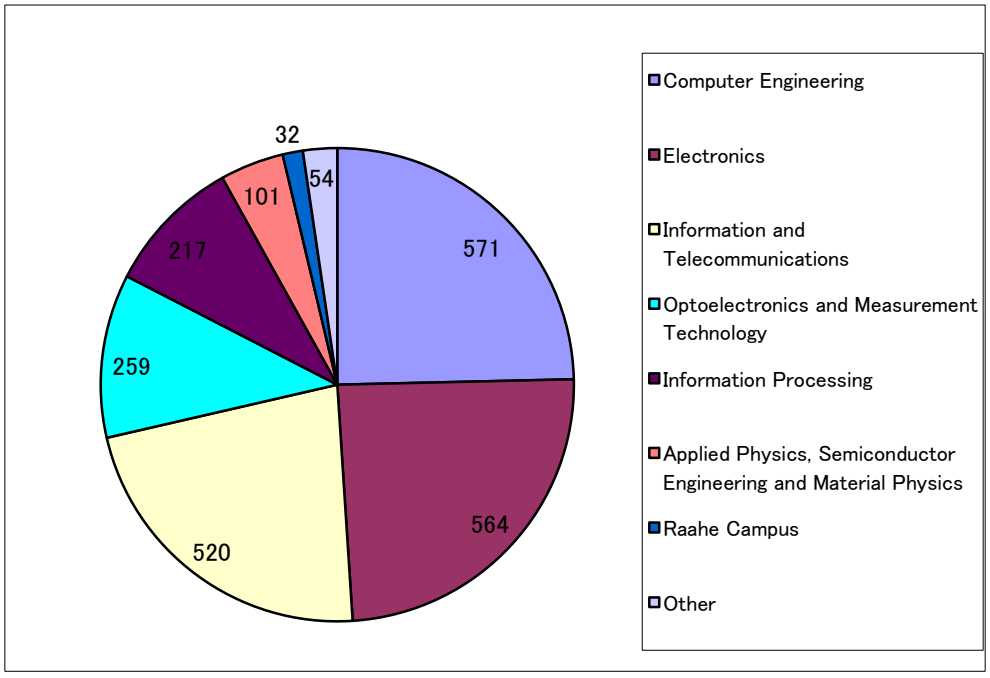
> Drs. Oksman and Otala must be commended for initiating electronics research at the University of Oulu at an early stage compared with other institutions in Finland. But more than that, they were astute in choosing which areas of electronics to focus on (information technology and telecommunication) at a

[102] Research in embedded software was already going on at the Helsinki University of Technology; the question of which university was more advanced in this area would be difficult to answer. (Interview with Erkki Veikkolainen)

time when Finland's research in electronics technology was ten to twenty years behind that of, for example, America or Japan. (Additions in parentheses are the author's.)

The events that sparked the formation of an ICT cluster in Oulu, a place unfamiliar with high technology through the end of the 1950s, were the founding of the University of Oulu, the establishment of its Department of Electrical Engineering, and the choice of priority research areas by Dr. Oksman, Dr. Otala and their colleagues in the department.

Figure 4-14 Graduates of the University of Oulu Department of Electrical Engineering, by Laboratory (1969-2005: 2,318 graduates in total)



Source: Ilkka Heikura (2005), pp. 200-254 (List of Graduates, Department of Electrical Engineering, the University of Oulu).

② The VTT Electronics Research Laboratory: Inducement and Establishment

Another local actor with an important role in the Oulu ICT cluster is the VTT Electronics Research Laboratory, established in 1974 as part of the VTT Technical

Research Center of Finland.[103]

The VTT Technical Research Center was created in 1942 within the Helsinki University of Technology to serve as a center for research in applied technologies. In addition to technological R&D projects taken on for clients, the center pursues interim research projects of its own choosing. At least one laboratory was established for each research field. These are the six fields operating at present, with the number of researchers in parentheses: electronics (304), information technology (401), industrial systems (516), processes (567), biotechnology (290), construction and transportation (425). Laboratories are located in the Helsinki area (1,724 people, including 1,710 at the Espoo headquarters, 11 in Nurmijärvi, and 3 in Helsinki); in Tampere (293); in Oulu (320, including 4 at nearby Raahe); in Turku (18); in Jyvaskyla (130); in Lappeenranta (12); and in Vaasa (6).

The VTT Electronics Research Laboratory was founded in Oulu in 1974. The decision to locate the laboratory in Oulu was largely the result of a cooperative inducement effort by Markku Mannerkoski, then president of the University of Oulu, and Pekka Jauho, an Oulu native and director of the entire VTT complex since 1970. The inducement proposal was written up by Seppo Leppävuori, then an acting professor at Dr. Otala's electronics research laboratory in Oulu. Although electronics was regarded as a growth field at the time, it was still remarkable that VTT chose Oulu, and not the Helsinki area, as the site of its new electronics laboratory. Jorma Lammasniemi, director of the VTT Electronics Research Laboratory, has this to say:

> In those days, it was quite exceptional for an institution like the VTT Electronics Research Laboratory to locate in Oulu – in Japan, it would be something like locating a research facility for a groundbreaking field in Sapporo, say, rather than Tokyo.[104] What brought VTT Electronics to Oulu were the individual actions of a number of people. There were people in Oulu with the vision to see electronics as a growth field. I think there was a political element as well, as people (in the central government) were interested in promoting regional development. (Additions in parentheses are the author's.)

[103] Sections on the VTT Electronics Research Laboratory are based on information found on the VTT website (http://www.vtt.fi/) and Mika Kulju (2002), pp. 63-74.
[104] Dr. Lammasniemi had visited Hokkaido on business.

Mika Kulju (2002) says that the effort to bring VTT Electronics Research Laboratory to Oulu involved a large number of local individuals, including President Mannerkoski, parliamentarians, and members of local government. It helped that regional development policy was a priority of the central government at the time. The Development Region Law, for example, provided that financial subsidies be given to companies locating in a designated "development region."[105] Oulu did not, however, depend solely on government largesse. Just as the University of Oulu was among the first to do electronics research, Oulu succeeded in attracting VTT Electronics through a mixture of vision and strategy. Juha Röning, the current dean of the University of Oulu's Department of Electrical and Information Engineering, believes that the presence of electronics researchers at the university was a factor in VTT's decision to locate its electronics laboratory in Oulu:

> VTT chose Oulu for the Electronics Research Laboratory because of the large number of (electronics) researchers working at the university there. Kajaani, which also had an industrial conglomeration at the time, was also being considered, but Oulu was chosen because of the university. (Addition in parentheses is the author's, taken from the context.)

Dr. Otala, the first director of the VTT Electronics Research Laboratory, proved to be a potent leader. Having gone from being head of Nokia's wireless telephone division to serving as the University of Oulu's first professor of electronic engineering, he valued the practical in both research and education and assigned his students research projects that reflected industry's actual needs. While his approach sparked debate at the university[106], once he was installed as director of VTT, an institution devoted to applied research, he pursued it as a matter of course. According to Mika Kulju (2002), people at VTT headquarters regarded Dr. Otala's methods as revolutionary, and they provoked considerable controversy there.[107] Eero Timonen, head of operations development at VTT Electronics, tells how Dr. Otala, as director, focused on applied research in support of private business, and how that resulted in the expansion of the VTT Electronics Research Laboratory.

> Dr. Otala played a vital role as (the first) director of the VTT Electronics

[105] Such regions were located in northern and eastern Finland, among other areas.
[106] Interview with Dr. Oksman.
[107] Ibid., p.69.

> Research Laboratory. He taught the importance of working closely with firms in the private sector. Their budget was small in the beginning, but as they performed more and more of what we might call pro-business product development, the greater became their usable budget. Larger government (institutional) budgets had something to do with this. A significant factor was the decision by Tekes[108] (established in 1983) to supply funds for research and development in applied science under its policy to promote tie-ups between industry and academia. As Tekes saw microelectronics and software as particularly important fields, the VTT electronics lab received (relatively generous) financing. (Additions in parentheses are the author's.)

Dr. Otala left the laboratory in 1983 for a position at Kone, an elevator manufacturer in southern Finland. But it seems clear that the institution's subsequent development, including that of its research funds, owes a great deal to his management policy while at the helm. And, as the University of Oulu had been quick to choose priority fields for research, the VTT Electronics Research Laboratory was quicker than Helsinki to designate certain research areas as significant. This says something about the strategic astuteness of the laboratory's leaders. Dr. Lammasniemi, director of the laboratory since 1983, says the following about the VTT Electronics Research Laboratory's being earlier than Helsinki to initiate research in a number of important fields since the 1970s.

> A reciprocal relationship existed between the VTT Information Technology Laboratory in Helsinki (Espoo) and the electronics research laboratory in Oulu. Research (in Oulu) on subjects such as microprocessor technology, application software, and digital electronics began in the 1970s; Helsinki later took up these same subjects. In 1994 there was a reorganization within VTT; some functions of the electronics laboratory were moved to Helsinki, while the headquarters remained in Oulu. It was Oulu's early specialization in electronics, I believe, which enabled this to occur. When an institution moves quickly into a new field, it builds its store of know-how and achieves real growth – even when located in an outlying region. Therefore, while similar activities were being pursued in, for instance, the capital area, Oulu had the qualities that enabled it to become a key location for the field. For those times, it was a brave decision

[108] The Finnish Funding Agency for Technology and Innovation. A government agency affiliated with the Finnish Ministry of Trade and Industry, it extends economic support to surveys and research and development, primarily in science and technology.

> on Oulu's part, and by no means a natural or self-evident one. (Addition in parentheses is the author's.)

Dr. Oksman comments on the fine strategic sense displayed by the VTT Electronics Research Laboratory:

> By skillfully introducing, say, automation (mechatronics) into its range of disciplines (in the early 1980s), VTT Electronics came out on top in the territorial competition between it and the VTT Information Technology Research Laboratory in Helsinki (Espoo). (Additions in parentheses are the author's.)

The 1970s saw VTT Electronics begin joint research with the University of Oulu and electronics firms on PCB mounting technology; programs were launched in mechatronics in 1982 and embedded software in 1983. The introduction of these peripheral disciplines led to the institution's successful effort to induce Aspo, headquartered in southern Finland, to expand its research and development and production activities in the Oulu area. (Aspo established itself in Oulu through a subsidiary in 1972; the Oulu plant was enlarged in 1980.) It was also instrumental in getting Nokia to locate its mobile telephone software division in the region.[109]

In the 1980s, VTT Electronics saw it as its mission to offer support to start-up firms and existing companies venturing into new fields. Partly as a result of this policy, which was the institution's official one at the time (see the interview below), well over three hundred VTT employees left for jobs in the private sector or started companies of their own. Dr. Lammasniemi, the laboratory's director[110], and Eero Timonen[111], head of

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[109] VTT does not make a policy of benefiting only those companies located in the vicinity of its laboratories. In the words of Dr. Lammasniemi, VTT Electronics' director, "(The VTT Electronics Laboratory) has always collaborated not only with companies located in Oulu, but with firms in Helsinki and indeed with foreign firms and universities. In the early days, in fact, almost all of our research partners were in Helsinki. It was precisely for this reason that we were able to acquire as much know-how as we have and to use it to benefit local firms." This point is especially significant. It suggests that if events had merely been left to take their course, collaboration with local firms would not have developed as it did, and that conscious cooperation on the part of laboratory members can work to draw in firms from outside the region. In this sense, the existence of the "activity groups" I refer to in this paper, and the unofficial networks that support them, may indeed be of importance.

[110] Joined VTT in 1983; assigned to Oulu in 1978; director of VTT Electronics Research

operations development, comment on the situation at the time.

Dr. Lammasniemi:

> During the 1980s, it was the laboratory's official policy to give support to start-up firms. Actually we helped out not only start-ups, but also existing firms which were trying to move into new fields of business. Dr. Veikkolainen, who moved from VTT Electronics to Nokia, collaborated with Nokia on embedded software research while he was at VTT; (after leaving VTT in 1985) he then became Nokia's R&D manager (in Oulu; for mobile telephone embedded software). (Additions in parentheses are the author's.)

Mr. Timonen:

> Many people who leave the VTT Electronics Research Laboratory go on to found their own companies or find work with private firms. More than a hundred people have done so over the past five years. In total, some 350 people who trained at this institution and emerged as experienced research and development professionals have moved on to local companies (including start-up firms). These people were not laid off by VTT, but left on their own volition. (Additions in parentheses are the author's.)

Today, the VTT Electronics Research Laboratory is a large establishment with a workforce of over three hundred. Some private firms have voiced criticisms[112] regarding the cost of commissioned research, for example, or the speed with which it is done. But it is clear that VTT, at least during the period from its founding in 1974 up to through the 1980s, has played a vital role in the Oulu region,.

③ Initiatives Taken by Oulu Polytechnic (formerly the Institute of Technology)

Oulu Polytechnic[113] is a higher-learning institution founded in 1996. It was born out of the amalgamation of a number of schools specializing in vocational training, including

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Laboratory since 1983.

[111] Joined VTT Electronics Research Laboratory in 1982.

[112] I did hear such opinions during my interviews.

[113] In researching Oulu Polytechnic I drew information from the school's website (http://www.oamk.fi/). In 2006 the school's name was changed to the University of Oulu of Applied Sciences.

the Oulu Institute of Technology, the Raahe Institute of Technology and Business[114], Oulu Business College, and several nursing schools, under the aegis of the Oulu Region Joint Authority for Vocational Education[115]. The student body currently numbers 7,700 and includes 1,200 adults from the workforce. Oulu's history of engineering education is a long one, dating back to 1894 when Finland was under the rule of Tsarist Russia. The school established at that time, while regarded as having paved the way for today's Institute of Technology, actually focused on training technicians rather than engineers. In 1960, two years after the University of Oulu opened its doors, the older school was upgraded into the Institute of Technology as a training institution for engineers. The first courses concentrated on the training of civil and electrical engineers. In 1960 the student population numbered 400; by 1965 it had risen to 800 and currently stands at 2,200.

The Institute of Technology built up its programs roughly simultaneously with, or at the most three to four years later than, the University of Oulu: In 1968, three years after the university established its Department of Electrical Engineers, the Institute of Technology completed work on a new school building and added a Department of Mechanical Engineering. In 1973, the Institute expanded the telecommunications program in its existing training course for electrical engineers (Department of Electrical Engineering); in 1984, it further enlarged its Department of Electrical Engineering to include a formal course in information technology.[116] While both institutions were schools of higher learning engaged in the training of professional engineers, they differed in important ways: The University of Oulu put greater emphasis on theoretical research and study, as befitted a school engaged in the training of academics, while the Institute of Technology leaned toward functional education and the training of hands-on practitioners. Moreover, the minimum program at the Institute was, at four years, one year shorter than the five-year minimum at the university. Of the 2,200 students at the Institute of Technology today, 700 are with the Department of Electrical

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[114] A school of technology and related subjects, located in Raahe, a city on the Gulf of Bosnia, 75 km southwest of Oulu.

[115] A vocational training institution founded in 1994 with the assistance of the city of Oulu and surrounding communities, including Haukipudas, Ii, Kempele, Kiiminki, Kuivaniemi, Liminka, Muhos, Oulunsalo, and Ilii Ii (Raahe and Oulainen joined later). In addition to the higher learning institution that is Oulu Polytechnic, the institute includes the Oulu Vocational College, a 5,000-student vocational school on the high-school level.

[116] Jorma Keinänen (a professor at the former Institute of Technology), personal communication, April 24, 2006.

Engineering[117] specializing in some aspect of ICT. The Raahe Institute of Technology (now the Raahe Institute of Technology and Business), located some 75 km from Oulu, is now affiliated with Oulu Polytechnic. It has specialized in information technology since its creation in 1972, and indeed was one of the first schools to do so.[118] Graduates have gone on to work in ICT firms in Oulu as well as in Raahe. In fact, for some years after the school's establishment it supplied IT professionals to southern Finland as well. There were 600 students enrolled in Raahe's engineering programs at the time of this writing.

The Oulu Institute of Technology played an important role in the 1980s, a period of burgeoning activity for Oulu's ICT enterprises, by offering retraining programs for working professionals, particularly in the new field of wireless communications. In the world of high technology, the spotlight tends to fall on top research universities such as the University of Oulu. But just as a diverse range of companies is needed to create a healthy "industrial ecology," a region needs professionals in many practical fields in order to have an adequate mix of technological resources. For an educational institution to have consistently provided such hands-on professionals, and to have made it its mission to do so, is thus of great significance. Lauri Lantto, president of Oulu Polytechnic and a graduate of the University of Oulu, has this to say about the part played by the Institute of Technology in training wireless telecommunications professionals during the 1980s.

> Degree courses for working students, and short courses for specialists, were offered by Oulu Polytechnic (the Institute of Technology) from way back in the school's history. During the 1980s and beyond, the Polytechnic played a key role in reeducating working technicians for the mobile telecommunications industry. New companies were being founded in growing numbers, and they needed people fluent in the latest technologies. The University of Oulu, I

[117] In the Degree Program in Information Technology and Telecommunications.

[118] The Raahe Institute of Technology began as a practical training institution replacing a teacher training school which closed in 1971. A committee formed by the Education Minister at the time, had discussed the qualities which the new institution should have. At the strong urging of Yrjö Kilpi, a mathematician at the University of Oulu and the committee's deputy chairman, it was decided that the Raahe Institute would specialize in telecommunications. This was Finland's first institution with such a mission. Dr. Otala and others from the University of Oulu assisted in preparing the school's first-year syllabus. Dr. Kilpi went on to serve for many years as chairman of the Institute's board of directors. (Professor Jorma Keinänen of the former Institute of Technology, personal communication, May 15, 2006)

believe, also offered courses for working students[119], but it was Oulu Polytechnic that filled the need for practical retraining.

Graduates of the Polytechnic are adventurous, innovative, willing to take risks – more so, I think, than graduates of the University of Oulu (though they may not be as strong in theoretical knowledge). These are qualities prized by small and medium-sized firms. (Additions in parentheses are the author's.)

In a number of ways, therefore, the Institute of Technology has worked in tandem with the University of Oulu in helping to form Oulu's ICT cluster. The number of its graduates[120] reflects its standing as one of cluster's important local actors. Oulu Polytechnic's president, Dr. Lantto, tells how the school has supplied Nokia with employees:

Nokia employs 4,000 people in the Oulu region alone. Most of them work in development and design, and relatively few in production. The University of Oulu and the Polytechnic supply roughly equal numbers of these employees, though University graduates may be slightly more numerous. In 2004, the 400 or so graduates of the Polytechnic's Institute of Technology found work in diverse fields including civil engineering, mechanical engineering, and electronics. In the latter half of the 1990s (when Nokia was enjoying its highest growth), two-thirds of our graduates were hired by Nokia or other companies in the ICT sector. (Addition in parentheses is the author's.)

As the above shows, the Institute of Technology and Oulu Polytechnic as a whole have played a huge role in training talented workers for the Oulu ICT cluster.

④ Corporate Moves – Electronics Firms in Northern Finland Around the Time of the University of Oulu's Opening

There seem to have been few notable electronics firms in the city of Oulu for some years after the university opened its doors. According to Mika Karju (2002), the only such firms then in northern Finland were a telephone cable factory run by the Swedish

[119] The University of Oulu created a Department of Continuing Education in 1981.

[120] Currently, both the University of Oulu (Faculty of Engineering) and Oulu Polytechnic (Institute of Technology) have incoming freshman classes of approximately 600.

company L.M. Ericsson Ab, based 75 km southeast of Oulu in Raahe, and Salcomp Oy, a subsidiary of the television manufacturer Salora Oy, located in Kemijärvi in the polar region of Lapland. What drew both firms to northern Finland were the low labor costs that prevailed at the time. (It is worth noting that the former plant closed without ever being used for development purposes. The latter managed to remain viable thanks to new business development and productivity improvements initiated by Jorma Terentjeff, its director from 1979 to 1983. Responding to a downsizing order from the company's headquarters in the southern city of Salo, Mr Terentjeff, who later served as COE of JOT Automation, fully utilized the network of contacts he and his colleagues had developed while at the University of Oulu's Department of Electrical Engineering to carry out necessary improvements.[121] The company remains in operation today.)

Both of the firms discussed above were fundamentally production plants. It took until the late 1960s, when the university's Department of Electric Engineers had been established and industrial-academic partnerships were under way, before facilities appeared around Oulu that functioned as the "home bases" of electronics firms. In 1968 the papermaker Kajaani, influenced by Dr. Otala, set up a firm in Oulu to engage in electronics research and development. The new firm was called Janka Electronics rather than any variant of Kajaani. Two years later, in 1970, Kajaani officially established an internal electronics division, *Kayaani Oy Elektroniikka,* and moved its operations back to the city of that name. Despite its leaving Oulu, the company kept in close contact with the University of Oulu. Kajaani's first venture into the electronics field involved the development of measurement equipment for the pulp bleaching process, a product of joint research with Dr. Otala's research lab at the university; later achievements, however, included products such as fare meters for taxis, cash registers, and acoustic consoles for broadcasting stations, none of which had any direct connection to control systems for the papermaking process.[122] Although Kajaani withdrew from the electronics field in the early 1980s, its business involving process control systems is carried on by Metso Automation Oy, an affiliate of Metso Corporation, through the firm Valmet Oy. (Headquartered in Finland, Metso Corporation is the world's largest manufacturer of papermaking machinery.) It currently has facilities in both Kajaani and Oulu. A key source of competitive strength for this global firm is its electronics division, established by Kajaani in cooperation

[121] Interview with Jorma Terentjeff.

[122] Mr. Jarmo Koskinen of Metso Corporation, personal communication, April 11 and June 14, 2006.

with the University of Oulu. It is worth noting that the achievements of the university's business-academic partnerships in electronics were put to use not in the electronic and electric machinery industries per se, but in the production of control systems for papermaking, an existing industry in northern Finland, in a move that was instrumental in sparking that industry's world-class development. In 1983, Edacom Oy, headquartered in Kajaani and with facilities in Oulu, took over the funds-collection equipment division[123] of Kajaani's electronics business. In 1986 the division came under the control of Bascom Oy (headquartered in Oulu), which was created out of Bascom through an MBO. In 1992, Bascom designed the world's first fare-collection system for public transport based on IC cards using radio frequency identification (RFID). Introduced first in Oulu, it is now in use throughout the world. The firm remains a distinctive member of the region's industrial community.[124] According to Veikko Huttunen, who directed the production of acoustic benches for broadcast stations at Kajaani, that division was taken over by Jutel Oy in 1984 and continues today as an exporter of radio broadcasting system solutions using digital technology.[125]

In the early 1970s, Aspo, a petroleum and coal company located in southern Finland, entered the electronics field. Through contacts with Seppo Leppävuori of the Electronics Laboratory at the University of Oulu's Electrical Engineering Department (then the Department of Electrical Engineers), the company set up a subsidiary, Paramic Oy, in Oulu.[126] That firm worked with Dr. Leppävuori in the development of electronic circuitry using thick film hybrid technology, opening a factory in Oulu which later became Aspocamp Oy.

Joint research and other cooperative endeavors thus contributed to the establishment of electronics companies in and around the city of Oulu following the opening of the Department of Electrical Engineers. But it was Nokia's transfer of its cellular phone division to Oulu that – considered in light of Nokia's subsequent business development in the region – really had an impact on Oulu's future.

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[123] A descendant of Social Automation Oy, this business was established in 1973 as a division of Eurodata Oy and is currently located in the Oulu region; it was bought out by Kajaani in 1977. (Oinas-Kukkonen et al. (2006), pp. 11, 14.)

[124] Since 1988, Bascom has received investment from Polar Electro and has functioned as a member of that corporate group.

[125] Jutel Oy has received large-scale investment from Polar Electro since the 1980s.

[126] Interview with Jouko Möttönen, currently vice president of Polar Electro, who started working for Aspo (and its subsidiary Paramic) during his student days at the University of Oulu.

Nokia's cellular phone division and the appearance of Lauri Kuokkanen

Nokia today is among the world's top ten companies in terms of assets, a global colossus manufacturing cellular phones, base stations, digital switching systems and much more. That Finland, with a population just above five million, could produce such a mammoth enterprise is astonishing in itself. As is well known, Nokia had modest beginnings as a maker of paper, rubber, and electric cable.

Nokia was the name of a paper and pulp plant established in 1865. It was 1967, however, before the firm joined with Finnish Rubber Works, a rubber boot manufacturer founded in 1898, and Finnish Cable Works, founded in 1912, to form the Nokia Group.[127]

In 1960, an affiliated firm, Finnish Cable Factory, entered the electronics field, marking the start of Nokia's involvement with electronics. Nokia's first move into Oulu came in the same year with the opening of an electrical cable plant by a Finland Cable Factory affiliate, Northern Cable. The plant grew steadily, employing about a thousand people by 1970, but it had no connection with electronics.

Finnish Cable Works, which entered the electronics field in 1960, was a developer and manufacturer of computer terminals and wireless telephone systems; the director of its cellular phone division in the mid-1960s was Matti Otala, prior to his move to the University of Oulu. Dr. Otala was succeeded by Lauri Kuokkanen, a developer of cellular phone filters and an important figure in Nokia's development who later started his own firm, Lauri Kuokkanen Oy. Nokia bought Finnish Cable Works in 1966 and, in 1967, the Nokia Group was born. (Nokia's electronics division then had a total of 460 employees.)

In 1973 Nokia moved its entire cellular phone division, including factories, to Oulu's Rusko district. Oulu was not new territory for Nokia as it already had an electrical cable plant there. At the same time, in those days it was hardly to be expected that the company would make Oulu its home base for cellular phones. Lauri Kuakkonen, the chief of the cellular phone division at the time, speaks of his surprise at Nokia's move to Oulu.

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[127] Entries on Nokia are based on information obtained from the company's website (http://www.nokia.com/A4126375) and Mika Kulju (2002), pp. 75-91.

> The cellular phone division moved to Oulu in the winter of 1973. Almost twenty people came up from the South, and many more were hired from around Oulu. I think the main reason for the move was the presence of a thousand-person electrical cable plant in the city. Kirk Wikstedt, the president of Nokia Electronics at the time, and I were talking in a hallway. We decided then and there to move the cellular phone division to a developing region in the North or the East. I had imagined someplace like Karelia, in the East (near Mr. Kuokkanen's birthplace, Sortavala[128]). But I later learned that the decision had already been taken to move to Oulu, in the North. I was told that Oulu was the only possible choice. Only a few people seem to have been responsible for this decision, and I can't imagine that a great deal of research went into it. Björn Westerlund was president of the Nokia group in those days (time in office: 1967-1977), and the fact that his family had its roots in Oulu may have had something to do with it. I also heard that there had been some political pressure from the President (Urho Kekkonen, who served from 1956 to 1981). For Oulu, it was like winning the lottery. I don't think Oulu had the necessary preparations in place at the time. If (the cellular phone division of) Nokia hadn't chosen to move there, Oulu would have had a vastly different future. Mind you, there are regions that have attracted important companies only to see them withdraw; Raahe and Ericsson come to mind. (Oulu, therefore, may well have had what Nokia needed to stay in business there.) (Additions in parentheses are the author's.)

Considering the developments made in priority research fields by the university's Department of Electrical Engineers, and the massive efforts made by Dr. Oksman, Dr. Otala and their colleagues, Mr. Kuokkanen's assessment of Oulu seems a trifle severe. In 1973 the university had begun its research in electronics, information technology, and wireless telecommunications, but there was as yet no VTT Electronics Research Laboratory – it was just about to open – and the only component of an "electronics-based industrial conglomeration" was one Aspo subsidiary. Considered from this perspective, Mr. Kuokkanen's impressions seem only natural for someone who had previously had no connection with Oulu. Indeed, much that he said was valid.

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[128] Because Finland recognized the Soviet Union's sovereignty over Karelia under the peace treaty of 1947, this area is now the Russian Republic of Karelia.

In this paper, however, I take the view that it was a positive strategy taken by Oulu itself[129] – involving the active solicitation of major enterprises such as Nokia's cellular phone division and the VTT Electronics Research Laboratory – that caused good luck to translate into industrial development and the formation of a regional ICT cluster. In other words, I believe that not only was Oulu "saved" by Nokia's move, but that the Oulu region, through its strategic efforts, contributed in no small way to Nokia's growth.

In 1976, Nokia expanded the range of products manufactured at the Rusko plant by adding modems and PCM equipment[130] to the items handled there. By 1978 the plant employed 330 people and had grown into a major production site in Finland's electronics sector. Later, although Nokia moved the home base of its mobile phone division (handsets) to Salo as a firm named Mobira – a 1979 joint venture with Salora, which was based in Salo – Oulu developed as a center of base station production. Development of analog networks for NMT base stations began in 1979 at the Rusko plant, with production following a few years later. When Nokia took its base stations into the global market in the mid-1980s, this grew into an important business which helped fuel the growth of Oulu's high-tech cluster. In the latter part of the 1980s, the firm used Oulu Technology Village, the first science park in Northern Europe, as a site for the development of embedded software for mobile phones (handsets). At the same time, in cooperation with the University of Oulu and the local firm Electrobit, it launched research into CDMA[131] for third-generation mobile phone systems. For Nokia's operations in Oulu, the 1970s through the 1980s were a time of enormous expansion.

In 1976, three years after moving to Oulu to head the cellular telephone division at Nokia, Lauri Kuokkanen left the firm to start Insele Oy, a manufacturer of metal components for the electronics industry (later bought out by Nokia). The reason for his

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[129] Professors Oksman and Otala, and their colleagues at the University of Oulu, can be seen as the core "activity group" operating at that time.

[130] Equipment which converts analog signals for audio, for example, into digital data. PCM: pulse code modulation.

[131] Abbreviation for *code division multiple access*. A general term for a system of telecommunications technology enabling multiple communications to be sent on the same frequency within the same band. The original technology was used in satellite and military communications (cipher communications). Research aimed at making it available for civil use (third-generation mobile phones) took off in earnest in the 1980s.

resignation was that the company had asked him to take charge of all Nokia operations in Oulu, a job he regarded as unfeasible. A development engineer to the core, he could not see himself administering a field in which he had no expertise; nor did he feel suited to running a large organization with over two hundred employees. After launching Insele, Mr. Kuokkanen was urged by his stockholders to concentrate on automatic temperature controllers for household use. His own desire, however, was to focus on the development of duplex filters for wireless communications, which he saw as a promising field within his own area of specialty. In 1978 he launched Lauri Kuokkanen Oy with that aim in mind. As duplex filters were core components of the cellular phones that later would become Nokia's main business – at the time, they were delivered to Mobira, established in 1979 through the merger of Nokia and Salora's wireless telephone divisions – this not only helped Nokia but translated into substantial growth for Lauri Kuokkanen Oy. However, Mr. Kuokkanen did not take to running Kuokkanen Oy and in 1985 he sold most of his shares to Nokia. (Under the new name of LK Products, the firm later grew into one of Europe's major producers of duplex filters. In 1998 it became a subsidiary of the British firm Filtronic.) In 1986 Mr. Kuokkanen started a new firm, Solitra Oy, and began producing components and other items for Nokia – which was rapidly expanding its production scale in Oulu – to use at its base station plant in Rusko. Solitra did well, and in 1993 Mr. Kuokkanen sold his shares in the company. It was later bought by two U.S. firms in succession, ADC and Remec, and carries on in operation today. Establishing Ultracom Oy, he then focused on the development of wireless data transplant applications. Since 1993, Mr. Kuokkanen has launched and sold another firm, Ultraprint, and continues to run Ultracom Oy along with Ultra-Crea Oy, a manufacturer of high-frequency wireless devices founded in 1996.

Lauri Kuokkanen did much more than establish Nokia's wireless telephone business in Oulu. (Though the home base for mobile phone handsets moved to Salo along with Mobira, Nokia's joint venture with Salora, Nokia's mobile phone base station division put down roots in Oulu and did well there.) Even after leaving Nokia, he developed the core component used by Nokia in its mobile phones – delivered, however, outside the region, as Nokia produced its mobile phones in Salo – and launched a large number of high-tech companies important to the Oulu region. These accomplishments have been of enormous benefit to Nokia itself and to the Oulu ICT cluster. As both businessman and engineer, Mr. Kuokkanen remains a vital part of the industry today. Oulu has had the immense good fortune not only to be home to Nokia's wireless

telephone division, but also to have gained a peerless development engineer and entrepreneur in Lauri Kuokkanen. For his development of duplex filters for wireless communications and the launching of numerous important high-tech firms, the Nokia Foundation honored him in 1995 with the first Nokia Foundation Award. In 2002, at its graduation ceremony for doctorate recipients, the University of Oulu presented Mr. Kuokkanen and Dr. Oksman with its most distinguished title, the rarely awarded Honorary Doctorate of Engineering, in recognition of their tremendous contributions to the Oulu region.

Birth of Polar Electro: A High-tech Firm with Origins in Oulu

No discussion of the electronics firms operating around Oulu in the 1970s would be complete without mentioning Polar Electro Oy, the originator of the wristwatch-style heart-rate monitor.[132]

Polar Electro was founded by Seppo Säynäjäkangas, who was the first graduate of Oulu University's Department of Electrical Engineers – he was a member of the Department of Applied Electronics under Dr. Otala – as well the first from the department to earn a doctorate and the first to become a professor. According to Mika Kulju (2002), the inspiration for a wrist-worn heart-rate monitor came to Dr. Säynäjäkangas when, while skiing in nearby Kempele, a junior-class ski coach asked him to develop such a device to use in his students' strength training. With Finland's Olympic Committee covering part the research costs, Dr. Säynäjäkangas developed the product in collaboration with his students at the Applied Electronics laboratory. In 1978 he decided to launch his own company after attempts to sell the product and its technology to the private sector proved fruitless.[133] Polar Electro was quick to take off, and, by the early 1980s, the firm and Dr. Säynäjäkangas were able to invest in other high-tech startups in the Oulu region (including Bascom; Jutel, the maker of radio broadcast systems; and the software firm CCC). In those days, when Oulu could offer very little in the way of venture funds or other sources of risk money, Dr. Säynäjäkangas and his firm were an important presence indeed. By the early 1990s Polar Electro was exporting its products (winning the President's Export Award in 1992) and was well on its way to becoming synonymous with Oulu's high-tech industry. In the middle of the decade the firm was a central force in drafting and implementing

[132] Entries on Polar Electro Oy are based on information taken from Mika Kulju (2002), pp. 93-107, and the company's website (http://www.polar.fi/).
[133] Ibid., pp. 93-95.

Oulu's regional policy, along with the Oulu city government and Chamber of Commerce. It continued to function as an "angel" to the region's businesses by supplying hard-to-find venture capital. (When the Raahe steelmaker Rautaruukki withdrew from the electronics business, Polar bought its subsidiaries Idesco Oy[134], an IC card manufacturer, and Fincitec Oy, a designer of custom IC cards.) While nowhere near Nokia in scale, in terms of quality the firm was now a key actor in the Oulu ICT cluster. Dr. Säynäjäkangas remained as head of the Department of Electrical Engineers until 1981[135], when he left to concentrate on his business interests (continuing, however, to teach entrepreneurship at the university until 2002). As a businessman with roots in the academic community, he has long served as a role model for the region's up-and-coming entrepreneurs. It was significant that an entrepreneur of his ability should appear from academia almost overnight.[136] And the emergence of such a company in the virtual absence of an "industrial ecosystem" was, in a sense, equally remarkable. At the same time, Jouko Möttönen, a vice-president with the company, said in an interview that "Nokia's global business initiatives provided a good benchmark for Polar Electro's aggressive moves into the international market."

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[134] In March 2006, Polar Electro sold its shares in Idesco to the venture capital firm Sentica Partners Ltd.

[135] His feat is particularly astounding when one considers that while he was starting up his new company in 1978, he was also, until 1981, teaching large numbers of students at the university as head of the Department of Electrical Engineers. Given the general view of academic-industrial partnerships prevailing in the Finland of 1978, the fact that the university agreed to his holding his teaching post while simultaneously serving as a corporate CEO speaks eloquently of the university's strong commitment to the economy of northern Finland. (Dr. Oksman recalls, "Dr. Mannerkowski, the school's president at the time, easily agreed to Dr. Säynäjäkangas's dual career; but, now that I think of it, it was such a monumental decision that we should have had him sign some sort of document to back it up."

[136] Although it was not possible to obtain an interview with Dr. Säynäjäkangas, Mika Kulju (2002) describes him as having been born into a farming family in Kemijärvi, in Lapland. In 1944, while still young, he lost his father in the Continuation War with the Soviet Union, a tragedy that instilled in him a strong sense of responsibility and patriotism (Kulju, p. 99). Earning high marks as a member of the inaugural class at the University of Oulu's Department of Electrical Engineers as a favorite student of Drs. Oksman and Otala, he was for many years intimately involved in creating and implementing a vision for the promotion of electronics in northern Finland. After a chance opportunity led to the founding of Polar Electro, Dr. Säynäjäkangas presided over its development into a global exporter. A strong will was required to bring about this achievement, which was a first for a high-tech company originating in Oulu. To prepare a US sales network in the course of its global expansion, Polar Electro embarked on a series of buyouts that were distinctly bold for the times. In fact, there are any number of indications that Dr. Säynäjäkangas took a fairly daring approach to business. The abrupt appearance of such an entrepreneur is not only attributable to his upbringing, but also to his sharing of far-reaching visions with Drs. Oksman and Otala.

Thus, the principal electronics firms around Oulu in the 1970s were Nokia's wireless communications business, which moved to Oulu by a piece of good fortune; the electronics division of Kajaani, which, influenced and supported by a university professor (Dr. Otala), emerged through the diversification of the existing industry; Aspo, which moved to Oulu from the South in connection with joint research with a university professor (Seppo Leppävuori, acting professor for Dr. Otala); and Polar Electro, one of the university's earliest productions. While none of these firms was particularly sizeable at the time, each – aided by the activities of Oulu University and its Department of Electrical Engineers (since 1975 the Department of Electrical Engineering), and by Dr. Otala's energetic vision – was setting forth on a path that differed markedly from those of its predecessors.

4.3.2 Principal Initiatives in the 1980s

① Sense of Crisis in the Oulu City Government; the Founding of Technology Village

As we have seen thus far, the late 1950s through the 1970s was a fertile time for Oulu. The Department of Electrical Engineering at Oulu University and the VTT Electronics Research Laboratory were focal points for research on electronics, information technology and wireless communications, and produced between them a number of important companies. These were to prove vital to the development of the corporate conglomeration and individual firms that followed in the 1980s.

At the same time, however, Oulu was beginning to lose jobs in its traditional industries of chemical fertilizers and paper and pulp. Troubled by a heightening sense of crisis, the city government led the construction of the first technology park in Northern Europe: Technology Village. It is worth taking a look at the events that led up to its opening.

Speech by Aspo Director Antti Piippo

Aspo had moved into Oulu in the early 1970s via its subsidiary, Paramic Oy, and in 1980 it expanded its plant in the city. A dedication ceremony was held in March of that year, and an event that took place there proved epoch-making in terms of the formation of Oulu's ICT cluster.

Antti Piippo, director of Aspo's electronics division, saw great promise in Oulu as a center of electronics development, as the region benefited from the presence of both Oulu University and the VTT Electronics Research Laboratory. A frequent visitor to Oulu from 1979,[137] he praised the area's potential in an opinion piece contributed that fall to the local newspaper, *Kaleva*.[138]

> The important institutions in Oulu are Oulu University and the VTT Electronics Research Laboratory, where basic research is conducted in this field.
>
> The electronics sector is flourishing, and many towns are striving to keep up. Industries and individual firms in the electronics sector would benefit from investing in the same region.
>
> Oulu has the potential to grow into one of Finland's important centers of electronics. The level of education in the field and the wealth of research being conducted are strengths that are unique to the region.

In Antti Piippo's view, Oulu's decision-makers, starting with the city government, did not fully appreciate the opportunities the region presented and were not taking the steps necessary to pursue them. An interview with him, in which he voiced this criticism in biting terms, appeared in *Kaleva* on the day of the ceremony marking the plant's expansion; these same views were expressed in a speech he gave at the ceremony itself. Jouko Möttönen, who worked at Aspo at the time, recalls that in the speech, "Antti Piippo said that compared to Silicon Valley, Oulu was still 'asleep' and that development opportunities were likely to recede into the distance while it slept." Representatives of the city sought to counter his criticisms in their own speeches.[139]

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137 According to Seppo Mäki, Antti Piippo made frequent business trips to Oulu, and with each visit became more impressed with the city's living environment and its potential as a high-tech community.

138 Mika Kulju (2002), pp. 114-115.

139 Jouko Möttönen, now vice-president of Polar Electro, describes the scene as follows: "After Antti Piippo gave his speech at the dedication ceremony for Aspo's new plant, a representative of the city (the head of the city council) voiced a decidedly primitive sort of objection in which he denied every one of Piippo's points. The atmosphere was far from friendly. The general feeling was that Piippo was wrong to speak so disparagingly of the region on such a public occasion. But Antti Piippo is a person who says what needs to be said,

But soon after the ceremony's conclusion, two of the more thoughtful people in the audience showed that Antti Piippo had made his point. These were Veli-Markku Korteniemi, head of product development and marketing at the VTT Electronics Research Laboratory, and Juha Linna (formerly Castrén), representative of the Oulu branch of KERA (now Finnvera[140]), a government bank for regional development. The day following Piippo's speech, the two submitted a proposal to the city council urging that a "technology village" be constructed at an early date.

The idea for a technopolis had been considered at least since the late 1970s, when it was a topic of discussion among some members of the University of Oulu and VTT Electronics Research Laboratory communities. The technopolis concept was first raised publicly by Martti Karppinen, then on the staff of VTT, in a speech given in 1978.[141] According to Dr. Mannerkowski, the university's president at the time, "A visit by Erkki Koiso-Kanttila, the university's previous president, to Stanford University (and Silicon Valley) in the late 1960s led to the development of the technopolis concept in Oulu."[142] As I have mentioned, the feeling in Oulu in the late 1970s – a time of declining employment in traditional industries – was that *something* had to be done.[143] Antti Piippo's blistering comments seem to have ignited an explosive reaction among those who had already sensed a problem. For that reason alone, the city's response to the proposal was swift in coming. Ilmo Paananen, Oulu's mayor at the time, had no background in engineering, but he did possess a deep understanding of new industries. His efforts toward realizing Technology Village were greatly appreciated by all concerned. Seppo Mäki says the following about Mayor Paananen's ability to comprehend the situation.

I remember Dr. Otala's speech from 1975, and believe that the mayor listened

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regardless of the audience. He remains extremely active even today." Piippo is currently chairman of the board and a major shareholder in Elcoteq SE, now Europe's largest EMS firm.

[140] Finnvera is a wholly government-funded, public financial institution. It supplements private banks in financing projects aimed at corporate growth, regional development, and export promotion. Headquartered in Helsinki and Kuopio, it has regional offices in 16 municipalities including Oulu.

[141] Mika Kulju (2002), p. 117.

[142] Mika Kulju (2002), p. 117.

[143] Seppo Mäki describes the situation at the time: "Since the late 1970s, the chemical fertilizer producer Kemira Oy, and the paper and pulp makers Oulu Oy (now Stora Enso) and Toppila Oy (out of business since the mid-1980s) had been laying off workers. In the Oulu city government there was a growing feeling the something should be done." (Additions in parentheses are the author's.)

very carefully to what the university scholar had to say. Mr. Paananen had been to Silicon Valley and observed the situation for himself. He provided a great deal of moral support.

With the mayor's strong backing, the City Council formed a study team, the Electronics Working Group, which in September of 1980 presented a report proposing the construction of a technology village on a site adjacent to Oulu University.[144] Members of the Working Group included representatives of the VTT Electronics Research Laboratory, where the two authors of the reportl were employed, and the government institution KERA, as well as the University of Oulu, Aspo, and the Oulu city government (city government employees, rather than city council politicians).

The report was compiled by Paavo Similä, a member of the Oulu city government who went on to become head of the city's Bureau of Economic Affairs and currently president of the Business School at Oulu Polytechnic. More a development plan than a study,[145] the proposal called for the project to be developed as a "technology village" comprising processing industries and information technology as well as electronics, rather than an "electronics village."[146]

Acceptance of the development plan was followed by a massive effort, led by the city government, to make Technology Village a reality. Seeing a need to supplement city government employees with people from the private sector, Imo Paananen looked at over twenty candidates before selecting Seppo Mäki to be the project's business relations manager. Mäki had joined the agency in April 1981, bringing with him a wealth of experience in business management. He was central to the establishment of the Technology Village Committee in June of the same year. In September, Paavo Similä prepared another report which essentially was a business plan for Technology Village Corporation (Oulun Teknologiakylä)[147] While the report took cues from science parks

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144 The area, called Linnanmaa, was originally marshland.

145 Among those who regarded the report as a study was Olavi Jakkula, who worked in the President's Office at the University of Oulu. The report of September 1980 is said to incorporate the essence of a publication he issued in 1978 entitled *The Potential of Northern Finland's Electronics Industry*, which reflected the views of such experts as Dr. Oksman and the president the University of Oulu.

146 Interview with Seppo Mäki.

147 In 1998 the company name was changed to Technopolis Oulu Corporation (Technopolis Oulu Oyj). In 1999 the firm was listed on the Helsinki Stock Exchange, and in 2000 the name was shortened to Technopolis Corporation (Technopolis Oyj). *Oulun Teknologiakylä 1980-1988: Miten Syntyi Oulu-ilmiö*, an account of the activities of Oulu Technology Village

in other countries, in their actual workings these other parks were quite different from the model of entrepreneurial support envisaged by the Technology Village Committee.[148]

On March 31, 1982, six months after the publishing of the report-cum-business plan, Technology Village Corporation held an inaugural meeting at Oulu City Hall. Half of the 2 million Finnish marks in capitalization was supplied by the Oulu city government; eighteen private companies, the University of Oulu, and KERA, the bank for regional development, supplied the rest.

Obtaining capital from the private sector was not an easy task.[149] The city fathers regarded the project as basically a private-public partnership (PPP), still a novel concept in their view despite its growing popularity. According to Seppo Mäki, the project would have had to be abandoned if funds from private companies had not been forthcoming. Indeed, it was in order to realize Technology Village as a PPP that Oulu's city leaders had scouted Mäki[150] as someone who could bring them the management skills they needed. Until he left the city government in 2000, Mäki remained at his post of business relations manager, marketing the city of Oulu at home and abroad. But it was his single-minded efforts to get investors for Technology Village that still inspire head-shaking admiration among key people involved in project. The following is an account from Jaakko Okkonen, executive director of the Oulu Chamber of Commerce and Industry:

> In the 1980s, the main role in fund-raising was played by the Oulu city government. The most prominent figure was Seppo Mäki, who served as Oulu's spokesman and architect of the Technopolis. Each and every day he would go around the city selling shares in the company.

Mäki's efforts after the inaugural meeting were no less impressive than those that led up to it. As Technology Village expanded, he worked tirelessly to raise the necessary

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Corporation published by SITRA in 1988, gives the English name for Oulu Technology Village as "Oulu Technology Park" (English summary). Titles used in a map of the Technology Village area suggest that the contemporary Finnish name was "Teknopolis Oulu."

148 Interview with Paavo Similä (pp. 92 of this paper).

149 Interview with Seppo Mäki.

150 Mäki says that his family has been involved in commerce and business management for many generations.

additional capital. Mäki himself has the following to say about the increase in investors and the city government's basic stance on public-private partnerships.

> There were twenty-one shareholders in Technology Village at the outset; these included eighteen private companies, the City of Oulu, the University of Oulu, and KERA. By 1992, when I resigned as chairman of the board, there were about four hundred; in 1999 we went public and today the number stands at four thousand or so. Today's shareholders include foreign investors, some of which are American pension funds. At the time the corporation was founded, Oulu City held 50% of the shares, but only two of the city's seven directors were committed to the company and those were city government employees. No city council members were included. In Imo Paananen's view, as public employees we did not wish to lead (a project which required inputs of private-sector expertise). For the politicians involved, there was also the issue of elections to consider. That was when the idea of a private-public partnership really took hold.

At the beginning there were seven people on the board of directors, with Seppo Mäki serving as chairman.[151] The post of vice-chairman was filled by Jarmo Karvonen, a former member of the VTT Electronics Research Laboratory who went on to become director of development for Kajaani Electronics. Also on the board were Martti Karppinen, another employee of the VTT lab and the first to speak out on the technology village concept; Sakari Kurronen, dean of the Engineering Department at the University of Oulu; Tapio Takalo of KERA; Heikki Ojanperä of the chemical firm Pharmos G (later Orion G); and Paavo Similä of the Oulu city government. Most were members of the Technology Village Committee since June 1981. (The board was later expanded to nine members, including Reijo Lehtonen, president of a cable company and head of the Oulu Chamber of Commerce and Industry.)

Having managed to secure sufficient capital, Technology Village Corporation was now in business. Science parks did exist in other countries, but the scheme envisaged for

[151] Seppo Mäki served as board chairman from the company's founding until 1992. The mayor of Oulu later took over the position. (At present the deputy mayor represents Oulu City on the board.)

Oulu – a place where high-tech startups could obtain everything they needed – was absolutely new. The founders had to feel their way forward. Paavo Similä, author of the committee's report, says the following about the corporate philosophy of meeting the needs of Technology Village's high-tech tenants and supporting their growth, which underlay the project's business model:

> The report (of the Technology Village Committee) issued in September 1981 reflects the views of the many people interviewed in its making. It outlines a business plan for Technology Village. In compiling the report, we searched the literature on science parks in France, the United Kingdom, and America. After Technology Village was launched we carried out on-site surveys (of these science parks). When we put the report together, we relied on written materials and pamphlets sent to us by the science parks themselves. From these we learned how the parks were organized, and also about their functions, targets, operation, and relationships with local universities and firms. We found that they were structured in a way that was quite different from what we envisioned. Our on-site investigations found that many local companies had complaints. In Edinburgh , for example, the park's efforts extended only to making land for research facilities available next to the university. A number of firms saw no particular benefit in this other than proximity to the school. We, on the other hand, recognized that the needs of high-tech companies are diverse, and we intended to answer these needs and go on answering them. It was not I who came up with this idea, but the whole committee, through day after day of spirited debate. To a great extent, our methods developed as a result of frequent discussions held by Timo Patja, the first president of Technology Village Corporation (from 1982 to 1985), and Pertti Huuskonen, his successor (1985 to the present), with our tenants. Technology Village owes a lot to these two men, both of whom had launched high-tech firms of their own. If the only goal had been to provide corporations with land, it could have been met just as easily by the construction industry. We wanted something different for Technology Village. (Additions in parentheses are the author's.)

In these remarks we can see the entrepreneurial principles behind Technology Village, which, in 1999, accomplished something unusual for a science park when it was listed on the Helsinki stock exchange. Also evident is a philosophy that stresses the accumulation of information and skills from all available sources. The role of the

company's two presidents was, as Paavo Similä pointed out, profoundly important. At no time was this truer than at the startup stage, when the company chose an old dairy plant to house its first facilities. A commitment to learning enabled Mr. Patja to overcome the many obstacles involved in remodeling the old buildings into a modern workplace.[152] In October 1985, work on the first buildings began at Linnanmaa, adjacent to the University of Oulu, in accordance with the original plans. The company was now under the leadership of Pertti Huuskonen, a graduate of the university's Department of Electrical Engineering and himself an experienced entrepreneur. Using his network of contacts to the fullest, he worked hard to expand the company's operations, taking every opportunity to publicize the Oulu Technopolis at international conferences[153] and other global venues. The project was fortunate to have exactly the right president for both the startup and development stages.

While the two presidents provided vital leadership, others also made essential contributions. During the 1980s in particular, Technology Village Corporation and the City of Oulu tended to be of one mind about the project. The city government took charge of promotion policies for the city's high-tech industries and for regional strategies as a whole, while the job of Technology Village Corporation was to develop and implement the skills needed to support high-tech firms. (Although the corporation was a third-sector company with a contribution half that of the City of Oulu, the city government advocated a PPP arrangement from the beginning as it wished to avoid interfering in the firms' business at all costs. With a president who was himself a talented entrepreneur, the corporation avoided the inefficiencies that are liable to befall a third-sector enterprise.)

In this sense, the city government played a key role in the formative strategies for Oulu's ICT cluster during the 1980s. Following the launch of Technology Village Corporation it prepared a five-year industrial policy for the years 1983 – 1987. This was a comprehensive policy which covered the operation of Technology Village Corporation and attracted a good deal of interest when, in 1984, it was announced along with thecatchphrase "City of Technology."

The five-year program, "Economic and Business Development Program: Oulu as a City

[152] Mika Kulju (2002), pp. 124-127.
[153] For example. annual general meetings of the International Association of Science Parks (IASP).

of Technology," offered practical plans for what many regarded as the two central issues: how to promote the emergence of new industries and new companies in Oulu, and how to offer these new industries and companies the information and skills they would need to grow. With cooperation from the University of Oulu, the VTT Electronics Research Laboratory, Technology Village Corporation, Polar Electro, and other leading local firms, the program was put together by a four-man team: two experts in the form of Paavo Similä and Seppo Mäki; Hannu Salomaa of the consulting firm Hansakon; and publicity chief Jorma Ventila, formerly head of publicity for the steelmaker Rautaruukki. The program's regional strategies – some of which would only later see the light of day – involved, among other things, the creation of a University of Oulu liaison officer, starting in 1986 and operating with city funding for the first three years; the Enterprise Forum, an entrepreneurial seminar for students, initiated in 1986 and administered by the university liaison officer; and the Oulu Soft Project, an industry-university collaboration for local software.

The author of the report outlining this strategy was Paavo Similä, who had written the report of the Electronics Working Group in 1980 and would now manage the project team formed to implement the program.[154] According to Mr. Similä, the economic development program was planned and put into practice by a network of individual "key persons" in the Oulu area.

> In 1984, we called for a basic strategy for the city of Oulu – the "City of Technology" strategy. I was the project's manager. The major players at that time included the University of Oulu, the VTT Electronics Research Laboratory, the Polytechnic (then the Institute of Technology), the Oulu city government, Polar Electro and a few other companies, and Technopolis. Unlike the situation in 1990, this group did not include local governments or a great many private firms from the Oulu region. Rather, I think it was the functioning of a network of key persons that produced results. (Additions in parentheses are the author's.)

The "City of Technology" catchphrase proved a big hit and was used for years thereafter to symbolize the city of Oulu. Various strategies were drawn up to publicize

[154] When the city government established a Bureau of Economic Affairs upon the project's completion in 1988, Paavo Similä was named its director.

the phrase, including posters made out of composite photographs. Seppo Mäki describes the process:

> Our publicity expert, Jorma Ventila (one of the formulators of the program), wracked his brains to find ways to make the concepts behind Oulu's regional strategies understood by people in other areas. He came up the phrase "City of Technology" as a means of doing this. He also arranged a variety of events and invited people from Helsinki to attend. He really left no stone unturned in his attempts to get the phrase across. To get people to comprehend the idea of a "City of Technology," he had an aerial photograph taken of the city center, superimposed on it an image of electronic components on a circuit board, and had this made into posters and postcards. That was my idea. To a modern eye the image of electronic components mounted on a circuit board may seem a trifle dated, but the technology it depicted was new at the time. Since we didn't want to pay for our publicity activities with Oulu taxpayers' money, we decided to rely on more tangible things, such as events, to publicize the Technopolis and regional strategies. (Additions in parentheses are the author's.)

The Oulu region had not yet become known as the site of an ICT cluster. The region was still trying to sell Oulu as a high-tech city, using Technology Village – the first science park in Scandinavia – as a lever. But even in terms of building the city's reputation as a center of high technology, we can see a considerable element of strategy in, say, the use of professionals to handle publicity.

Visit to Oulu by USSR President Mikhail Gorbachev

In 1989, USSR President Mikhail Gorbachev visited Oulu at the invitation of SITRA, the Finnish national fund for research and development. The Oulu Bureau of Economic Affairs arranged the visit, one of its most important accomplishments of the 1980s. By the end of that decade Technology Village had gained considerable fame in Scandinavia as a science park. In 1988, SITRA had published a log of the activities of Technology Village Corporation subtitled "A Chronology of the Oulu Phenomenon,"[155] sparking the interest of the Soviet Union Academy Group which sent a delegation to

[155] According to Dr. Oksman, the term "Oulu phenomenon" came into use in the late 1970s, when the electronics industry was putting down roots in the Oulu region.

the city. One member, an advisor to the Prime Minister, was so impressed with the development that Technopolis had brought to the region and with the strategic thinking and hospitality[156] of the city's Bureau of Economic Affairs, that he strongly recommended that Oulu be included on President Gorbachev's itinerary for his visit to Finland in 1989. The Soviet President's visit served as an important pillar of the publicity effort for many years to come.[157]

② Corporate Trends from 1985 through 1989

The establishment of Technology Village in the 1980s was instrumental in promoting corporate conglomeration. In the following I summarize the more important trends in this process.

Development of Embedded Software by Nokia Mobira

In March 1986, work was completed on a structure begun the previous year in Linnanmaa, adjacent to the University of Oulu, where Technology Village had moved from the city center. In addition to Nokia Mobira, three other companies rented space in the buildings.[158] Nokia had begun developing base stations in Oulu's Rusko district in the latter half of the 1970s, and by the early 1980s was manufacturing there on a considerable scale. It was in the latter half of the 1980s, however, that Nokia Mobira started developing embedded software for mobile telephones – just when Technology Village was starting full-fledged development in Linnanmaa.[159]

The central figure at this time was Erkki Veikkolainen, who had moved to Nokia Mobira from the VTT Electronics Laboratory. Veikkolainen had graduated in 1980 from the Department of Electrical Engineering at the University of Oulu, joining VTT in September 1981 after working for a short time in western Finland. In 1983 he became deputy head of the division working on embedded software and engaged Nokia Mobira in its joint development. In 1984, Mobira had decided to develop its embedded

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156 Seppo Mäki made an enormous contribution to the selling of the city of Oulu internationally.

157 During his visit to Helsinki, President Gorbachev was filmed using a Nokia mobile phone to call Moscow. The image was aired throughout the world and was an outstanding publicity boon for Nokia. (Staffan Bruun & Mosse Wallen (1999), p.94 of the Japanese translation)

158 These were Noptel Ky, Prometrics Oy, and Outel Oy (Mika Kulju (2002), p. 142).

159 Entries on Nokia in and after the latter 1980s are based on Mika Kulju (2002), pp. 130-134.

software for mobile phones in Oulu[160], and commissioned that work to the division at VTT. (Mobira had only one or two embedded software experts at the time.)

Dr. Veikkolainen joined Nokia Mobira in 1985, and immediately upon doing so he assumed responsibility for the development of embedded software for mobile phones. He increased the number of development staff in Oulu from the start, turning also to outsourcing for many processes. His reasons were twofold: first, he saw this as the most rational method of software development; second, he wanted to make sure that high technology became firmly established in the Oulu region and northern Finland as a whole. Dr. Veikkolainen has this to say about the distinguishing features of software development and his flexibility in using outside companies for some of the processes involved:

> As I saw it, taking a flexible approach to outsourcing, rather than insisting on having all development personnel in-house, brought advantages in terms of time and dynamics. Nokia would benefit, of course, but so would the entire region. Nokia Mobira had just launched its development unit for embedded software for mobile phones, and in order to achieve success, I felt we needed to create an environment in which we could work together with a set of partner companies. And, we needed to share a vision with these partner companies. This kind of thinking is the norm today, but in those days I was in the minority. It was a logical way to think, however, since for each software development project one has to form dedicated teams to deal with hardware, radio frequency (for wireless communications) and mechanicals. When several projects are pursued at a time, it is impossible to gather the number of people required from within the company (or, conversely, you might find yourself with an excess of personnel). (Additions in parentheses are the author's.)

In terms of his contribution to regional development while at the University of Oulu and the VTT Electronics Research Laboratory, Dr. Veikkolainen was strongly influenced by Dr. Oksman and Dr. Otala, who headed the Laboratory at the time. Dr.

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[160] In Dr. Veikkolainen's words (reprinted from Chapter 4-3-1), "One reason for Mobira's choice of Oulu as its center for (software) development was the leading-edge research in software being conducted at the University of Oulu and VTT Electronics. Oulu at that time was already the site of the most advanced work in Finland. Another attraction was a talented workforce in the form of the University of Oulu graduates. People involved with the university worked hard to attract Mobira to the region. (Addition in parentheses is the author's.)

Veikkolainen, who took part as a student in a "Sauna Event"[161] held by the two professors in 1978 or 1979, recalls that at the event the three found they shared a vision of what should be done for the future of northern Finland. Perhaps this was why, immediately after joining Nokia Mobira as a local businessman, Dr. Veikkolainen took bold action based on clear-cut intentions. Dr. Veikkolainen says the following about his state of mind and the events which occurred at that time.

> In 1985 I wrote an article for a local newspaper, titled "Nokia Seeks Outsourcing Agents for Software." Juha Hulkko, who had just launched Elektrobit, read the article and paid me a visit. This was start of the alliance between Nokia and Elektrobit. Elektrobit was aiming to develop original products at that time, but for a while its main work was development subcontracting for Nokia. CCC was another such firm, and there were a number of others as well, but some of these were absorbed by other companies.
>
> During those years, many engineers who grew up in northern Finland and got their schooling at the University of Oulu went south after graduation and built up experience there. The shared perceptions that took root after the Sauna Event may have had something to do with it, but Nokia saw cooperation with Oulu's local companies as a good opportunity to contribute to the communities of the North. Juha Hulkko, the founder of Elektrobit, shared this view. Actually, the first thing I did upon moving to Nokia Mobira was to get in touch with people working in the South and asking them if they wouldn't like to come back to Oulu. Quite a few engineers in fact did." (Additions in parentheses are the author's.)

Both Elektrobit and CCC were started in 1985 by graduates of the University of Oulu.[162]

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[161] For the Finns, the sauna is both a form of hygiene and a social occasion (interview with Seppo Mäki). When, in the latter half of the 1960s, Dr. Oksman and Dr. Otala agreed on the need for promoting northern Finland and a vision for the development of the electric and electronics industries, this was referred to as the "Sauna Meeting." (Matti Otala, "Uskalla olla visas," Ajatus Kirjat, Jyväskylä, 2001 (here, from Mika Kulju,(2002), p. 56), and interviews with Dr. Oksman.

[162] Elektrobit was founded by Juha Hulkko, a graduate of the Department of Electrical Engineering; CCC by Timo Korhonen, a graduate of the Faculty of Science's Department of Information Processing Science.

They enjoyed growth as subcontractors of Nokia and grew into two of the most prominent high-tech firms of the Oulu region. The times were fortuitous for Dr. Veikkolainen and other Oulu business leaders. But to a great extent, they were motivated by people who worked at the university in the 1970s.

The mid-1980s were propitious in a number of respects: With progress in the accumulation of companies and the rapid growth of key firms, this was when the Oulu ICT Cluster began to take off. Five factors stand out as particularly important:

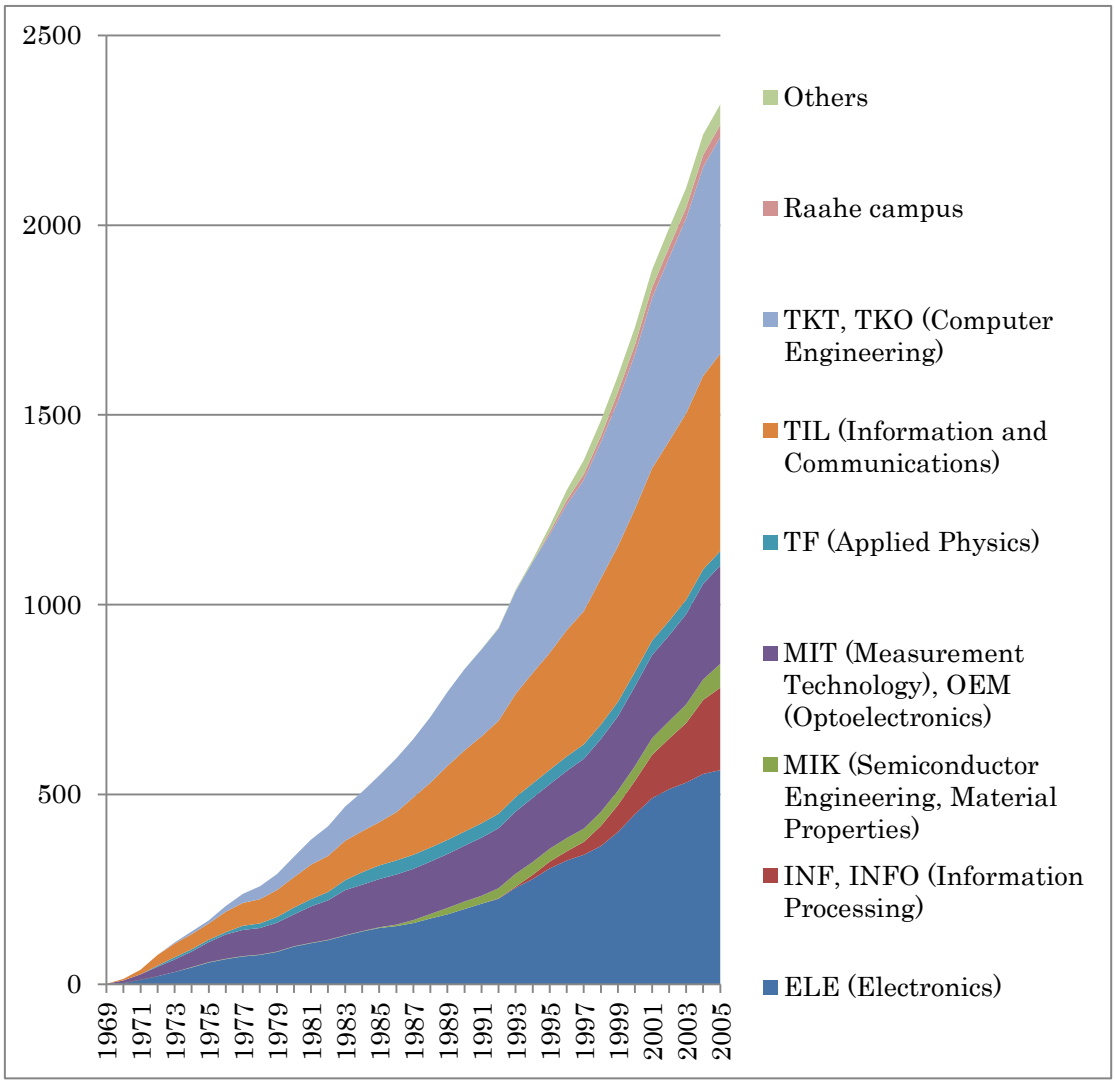
(1) Engineers were settling in the region in growing numbers. (While most graduates of the university's Department of Electrical Engineering looked for work in the South, several hundred remained in the North from the department alone; see Figure 4-15.)
(2) A key company, Nokia, was starting to expand its range of business and experience significant growth. (Nokia began taking its base systems global in 1984 and started developing embedded software for mobile phones in 1985; in the latter half of the decade it started research and development of CDMA technology for third-generation mobile telephone systems.)
(3) Oulu was an advantageous place to locate not only in the physical sense, but also because it now offered, adjacent to the university, a technology village filled with companies aspiring to serve as support systems for the new companies. (In March 1986, the first building on this site was completed.)
(4) In 1984, the City of Oulu implemented in full scale its "City of Technology" industrial policy.
(5) Augmenting all of the above was the Finnish Government's support for technological development. In 1987, Nokia Mobira, in partnership with the nation's Ministry of Defense, began working in Oulu with Elektrobit and the University of Oulu on the development of spectral diffusion technology, used in CDMA and other third-generation mobile phone systems[163] – a big factor in Oulu's subsequent development into a global center of mobile technology.

Petro Pulli, a professor at the University of Oulu's Department of Information Processing Science, and his colleagues believe it was the national government's unstinting support for the development of wireless communication technologies until 1995, when Finland became a member of the European Union, that enabled Nokia to

[163] Email message from Eero Vallström (April 28, 2006).

solidify its advantage in the global market in terms of, for example, technological development and market share. In their analysis, this was a major factor in Nokia's becoming the world's top manufacturer of mobile telephones and base systems in the decade's latter half.[164] This meant that Oulu reaped the benefits of national policies on industry and technology – an important point that should not be overlooked.

Figure 4-15 Numbers of Graduates of the Department of Electrical Engineering, University of Oulu, by Laboratory (Cumulative)



[164] Interview with Petri Pulli.

Data for Figure 4-15

Calendar Year	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
ELE (Electronics)	1	3	12	21	32	44	57	66	73	77	85	99	108
INF, INFO (Information Processing)	0	0	0	0	0	0	0	0	0	0	0	0	0
MIK (Semiconductor Engineering, Material Properties)	0	0	0	0	0	1	1	1	1	1	1	1	1
MIT (Measurement Technology), OEM (Optoelectronics)	0	7	14	25	33	41	53	64	69	70	76	84	96
TF (Applied Physics)	0	0	0	3	6	6	6	6	11	12	15	18	19
TIL (Information and Communications)	0	4	12	28	36	40	43	54	60	64	71	80	91
TKT, TKO (Computer Engineering)	0	0	0	0	3	7	8	15	24	34	42	54	66
Raahe campus	0	0	0	0	0	0	0	0	0	0	0	0	0
Others	0	0	0	0	0	0	0	0	0	0	0	0	0
Total number of graduates	1	14	38	77	110	139	168	206	238	258	290	336	381

Calendar Year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
ELE (Electronics)	116	128	139	148	153	161	173	184	198	212	225	254	277
INF, INFO (Information Processing)	0	0	0	0	0	0	0	0	0	0	1	3	11
MIK (Semiconductor Engineering, Material Properties)	1	1	1	2	4	8	12	17	20	21	27	34	34
MIT (Measurement Technology), OEM (Optoelectronics)	104	119	122	127	132	135	138	142	147	153	158	164	169
TF (Applied Physics)	22	26	33	36	37	37	37	37	37	38	38	38	38
TIL (Information and Communications)	95	104	108	114	127	151	171	195	214	229	245	272	291
TKT, TKO (Computer Engineering)	78	90	104	123	142	154	173	195	214	229	243	271	293
Raahe campus	0	0	0	0	0	0	0	0	0	0	0	0	0
Others	0	0	0	0	0	0	0	0	0	1	2	3	6
Total number of graduates	416	468	507	550	595	646	704	770	830	883	939	1,039	1,119

Calendar Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
ELE (Electronics)	305	326	341	364	401	448	490	514	531	554	564
INF, INFO (Information Processing)	18	24	34	53	71	88	114	133	157	195	217
MIK (Semiconductor Engineering, Material Properties)	34	35	35	37	38	39	44	46	49	54	63
MIT (Measurement Technology), OEM (Optoelectronics)	170	177	184	192	196	210	219	226	238	252	259
TF (Applied Physics)	38	38	38	38	38	38	38	38	38	38	38
TIL (Information and Communications)	308	333	351	385	410	429	454	474	491	510	520
TKT, TKO (Computer Engineering)	312	331	346	359	382	408	448	483	514	550	571
Raahe campus	7	11	15	16	24	25	28	28	28	32	32
Others	15	27	37	41	43	46	47	50	52	54	54
Total number of graduates	1,207	1,302	1,381	1,485	1,603	1,731	1,882	1,992	2,098	2,239	2,318

Source: Ilkka Heikura (2005), pp. 200-254, from directories of graduates of the Department of Electronic Engineering, University of Oulu.

③ Medipolis – The Technopolis Takes a New Direction

Information and computer technologies are the principal, but not the only, industries

comprising the Oulu hi-tech cluster. Bioindustry and the "wellness" sector also are major components. In the mid-1980s, promotion of bioindustry emerged as a topic of discussion for the Oulu city government's project team for the City of Technology. According to Mika Kulju (2002), Technology Village Corporation CEO Pertti Huuskonen had made the establishment of incubators for the bio- and wellness industries part of his business strategy as early as 1987.[165]

In 1988, after the Technopolis had moved to the Linnanmaa site next to the university, a working group took up the idea of a "Medipolis" to serve as the focus for firms in the bio- and wellness industries. The group included representatives of the Economic and Health and Welfare bureaus of the Oulu city government, Technology Village Corporation, the Faculty of Medicine of the University of Oulu (including the Institute of Biomedicine), Oulu University Hospital, and the public-sector Research Institute for Workplace Health.

The Medipolis project officially began in 1989. In June of the following year, Medipolis Oy was established as a 100%-owned subsidiary[166] of Technology Village Corporation and construction started at Kontinkangas, not far from the city center. A building was designed with an elevated hallway to connect it with Oulu University Hospital, and its construction in May 1992 marked the completion of Phase 1 of the Medipolis. This was followed by a 100-thousand-euro manufacturing facility, constructed according to good manufacturing practice (GMP)[167], for the commissioned production of pharmaceuticals. Taken as a whole, these investments have been criticized as growing at a slower pace, and delivering less than expected, when compared with industries in the ICT sector. Today, however, the Medipolis is home to fifty firms employing six hundred people.

4.3.3 Principal Initiatives in the 1990s

① Cooperation between the Oulu City Government and the Oulu Chamber of Commerce and Industry

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165 Huuskonen got the idea for a business plan while taking part in a conference on science parks held in Turku (Mika Kulju (2002), p. 149).

166 The City of Oulu contributed somewhat later (contribution ratio: 24%).

167 These are a set of standards for production and quality control in the manufacture of products including pharmaceuticals. Quality control is conducted at each stage of the production process in order that ensure that pharmaceutical products are of high quality and free of contamination. Manufacturers of drug products are required to obey the rules.

The second half of the 1980s was a busy time for the main regional actors working for an Oulu ICT cluster. The early 1990s, however, brought the breakup of the Soviet Union, and Oulu was among the regions that suffered from the ensuing economic depression. By that time, however, ICT industries were springing up around Oulu, and the economy as a whole recovered relatively quickly.

It was in this environment that the Oulu Bureau of Economic Affairs and the city's Chamber of Commerce and Industry drafted a new economic development strategy designed to lift the region out of stagnation and nurture the growth of new industry.[168] This strategy differed in two important respects from that which had been put forward in the 1980s (the "City of Technology" economic development program carried out from 1983 through 1987): first, it applied not only to the city of Oulu, as the earlier strategy did, but to surrounding communities as well, and second, it involved many top managers of private companies.

There were good reasons for the differences in the new policy. Buffeted by the effects of the economic slowdown, local governments were faced with the need to take both industrial and employment policies. But straitened finances, among other things, prevented them from implementing industrial policies on their own. In those days, Nokia was expanding its base station business (both the development and production sides) in the Oulu region, as well as its research and development of embedded mobile-phone software and third-generation CDMA technology. Partly for that reason, Elektrobit, CCC, JOT Automation and other firms were enjoying growth as subcontractors of Nokia. Polar Electro, founded in the 1970s by colleagues from the University of Oulu[169], had achieved a national reputation. And existing industries, such as processing, were obviously hit hard by the recession as well, and were anxious to find a way out of their predicament. All of these sectors, therefore, were enlisted to contribute to the formulation of an effective industrial policy.

Paavo Similä, of the Oulu city government, and Mr. Makella, Managing Director of the city's Chamber of Commerce and Industry, were the principal planners of the strategy.

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[168] Descriptions of cooperation between the Oulu city government and the Oulu Chamber of Commerce and Industry were mainly obtained through interviews with Paavo Similä, Seppo Mäki, and Jaakko Okkonen (Managing Director of the Oulu Chamber of Commerce and Industry).

[169] Seppo Säynäjäkangas, Polar Electro's founder and a professor of entrepreneurial skills at the University of Oulu, and Tapio Tammi, the firm's CEO, were instrumental in formulating the regional strategy and promoting Oulu internationally.

Paavo Similä reflects on an organizational approach which took in a wide range of participants:

> When we planned the regional strategy in the early 1990s, (unlike the planning process in the 1980s) we sought the involvement of a large number of companies. Neighboring communities also participated, so that the program covered a much wider area in the geographical sense as well. The governments of these communities could never have accomplished this on their own (and Oulu, too, benefited from their participation). Prior to formulating the strategy, we held a number of discussions – Mr. Makella, Managing Director of the Chamber of Commerce and Industry, some others involved, and I. Unfortunately, Mr. Makella passed away shortly afterward. He and I formed a working group to discuss a vision for Oulu's industries and the directions they should take. We assembled corporate leaders, academics from the university (including a liaison officer), some people from the city government (Seppo Mäki and Paavo Similä), political leaders (Risto Parjanne had become mayor), and others. It was especially important that we included so many corporate leaders – Tapio Tammi and Seppo Säynäjäkangas of Polar Electro were notably enthusiastic – and that they demonstrated such a commitment to the strategy. The 1980s strategy was drafted by a personal network of key people; the 1990s strategy was an organization-wide effort. Ultimately, it was I who compiled the Working Group report (in 1993). This was the region's common will and common strategy. (Additions in parentheses are the author's.)

The Oulu Region Economic Development Strategy was planned with the full participation of local businesses. Jaakko Okkonen of the Oulu Chamber of Commerce and Industry says that coordinating the planning process was far from easy, but the end result was "business-oriented" and enjoyed widespread support from private companies; this greatly facilitated the job of putting it into practice.

Industrial strategy in the Oulu region at the time did not focus only on high-tech industry in the strict sense. Projects also were launched or envisaged in fields such as mechanical engineering (a 1992 project aimed at utilizing the steel and stainless steel-making plants around Raahe and Tornio to create a cluster of related industries), chemicals and other processing industries (a project in the same year provided support for spinouts of processing firms), and transportation (a "Logistics Village" was a

subject of discussion in 1991). This was also a time of alliances with other parts of Europe, as, in 1992, a regional cooperation project between Oulu and the German state of Baden-Wuerttemberg was expanded into "Euroregion 2000." Comprehensive strategies were becoming the general trend. For one thing, while substantial effort had gone into regional strategies carried on continuously since the 1980s[170], there was still much left to do and a growing demand for new approaches. The economic downturn, moreover, meant that people in industries outside of the ICT sphere were increasingly interested in measures employable on a regional scale.

② Moves to Improve the Environment for New Business: TeknoVenture and Oulutech

In 1994, conditions affecting new business creation in Oulu underwent enormous change, partly because of the need to accelerate the fostering of new companies and shake off the recession that took hold in the decade's early years, and partly owing to the effects of "trial and error" measures taken since the 1980s to build up a high-tech industrial cluster. The founding of TeknoVenture Oy, a local venture fund, and Oulutech Oy, a virtual incubator[171], changed the environment significantly.[172]

TeknoVenture is a regional fund financed by KERA, a government financial institution focusing on regional development (now Finnvera[173]; more than 40% contribution); the City of Oulu (25% contribution) and other neighboring municipalities (more than 40% aggregate contribution); and SITRA, a public fund extending support to venture firms (5.1% contribution). TeknoVenture is operated by the privately-financed TeknoVenture Management;[174] It was established in 1988 with capitalization of 80 million Finnish

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170 These included the opening of a business school at the University of Oulu in 1990, the startup funds furnished by the City of Oulu and the Oulu Chamber of Commerce and Industry. (Interview with Seppo Mäki) The university had been providing business education since 1988, however, as part of the Faculty of Economics. (Home page of the university's Faculty of Economics and Business Administration: http://www.oulubusinessschool.fi/)

171 "Virtual incubation" refers to all fee-based support services except the rental of space. Space rental is handled by Technology Village.

172 Descriptions of TeknoVenture are taken principally from the company's home page (http://www.teknoventure.fi/) and email correspondence with its president, Ilkka Lukkariniemi (November 24, 2005). Descriptions of Oulutech are taken principally from the company's home page (http://www.oulutech.fi/) and interviews with its president, Martti Elsilä.

173 Finnvera is a public financial institution, wholly funded by the government, which supplements private financing of projects aimed at corporate growth, regional development and export promotion. Headquartered in Helsinki and Kuopio, it has regional offices in 16 municipalities including Oulu.

174 In English, the name translates as The Finnish Fund for Research and Development. It was established in 1967, the fiftieth anniversary of Finland's independence, for the purpose

markka (mk) (about 15 million euro) when Technoinvestment Oy, a venture fund financed by KERA and local private financial institutions, proved unable to achieve its initial goals due to insufficient capitalization (10 million mk). In the two years following its founding, TeknoVenture invested in ten companies selected from among one hundred it examined. Among the ten was JOT Automation, which in 2002 would merge with Elektrobit to form the Elektrobit Group.

Oulutech provides entrepreneurs and high-tech startups with all types of support except rental space. Funding for the firm's establishment came from SITRA (40% contribution), Technology Village Corporation (30% contribution) and the University of Oulu Fund (30% contribution). Oulutech grew in part out of an entrepreneurial support organization called Innonet founded in 1992 at the University of Oulu. Technology Village Corporation had made it its mission to supply the diverse range needed by tenants; Oulutech was created to provide a wider range of more specialized services. These include management services, such as assistance in preparing business plans and controlling intellectual property rights[175], and, in the realm of finance, obtaining research and development funds from public institutions and connecting with sources of venture capital. Oulutech also introduces startup firms to sales networks and helps them develop such networks internationally. It refers firms to management teams, conducts employee training programs, and provides many other services tailored to each company's stage of development.

③ Oulu Named Model Region under Ministry of the Interior's COE (Center of Expertise) Program

The Finnish Government was among those that recognized the excellence of Oulu's regional strategies and the corporate growth that took place there, in terms of both number and development, from the mid-1980s. As the country sought ways of digging out from under the recession, Oulu played host to a series of observation teams eager to see what it could teach them.[176]

Having studied Oulu's regional strategies, Finland's Ministry of the Interior, then

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of furthering the nation's economic development and improving its competitiveness internationally. Previously under the supervision of the Bank of Finland, SITRA has since 1997 operated as an independent institution under the supervision of the Finnish Parliament. Its headquarters are in Helsinki.

[175] Licensing services are currently outsourced.

[176] Interview with Paavo Similä.

training staff for the region's major research and educational institutions, decided to introduce the CEO (Center of Expertise) Program as a nationwide regional policy (Regional Development Law No. 1135, 1993). Under the program, plans were developed by individual regions and submitted for appraisal to the Interior Ministry. Those that qualified as "COE regions" would have half of all their expenses paid by the Government. Oulu applied in the fields of electronics, telecommunication, software, measurement technology, and medical and biotechnology. When the first selections were made in 1993, Oulu – to no one's surprise – ranked first among the five regions chosen[177] (coverage was later expanded to the current fourteen geographical areas). Each region had its own strategies, with some relying too much on alliances with universities and not enough on corporate participation. But Oulu's strategy, as we have seen, was based on the full commitment of local businesses, and in that sense it proved remarkably effective.[178]

Utilizing the funds made available through the COE Program, and profiting as well from the rapid growth of Nokia, Oulu's ICT cluster continued to develop in the late 1990s. Growth peaked in the year 2000, mirroring trends in the IT sector throughout the world.

4.3.4 Principal Initiatives in the 2000s

① The Oulu Growth Agreement

Starting in 2001, Oulu began to be affected by the tendency of firms shaken by the IT slump and the trend toward globalization to shift production to other regions. From 2001 through 2002, shipments and other indicators underwent a serious, if temporary, decline. The impact of this trend on Oulu was relatively mild, however, as most of the local operations of its core company, Nokia, involved research and development rather than manufacturing.[179]

Oulu dealt with the situation by formulating a business strategy covering the five years

177 Interview with Jaakko Okkonen of the Oulu Chamber of Commerce and Industry.
178 Ibid.
179 Nokia's workforce in Oulu fell off from 4,700 persons in 2000 to 4,271 in 2001 and 4,134 in 2002. It later recovered, however, reaching 4,580 in 2005. (The figure for 2000 is an estimate provided by Eero Vallström in an interview. Other figures were provided by the Oulu Regional Business Agency.)

from 2001 through 2006 within the framework of the COE Program (Table 4-1). Known as the Oulu Growth Agreement, the strategy aimed creating five industrial clusters: for ICT, bioindustry, wellness (health and welfare), the environment, and contents and media. Also included were two support programs for the logistics and business development industries (Table 4-2). The principal activities of each cluster would be carried out by related industries at voluntary, cooperative venues called "forums." The ICT cluster had three such forums, for mobile technologies, software, and electronics (the NCEM forum). The biocluster had a bio-forum, the wellness cluster a wellness forum, the environment cluster an eco-forum, and the contents and media cluster a media forum, each used for specific cooperative projects. The mobile forum – the first to be organized, along with the software forum, in 1996 – went on to build an international network. Participating in its work was the Center for Wireless Communication, founded in 1995 under the guidance of the director of the Telecommunication Laboratory at the University of Oulu's Department of Electrical Engineering. By preparing a testing environment for "Octopus," a mobile application, the mobile forum not only promoted innovation by local actors but also made participating in the forum more appealing to those outside the region.

The Oulu Growth Agreement resembled the regional policy of the 1990s in that the business community was involved from the earliest planning stages, and also in that, in addition to having specific numerical targets, it was designed so that results for each year would be confirmed in the annual report. Numerical goals were set at the planning stage for the creation of 150 new companies and six thousand new jobs, as well as 1.5 billion euro in increased sales. The planners envisioned that 310 million euro would be needed to get the project off the ground. Of this amount, they planned to obtain 180 million euro from public sources, including the EU, and 130 million euro from the private sector (for example, private contributions to joint research and development projects). In this way, the project was supported by a firm commitment from the business community from the start.

In FY 2006 the Oulu Growth Agreement was approaching its final year. Concrete results were yet to be tabulated, but fundraising, at least, was close to meeting the initial goals. Discussions have begun on a project to succeed the agreement.

Table 4-1 Outline of the Oulu Growth Agreement

	Contents of the Agreements
Participating region	Oulu region
Period	2002-2006 (announced February 2002)
Implementation structure	Participation by local companies in Oulu COE Program. 7 forums: Mobile, NCEM (Electronics), Software, Media, Wellness, Bio-industry, Environment; coordination by City of Oulu * IT cluster: participation by 3 forums: Mobile, NCEM, Software
Objectives	Strengthen Oulu's position as a global Center of Excellence Enhance the competitiveness of the Oulu region Develop and strengthen Oulu's growing companies Create new employment and business opportunities Diversify Oulu's high-tech industries Utilize EU funds
Numerical goals (2002-2006)	150 new companies (companies in 2002: 780) 6,000 new jobs (jobs in 2002: 14,700) 1.5 bn euro in increased sales (sales in 2002: 3.7 bn euro)
Total budget (2002-2006)	Public funds: 180 million euro Private funds: 130 million euro Total: 310 million euro
Constituents	5 industrial clusters: IT (information technology), Wellness (health and welfare), Bio-industry, Environment, Contents & Media 2 support programs: Business Development, Logistics

Source: Oulu City homepage (http://www.oulu.ouka.fi/kasvusopimus/english/index.html).

Table 4-2 Cluster Programs under the Oulu Growth Agreement

Cluster	Objectives	Scale (2001-2002) (Units: No. of companies, million euro, persons)
IT	Develop the telecommunications sector, especially wireless technology	Companies: 261→259
	Globalize the software industry	Sales: 3,425→3,128
	Strengthen the fields of precision- and nanotechnology	Employed: 8,379→8,467
	Enhance the competitiveness of IT industry in northern Finland	
Contents & Media	Expand the activity areas of traditional media	Companies: 314→325
	Promote cooperation between traditional and new media	Sales: 127→131
	Use and develop multichannel communications	Employed: 1,289→1,289
	Promote international networking	
Wellness	Develop wireless communications technology for hospitals	Companies: 134→239
	Develop programs and services for health maintenance	Sales: 245→224
	Utilize IT for exercise monitoring	Employed: 3,599→3,718
	Create new business opportunities	
Bioindustry	Identify biomolecules	Companies: 20→22
	Work on bioprocesses	Sales: 25→27
	Develop agricultural and botanical biotechnologies	Employed: 234→257
	Promote bioindustry	
Environment	Develop new methods for water treatment, recycling and sludge treatment	Companies: 31→32
	Enhance technologies for exhaust gas cleansing	Sales: 174→189
	Promote advancements in the collection and recycling of electric and electronic appliances	Employed: 974→997
	Work on renewable energy and energy conservation	
Total, 5 clusters		Companies: 760→777
		Sales: 3,996→3,699
		Employed: 14,475→14,728

Source: Oulu City homepage (http://www.oulu.ouka.fi/kasvusopimus/english/index.html).

② Structural Change in Local Actors

Entering the new millennium, evidence of structural change could be seen among local actors, particularly in the City of Oulu. In 2000, the City of Oulu and ten of its surrounding municipalities formed the Oulu Regional Business Agency as a means of integrating their support for business. The new organization is located in the Linnanmaa Technopolis. Dedicated staff concentrate on one of several specific fields – construction and transportation, chemicals, lumber, services, women entrepreneurs, tourism and handicrafts. Support is provided to managers and entrepreneurs of high-tech and other firms, in principle free of charge. The Start Business Center, an incubator, was founded +at the same time.

Oulu Innovation Ltd., which opened in 2005, also deserves a few remarks. In addition to coordinating the COE (Center of Expertise) program – a job that previously had belonged to the Technopolis Corporation – and overseeing the work involved in the Oulu Growth Agreement, this organization links various regions and clusters, mostly in northern Finland, into the "Multipolis Network," the aim of which is to spread Oulu's success throughout all of northern Finland.

4.4 Verification of the Working Hypothesis

4.4.1 Verification of the Five Formative Processes

I have now described the initiatives taken by the principle local actors in a roughly-drawn time sequence. My focus has fallen on the moves made in each period by activity groups aiming at the formation of an ICT cluster, and on steps taken by the corporations which are the foundation of an industrial cluster. If some corporate initiatives have little connection with the work of the activity groups, others appear to have a very strong connection indeed.

In the following, I use the ICT cluster in the Oulu region to verify the working hypotheses on the formative mechanisms of high-tech industrial clusters. As described in Chapter 3, I divide the formative period into the foundation period and the development period. Five principal formative processes occur in sequence during the foundation period:

I. Improvement of the environment for innovation;

II. A growing agglomeration of firms;
III. The emergence of anchor firms;
IV. Improvement of the entrepreneurial environment; and
V. Establishment of a reputation.

Mutually enhancing causal correlations exist among the various formative processes, resulting in the cluster building momentum during the development period which follows. Taking each process in turn, I shall now examine whether the working hypothesis can be verified in the formative processes of the Oulu ICT cluster. I shall first consider the foundation period, which starts when the formative processes have hardly begun and continues to the point where all five processes are moving forward, and establish a rough order for these processes that accords with the order adopted for the working hypothesis.

(1) Improvement of the Environment for Innovation

① Founding of the University of Oulu and Changes in Fields of Research

The Oulu ICT cluster began its formative process in 1958, with the founding of the University of Oulu – although a more accurate date might be 1965, when the university launched its Department of Engineers. Prior to the university's opening, electronics and other ICT firms were almost unknown not only in the Oulu area but in all of northern Finland. It was only after the founding of the university and the VTT Electronics Research Laboratory that electronics companies began moving into the region or starting up there. Joint research with the university and VTT, and the hiring of people trained there, enabled electronics firms to establish a base of operations in the Oulu region. Nokia's transfer of its mobile phone division to Oulu in the winter of 1973 may not have been directly connected to the university's existence, but its subsequent expansion of both the scale and content of its business in Oulu, and its stepping up of research and development work there, was firmly linked to training and research carried out, sometimes in tandem with Nokia, at the University of Oulu, Oulu Polytechnic (the Institute of Technology and the Raahe Institute of Technology), and the VTT Electronics Research Laboratory. Technical training schools had existed in northern Finland before the university opened its doors, but none were capable of educating engineers. In the mid-1980s, when the ICT cluster was starting to take shape in earnest, the number of engineers trained at the University of Oulu reached into the hundreds, even counting only those who were graduates of the Department of

Electrical Engineering. A critical point had been reached in terms of the accumulation of engineers.[180]

Technopolis Corporation CEO Pertti Huuskonen viewed the founding of the University of Oulu as "the most rational regional policy of the last one hundred years,"[181] a statement that could equally point to the creation of the Oulu ICT cluster.

The arguments set forth in the following are based on the thesis that the establishment of the University of Oulu, and the creation in 1965 of its Department of Electrical Engineering, marked the starting point for the formative process of Oulu ICT cluster.

② Invitation and Establishment of the VTT Electronics Research Laboratory

We have seen how, to a large extent, it was the dedication of people from the University of Oulu and others in the region that caused the VTT Electronics Research Laboratory to locate there. This outcome would have been unlikely without the presence of the university. Though the university had presented it with a proposal[182], VTT was also considering locating in Kajaani, another city in northern Finland (according to contemporary sources, the two cities differed little in terms of industrial agglomeration[183]). In the end, the deciding factor in choosing Oulu was the presence of the university, where, even then, high-quality research was being pursued in the electronics field. Named as director of the new VTT Electronics Research Laboratory was Matti Otala, the first professor affiliated with the university's Applied Electronics laboratory. In his new post Dr. Otala would oversee research in fields more closely connected to practical needs than those which concerned him at the university. Especially at the outset, therefore, the VTT Electronics Research Laboratory depended to a great extent on the University of Oulu for its viability, while at the same time providing the university with valuable support. The relationship was mutually beneficial: each institution served to "improve the environment for innovation" while strengthening the foundations of the other.

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180 In fact, Dr. Oksman was of this opinion (interview with Dr. Oksman). Although many such people were working in Southern Finland at the time, some returned to Oulu as opportunities for finding work there improved.

181 Mika Kulju (2002), p. 193.

182 Seppo Leppävuori, acting professor for Dr. Otala at the time.

183 Interview with Prof. Juha Lanning (currently director of the Department of Electrical and Information Engineering, University of Oulu). Kajaani, however, was home to Kajaani Electronics, a leading electronics company which came into being as a result of joint research with Dr. Otala (and could be considered a product of the university).

Many of the people who trained or worked at the VTT Electronics Research Laboratory went on to join existing businesses or start new ones.

In this way, the VTT Electronics Research Laboratory occupied a middle region in the innovation framework of the Oulu region, linking research conducted at the university[184] with corporate R&D. It also, however, functioned as a hub in promoting the flow of technical talent between different fields of research.

③ Improvement of Physical Infrastructure

I shall now consider Technology Village (the Technopolis) in light of improvements made to the physical infrastructure in order to enhance the environment for innovation. As it provided a site in which multiple companies could locate, Technology Village promoted the agglomeration of firms (process II). And, since it included incubators (established in Technology Village in 1987), it was effective in improving the entrepreneurial environment (process IV). Perhaps most important, the completed Technology Village, as a science park adjacent to the University of Oulu and the VTT Electronics Research Laboratory, offered an environment highly conducive to that union of technology and know-how that constitutes innovation. These two institutions made immeasurable contributions to the science park's development[185], and thus we can accurately trace its origins to the founding of the university.

The original site of Technology Village was, as I mentioned earlier, a refurbished dairy plant in the central city. In 1985, according to plan, construction of new buildings began on city-owned land adjacent to the university. After the VTT Electronics Research Laboratory was established in 1974, it, too, occupied a number of different sites (first at Kantingangas, later in rented rooms at Kemira's research laboratory)[186] before its new facilities in Linnanmaa were completed in 1989. Since these also abutted Technology Village, there now existed a concentration of academic institutions, research facilities and commercial land in one spot. One outcome of this was progress in improving the environment for innovation, in the sense that it was now easier for local actors to

[184] In the case of the Engineering Faculty of the University of Oulu, and especially in the Department of Electrical Engineering, the university itself focused its research on fields closely connected to companies' needs.
[185] While the University of Oulu may have been capable of developing a science park on its own, the contribution of the VTT Electronics Research Laboratory brought huge advantages in terms of improving the environment for innovation.
[186] Mika Kulju (2002), p. 68.

engage in cooperative work. Personal networks[187] had, of course, existed in Oulu prior to this, and local actors had used them when collaborating. But conditions clearly improved with the construction of Technology Village. Progress also was made in establishing a reputation (process V) as the entire region became associated with "Oulu, City of Technology."[188]

④ Creation of an Institutional Infrastructure

Technology Village was a form of physical infrastructure intended to produce innovation. Its third-sector manager, Technology Village Corporation, was committed to providing high-tech firms with whatever support they needed, and thus it may be seen as a form of institutional infrastructure. One should keep in mind that not all science parks share this corporate philosophy. Technology Village Corporation's management of the park coexisted in complete harmony with the City of Oulu's industrial policy, and the city's promotion policy for high-tech industry, begun in the 1980's as "The City of Technology: A Strategies for Economic Development," in large part supported the corporation's work. Indeed, the "city of technology" catchphrase was used by Technology Village Corporation itself. One of the city's policies was to place a liaison officer at the University of Oulu (for a period of three years from 1986), with the city paying the cost. Other than firms which essentially were products of the university or which employed many of its graduates, most local companies at the time had little idea of how to form a partnership with an academic institution, even if they were interested in doing so.[189] At the University of Oulu, too, and especially in the Department of Electrical Engineering, the idea of cooperating with private firms was attracting growing interest – but the university as a whole had yet to take any concrete steps toward that end. It was to remedy this problem that city government employees Paavo Similä and Seppo Mäki decided to place a liaison officer at the university at the city's expense. The first to take up the position was Raimo Kuismin, a construction and civil engineer with extensive connections to local industry.[190] After three years of city funding, financial responsibility for the liaison officer system was turned over to the

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[187] These included a network of people with ties to the University of Oulu's Department of Electrical Engineering and a network, called the Revontuliryhmä (the "Aurora Group") of individuals involved with high-tech firms and other organizations. The latter, which existed at least since the late 1970s, included from Nokia and Polar Electro as well as key local actors from organizations such as the VTT Electronics Research Laboratory and the University of Oulu. (Email from Mr. Möttönen, April 10, 2006.)

[188] Soviet President Gorbachev, for example, visited Oulu in 1989, the same year that the VTT Electronics Research Laboratory and other leading actors converged in Linnanmaa.

[189] Interview with Paavo Similä.

[190] Interview with Seppo Mäki.

university according to Similä's original plan. The idea first saw light as an element of the city's economic development program of 1983. In 1984, a project team was inaugurated to implement the plan; in 1988, when the project period ended, the system became a permanent part of the city government as the Economic Bureau. At the outset, the bureau's principal work consisted in the further development of the City of Technology. In the sense that they enriched the area's institutional infrastructure, City Hall's new measures and structural overhauls led to a better "environment for innovation" in the Oulu region.

⑤The Presence of "Fool Kings"

Petri Pulli[191], a professor at the university's Department of Information Processing, has said that investment in next-generation technology is necessary if one's own system is to prevail over one's competitors, but because of the uncertain nature of development in this field, one cannot obtain such investment without a generous provider of capital, which he calls a "fool king." The presence of a fool king creates an advantageous environment for the development of next-generation technologies.

Finland began research on military radar during the Second World War. When the war ended, concerns about preparedness for a possible Soviet threat inspired the country's Ministry of Defense to pursue further research into radar and wireless communications systems. While the research initially targeted military applications, in the mid-1960s it was noticed that some technologies could have non-military uses.[192] Moreover, Finland's telecommunications market was unusual in that numerous competing businesses operated in coexistence with Post and Telecommunications, a public corporation which, large in scale and rich in capital, could use its governmental status for the benefit of private companies in the country's telecommunications system. Against this background, after World War II, and particularly during the period from

191 While at the VTT Electronics Research Laboratory, Pulli was a key player in the founding of Cybelius, a CCC subsidiary which, with CCC and the University of Oulu, conducted joint research on virtual design simulation software.

192 In 1963, Finland's Defense Ministry announced it would be holding a contest for the development of wireless telecommunications systems for military use. In the end the contest was cancelled, but the prospect sparked development by firms including Finland Cable Factory (later to become Nokia), the television manufacturer Sarola, and the government-run Televa. One result was progress in Finnish technology for company radios (wireless communication systems for use within companies); individual firms found customers among police forces, coast guard services, and the national railway, among others. (Mika Kulju [2002], p. 78; Staffan Bruun, Mosse Wallen [1999], pp. 83-84 of Japanese translation; email from Lauri Kuokkanen [March 25, 2006]).

the 1970s until Finland's accession to the European Union in 1995, the Ministry of Defense and the Post and Telecommunications Corporation served as "fool kings" for Finland's wireless telephone businesses and, since the 1980s, for Nokia. In consideration of national regional policy, Oulu received a certain portion of capital and achievements from these "kings," especially from the 1970s on. Specifically,

(1) In the 1970s the Finnish Ministry of Defense held a contest for the development of wireless telephones for military use. Nokia ultimately won the contract, but because it of conditions placed upon its commercialization (by means of licensed production in the United States) and development (in the North, East and other areas), Nokia's production of military-use wireless telephones took place in Oulu for only two years, 1972 and 1973.[193]
(2) Since the 1980s, all of Finland has used the NMT (Nordic Mobile Telephone) first-generation mobile telephone system. The Post and Telecommunications Corporation served as the "fool king"[194] during the development period for the NMT analog system starting in 1978, but Oulu was responsible for the development and production of the base station system.
(3) In the late 1980s, the Ministry of Defense supplied the university, Nokia and Elektrobit with funds for the research and development of CDMA (Code Division Multiple Access) technology in Oulu.[195]

Oulu was fortunate enough to obtain these benefits because it had focused since the 1970s on the research and production of wireless telecommunications systems; that they helped to build an environment conducive to innovation is without question. Other essential factors in this mix were, of course, the University of Oulu, the VTT Electronics Research Center, and especially Nokia, which, in combination with the other two, vastly enriched research and production in the Oulu area.

(2) A Growing Agglomeration of Firms

Corporate actors, either newly established or operating in an expanded range of activities, helped set the stage for the events which worked to improve the environment for innovation in the Oulu region. I shall discuss these now in order of

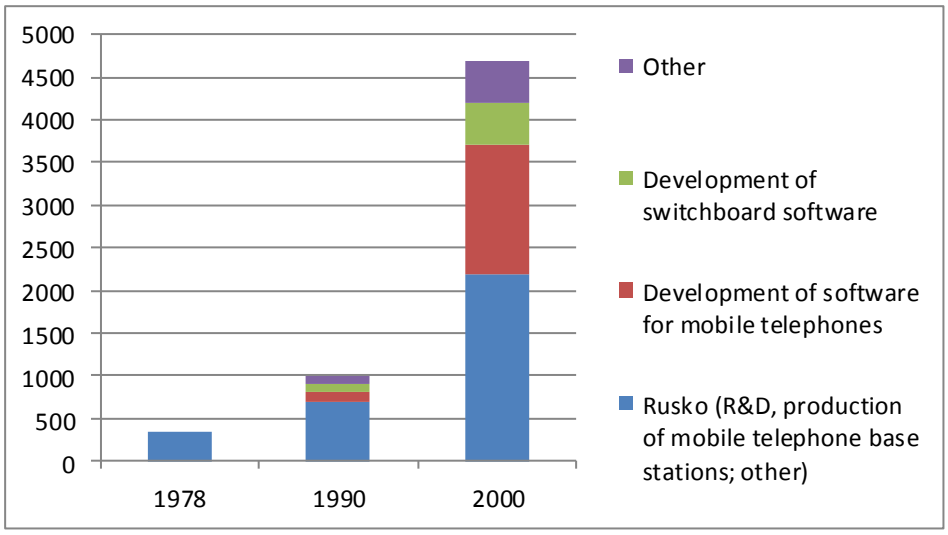
193 Mika Kulju (2002), p. 80; interview with Dr. Oksman.
194 Interview with Petri Pulli.
195 Interview with Eero Vallström.

their importance.

① Establishment of Nokia in the Oulu Region

Nokia's transfer of its wireless telephone division to Oulu in 1973 was the result of a bold decision by Björn Westerlund, president of the Nokia group, in view of the government's policy of drawing industry to "development regions," such as the country's North and East, as well as the presence in Oulu of a Nokia cable plant. For Oulu, having Nokia bring in its wireless telephone division was, as Lauri Kuokkanen put it, "like winning the lottery." In 1976, Nokia started manufacturing modems and PCM equipment at its Rusko plant in Oulu. Development and production of NMT analog base systems began in 1979, followed by the development of embedded mobile phone software in 1985 and basic research and development of CDMA for third-generation mobile phones in 1987.

Figure 4-16 Number of Nokia Employees in Oulu



Data for Figure 4-16

Calender Year	1978	1990	2000
Rusko (R&D, production of mobile telephone base stations; other)	330	700	2200
Development of software for mobile telephones	0	100	1500
Development of switchboard software	0	100	500
Other	0	100	500
Total	330	1000	4700

Source: Interview with Eero Vallström.

Several things prepared the way for Nokia to expand its R&D-based business in Oulu. These clearly would include the training programs given at the University of Oulu, the Institute of Technology and elsewhere, and the strengthened ties forged by joint research projects involving the university, the VTT Electronics Research Institute, and Nokia. This view is amply corroborated by people at the University of Oulu[196], the Institute of Technology, and the VTT Electronics Research Institute, and also by Erkki Veikkolainen of the former Nokia Mobira. We can conclude that Nokia's putting down roots in Oulu owed a great deal to the engineering education offered by the university and the Institute of Technology, research conducted there in related fields, the founding and enhancement of the VTT Electronics Research Institute, and the improved innovation environment exemplified by the creation of Technology Village.

② Emergence of Polar Electro

Polar Electro was founded in the late 1970s, when conditions for startups were immature, not least in respect of capital. Nevertheless, the company managed to develop into such a strong exporter that it not only made Oulu's name as a "city of technology," but served as an "angel" for other firms in the Oulu region. Seppo Säynäjäkangas, the company's founder, taught entrepreneurship for many years at the University of Oulu and was a role model for graduates who were prospective entrepreneurs. His impact on other companies and entrepreneurs was enormous. Having started life at a time when the entrepreneurial climate was barely developed, Polar Electro was, in a sense, a "mutant[197]," its rapid growth fuelled by an ability to create markets outside its own region. That the firm could accomplish so much[198] is

196 Dr. Oksman says the following about the relationship between Nokia and Oulu: "I think we can say it was a mutually beneficial relationship. During the latter half of the 1980s, when Nokia's workforce was soaring, five to six hundred people graduated from the university's Department of Electrical Engineering. This stock of human resources is very important to a region, so the timing could not have been better. Starting in 1982, Nokia began to produce base systems in Oulu on a full scale. Research and development work on CDMA technology for third-generation mobile phones took off in the middle of the same decade, also in Oulu. Researchers were needed, and Oulu could provide them. Nokia was glad to hire the young people from the university who were working in that field. Both the company and the university profited from the relationship."

197 I use this expression as Osama Yamada of Nippon Technology Venture Partners, who handled GP business for the first investment partnership in Ichiba, Tokushima, used it to explain the appearance of Dell Computers in the city of Austin, Texas, to an interviewer on December 16, 2005. Dell Computers was founded in Austin in 1984, when, thanks to efforts (in 1983) to attract MCC and other companies, high-tech firms and engineers were beginning to accumulate in the city. In a short span of time the firm created huge demand outside the Austin area and grew rapidly into a major brand.

198 In addition to the reasons outlined here, an important factor was the presence of Nokia, which was actively opening up foreign markets at that time. Mr. Möttönen, Polar Electro's

attributable in part to Säynäjäkangas's background and personality, which I discussed earlier, and his years at the University of Oulu under the tutelage of his mentors Dr. Oksman and Dr. Otala. Its technological development, however, has a great deal to do with the founder's having been an active instructor at the university, a member of the first class graduating from the Department of Electrical Engineers who went on to acquire a doctorate and teach there. Students from his research lab took part in the actual development of technologies.[199] For all of these reasons, Polar Electro can be construed as a product of the University of Oulu, its birth a result of the founding of the university and its Department of Electrical Engineers (I: Improvement of the Environment for Innovation).

③ Emergence of Kajaani Electronics

This, too, could not have happened without the strong message sent to northern Finland's future electronics industry by Dr. Otala when he was invited to teach at the University of Oulu. Mika Kulju (2002) relates that Kajaani's chairman, intrigued by Dr. Otala's message, telephoned the latter at his home one day in 1968. Some thirty minutes later he went to meet him for the first time, and two hours after that he had conceived the idea that would become Kajaani Electronics. Kajaani had, of course, been seeking means of diversifying, but Dr. Otala was clearly the force which drew it into the electronics field in Oulu.[200] Were it not for the founding of the University of Oulu and its Department of Electrical Engineers (I: Improvement of the Environment for Innovation), it is most unlikely that the move would have been made.

④ Expansion into Electronics by Rautaruukki Corporation, a Raahe Steelmaker

Rautaruukki is another established firm that moved into the electronics field in northern Finland. Its expansion from steelmaking into electronics helped pave the way for firms such as Fincitec, a custom IC designer founded in 1986, and Idesco, a maker of IC cards and access control systems founded in 1989. As in the case of Kajaani, the establishment of the University of Oulu and its Department of Electrical Engineers was a fundamental background event (I: Improvement of the Environment for Innovation).

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vice president, says that Nokia set a good benchmark for the firm as it sought to expand internationally during the 1980s.

[199] Mika Kulju (2002), p.95.

[200] Although Kajaani moved its electronics division 180km from Oulu to Kajaani in the 1970s, some of the division's businesses returned to Oulu during the 1980s. In a broad sense, therefore, Kajaani can be considered a member of the Oulu ICT community. (Bascom, Jutel, and Metso Automation all moved into Oulu at the decade's end.)

Elektrobit, JOT Automation, CCC, and NetHawk are representative examples of high-tech firms created in Oulu. These are discussed in the chapter on anchor firms as they are closely connected with Nokia's assuming that role.

The growth of two firms established by Lauri Kuokkanen – Lauri Kuokkanen Oy in 1978 and Solitra Oy in 1986 – appears to owe virtually nothing to an "improved environment for innovation." Rather, the firms' success was due almost exclusively to Mr. Kuokkanen's own abilities and the growth of the mobile telephone business in northern Europe – the latter furthered to some extent by Mr. Kuokkanen's contributions. Solitra, however, did benefit from the growth of Nokia's base station business in Oulu.

(3) The Emergence of Anchor Firms

We have seen how the events encompassed in process I, "improvement of the environment for innovation," took place only after the emergence in Oulu of firms and businesses hitherto unknown in the region (process II, "growth in the agglomeration of firms"). The third process to take place, the "emergence of anchor firms," is particularly important to the formation of a high-tech industrial cluster. The term "anchor firm" is used herein to mean "a firm which brings a significant amount of demand into a cluster from outside the region, and which orders a certain amount of business from other firms within the cluster." As this definition makes clear, in order to be considered an anchor firm a company must not only draw in demand from outside the region, but also create (procure) work within it. One form of business that would not qualify, for example, is the branch plant system, in which companies bring in raw materials from outside the region and use low-cost labor to process them within it. If a company is to become an anchor firm, both the firm itself, which produces work, and the subcontractors which accept it must actually be growing or be poised for growth. When an environment has developed that makes this possible, companies which produce work take on the character of anchor firms. As I discuss in more detail later on, the emergence of anchor firms serves to enrich the industrial ecology, making it easier to create the kinds of companies that fill in ecological gaps. This prepares the way for process IV, "improvement of the entrepreneurial environment." Here, we shall look at process III, "emergence of anchor firms," in its connection with the founding and growth of start-up firms as a product of process IV, "improvement of the entrepreneurial environment."

In the Oulu region, Nokia is the largest of the companies which have qualified as anchor firms since the latter half of the 1980s. Following Nokia, though far smaller in scale, is Polar Electro; smaller still are several independent high-tech firms spun off from Kajaani's electronics division. I shall now trace the development of Nokia and Polar Electro into anchor firms.

① Nokia's Development into an Anchor Firm and the Growth of Elektrobit, JOT Automation, CCC, and Solitra

Nokia's establishment of a high-tech business hub in Oulu began in earnest in 1973, when the firm moved its wireless telephone division to Oulu from the Helsinki area. It went on to bring other functions, such as modem and PCM equipment manufacturing, into Oulu. Nokia began to develop base station systems in Oulu in the late 1970s and to produce them there in the early 1980s. Later in the 1980s, Nokia chose Oulu for the development of embedded software for mobile telephones and research on CDMA technology for third-generation mobile phone systems. In terms of business volume – export to other regions and the creation of added value – Nokia Telecommunications (since 1999, Nokia Networks) ranked highest in both the development and the production of portable base stations; Oulu was in fact the home base of these two divisions. Eero Vallström[201], who led the base station division from 1984 to 2002, was a graduate of the Institute of Technology. Referring to Nokia's role as Oulu's anchor firm, he has this to say about what he calls the region's "driving business":

> Everyone has a different opinion on the reasons for Oulu's success. In my view, much of it is due to the existence of the University of Oulu, which has supplied the area's businesses with a steady flow of talented personnel. Also very important has been the presence of Oulu's driving business, Nokia, which came to the region in 1973 to manufacture wireless telephones. In 1979, Nokia began work in Oulu on the development and production of base stations using NMT analog networks. Its business scale then represented only 1% of the global market, but it was growing steadily. In 1984, Nokia moved into the world market in that field and growth really took off. (According to Vallström, as of 2000, Nokia's share of the global base station market had reached 25%.) Third

[201] In 1984, at the age of 29, Vallström became the company's general manager, taking charge of the Rusko works and overseas marketing for base station business. Nokia's base station business enjoyed steady growth, requiring Vallström to spend up to 150 days per year on business journeys.

> and finally, there were some additional factors that were particular to Oulu, such as the presence of Technology Village and a culture that was not averse to a challenge.

Embedded software development by Nokia Mobile Phones – started in 1985 with a miniscule staff of three – was vital to the growth of hi-tech firms originating in Oulu. As we have seen, Eero Vallström, who led this division, was a 1980 graduate of the university's Department of Electrical Engineering. He joined Nokia (then Nokia Mobira) in 1985, after a period spent researching embedded software with the VTT Electronics Research Laboratory. The idea of developing a community of high-tech companies in Oulu had been with Walstrom since the beginning of his time with Nokia. Losing no time in putting his scheme into practice, he wrote an article for a local newspaper stating that Nokia was looking for subcontractors. The stage was thus set for the founding of Elektrobit[202], which grew into the very model of an Oulu-bred, listed electronics firm, and CCC, now one of Finland's leading software companies. As Oulu's anchor firm, Nokia provided work for high-tech companies in the region, preparing the groundwork for their later growth. In Eero Vallström's words,

> Elekrobit, CCC, and NetHawk all grew as subcontractors of Nokia. Their dependence on Nokia has fallen since then – these days it stands at 35%, 10 to 40%, and 30% respectively – but during their start-up periods practically all of their sales went to Nokia.

Jouko Möttönen, a vice-president of Polar Electro, with a career in Oulu's private sector dating back to the 1970s, has similar views:

> Nokia numbered a great many firms in Oulu among its suppliers and subcontractors, including Elektrobit, JOT Automation, and CCC. Nokia had wanted very much to establish such a network. There is no question that this policy gave many companies a chance to grow. I don't believe there were many spinoffs from Nokia, however. NetHawk was one of Nokia's (few) spinoffs. From around 1990 on, jobs subcontracted by Nokia accounted for a good proportion of the sales of companies like these. Without Nokia, none of them could have achieved their present growth. (Addition in parentheses is the

[202] Elektrobit's listing was a result of its merger in 2002 with JOT Automation, which had been listed since 1988.

author's.)

Figure 4-17 shows transitions in Elektrobit's sales figures. Sales began to take off around 1993 and grew by large margins through 2002, the year of the firm's merger with JOT Automation. This pattern was consistent with that for the growth of Nokia's total sales (Figure 4-18), which started around 1992 or 1993. Sales figures for Net Hawk (Figure 4-19) begin to improve in the mid-1990s, suggesting that its growth, too, was supported by that of Nokia. One must remember, however, that, as Eero Wallstrom said, these companies may have consolidated, and grown, as Nokia subcontractors, but they now depend on Nokia for only one-third of their sales. In the intervening years they worked hard, both at home and abroad, to establish themselves as independent high-tech firms. Just as Nokia provided a good benchmark for Polar Electro when the latter went international [203], these firms learned and were inspired by the experiences of Nokia, Polar Electro and other regional companies which had preceded them into the international arena. It would not be too much to say that Nokia served as the springboard for these companies' consolidation and growth.

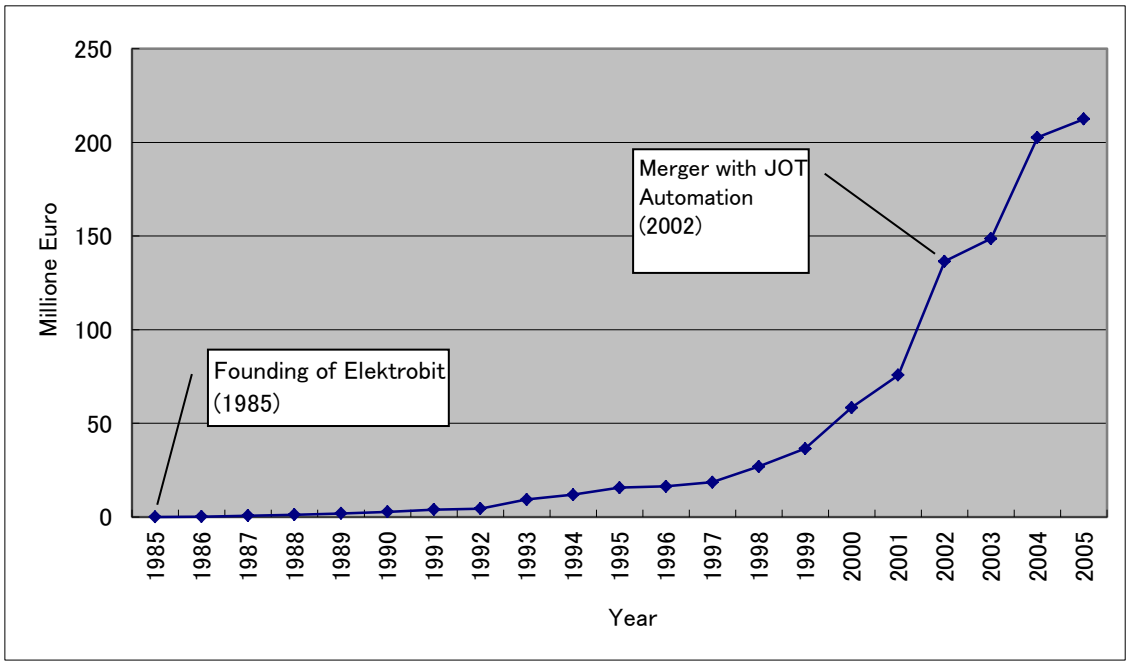
Nokia's connection to Solitra also bears mentioning, though the relationship is somewhat different from those it has with such Oulu firms as Elektrobit. Founded in 1986, Solitra owed much of its growth to Nokia's expanding base station business. Lauri Kuokkanen, having presided over the development and production of duplex communication channels at Lauri Kuokkanen Oy, the company he had founded in 1978, had made an invaluable contribution to Finland's mobile telephone industry. Displeased with his firm's increasing size, however, Kuokkanen sold his entire stake to Nokia and launched Solitra. The new firm embarked on the development and production of parts for Nokia's base station division, just then enjoying its first wave of growth. Lauri Kuokkanen was not only a talented engineer, but also an astute businessman, and in this case his timing was perfect. Solitra went on to prosper as one of Nokia's top developer/subcontractors. Ultimately, Kuokkanen felt this firm, too, was growing too large, and sold off his shares in 1993. Ownership went to two American firms in succession, ADC and Remec. Today, Solitra continues to operate in Oulu.

For any number of high-tech firms originating in Oulu, the expanding scope of Nokia's activities, coupled with the increasing scale of its business in general and its base station division in particular – in other words, the emergence of Nokia as Oulu's

[203] Interview with Jouko Möttönen.

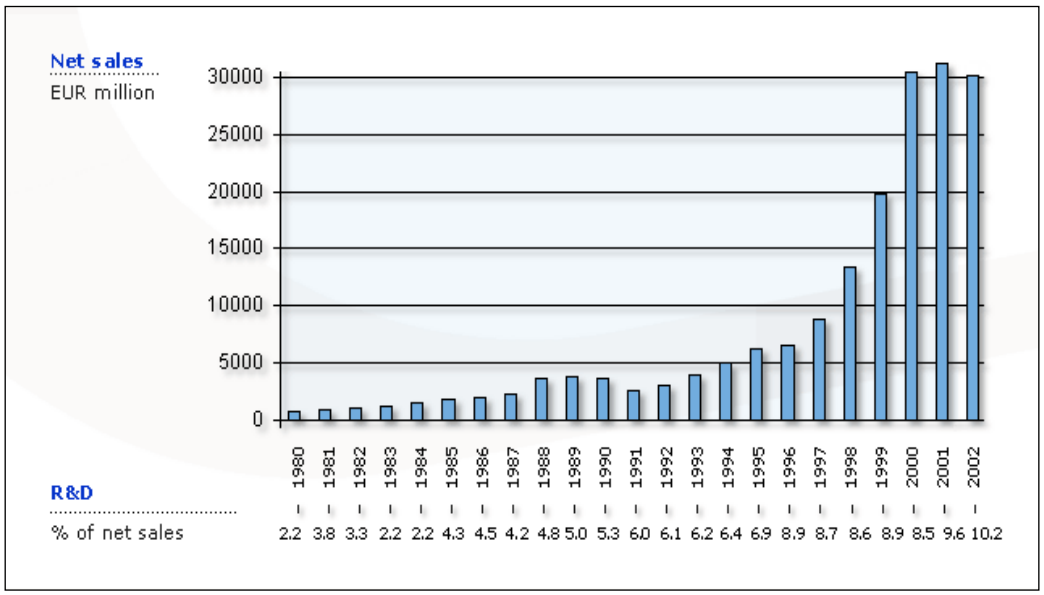
anchor firm – was instrumental in setting the groundwork for growth.

Figure 4-17 Sales Trends at Elektrobit



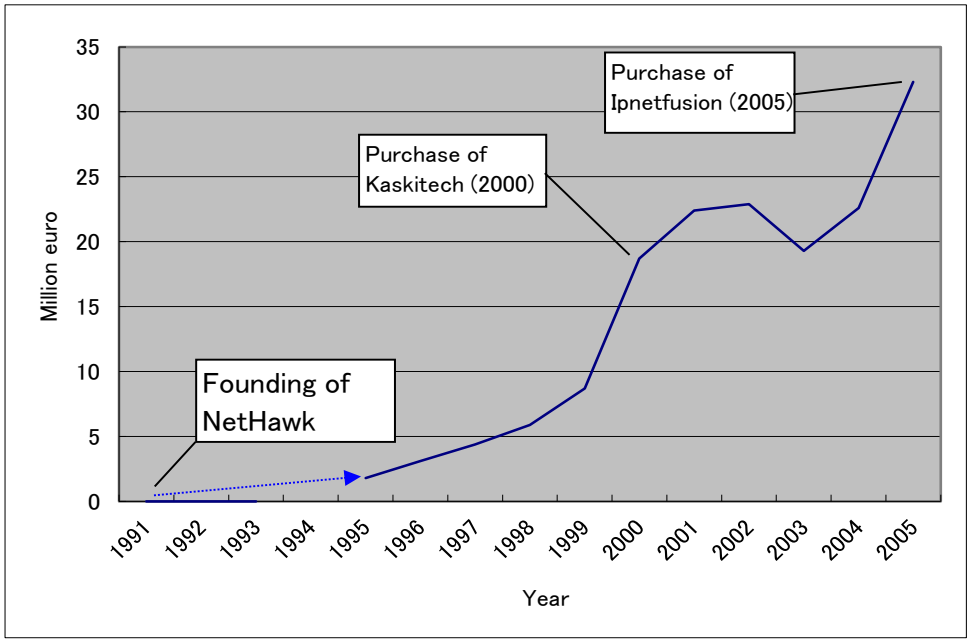
Source: Elektrobit.

Figure 4-18 Sales Trends at Nokia (Company-wide)



Source: Nokia website (http://www.nokia.com/A402756).

Figure 4-19　Sales Trends at NetHawk



Source: NetHawk.

② Polar Electro and Other Firms

While a far smaller company than Nokia in terms of sales, Polar Electro has indeed brought a substantial amount of demand into the region over the years. Jouko Möttönen, Polar Electro's vice president, has this to say about his company's role as an anchor firm:

> Polar Electro used companies like Fincitec and Elektrobit as subcontractors; so, in this sense, we can probably call Polar Electro an anchor firm. And, since it collaborated in a large number of research projects with a local rehabilitation hospital, the Merikoski Rehabilitation and Research Center, Polar Electro was also an anchor firm for the wellness and health cluster. It was rather small, though, for an anchor firm.

In addition to functioning as an anchor firm, Polar Electro has played an important role as a business angel in the ICT and wellness fields, as I mentioned earlier. Company founder Seppo Säynäjäkangas was a key role model for starters of university-launched ventures and in the 1990s functioned as spokesman for Oulu's regional strategy to

people outside the area. All things considered, Polar Electro has played a multifaceted role in the creation of the Oulu ICT cluster, particularly in relation to the scale of demand (about 200 million euro) it has brought in.

(4) Improvement of the Entrepreneurial Environment

The phenomenon described in the previous chapter - the emergence of anchor firms, along with the growth of a number of other hi-tech enterprises – is the aspect most fundamental to enriching the "industrial ecology" which is the entrepreneurial environment. Entrepreneurial environments in general, and those for high-tech start-ups in particular, offer incubators, business support services for start-up firms, and risk money and other forms of capital. These functions have played significant roles in the Oulu region.

① Oulutech and TeknoVenture

On its founding in Oulu in 1982, Technology Village Corporation made support for high-tech firms its corporate philosophy. This may have been a reason why Oulu was among the first areas to work on improving its entrepreneurial environment. However, an interview survey found that most recipients of support from Technology Village Corporation felt a lack of organization, as services (such as the introduction of customers and the proposal of ideas) tended to be provided on an individual level by whoever was in charge. In the 1980s, the Oulu city government and Technology Village Corporation acted as one. The city government was a prime mover in many sorts of improvements, especially in the institutional sphere. But an institutional framework had yet to be developed for the provision of organized, comprehensive support to companies and entrepreneurs.

At what point, then, did signs of such an institutional framework appear? Not until the mid-1990s, with the founding of Oulutech. Oulutech opened its doors in 1994, capitalized by Technology Village Corporation (30%), a University of Oulu fund (30%), and SITRA (40%). Technology Village Corporation was responsible for the rental of space, so firms did not have to concern themselves with that aspect. Oulutech, however, was created to be a specialized provider of every other type of incubating service. Stressing areas such as the commercialization of new technologies and support for high-tech start-ups, Oulutech employed specialists to deal with each field of technology, helping start-ups prepare business plans, evaluate and transfer technologies, protect

patents and technologies, organize finance[204], find sales networks and hire managers and specialists. The support that Technology Village Corporation had provided on a individual, piecemeal basis now was systematic and complete.

One of the people Oulutech turned to for risk money was Seppo Säynäjäkangas, who had founded Polar Electro in the mid-1980s and now, with his firm, was beginning to act as an investor. KERA (now Finnvera), a government regional development bank, also began offering positive support to start-ups at about this time.[205] Technoinvest Oy, a venture fund specializing in the provision of risk money, was established in 1988; undercapitalization (at 10,000,000 Finnish marks), however, prevented it from performing as hoped. Taking a lesson from Technoinvest's experience, the venture fund Techno Venture opened in 1994 – the same year as Oulutech – having spent two or three years on the fund's preparation. Techno Venture targeted companies in the north of Finland, primarily in the Oulu area. The government-affiliated KERA supplied somewhat over 40% of the necessary investment; neighboring communities also supplied over 40%, and SITRA and private financial institutions supplied the rest. The fund was managed by TeknoVenture Management Oy, established in 1991 by individual investors and currently the manager of four funds. TeknoVenture Management has 38.6 million euro in investment capital, made up of its own funds, other venture capital, and contributions from local governments and financial institutions. Involved in the establishment of the first of these funds (TeknoVenture, in 1994) was Jorma Terentjeff, a graduate of the University of Oulu's Department of Electrical Engineering who was instrumental in the development of numerous electronics companies in the Oulu region. From this regional fund he invested in JOT Automation and served as its advisor on mergers with similar firms in the south. In 1995 he was named CEO of JOT Automation and guided the firm to its listing on the stock exchange. A representative example of the Oulu entrepreneur, he stepped up to the company's presidency and started new regional venture funds. He went on to

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[204] For example, TEKES funds for market and business concept surveys and checking on intellectual property rights (up to 10,000 euros/project); TEKES and SITRA funds for the preparation of business plans (up to 40,000 euros/project); funds from a seed consortium including SITRA, TeknoVenture Oy, Okobank and others (up to 168,000 euro/project).

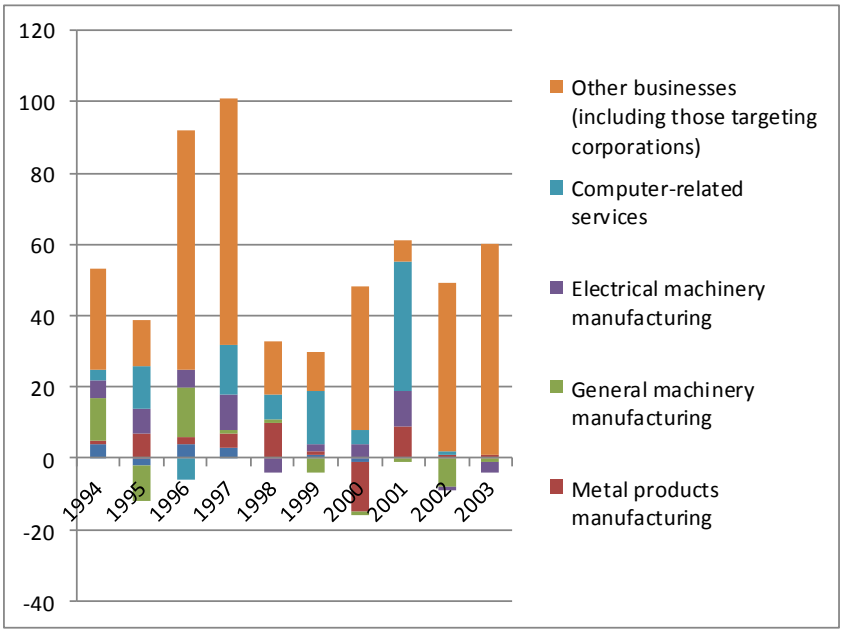
[205] Polar Electro Vice-President Jouko Möttönen comments: "(For Polar Electro as an investor,) KERA was a key partner that played important roles. The people at KERA understood entrepreneurs. There were many start-up firms which benefited from KERA's support. Start-ups today have a much easier time procuring funds, but in those days it was really difficult. We shall never forget what KERA did for us." (Additions in parentheses are the author's.)

create four funds[206] in all, with investments in a total of 57 companies, 22 of which have already been exited.[207]

② Increase in ICT-related Business Establishments, 1995-2000

We have seen how the "industrial ecology" developed with the emergence of Nokia and other companies as anchor firms from the mid-1980s. In 1994, with Oulu now capable of incubating start-ups and providing firms with risk money, the region's entrepreneurial environment had greatly improved. Since it was not possible to confirm the actual number of business openings, I investigated the number of business establishments in the Oulu region operating in sectors related to the ICT cluster (Figure 4-20). We see significant increases in the number of business establishments, largely in "other businesses" (including consultancy and professional service businesses targeting corporations) and computer-related services (such as software), particularly in 1996 and 1997. Substantial numbers of business openings may be inferred in these fields after the mid-1990s.

Figure 4-20 Numbers of Business Establishments Operating in the Oulu Region in Sectors Related to the ICT Cluster (Change from previous year)



[206] Manages four funds as general partner with unlimited liability: TeknoVenture Oy (est. 1994, fund capital 15 mil. euros), Lapin Rahasto I KY (est. December 1999, fund capital 3,200,000 euros), Jokilaaksojen Rahasto I Ky (est. November 2000, fund capital 5, 400,000 euros), and four funds of TeknoVenture Rahasto II Ky (est. May 2002, fund capital 15 mil euros).

[207] Email from company president Ilkka Lukkariniemi (November 24, 2005).

Data for Figure 4-20

(Change in number of business establishments from previous year)

Year	Number in 1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	Number in 2003
Rubber and plastic goods manufacturing	11	4	-2	4	3	0	1	-1	0	0	0	20
Metal products manufacturing	56	1	7	2	4	10	1	-14	9	1	1	78
General machinery manufacturing	84	12	-10	14	1	1	-4	-1	-1	-8	-1	87
Electrical machinery manufacturing	82	5	7	5	10	-4	2	4	10	-1	-3	117
Computer-related services	110	3	12	-6	14	7	15	4	36	1	0	196
Other businesses (including those targeting corporations)	634	28	13	67	69	15	11	40	6	47	59	989
Total	977	53	27	86	101	29	26	32	60	40	56	1,487

Source: Statistics Finland.

(5) Establishment of a Reputation

Numerous factors must be taken into account when judging whether a concentration of businesses has established a reputation as an industrial cluster. These factors may be difficult to specify, but we can at least say that one necessary condition is a stable, reasonably-sized agglomeration of companies in the field concerned. Other important factors include an increase in the number of firms (including start-ups) locating in the cluster as a result of efforts by activity groups, and an overall vitalization of industrial activity due to the growth of businesses originating in the region. When conditions like these are in place, the public will begin to see television and magazine reports on the emerging high-tech cluster and conferences will take it up as a topic of discussion. At this point, the region will have established a fairly widespread reputation as a high-tech industrial cluster. Reports on the rapid growth of high-tech firms originating in the area, and on their being listed on the stock exchange, are particularly effective in building a reputation, especially when numerous such firms appear in sequence. Visits by foreign politicians and the holding of major international conferences also enhance a region's reputation both at home and abroad. In any case, sporadic news reports are only part of what is needed for a region to earn a reputation as a high-tech cluster. The major constituents essential to the establishment of a reputation are an increase in the number of companies in operation, vibrant industrial activity and innovation.

How does Oulu fare in this respect? It was only in 1975 or so – surprisingly recently – that people began to use the expression "the Oulu phenomenon"[208]; certainly neither

[208] Interview with Dr. Oksman.

"industrial agglomeration" nor "industrial cluster" would have described what existed in Oulu at that time. In all likelihood the term was used to indicate the beginnings of a new phenomenon for Oulu, namely the extraordinary rise of the electronics industry. In the second half of the 1970s, the University of Oulu's Department of Electrical Engineering had already been open for more than ten years. Influenced by Drs. Oksman and Otala, growing numbers of electronics firms had for several years been taking root in the Oulu area where none had existed before. The term was evidently in wide acceptance in September 1988, when SITRA published its activity report on Technology Village Corporation subtitled "A Chronology of the Oulu Phenomenon." The late 1980s was when Nokia was becoming Oulu's anchor firm; companies like Elektrobit, JOT Automation, CCC, and Solitra were developing well in that enriching environment. Technology Village Corporation was expanding its operations at Linnanmaa, next to the university, and the Oulu city government was promoting its "City of Technology" publicity strategy as part of its larger industrial policy. In that sense, the industrial cluster was visibly taking shape. However, Oulu had not yet produced any listed companies, and the institutional infrastructure required for entrepreneurship remained immature. A great deal of practical work remained to be done. After the recession-marred first years of the 1990s, Nokia moved quickly to reignite growth through its mobile telephone business; by 1994, with the founding of Oulutech and TeknoVenture, the environment for new business was improving markedly. In the same year, the Finnish Ministry of the Interior began its COE program designed to roll out the "Oulu model" nationwide. The industrial cluster had noticeably improved in the practical sense, and, with the government's endorsement of Oulu as a successful example of regional industrial development, its reputation had as well.[209] Later events included the listing on Helsinki's Stock Exchange of the PKC Group in 1997, JOT Automation in 1998, and Technopolis Oulu Corporation itself in 1999. Oulu had firmly established its reputation as an ICT cluster. The listing of JOT Automation and the other firms mentioned brought tremendous assets to local business people, some of whom began acting as business angels themselves. This produced yet more risk money for the region, in a positive cycle which further improved the environment for entrepreneurs (Tables 4-3 and 4-4).

[209] In Japan, Oulu was becoming known among people involved in the Hokkaido cluster, at least from the mid-1990s. In 1997, members of the Association for Creation of the Hokkaido Industrial Cluster and the Industrial Cluster Research Association Okhotsk visited Oulu and initiated a series of mutual exchanges.

Table 4-3 Major Listed Companies in the Oulu Region (Helsinki Stock Exchange)

Company name	Line of business	Year listed
PKC Group Oyj (est. 1969)	Wire harness manufacturing and manufacturing services	1997
Incap Oyj (est. 1992)	Electronics manufacturing services (EMS)	1997
JOT Automation Group Oyj[1] (est. 1988)	Automatic production systems	1998
Technopolis Oyj (est. 1982)	Operation of science parks	1999
Scanfil Oyj (est. 1976; began operating in Oulu in 1990)	Production systems and EMS	2000
Elektrobit Group Oyj (merger by Elektrobit Oy [est.1985] with listed firm JOT Automation Oyj)	Electrical and electronic equipment, software, and automatic production systems	2002
Ruukki Group Oyj (est. 1994)	Business group investing in diverse venture businesses in Finland	2003

Note1: Merged with Elektrobit Oy in 2002, becoming Elektrobit Group Oyj.

Note2: QPR Software Oyj, established in 1991, moved to Helsinki after its listing in 2002.

Table 4—4 Principal Business Angels and Consultants to Hi-tech Firms in the Oulu Region

Year established	Company name (Investment company or consultants)	Founder	Founder's previous position (ex.)	Remarks
1977	Polar Electro Oy	Dr. Seppo Säynäjäkangas	University of Oulu	Investments made by both the company and Mr. Säynäjä kangas.
1995	Fortel Invest Oy	Mr. Juha Sipila	Solitra Oy	
1999	Head Invest Oy	Mr. Veikko Lesonen	JOT Automation Oyj	Head Invest Oy is an umbrella company comprising Winwind Oy and other new firms started by Mr. Lesonen.
1999	Acted as individual consultant	Mr. Tapio Tammi	Polar Electro Oy	Mr. Tammi works as a consultant while operating Gamga Oy.
2000	Avant Management Oy	Mr. Jorma Terentjeff	JOT Automation Oyj	
2000	Acted as individual consultant	Mr. Raimo Kuismin	University of Oulu liaison officer	Mr. Kuismin works as a consultant while operating CadFaster Oy.
2003	IT-Pilot Oy	Mr. Eero Vallström	Nokia Networks	
2003	Oulu Business Networks Oy (→became OBN Oy)	Mr. Toivo Vilmi	Nokia Networks	Primarily a business consultant.
2004	MEVita Invest Oy	Mr. Erkki Veikkolainen	Nokia Mobile Phones	

One result of an established reputation is feedback. In Figure 4-20 we see how ICT establishments have increased since the mid-1990s. Overall, the entrepreneurial environment improved considerably after 1994. With government recognition as a model region, Oulu had succeeded, to a certain extent at least, in establishing a reputation. These developments, along with Nokia's expansion of its local operations, created a fertile environment for the growing numbers of new business establishments being founded there in the second half of the 1990s. Toward the end of the decade, firms originating in Oulu were listed on the Helsinki exchange for the first time. Both at home and abroad, Oulu's reputation was now secure. Technopolis Oulu Oy itself was listed in 1999, and the firm embarked on new Technopolis projects near Helsinki: Technopolis Helsinki Vantaa, adjacent to the capital's Vantaa Airport, and Technopolis Innopoli II in the Otaniemi district of Espoo. Noteworthy high-tech regions were on the rise in Finland, and while there is no denying that Oulu came to be seen in relation to these, its reputation as an international center of mobile technology was long-standing and it continues to enjoy distinction as an ICT cluster.

In the foregoing I have examined the progress of a cluster's five formative processes in the sequence given in the working hypothesis. Rather than representing a strict order in which one process begins at the conclusion of the one before it, this sequence expresses a rough probability of progress backed by mutually enhancing causal correlations. In this sense, this part of the working hypothesis – principally the proximate order of the five formative processes during the "foundation period" – appears to be sound.

4.4.2 Verification of Mutually Enhancing Causal Correlations among the Formative Processes

Next I discuss the mutually enhancing causal correlations among the different formative processes (Figure 3-5, p. 47), starting from the relationships originating in I, "Improvement of the Environment for Innovation."

①: "Places with good universities and public research and development institutions are more attractive to high-tech firms." The creation of the Department of Electrical Engineers at the University of Oulu opened the way for joint research programs between Dr. Matti Otala and Kajaani Electronics, and Seppo Leppävuori, then an acting professor, and Aspo. These prompted a number of electronics firms to locate in the Oulu region, and later encouraged other firms, clearly involved in causal correlations, to move there as well. One such firm was the steelmaker Rautaruukki Corporation, which set up an electronics division in Oulu.

②: "An environment supporting innovation promotes the growth of existing firms, encouraging them to make the district their home base and facilitating the emergence of anchor firms." Upon moving to Oulu in 1973, Nokia launched joint research with the University of Oulu and the VTT Electronics Research Laboratory, employing people educated and trained at the university and Oulu Polytechnic (the Institute of Technology and other institutions) as it expanded the range and scale of its business. This case demonstrates a fairly strong causal correlation between improvement of the environment for innovation in Oulu and Nokia's development into an anchor firm.

③: "As the presence of universities and public research and development institutions produces more innovative "seed" technologies and workers familiar with them,

opportunities for start-ups increase." The strength of this correlation is proven by the fact the seed technologies of Oulu's native high-tech firms were largely derived from work conducted at the University of Oulu or the VTT Electronics Research Laboratory[210]; the founders of these local firms were often connected with the University as well.[211]

④: "Places with good universities and public research and development institutions enjoy good reputations as research meccas." The founding of the University of Oulu and the VTT Electronics Research Laboratory helped to expand research in the field of wireless telecommunications. In 1987, research on CDMA began in Oulu, involving actors from both industry and academia. Events like these were instrumental to Oulu's budding reputation as a thriving center for research in wireless telecommunications and related software. Another institution contributing to Oulu's reputation as a research mecca was the Center for Wireless Communication (CWC), a project-oriented research facility founded in 1995 as an outgrowth of the Telecommunication Laboratory of the University of Oulu's Department of Electric Engineering. Oulu's own COE program holds forums promoting collaboration among actors from various fields. Along with the Software Forum, the Mobile Forum was, in 1996, the earliest of these to go into operation. The many accomplishments of the Mobile Forum included creating the Octopus testing environment for mobile applications. While these achievements of the latter 1990s took place against the backdrop of Oulu's growing reputation as a mecca for mobile technology research, I cannot say that the region's "research mecca" reputation was their direct cause.

⑤: "As firms grow in number, they serve as leaders in facilitating innovation." While there was a clear increase in the number of ICT-related business establishments in Oulu between 1995 and 2000 (Figure 4-20)[212], the number of patent applications by inventors residing in Oulu (Figure 4-21) – an indicator of innovation – showed no real growth over the figures for 1994, either in sum total or in the fields of electricity or physics.

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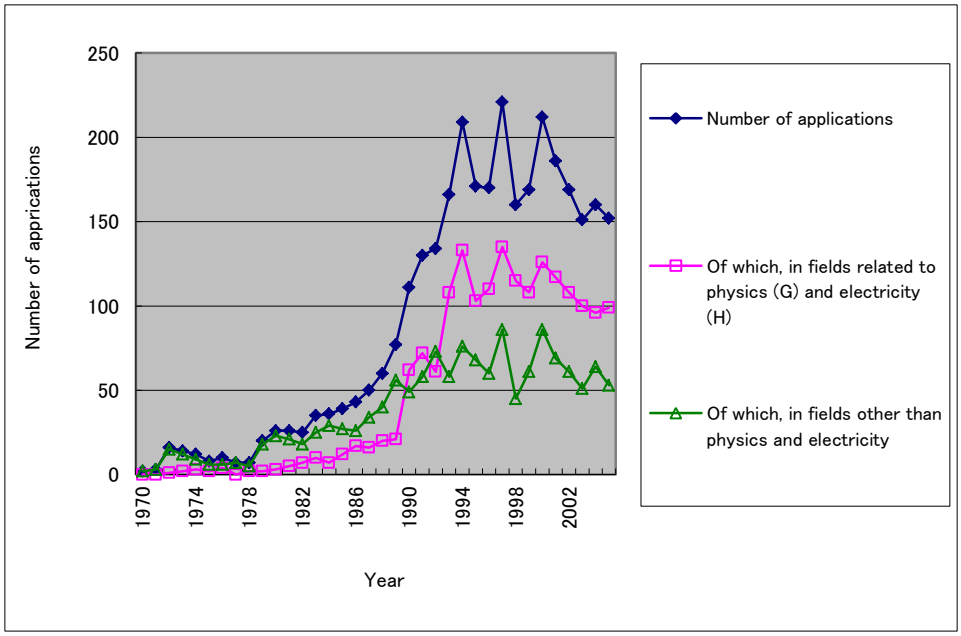
[210] Polar Electro is a typical example, but there are many others. Codenomicon Oy, a developer of robustness testing tools for software security, is among those firms which clearly originated in the University of Oulu. The custom IC designer Fincitec Oy (purchased in 2002 by National Semiconductor) is among those originating in the VTT Electronics Research Laboratory. One firm which had its origins in both the University and VTT is Cybelius Software Oy, a CCC subsidiary which develops simulation software for the field of virtual design.

[211] Most of the Oulu-born high-tech firms mentioned in this paper – such as Elektrobit, CCC, and NetHawk – were founded by graduates of the University of Oulu.

[212] Because of statistical limitations, analyses were made for 1993 and the years thereafter.

Thus I was unable to confirm a correlation between these sets of circumstances.

Figure 4-21 Number of Patent Applications in the Oulu Region (Classified by business field. Applications by inventors residing in Oulu.)



(Data for Figure 4-21)

Year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Number of applications	2	3	16	14	12	8	10	7	7	20	26	26	25	35	36	39	43	50
Of which, related to physics (G), electricity (H)	0	0	1	2	3	2	4	0	2	2	3	5	7	10	7	12	17	16
Of which, in fields other than physics and electricity	2	3	15	12	9	6	6	7	5	18	23	21	18	25	29	27	26	34

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Number of applications	60	77	111	130	134	166	209	171	170	221	160	169	212	186	169	151	160	152
Of which, related to physics (G), electricity (H)	20	21	62	72	61	108	133	103	110	135	115	108	126	117	108	100	96	99
Of which, in fields other than physics and electricity	40	56	49	58	73	58	76	68	60	86	45	61	86	69	61	51	64	53

Source: The Finnish Patent Office.

⑥: "As firms grow in number, the probability of anchor firms emerging increases as well." As a causal correlation, this presupposes a low probability that a firm enjoying vigorous growth will emerge from among a large number of firms. In Oulu, Nokia and Polar Electro did not exactly emerge from a large number of high-tech companies to become anchor firms. Rather, it was the "improvement of the environment for innovation" which played the key role in Nokia's development into an anchor firm.

This particular correlation, therefore, was not verified.

⑦: "As firms grow in number, the district's industrial ecosystem deepens, increasing the opportunities for new business creation." Since numerical data on start-ups are only available for the years since 1999 (Table 4-5), it is impossible to confirm a causal correlation with the increase in the number of business establishments during the first half of the 1990s. However, considering how markedly start-ups have increased since 2000, it would appear that opportunities for business creation did, to a certain extent, result from the formation of the industrial cluster prior to that year.

Table 4-5 Numbers of Business Start-ups in Sectors Related to the Oulu ICT Cluster

Year	1999	2000	2001	2002	2003	2004
Rubber and plastic product manufacturing	1	1	0	0	0	0
Metal product manufacturing	4	4	8	2	3	3
General machinery manufacturing	2	7	3	3	4	4
Electrical machinery manufacturing	6	5	3	8	8	4
Computer-related services	28	29	34	35	37	41
Business consulting	21	17	19	16	22	28
Total	62	63	67	64	74	80

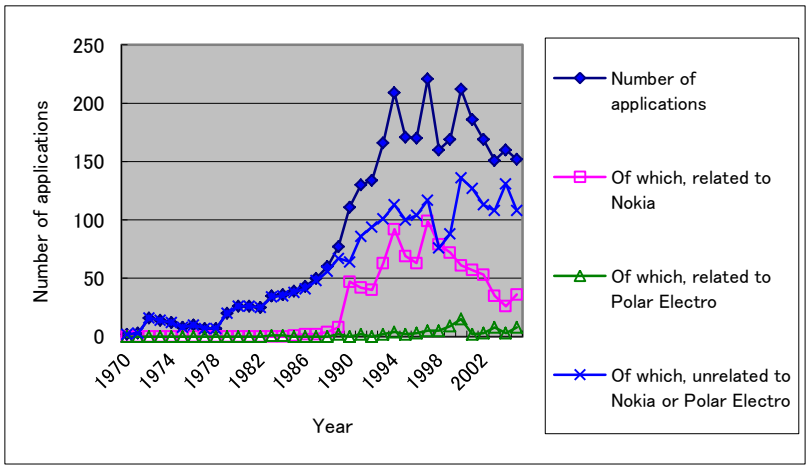
Source: Statistics Finland

Note: "Business consulting" is given as an example of "other business (including corporate services)" in the "services" category.

⑧: "As firms grow in number, the district enjoys a rising reputation as an industrial agglomeration." Although there was simultaneity between the growth in the number of start-ups during the first half of the 1990s and the growth in Oulu's international reputation as an ICT cluster through the end of the decade, it was not possible to identify circumstances which were clearly expressive of a causal correlation.

⑨: "Anchor firms link demand to technology, facilitating innovation." In Oulu, the question is whether Nokia and Polar Electro furthered innovation in the Oulu region by having become anchor firms. The number of a firm's patent applications (Figure 4-22) is an indicator of innovation output. Nokia's patent applications began increasing markedly after 1990, some years after it became an anchor firm in the latter 1980s. Nokia's applications served to push up the applications made by the region as a whole. For this reason, I was able to can confirm that this correlation did exist in Oulu, mainly in the 1990s. Applications made by companies other than Nokia and Polar Electro began increasing in the 1980s, and, it should be noted, they have shown firm growth even since 2000, when applications by Nokia started gradually to decline.

Figure 4-22　Numbers of Patent Applications by Companies in the Oulu Region (By applicant. Inventors have addresses in the Oulu region.)



(Data for Figure 4-22)

年	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Number of applications	2	3	16	14	12	8	10	7	7	20	26	26	25	35	36	39	43	50
Of which, related to Nokia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	2
Of which, related to Polar Electro	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0
Of which, unrelated to Nokia or Polar Electro	2	3	16	14	12	8	10	7	7	20	26	26	25	34	35	38	41	48

年	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Number of applications	60	77	111	130	134	166	209	171	170	221	160	169	212	186	169	151	160	152
Of which, related to Nokia	4	8	47	42	40	63	92	69	63	99	79	72	61	57	53	35	26	36
Of which, related to Polar Electro	0	2	0	2	0	2	4	2	3	5	5	9	15	2	3	8	3	8
Of which, unrelated to Nokia or Polar Electro	56	67	64	86	94	101	113	100	104	117	76	88	136	127	113	108	131	108

Source: The Finnish Patent Office.

⑩: "As anchor firms emerge, they produce increased business opportunities which attract outside firms to the area." One example here might be Scanfil Oy, a manufacturer of production systems for the electrical machinery industry which was founded in 1976 and listed on the Helsinki Stock Exchange in 2000. In 1990, some years after Nokia's emergence as an anchor firm, Scanfil established a base in the Oulu region. While that much is clear, limitations on the collection of data make it impossible to establish a definite causal correlation.

⑪: "As anchor firms emerge, business opportunities increase, providing more opportunities for the creation of new subcontracting firms." As has been mentioned a number of times in this paper, Nokia's emergence as an anchor firm has been shown to

have had a clear causal correlation with the establishment of operating bases by Elektrobit, JOT Automation, CCC, Solitra and other native Oulu firms.

⑫: "The reputation of a district benefits when it becomes known as the 'home base' of an anchor firm." With Nokia's emergence as an anchor firm in Oulu and the company's rapid growth as a whole during the second half of the 1990s, Oulu built a reputation as Nokia's "home base" for base stations and embedded software development and as a thriving ICT cluster as well. In 1992, Polar Electro won the President's Prize for Exporters. As a result of these events, Oulu gained renown as a city based on high technology. In this respect, I had no trouble in identifying a strong causal correlation.

⑬: "Improvement of the entrepreneurial environment results in more new firms, thus facilitating radical and disruptive innovation." Since data on start-ups in the Oulu region are available only for 1999 and thereafter, I could not verify whether a causal correlation existed during the cluster's formative period. However, since much of the increase in business establishments during the second half of the 1990s appears to have been due to start-ups, it appears that the number of new business openings has been on a gradual ascent since that time. And, as we have seen in the foregoing, the number of patent applications since 2000 by firms other than Nokia and Polar Electro[213] is holding strong. Thus, there may be simultaneity in the timing of the two events, but one cannot confirm a direct causal correlation.

⑭: "Improvement of the entrepreneurial environment leads to more new firms and a deepening of the corporate agglomeration." As logic, this is self-evident, provided that business closings do not exceed business openings. However, one is prevented from confirming a direct correlation because of the lack of statistical data on the number of high-tech business openings and closings in Oulu throughout the 1990s. It is clear that the number of ICT-related establishments increased in the decade's second half, and this increase did include firms moving into Oulu from other regions. Business openings probably exceeded closings during this period, arguably by greater margin than in former years.

⑮: "An improved entrepreneurial environment leads to more new firms, thereby enhancing the district's reputation as a home for rising industries." The receipt of the

[213] I examine this here as an indicator not only of "radical and disruptive" innovation, but of innovation as a whole.

President's Prize for Exporters in 1992 by Polar Electro, a native of Oulu, enhanced the reputation of Oulu itself. Later, Oulu's reputation as a high-tech cluster was further augmented by the listing on the Helsinki exchange of JOT Automation in 1998 and of Technopolis Oulu – the embodiment of the ICT cluster – in 1999. These events are indisputable and indicate the existence of a clear causal correlation.

⑯: "An established reputation facilitates the inflow of information on markets and technology, thus encouraging innovation." Patent applications are an indicator of innovation output. Since the mid-1990s, when the region's reputation was fairly established (since the completion of the foundation period, in other words) the number of patent applications has remained steady (Figure 4-22. While applications by Nokia have declined from their peak in 1997, those by non-anchor firms have stayed firm since the latter 1990s through 2000 and beyond.). Also, the Mobile Forum, Software Forum and others operating under Oulu's COE Program have been quite active since 1996, helped by the participation of companies from outside the region. Both events may point to this causal correlation. In regard to the rise in applications, however, its occurring simultaneously with the establishment of Oulu's reputation is not proof of causation. With respect to the latter event, I was not able to compare the situation with that which preceded it, and therefore could not verify any clear causal correlation.

⑰: "Districts with an established reputation are more appealing to firms considering location sites." Since the mid-1990s, when the region's reputation was fairly established (the completion of the foundation period), the number of start-ups has grown as a whole. However, I was unable to obtain data that would indicate how many of that number came to Oulu from other regions. I was thus unable to establish a clear causal correlation between the establishment of Oulu's reputation and location in Oulu by high-tech firms arriving from other regions.

⑱: "Districts with an established reputation hold more interest for potential supporting businesses." This phenomenon is observed frequently among high-tech industrial clusters in the United States. Accountants, patent offices, and law offices moved into Oulu relatively early, encouraged by incentives provided by Technology Village Corporation and the city government.[214] Most of the business angels active

[214] Technopolis Accounting Office, for example, an accounting firm in business since the first half of the 1980s, when Technology Village had its start, was established by a group of Oulu natives; the patent office Kolster Oy and the law firm Roschier Holmberg Asianajotoimisto Oy,

there were Oulu natives, as shown in Table 4-4. Few facts exist to indicate a clear causal correlation between the establishment of Oulu's reputation and an influx of support businesses from outside.[215]

The working hypothesis constructed in Chapter 3 for the formative mechanism of a high-tech cluster involved mutually enhancing causal correlations between the various processes involved in the formative process. In Figure 4-23, the bold lines show which of those correlations I could verify in Oulu. While I was unable to verify the remaining correlations, neither could I deny their existence completely when all factors were considered. I therefore chose to leave the working hypothesis as it was with no modification.

As the figure shows, the correlations originating with I, "Improvement of the Environment for Innovation," and III, "Emergence of Anchor Firms," have evidently had a stimulatory effect on the other formative processes in the development of Oulu's ICT cluster. Furthermore, processes III, "Emergence of Anchor Firms," and IV, "Improvement of the Entrepreneurial Environment," are shown to have had a similarly clear effect in stimulating process V, "Establishment of a Reputation," which may be regarded as an outcome of industrial cluster formation. "Improvement of the Environment for Innovation" and "Emergence of Anchor Firms" are, in themselves, easily understood and have stimulatory effects on other formative processes that are easily perceived. Yet both seem to occupy places of special importance in the hierarchy of formative processes.

In Oulu, activity groups played a big role in encouraging process I, "Improvement of the Environment for Innovation," which as a result has had a huge stimulatory effect on other formative processes (II, III and IV). We can say this because "as a result," in this case, means "as a result of stimulatory measures, helped by a certain amount of luck." Meanwhile, as the mechanism moved on to process V, "Establishment of a Reputation" – an outcome of formative processes I through IV – activity groups were unable to work directly on process III, "Emergence of Anchor Firms." And, while activity groups did promote the building of physical and institutional infrastructure,

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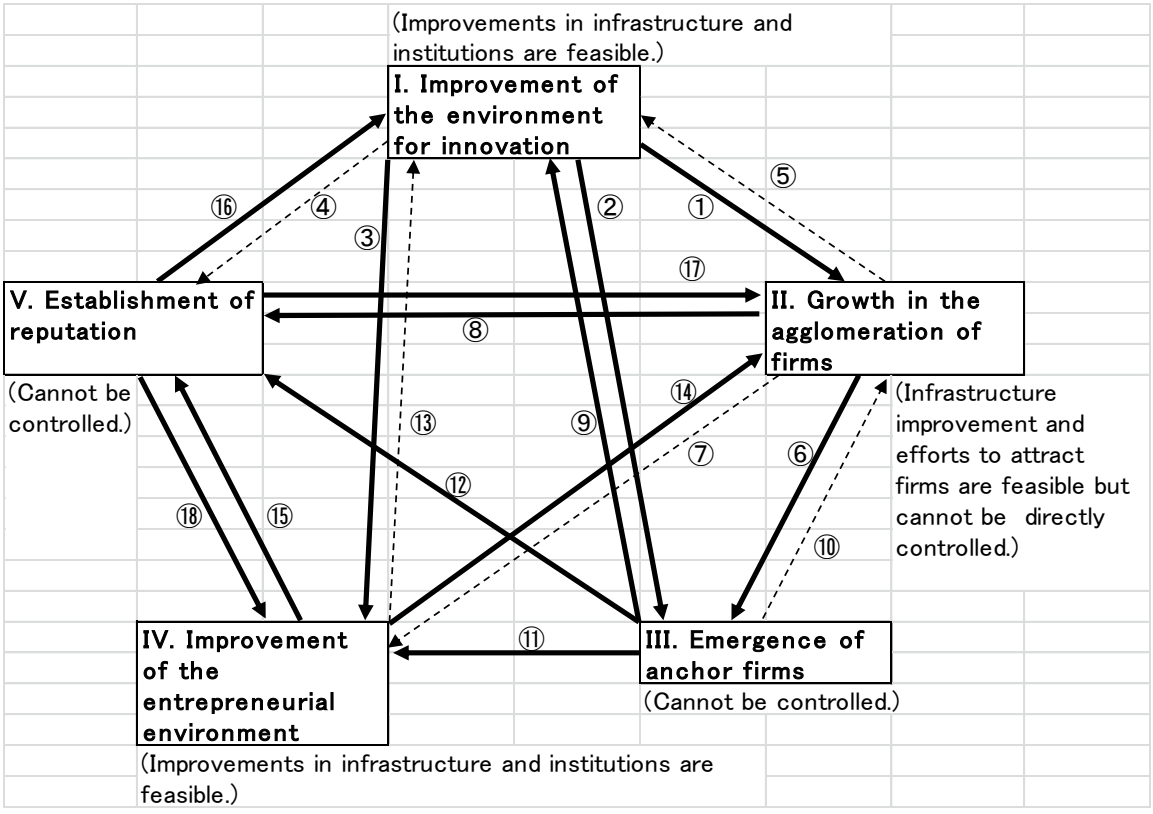
leaders in their fields, set up bases in Oulu in the second half of the 1980s or beginning of the 1990s. (Interview with Seppo Mäki)

[215] In the venture capital arena, funds flow into the region from other areas through networks maintained by local venture capital firm TeknoVenture Management and virtual incubator Oulutech.

the greatest contribution to the entrepreneurial environment was process III itself, the "Emergence of Anchor Firms." It was therefore by no means easy to rely on activity groups to promote formative processes III, IV and V. Efforts by activity groups to promote the formation of high-tech industrial clusters can be construed as actions which strengthen the probability that the above processes will advance, while encouraging those aspects which are most controllable (elements of processes I, II and IV) and hoping all the time for good luck.

Figure 4-23 The Mechanism of High-tech Industrial Cluster Formation: Five Formative Processes, the Promotion of Causalities Among Them, and Causalities Verified in the Oulu



Note 1: Broad arrows show comparatively strong causalities; narrow dotted arrows show comparatively weak causalities.

Note 2:

① Places with good universities and public research and development institutions are more attractive to high-tech firms.

② An environment supporting innovation promotes the growth of existing firms, encouraging

them to make the district their home base and facilitating the emergence of anchor firms.

③ As the presence of universities and public research and development institutions produces more innovative “seed” technologies and workers familiar with them, opportunities for start-ups increase.

④ Places with good universities and public research and development institutions enjoy good reputations as research meccas.

⑤ As firms grow in number, they serve as leaders in facilitating innovation.

⑥ As firms grow in number, the probability of anchor firms emerging increases as well.

⑦ As firms grow in number, the district’s industrial ecosystem deepens, increasing the opportunities for new business creation.

⑧ As firms grow in number, the district enjoys a rising reputation as an industrial agglomeration.

⑨ Anchor firms link demand to technology, facilitating innovation.

⑩ As anchor firms emerge, they produce increased business opportunities which attract outside firms to the area.

⑪ As anchor firms emerge, business opportunities increase, providing more opportunities for the creation of new subcontracting firms.

⑫ The reputation of a district benefits when it becomes known as the ”home base“ of an anchor firm.

⑬ Improvement of the entrepreneurial environment results in more new firms, thus facilitating radical and disruptive innovation.

⑭ Improvement of the entrepreneurial environment leads to more new firms and a deepening of the corporate agglomeration.

⑮ An improved entrepreneurial environment leads to more new firms, thereby enhancing the district’s reputation as a home for rising industries.

⑯ An established reputation facilitates the inflow of information on markets and technology, thus encouraging innovation.

⑰ Districts with an established reputation are more appealing to firms considering location sites.

⑱ Districts with an established reputation hold more interest for potential supporting businesses.

Note 3: For processes IV→III (improvement of the entrepreneurial environment → emergence of anchor firms) and V → III (establishment of reputation → emergence of anchor firms), direct causal correlations are difficult to conceive and therefore are not included in the above.

4.4.3 Verifying the Boundary between the Foundation Period and the Development Period

The working hypothesis constructed in Chapter 3 presents the formative period as consisting of a foundation period and a development period. I assumed the "foundation period" to be that in which the five formative processes advance at a reasonable rate, and the "development period" to be that in which all mutually enhancing causal correlations originating in each formative process begin to operate, the high-tech cluster gathers momentum, and firm accumulation grows steadily greater. If we take the founding of the University of Oulu, in 1958, as the "preparation stage" of the ICT cluster's formation, we can regard the formative process of the high-tech cluster ("improvement of the environment for innovation") as having begun in 1965 with the creation of the university's Department of Electrical Engineers. We can consider "growth in the agglomeration of firms" as having started in the early 1970s, when electronics firms began to put down roots in the region. The point at which we see the "emergence of anchor firms" would be 1984, when Nokia began to aim at a world market for its base station business, or 1985, when it started developing embedded software for mobile phones. Also founded in 1985 were Elektrobit, built to a large extent upon its business with Nokia, and CCC. "Improvement of the entrepreneurial environment" started in 1982 with the founding of Technology Village, but the basic environment came together in the period between Nokia's emergence as an anchor firm in the second half of the 1980s and the founding of Oulutech and TeknoVenture in 1994. Some controversy exists over when, after these four processes had started, the region came to enjoy a certain reputation as an IT cluster. On the one hand, we can assume that Oulu's reputation was established around 2000, as it was widely recognized by then and had produced a variety of outcomes including IPOs of locally founded companies. On the other hand, we can assume its reputation to have been established in the mid-1990s, as suggested by its designation as a model region under the government's COE project (1994-present); we can interpret the increase in the number of ICT-related firms that occurred toward the end of the 1990s, and the success of the Mobile Forum operated as part of Oulu's COE program, as having resulted from overall progress in the formative process. Viewed from the latter perspective, the foundation period of the Oulu ICT cluster lasted from 1965 through 1994 and the development period from 1995 through 2000. The years since 2000 might appropriately be viewed as the "period of maturity" that followed once formation had taken place, or a "period of change" ahead of a new era. The Oulu Growth Agreement, prepared in 2002 with guidance from the city government and the business community, posits new

development strategies rather than a continuation of previous ones. Strategies are now being rolled out which call for utilizing ICT, especially mobile technology, to provoke innovation in other industrial sectors. Judging from the situations that existed before and afterward, the late 1990s can be regarded as the "development period" envisaged under the working hypothesis, whereas 2000 can be seen as the endpoint of the formative period as a whole. In the case of Oulu, the division of the formative period into a foundation period and a development period can be explained with consistency, and, therefore, verified in its essentials.

4.5. Principal Actors in Activity Groups Involved in the Formative Process of the Oulu ICT Cluster

In the previous section I have attempted to verify the working hypothesis constructed in Chapter 3. In regard to the "activity groups" included in this paper's definition of an industrial cluster, the working hypothesis presupposes, first, their existence, and, second, that they have made efforts of some sort to promote the formative process. Looking at the Oulu cluster's chronology to date, we see that activity groups have existed at each stage, pushing for the cluster's formation, regardless of who played the leading roles in each group. In this section we shall see who these principal actors were.

That companies themselves are the lead players in any industrial cluster is something that hardly needs repeating. In Oulu, the first "activity group" can be said to have been Professors Oksman and Okala, who in the late 1960s identified the possibilities of an electronics industry in northern Finland, in the sense that they set forth a vision for the cluster and took concrete steps to realize that vision. The proclaimed intention at that time was to develop the electronics industry in order to create jobs in northern Finland. Central to this concept was increasing the number of factory workers earning relatively low salaries. In other words, the aim was to use the research functions of the University of Oulu to draw in the productive functions of the electronics industry and cause them to stay. Entering the 1970s, the increasing number of instructors and researchers at the university's Department of Electrical Engineers helped attract the VTT Electronics Research Laboratory to Oulu. Dr. Otala was named its director. Having pushed forward with commercialization research tailored to company needs, Dr. Otala could be counted on to lead an institute with VTT's history. Most graduates of the University

of Oulu, moreover, went on build their applied research experience at the VTT institute. In this sense, VTT, even as it contributed to Finland as a whole as a national center of applied research, was also a kind of "flying column" of the University of Oulu – particularly its Department of Electrical Engineering, which was then the central activity group pushing for an ICT cluster in the region. Toward the end of the decade, through their "Sauna Event" and other initiatives, Drs. Oksman and Otala continued to advance the philosophy that electronics engineers could, and should, contribute to regional development and job creation in northern Finland. The thriving success of Nokia and Mobila in later years showed that young engineers shared this view. Another key person was Seppo Säynäjäkangas, the first student of Drs. Oksman and Otala to graduate, earn a doctorate and become a professor. In 1977 he went on, as we have seen, to found Polar Electro, a university-launched company which accurately embodied their values. From the mid-1960s into the 1970s, it was Dr. Oksman, Dr. Otala, and their colleagues at the University of Oulu and the VTT Electronics Research Laboratory, who, with their keen vision, drove the creation of the Oulu ICT cluster.

Earlier we have seen how, starting in the late 1970s, members of the Oulu city government became beset with a sense of crisis. Paavo Simila was the first in government to become aware of a problem, but in the 1970s he had not yet moved people in the upper levels of City Hall, or in local politics, to take action. Socialist ideas were still prevalent at the time, and general sentiment opposed active government assistance to private companies.[216] Movement by the city government and the city council probably lagged to that extent. Great potential, but little change, was the order of the day – but the situation was about to change, suddenly and dramatically, with a speech by Antti Piippo, the outside entrepreneur who headed Aspo. The day after Piippo's speech in March 1980, Juha Linna (formerly Castrén), representative of the Oulu branch of KERA and a confidant of the mayor of Oulu, and Veli-Markku Korteniemi, Manager of Product Development and Marketing Units at the VTT Electronics Research Laboratory, submitted to the mayor of Oulu a proposal to establish a committee on electronics. Mayor Ilmo Paananen, who had studied conditions at Silicon Valley, lost no time in taking action. He invited the entrepreneur Seppo Mäki to join the city government, and the latter charged ahead to raise investment funds. In March 1982, the doors opened to Oulu Technology Village, Scandinavia's pioneering science park. Employees and know-how from the private sector were skillfully used in operating what was positioned as the "business unit" of

[216] Interview with Paavo Simila.

the city government's high-tech industries promotion policy. In June of 1984, the city government made its "City of Technology" announcement, paving the way for a rapid succession of industrial promotion policies.

As Nokia emerged as an anchor firm in the mid-1980s, the increasingly successful Polar Electro was starting investment aactivities with Seppo Säynäjäkangas. At Nokia, Dr. Veikkolainen, leader of the team developing embedded software for mobile telephones, began working with other high-tech companies in the Oulu area. In 1984, Eero Wallstrom, an alumnus of the Oulu Institute of Technology, became responsible for Nokia's base station division and took it into the global market; its subsequent run of success drew enormous outside demand into the Oulu region. Wallstrom was a central figure in the group of key people active in Oulu.[217]

If the 1990s were a decade of growing organized activity, as I discuss later, the 1980s were characterized by individual networking. The volunteer groups mentioned earlier included, besides corporate people, individuals who, although belonging to organizations of all kinds, chose to participate on a personal, voluntary basis rather than as part of some systematic strategy. It would be impossible to list all of these members by name, but they comprised a burgeoning network of key persons not only from companies, Technology Village, the city government, the University of Oulu, and the VTT Electronics Research Laboratory, but also from Finnish government agencies, financial institutions, business support firms and other entities. The casual observer may hardly have been aware of these networks, but a sense of unity was developing rapidly among their members – so much so that outsiders could be forgiven for thinking of them as an "Oulu mafia." Most people seen this way were probably members of one or another type of activity group.

The 1980s, then, were when activity groups began to include, in addition to people working at the University of Oulu, a wide range of others comprising city government officials, entrepreneurs who were the original force behind the industrial cluster (especially those involved with anchor companies), key individuals from various organizations, and their networks.

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[217] Jouko Möttönen, vice-president of Polar Electro at that time and a key member of the Revontuliryhmä, or "Aurora Group," mentioned earlier, referred to Eero Wallstrom as Nokia's "big boss" and the "soul of Oulu."

Entering the 1990s, the business community became yet more energetic just as activity groups themselves grew more organized. In Oulu's business community at that time, Nokia and Polar Electro, the pillars of activity groups for over a decade, were beginning to share that role with the Oulu Chamber of Commerce and Industry and Oulu-launched high-tech companies that had been gaining strength since Nokia's emergence as an anchor firm in the mid-1980s. The Chamber of Commerce and Industry, Polar Electro, Elektrobit and CCC were among the key entities that took part in preparing an industrial strategy for the Oulu region in the first half of the 1990s. Toward the end of the decade, local firms with assets amassed through public offerings began to function as business angels as well. On the whole, the 1990s were a period when a broader range of entrepreneurs, especially those who benefited from having Nokia as an anchor firm, emerged as the central figures of activity groups, and when, thanks to the work of the Chamber of Commerce and Industry, the business community began to act more systematically than before.

Earlier in this paper I stated that 2000, when shipments by the Oulu ICT cluster peaked, marked the point at which the cluster was essentially "formed." What form, then, did activity groups take during the period of maturity that followed 2000 (or the period of change that preceded a new age)? Since all important actors[218] had already joined an activity group by 1990, the examples that follow do not represent any new appearances on the list of key figures; they do, however, point to a few instances of systematic progress. There is, for example, the Oulu Regional Business Agency. Set up in 2000 by the City of Oulu and the business support departments of ten neighboring local governments, the agency offers free, individualized, expert support to entrepreneurs and start-up firms, even in sectors other than ICT or high technology. Oulu Innovation Oy, founded in 2205, coordinated the COE (Centers of Expertise) programs that were hitherto overseen by Technopolis Corporation, managed the Oulu Growth Agreement implemented principally by the city government, and worked on the Multipolis Network, a group of cooperative projects involving regions or clusters in northern Finland, each with its own unique characteristics. Thus, changes that took place in activity groups after 2000 did not involve any increase in the range of participating regional actors, as occurred from the 1970s through the 1990s. Change was limited to systematic progress by regional actors and changes in the internal makeup of organizations. It seems safe to say that up to 2000, growth in the number of activity group supporters took place over a single continuous period that began in the late

[218] The actors referred to here are organizations.

1960s.

4.6 Summary

We have seen how the formative process of Oulu's ICT cluster began with the opening of the University of Oulu in 1958 and the founding of its Department of Electrical Engineers in 1965, followed by the gradual establishment of electronics firms in the region in the early 1970s and the successful overture made to the VTT Electronics Research Laboratory in 1974. These regional actors became the key components of Technology Village, northern Finland's first science park, established in 1982 under the leadership of the Oulu city government. The move by Technology Village to a site next to the university in 1985, followed by a move to the same location by the VTT Electronics Research Laboratory in 1989, brought the major actors together in Linnanmaa, thus further improving the environment for innovation and drawing in greater numbers of ICT firms. Into this nurturing environment came Nokia, which started in the mid-1980s to gradually expand its business in Oulu. Nokia's emergence as the region's anchor firm brought a wealth of business opportunities, and much real growth, to such Oulu-launched high-tech companies as Elektrobit, JOT Automation, CCC, and Solitra. Not only did the presence of an anchor firm enrich the region's industrial ecology, but dedicated efforts by activity groups – such as the establishment in 1994 of the regional venture fund TeknoVenture and the virtual incubator Oulutec – further enhanced the environment for entrepreneurs. Around the same time, Oulu was named a model region under the Ministry of the Interior's COE program, improving its reputation still more. This continuing progress in the formative process, and the ongoing growth of Nokia as the region's anchor firm, backed further growth in the number of ICT-related places of business as the 1990s wound down. At the decade's end a number of Oulu-launched firms went public, including JOT Automation and the company that exemplified the Oulu ICT cluster, Technopolis Oulu. Each of these events helped to solidify Oulu's reputation as a high-tech industrial cluster. Thus I have verified the rough order followed by the five formative processes of the working hypothesis.

The following mutually enhancing causal correlations have also been verified: ① Places with good universities and public research and development institutions are more attractive to high-firms; ② An environment supporting innovation promotes the

growth of existing firms, encouraging them to make the district their home base and facilitating the emergence of anchor firms; ③ As the presence of universities and public research and development institutions produces more innovative "seed" technologies and workers familiar with them, opportunities for start-ups increase; ⑨ Anchor firms link demand to technology, facilitating innovation; ⑪ As anchor firms emerge, business opportunities increase, providing more opportunities for the creation of new subcontracting firms; ⑫ The reputation of a district benefits when it becomes known as the "home base" of an anchor firm; and ⑮ An improved entrepreneurial environment leads to more new firms, thereby enhancing the district's reputation as a home for rising industries. The other causal correlations were not proved to be absent, but neither could they be verified in the case of Oulu. That task must be addressed at a later date.

We have seen that the founding of the University of Oulu served as the preparation stage for the Oulu ICT cluster's formative period, and that the formative processes began in earnest with the "improvement in the environment for innovation" that came with the university's establishment of the Department of Electrical Engineers in 1965. The "progress of firm accumulation" began early in the 1970s, when electronics firms started putting down roots, and the "emergence of anchor firms" came in the mid-1980s as Nokia's base station business gained momentum and the firm began developing embedded software for mobile telephones. I placed the start of the "improvement of the entrepreneurial environment" in 1982 with the opening of Technology Village, although it took until 1994 for the major components of such an environment to be in place, with Nokia having emerged as an anchor company and Oulutech and TeknoVenture open for business. The question of when the region attained a reputation as an ICT cluster is a difficult one, but I was able to place it at around 1994, when the Finnish Ministry of the Interior's COE program took off with Oulu as its model region. I considered the years up to this point as the "foundation period" and the second half of the 1990s, when the number of ICT-related firms was on the rise, as the "development period" with all the expansion of scale that that implies. I put the region's establishment of a solid reputation at the end of the decade, when growing numbers of its firms were going public. I drew a line under the development period in 2000, when the peak in shipments and other indicators showed that the Oulu ICT cluster was essentially formed. I therefore placed the years from 1965 through 1994 as the foundation period, those from 1995 through 2000 as the development period, and those since 2000 as a period of maturity or change ahead of a new era.

As for the principal figures in the activity groups working for an ICT cluster in Oulu, from the late 1960s through the 1970s these were Dr. Oksman, Dr. Otala and their colleagues at the University of Oulu, as well as the staff of the VTT Electronics Research Laboratory. All of these had a vision which propelled the cluster forward. In the 1980s they were joined by individuals in the Oulu city government and the entrepreneurs – particularly managers of anchor firms – who had originally propounded the idea of an industrial cluster. The 1990s were characterized overall by more organized efforts on the part of the business community. Activities were now undertaken by a broader group of people than in the past, including especially those entrepreneurs whose companies were growing stronger thanks to Nokia's and other companies' emergence as anchor firms. The decade also witnessed the inclusion of chambers of commerce and industry among the major activity groups. The 1970s through the 1990s saw continual expansion of the membership of activity groups, but changes since 2000 have been limited to progress in the organization shown by local actors and turnover among the groups' members.

Chapter 5 Conclusions

In the preceding sections I have used the chronology of the Oulu ICT cluster's formation to examine the working hypothesis[219] on the formative mechanism of high-tech industrial clusters constructed in Chapter 3. My findings have substantially verified that the five formative processes began to function in the following rough order, primarily during the foundation period: I. Improvement of the environment for innovation; II. Growth in the agglomeration of firms; III. Emergence of anchor firms; IV. Improvement of the entrepreneurial environment; and V. Establishment of a reputation.

I have also substantially verified the following mutually enhancing causal correlations: ①Places with good universities and public research and development institutions are more attractive to high-firms; ② An environment supporting innovation promotes the growth of existing firms, encouraging them to make the district their home base and facilitating the emergence of anchor firms; ③ As the presence of universities and public research and development institutions produces more innovative "seed" technologies and workers familiar with them, opportunities for start-ups increase; ⑨ Anchor firms link demand to technology, facilitating innovation; ⑪ As anchor firms emerge, business opportunities increase, providing more opportunities for the creation of new subcontracting firms; ⑫ The reputation of a district benefits when it becomes known as the "home base" of an anchor firm; and ⑮ An improved entrepreneurial environment leads to more new firms, thereby enhancing the district's reputation as a home for rising industries.

I was not able to verify the other causal correlations and will address that task at a later date.

I have divided the formative period as a whole into a foundation period and a

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[219] In this paper I use the term "working hypothesis" as defined in the *Kojien*: "A hypothesis, established not with the objective of providing an ultimate explanation for a given phenomenon, but as an effective means of controlling or facilitating research or experimentation currently under way." I do not attempt to offer a uniform theory for the formative mechanism of high-tech industrial clusters. Instead, I assume a case in which a high-tech cluster is formed in a region without an existing industrial agglomeration. To construct a formative mechanism, I call this a "working hypothesis for the formative mechanism for a high-tech industrial cluster."

development period. I assumed that progress takes place in the foundation period in the rough order outlined in I to V above, and that the formation of the cluster gains momentum due to mutually enhancing causal correlations occurring in the development period. These assumptions, too, have been confirmed and substantially verified by an examination of the developmental chronology in Oulu. Thus I was able to conclude that 1965 through 1994 was the Oulu ICT cluster's foundation period, 1995 through 2000 its development period, and the years since 2000 a period of maturity that followed its formation (or a period of change leading to a new era).

We have seen that the "activity groups" referred to in this paper's definition of industrial clusters have existed at each stage of the cluster's formation, working to accelerate the formative process; that the principal figures in these groups have been joined in each period by new regional actors; and that with the passage of time, the nature of their activities has changed from efforts dependent on personal networks to those of a more organized form involving broad participation from the business community.

In this paper I have attempted to deduce a working hypothesis for the formative mechanism of a high-tech industrial cluster and verify that hypothesis by examining the formative chronology of the ICT cluster in Oulu, bearing in mind cases in which high-tech industrial clusters have formed in regions having no existing industrial agglomerations which could serve as the nucleus of such a cluster. As a result, I have been able to verify the rough progression of five formative processes during the foundation period and a number of mutually enhancing causal correlations among the formative processes, as well as the effectiveness of dividing the formative period as a whole into a foundation period and a development period. These findings, it goes without saying, are provisional, the working hypothesis supposing that the high-tech cluster will develop in a region having no existing agglomeration of industry. Also, there were a number of mutually enhancing causal correlations among the five formative processes which I was not able to verify for this paper. I am confident, however, that, by offering a dynamic reading of the subject, this paper will contribute to the research on the formative mechanisms of high-tech industrial clusters.

In the future I would like to test the above-mentioned working hypothesis in other regions and examine the formative mechanisms in areas where high-tech industrial clusters have developed out of existing agglomerations of industries. In doing so I

would consider the questions left unresolved by this study, particularly as they concern the mutually enhancing causal correlations among the formative processes.

Appendix　Implications of IT Cluster Formation for Regions in Japan

Here I should like to consider the conclusions drawn in this paper in terms of their implications for regions in Japan that aspire to create their own IT clusters. Ideally, this would be done after focusing on a specific region and gaining a thorough understanding of its circumstances. Since it was not possible to expand the range of this research to include analyses of particular Japanese regions, I shall examine the general implications for Japanese regions featuring initial conditions similar to those of the regions shown in the upper left of Figure 3-6 (those without an industrial agglomeration capable of forming a base for IT industry).[220] While a certain degree of abstraction is inevitable when an examination lacks a specific focus region, some points of importance do emerge and I shall consider these in reference to the five formative processes discussed in this paper.[221]

① Existence of some degree of urban infrastructure

Before embarking on a discussion that relates to the formative processes, I should touch upon one initial condition, the "existence of some degree of urban infrastructure." Oulu has long been one of northern Finland's central cities, and as such it fulfills the initial condition of having a certain degree of urban infrastructure. The IT clusters

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[220] This paper does not specifically analyze the cases shown in the upper right quadrant of Figure 3-6 (cases in which high-tech industrial clusters have formed in regions with existing agglomerations of machinery or other industries). In such regions, we can assume that existing agglomerations of machinery or other industries, present as initial conditions, serve as groundwork for the second of the formative processes discussed in this paper, "progress in the accumulation of companies." Needless to say, these groups of companies do not qualify, in their original form, as high-tech industrial clusters; to do so they must transform themselves into a form definable as "high-tech." Formative process I, "improvement of the environment for innovation," is envisioned as the necessary process these groups of firms must undergo to emerge more sophisticated and "high-tech." Thus, even in regions like these, we can conclude that there is little to object to in the logic behind the rough order of the five formative processes (the mutually enhancing causal correlations among the formative processes). At the same time, such regions not only have existing agglomerations of companies, but existing companies that exhibit features of anchor firms, suggesting that an environment favoring entrepreneurship already exists to a certain extent. If that is the case, the probability of the entire formative process moving ahead may be greater for such regions than for those listed in the figure's upper left quadrant; the probability of the five formative processes of the foundation period progressing roughly in order from I to V may be relatively lower.

[221] In the following I cite Oulu as an example; it should be remembered, however, that this is done only to illustrate this paper's themes in an easily understandable way.

listed in Figure 3-6 may differ widely in terms of their existing industrial agglomeration, but each of them had some degree of urban infrastructure as an initial condition, either within the city itself or in a neighboring area. It would be difficult to say just how much urban infrastructure is required as an initial condition. In order to attract and retain engineers, scientific researchers and home bases of high-tech companies, a region must have the fundamental requirements for daily life and economic activity – a certain accumulation of commercial and service businesses, as well as medical, educational, and transportation infrastructure[222] – available either at home or in a neighboring area. Over the long term, moreover, a community's surrounding natural environment and local culture, as well as its more functional aspects, may become important gauges of its attractiveness as a place to live.[223] It is not difficult to imagine how such urban functions or ease of living might obstruct, or promote, each formative process of a high-tech industrial cluster.

② Target sectors of high-tech industrial clusters

Among the five formative processes of high-tech industrial clusters, "improvement of the environment for innovation" is a possibility at a relatively early stage. The question

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[222] The functions provided by an airport are considered vitally important to the formation of a high-tech industrial cluster. While a nearby airport with frequent international flights is not absolutely necessary, access to major foreign cities via a domestic hub facility – if possible, one within the economic sphere of the capital or another large city – is undoubtedly important. In Japan, the opening of Chubu International Airport in 2005 improved connections with international flights. For example, as of August 2006, there were three flights per day between Shin-Chitose and Narita airports, but fifteen between Shin-Chitose and Chubu International, and two between Sendai and Narita but six between Sendai and Chubu International. As long as business and public functions remain concentrated in the Tokyo metropolitan area, people from outlying prefectures will continue to suffer the drawbacks of having poor access to international flights via Tokyo-area airports. As regions outside the metropolis expand their exchanges with regions overseas, there will not only be greater traffic not only between the regions concerned, but there will also be the necessity to utilize the functions of both countries' capital areas, such as accumulations of diverse businesses, diplomatic missions, and the central government and its agencies.

[223] Among students of industrial clusters, not a few stress "quality of the living environment" as an important factor in the formation and continuation of a high-tech industrial cluster. According to David Gibson, a member of the IC² Research Center at the University of Texas at Austin who has carried out a lengthy, ongoing study of that city, the quality of life of a region – whether it is good enough to draw in talented, educated people – is the bottom line in deciding the success of a high-tech region (Interview with Gibson on December 5, 2006). This has much in common with the "creative class" theory put forward by Florida (2002), which argues that people in the creative professions, such as musicians, artists, scientists, teachers, and others, tend to be sensitive about their living environment.

of which kinds of "innovation" are needed seems to depend on the specialty of the intended high-tech cluster. In Oulu's case, the University of Oulu was from a very early stage a nucleus for research and education in electronics, wireless communications and the software these fields required. It performed this role because of the judgment of those at the university that such fields would contribute to the development of the university's engineering program and to job creation and industrial development in Oulu and northern Finland in general. They arrived at this assessment not only because they felt the electronics industry promised great future development – a sentiment shared throughout the world at the time – but because in Finland, it was only around Helsinki, with its University of Technology, that research and business agglomeration were taking place in the field of electronics. If Oulu were to launch into the field at that time, it might be able to display the outstanding features which characterized it as a region.

If Japanese regions are to progress in creating high-tech clusters under current conditions, one idea might be to select reasonably specific fields from the very wide range of high-tech areas which are considered promising – such as information and communications, life sciences, nanotechnology and nanomaterials, and the environment, the four fields given priority designation under the government's Basic Plan for Science and Technology – and prepare the conditions needed for innovation in those fields. The central issue is how a region can secure competitive advantage over other regions, and whether doing so will lead to job creation and sustained development for local industry (Oulu had only a small accumulation of machinery-related companies, but electronics research was launched at an early stage and the region had the potential to become second only to Helsinki in importance). How a cluster will bond with existing local industries[224] is another issue to consider. Knowledge, along with insight, is needed to examine the current status and future prospects of industries and scientific technologies; an accurate grasp of local industry and technology is essential. In any event, this kind of judgment, which we may define as "vision," almost inevitably involves much that is hard to pin down. Acquiring such vision is not easy, and setting it forth with responsibility is more difficult still. In Oulu, Dr. Oksman, the father of the university's Department of Electrical Engineers and for a time its director, and Dr. Otala, who was scouted by Dr. Oksman, saw their mission and took it on of their own accord. Their first concrete actions were to change the

[224] Possibilities for using the technologies of a high-tech field in an existing local industry; potential for integration with the cluster; etc.

Department of Electrical Engineers from a training place for electrical engineers (its purpose at its inception) to a venue for electronics research, and, especially in the case of Dr. Otala, to spell out for the mass media their vision of promoting the electric and electronics industries in northern Finland (he envisioned thousands of new jobs in the next few years).[225] In regional Japan, either then or starting in the mid-1990s, the central government provided backing in the form of industrial cluster promotion policies, while local populations themselves grew more keenly aware of the social and economic sustainability issues in their communities. Compared to earlier times, it was now somewhat easier to adopt cluster strategies that were likely to involve uncertain factors such as these. Localities were in fact encouraged to do so, in part by focusing on particular fields of industry or technology. However, except where it involves the continuing development of a region's existing industries or technologies, the task of selection is inherently quite demanding, and policymakers need to keep this in mind. To put it another way, if there is a high-tech field in which a region's existing industries or technologies can serve as the basis for development, that field will probably be a promising target for that region. With any such vision, moreover, there comes a good possibility that new fields will branch off from the one originally envisaged, and that these new fields will achieve high growth having been altered by the incorporation of new technological directions.[226] In the early stages of a cluster's formation, a vision should be broad enough to include the possibility of this kind of development.

③ Networks supporting activity groups

Some of the five formative processes, particularly III, "emergence of anchor firms," and V, "establishment of a reputation," offer little room for direct effort by activity groups. Process I, "improvement of the environment for innovation," has relatively numerous areas in which activity groups can function. While the specific nature of their efforts will be discussed later, they could include such challenging schemes as attracting projects involving government-affiliated agencies or research organizations. First, we should acknowledge that for such efforts to come about, it is necessary to obtain the

[225] In an interview, Dr. Oksman said "In 1975, (several years after Dr. Oksman and Dr. Otala set forth their vision,) employment in EEI (the electrical and electronics industries) reached 2,000 jobs; somehow, we were able to save face." (Additions in parentheses are the author's.) Both taking responsibility for their statement, they worked hard to advance collaboration between industry and academia; by spelling out their vision, they assumed no small amount of risk and responsibility.

[226] As wireless communications, for example was one field from the very broad sphere of electricity/electronics which took off and flourished.

understanding of influential people who can "improve the environment for innovation" – such as university presidents or deans, heads of local authorities, or leaders of economic organizations – and involve them in such activities; alternatively, they can be members of activity groups themselves. Most people see such activities as exceeding their professional responsibilities and not entirely necessary. Such tasks may often entail a certain amount of risk, and one needs a strong sense of purpose to take them on for the good of one's community. This can probably be said of all efforts by activity groups. While there are people who are happy to do this kind of work without outside encouragement, sustained, coordinated efforts are likely to depend on the existence of groups of people with shared beliefs and a desire to exchange ideas. In a cluster's early, formative stages, this is most likely to start with local networks of individuals who cooperate with and support each other on the strength of shared views and a common vision.[227] Oulu's ICT cluster traces its formative process to the vision of a group of university researchers in the latter half of the 1960s. However, the unofficial networks led by these researchers were Oulu's first real activity group. In the late 1970s, they were joined by another unofficial network, known as the Aurora Group[228], whose members were primarily business people. Later this network became a corporation, in which form it continues to operate today. Its members include people working not only in high-tech industry, but also in academia and at the VTT Electronics Research Laboratory, supporting businesses of all kinds, the Oulu city government, government agencies and various other organizations. We can easily imagine that the ideas and friendship that link these people also serve as a source of energy for everyone involved. At the same time, it pays to remember that these groups developed out of the particular circumstances obtaining in Oulu. Activity groups, and their supporting networks, will operate in ways that reflect the characteristics of their region.

④ Improvement of the environment for innovation

I shall now consider how activity groups serve to improve the environment for innovation. Earlier, I mentioned that in Oulu, processes I, "improvement of the environment for innovation," and III, "emergence of anchor firms," promoted the

[227] It is important, of course, that such activities be confirmed at some stage by official organizations or networks or taken up by a range of regional actors. In this paper I use "activity groups" to mean adaptable, flexible activity groups, whether official or non-official, that are devoted to the causes described.

[228] Called "Revontuliryhmä" in the original Finnish, this group has performed an important role as a personal network supporting the Oulu cluster's activity groups. Outside the region, however, its work has been less conspicuous.

progress of other formative processes in multiple, easily verifiable ways. That these formative processes play especially important roles in the creation of high-tech clusters is, in all probability, a universal phenomenon. Process I, "improvement of the environment for innovation," would seem to be the most important process of all, as it is the one which allows the greatest room for activity groups to operate.

Activity groups promote this formative process directly by strengthening fields associated with knowledge creation and the fostering of human resources (at institutes of higher learning and public research facilities) and building both physical and institutional infrastructure. In the former case, they might improve the organizational framework or academic curricula of higher-learning institutions so that innovation can proceed smoothly in the region's targeted fields. They could lend organizational expertise to a public research facility by obtaining research funding or allocating such funds among different departments, or by assisting in the creation of partnerships between the facility and private companies or other enterprises. In some cases, the region itself might work to attract new public research organizations or government projects. Translating these objectives into reality is by no means easy, but persistent efforts have often paid off, and when this happens the potential for long-ranging results can be enormous.

For an example of the latter case – the building of physical and institutional infrastructure – we can look at how activity groups played a role in the creation of the Science Park located next to the University of Oulu. Oulu's fortunes have been greatly served by its having a public research institution, the VTT Electronics Research Laboratory, and Technology Village, Scandinavia's first science park, operating adjacent to the university. However one looks at this convergence – as a venue for promoting innovation, a site for corporate agglomeration, or a means of establishing a reputation beyond the region – its positive effects have been huge. Technology Village, a true manifestation of the city's industrial policy, began as a third-sector project with land supplied free of charge by the city. We must remember, however, that while the Science Park has been important in the physical sense (as "hard" infrastructure), the region's comprehensive industrial policy package has probably been more important, as "soft," institutional infrastructure providing comprehensive backing for the Science Park and its tenant firms' activities. Oulu's people have exercised their ingenuity in innumerable areas toward this end, including the selection of people to work in such fields. In more than ten years of doing so, they seem to have been less interested in serving as an

model for other regions than in removing obstacles to the achievement of fundamental, idea-based goals (in Oulu's case, promoting the creation, establishment and growth of high-tech companies) in keeping with the actual circumstances of individual companies and regions.

⑤ Growth in the agglomeration of firms

This process, the second on our list, offers relatively few opportunities for direct engagement by activity groups. Some efforts have borne fruit, however, such as the creation of the science park, industrial estates, and other locations for companies attracted to the area. With an eye toward corporate inducement measures included in a region's industrial cluster policy and deficiencies in its industrial ecology – a lack of supporting businesses, for example – activity groups are an important means of filling in the gaps.

This is one area where process I, "improvement of the environment for innovation," can have substantial promotional effects. Partnerships between local research facilities and academic institutions, for instance, can draw in new firms from outside the region or facilitate new business inroads by major local firms. In fact, strenuous efforts by professors with the University of Oulu's Department of Electrical Engineers (now the Department of Electrical Engineering) were a factor in the decision by Kajaani, an Oulu-based paper and pulp company, to enter the electronics market at the end of the 1960s. Early in the 1970s, Aspo, a leading firm from outside the region, followed by establishing an electronics subsidiary, Paramic, in Oulu. These and similar moves were instrumental in promoting the accumulation of firms in the area.

⑥ Emergence of anchor firms

Like process I, "improvement of the environment for innovation," process III, the "emergence of anchor firms," proved important in promoting the other formative processes. On the other hand, however, activity groups are unable to have much direct impact on this particular formative process. When a company has moved into a region from outside, becoming an anchor firm requires that its local division achieve substantial growth within the region, so that it functions as the home base for the division concerned. If the company is locally-based, it must itself achieve substantial growth. Here, as in other processes, process I, "improvement of the environment for innovation," can have important promoting effects. Whether the firm is a business division of an outside company or a home-grown enterprise, innovation is naturally a

key factor in achieving healthy growth. Thus, it is especially significant when a region creates an environment that favors innovation by companies like these, and when local research and educational institutions pursue active partnerships with local companies. Regions in Japan generally are keen to attract creative industry, with local government taking the lead. However, only a very few regions seem prepared to provide such businesses, once they have arrived, with backup, in the form of continuing communication with a variety of local actors, that will promote the innovation so necessary to growth. But if a region hopes to gain an anchor firm, it needs to promote that goal on a region-wide scale, involving not only the group that attracted the firm in, but other local actors such as higher-learning institutions and public research facilities. Activity groups in Oulu include diverse local actors, particularly individuals belonging to the university and the VTT Electronics Research Laboratory. The dedication they displayed, coupled with introductions made possible by their networks, led to partnerships which helped turn Nokia and other companies into anchor firms and further supported their business expansion.

⑦ Improvement of the entrepreneurial environment

Process IV, "improvement of the entrepreneurial environment," is a key formative process which, along with process III, "emergence of anchor firms," strongly supports the fifth and final process, "establishment of a reputation." Naturally enough, the increase in new business creation that occurs as this process moves forward promotes the progress of process II, "growth in the agglomeration of firms." As noted repeatedly in this paper, one of the most effective factors in promoting "improvement of the entrepreneurial environment" is an enhancement of the industrial ecology through the "emergence of anchor firms." Also effective is the creation of the kind of infrastructure, both physical and institutional, that will encourage entrepreneurship. In Oulu, this took the form of the Technology Village incubator (opened in 1987), the regional venture fund TeknoVenture (set up in 1994), the virtual incubator Oulutech (founded in 1994) and other similar organizations. Enterprise Forum, an entrepreneurial seminar for students led since 1986 by a liaison officer at the University of Oulu, is representative of the "soft" infrastructure built up over the years. Today, backed by the Ministry of Economy, Trade and Industry, regions throughout Japan are "improving the entrepreneurial environment" by establishing incubators, venture funds, and other forms of physical and institutional infrastructure. Japan has made significant progress in this respect. While this in itself is a desirable achievement, to create a high-tech industrial there would seem to be other important processes that should be promoted

first; Oulu, after all, completed its infrastructure-building in 1994.

⑧ Establishment of a reputation

Process V, "establishment of a reputation," is to a great extent an outcome of each of the processes I through IV; one would do well to assume that activity groups played a minimal part in promoting it. It is interesting, however, to consider that the catchphrase "City of Technology," a key part of the strategy for encouraging corporate agglomeration in Oulu, not only proved effective in promoting that goal, but also functioned as a bridge to the later "establishment of a reputation."[229]

⑨ Formative and strategic periods of a high-tech industrial cluster

Having described how high-tech clusters develop in line with the five formative processes, one other matter we might wish to consider is the formative period of a high-tech cluster. It is commonly pointed out that a high-tech cluster needs a long time to develop – something on the order of thirty to forty years – and requires consistent effort on the part of activity groups. To aim for quick results is to invite disappointment and resignation. The drafting of regional industrial promotion strategies, principally by local governments, can serve an important function in terms of an activity group effort; such strategies or policies appear to be more effective, however, if they are implemented on a mid-to-long-term, rather than a yearly, basis. While it is important to confirm progress each year, with the total formative process taking so long, a minimum of two to three years are needed for another formative process to move forward appropriately. In this sense as well, it is important that strategies be generated and implemented within a time-scale of several-year increments.

⑩ Region-led efforts and the need for think tank capabilities

The second point I should like to add is perhaps self-evident: that it is regions themselves that should take the lead in the creation of high-tech clusters. In Japan, policies set in motion by the Ministry of Economy, Trade and Industry and the Ministry of Education, Culture, Sports, Science & Technology have prompted regional governments to roll out their own policies and strategies on industrial clusters. In the future as well, the national government will play an enormous role, not only by encouraging the unique initiatives of individual regions in a general way, but by

[229] One person who handled Oulu's external relations for many years, and in that sense made a huge contribution to the "establishment of a reputation," was Seppo Mäki, who was business relations manager in the Oulu city government from 1981 through 2000.

providing bold support through government-affiliated organizations and the allocation of government projects. Regions, of course, should make the most of central government support. But since an industrial cluster is, in its very nature, a regional strategy, it is the region itself that should set and carry out the policies and strategies needed for their formation. To do this, a region must call on all of the intellectual resources of the members of its activity groups. But in addition, it must itself be able to gather and analyze required information, and to draft strategy, in ways that match changing local needs and the objectives of activity groups. In the latter half of the 1970s, the office of the president of the university filled this role in Oulu; since the 1980s it has been the Bureau of Economic Affairs and other sections of the city government[230], and at one period (albeit in part) it was the university's Department of Economics. In Japan, this function might be filled by public think tanks with deep local roots, the economics or business departments of local universities, or regional organizations such as joint research centers. Also important will be "think and do tanks" in the form of the industrial promotion departments of local governments and local economic associations. People can contribute a great deal by performing the functions of a think tank for activity groups, looking consistently into the issues surrounding high-tech clusters and developing proposals for their development; this would also be helpful in promoting effective, continuing work by the activity groups themselves.

[230] From the 1980s through the 1990s, it was Paavo Simila, of the city government, who actually organized and wrote papers on industrial strategy in Oulu. A graduate of the university's Department of Economics, he joined the Oulu city government in 1972. Between that year and 1999, when he left to take up the presidency of Oulu Polytechnic's business school, he carried out a series of studies, projects, and industrial policy works. A calm, composed strategist, Paavo Simila, along with Seppo Mäki, was one of the major figures from the city government in Oulu's activity groups.

Afterword

Industrial clusters, and high-tech clusters in particular, are sure to remain an important regional and national issue for Japan. In this paper I have consistently emphasized that the principal actors in any cluster, whether high-tech or not, are companies, especially those which are locally based. But vital as well are the regional actors – universities and other higher learning institutions, public research facilities, economic associations, local governments, local branches of the central government, and financial institutions and other supporting businesses – that work with these companies to improve local initiatives and functions. In planning for sustainable development, most regions in Japan give serious thought to high-tech cluster strategies. Even while home to top-notch universities, a number of regions have lost graduates to other parts of the country because of a lack of high-tech headquarters. These regions are now working hard to build high-tech clusters. Sometimes a region will develop something resembling an industrial cluster without having made any particular effort toward that end. While there is nothing wrong with this, only a few such regions exist in the world – probably few enough to count on one hand. And here we have the reason why so many "activity groups" have sprung up to promote the building of clusters.

When I defined industrial clusters for this paper, I included the existence of activity groups because I wished to discuss the formative mechanisms of high-tech clusters for regions that would benefit from them. I embarked on this paper in the hope that the discussions it contained would provide some hints for regional residents concerned with this issue. As to how meaningful these arguments will prove for regions in Japan, I await your criticisms and corrections.

Many people in Oulu were of immense help to me in my research. I thank not only those who sat for interviews, but also those who provided important statistical data. Seppo Mäki, former director of business relations for the Oulu city government, is deserving of special acknowledgment. Although he resigned from the city government in 2000, Mr. Mäki continues to be active in a number of positions. A kind and enthusiastic man whose contribution to the city government is difficult to overstate, Mr. Mäki helped me in ways too numerous to mention. I take this opportunity to offer him my deepest thanks.

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