Forschungsberichte
Working Papers

Institut für Wirtschafts- und Sozialgeographie
Department of Economic and Social Geography
Johann Wolfgang Goethe-Universität Frankfurt

Herausgeber Harald Bathelt und Eike W. Schamp
ISSN 1439-2399

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Knowledge-based industry and regional growth

IWSG Working Papers 02-2000

Die Herausgeber bedanken sich bei Johannes Glückler für die Gestaltung des Layouts und die Unterstützung der Produktion dieser Reihe.

Autorenanschrift
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1 Introduction

One of the most important but less understood phenomena in the beginning of the 21st century has been a shift toward knowledge-based economic activity in the comparative advantage of modern industrialized countries. Two broad trends has been observed in the global economy. That is, the output from the world's science and technology system has been growing rapidly and the nature of investment has been changed (MILLER, 1996). The relative proportions of physical and intangible investment have changed considerably with the relative increase of intangible investments since the 1980s. In addition, there has been increased complementarity between physical and intangible investments and more important role of high technology in both kinds of investment (MILLER, 1996). Even in the newly industrialized countries, the growth of technology intensive industries, the increase of R&D activities and the growth of the knowledge intensive producer services have been common feature in recent years. In this change of the structure of productive assets, the role of knowledge is well recognized as the most fundamental resources in recent years (OECD, 1996; WORLD BANK, 1998). The development of information and communication technology (ICT) and globalisation trend have promoted this shift toward knowledge-based economy.

The important role of knowledge in the economy and society is not a new idea. In Western society, a proverb from Francis Bacon saying that "Knowledge is power" has long history. There are also many proverbs and instructions regarding the knowledge in the oriental countries. It is recognized that "Adam Smith refers to new layers of specialists who are men of speculation and who make important contributions to the production of economically useful knowledge" (FOREY AND LUNDVALL, 1996: 11). The role of knowledge become more important over time and this idea has periodically reappeared in the economic history as implied in the long waves of Kondratiev. If the importance of the knowledge in the economy is not a new idea and recognized several centuries ago, then why should we emphasize the shift toward knowledge-based economy in recent years? There are three major reasons of emphasis on the shift toward knowledge-based economy as follows.

First, it was found that net job creation was predominantly taking place in the knowledge-intensive economic activities, which include both knowledge industry and knowledge-based industry. Knowledge industries are those whose output is knowledge such as patents, inventions, and new products, as well as services that

are mainly knowledge, while knowledge-based industries are those whose main product or service is dependent on technology or knowledge.[1] Knowledge industries and knowledge-based industries are interdependent since knowledge is output from the former and input to the latter, and they are together making the knowledge-based economy. Considering that knowledge is also an important input for the knowledge industry, knowledge industry can be included in the broad meaning of the knowledge-based industry.

Second, dominant proportion of work forces in the modern industrialized countries are knowledge workers such as information system designers, managers, professionals, educators, scientists, skilled manufacturing teams, and the like. It is expected that the traditional 'job' will fade and knowledge entrepreneurs will replace traditional service and factory workers in the more flexible workplace of tomorrow (HALAL, 1996). In the most of industrialized countries the principal contribution to employment growth has been the advanced service sector which are creating and using knowledge products in exactly the way that manufacturing transformed raw materials into physical products (BERRY, CONKLING, AND RAY, 1997). Concurrently, new technology has been adopted in the manufacturing and, as a result, there has been a dramatic growth of high technology industrial products with substantial R&D inputs. Such trends of changes are also witnessed in the newly industrialized countries in recent years (CLARK AND KIM, 1996). Accordingly, the knowledge industries and the knowledge-based industries are driving forces of the knowledge-based economy.

Third, the rapid development of ICT has promoted the shift toward the knowledge-based economy. Many characteristics of the knowledge-based economy such as new dynamics of tacit and codified knowledge, the growing importance of networked knowledge, and the acceleration of process of interactive learning are related with the increasing use of ICT (FREEMAN AND SOETE, 1993). The rapid diffusion of ICT to developing countries in recent years has resulted in the decreasing information gap between industrialized and developing countries and in the growing importance of the knowledge-based economy in the global society as a whole.

There is a wide agreement across all layers of society in the industrialized countries on the trend of the shift toward the knowledge-based economy and on the

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1) These definitions are based on personal communication with Edward Malecki, Grahm Humphrys, and Richard Le Heron, and OECD (1996).

crucial role of knowledge in the economic activities. This wide agreement implies a challenge for regional development theory and for regional and industrial policy with dynamics of economic space in the 21st century. The emergence of the region and the locality as the main arenas for growth in a globalizing world has been well noted during the last two decades. Much growth at the regional and local level results from the growth of new industries, which include cultural, health, high technology and knowledge industries. Basically, these new types of industries are mostly knowledge-based activities. The new motors of growth behind this emergence of new growth region have received less attention in economic geography. The purposes of this paper are dealing with the pressing issues related to understanding the role of the knowledge-based industries in promoting regional growth and to derive some directions of regional and industrial policy for regional growth.

2 Knowledge, Development, and Information Communication Technology

Knowledge is a crucial factor for advancing economic and social development. It has been well recognized that knowledge is power and well-being in long history of both Western and Eastern societies. The difference between poor countries and rich ones can be ascribed not only to less capital but also less knowledge in the poor ones (THE WORLD BANK, 1998). The results of empirical studies of OECD reveal that the overall economic performance of the OECD countries increasingly and more directly based upon their knowledge stock and their learning capabilities (OECD, 1996). Developing countries have less knowledge about technology than industrialized countries, resulting knowledge gaps across counties. Even within countries, knowledge gaps in acquiring, absorbing, and communicating knowledge exist among regions. In the capacity to create knowledge, the knowledge gaps are even greater between developing countries and modern industrialized countries because knowledge is often much costly to create.

The model of knowledge production function, formalized by Griliches (1979), at the unit of observation of countries or industries also supports the positive relationship between knowledge and development. In the knowledge production function model, firm exists exogenously and then engaged in the pursuit of new economic knowledge as an input into the process of generating innovative activity. Considerable empirical evidences suggest that there is strong relationship between

R&D and innovative output, measured in terms of either patents or new product innovation (AUDRETSCH, 1999). Some empirical analysis also shows that investment in knowledge is characterized by increasing returns (OECD, 1996). However, the model of knowledge production function becomes particularly weak when small firms are included in the sample for the unit of observation of the firm. This result at the firm level is consistent with the results of some empirical studies which suggest that formal R&D is concentrated among the largest corporations and small firms account for a disproportional share of new product innovation given their low R&D expenditures (ACS AND AUDRETSCH, 1990).

In the industrial engineering and industrial production, knowledge and technology are closely correlated since knowledge on technology in emphasized. In the knowledge-based economy, however, not only knowledge on technology but also knowledge on advanced services such as management, marketing, financing, etc. are also important. In the knowledge-based economy product innovation is not limited to the tangible manufacturing products, but it also includes the intangible new products such as new financial product and new management system which are mainly based on new knowledge and idea. Accordingly, there are not only consistent sectors or activities which have close correlation between knowledge and technology in the industrial production sector, but also inconsistent sectors between knowledge and technology dimensions. That is, some high technology sectors require high level of knowledge, but others may require relatively low level of new knowledge on the one hand. On the other hand, some low technology sectors or activities require the high level of knowledge, while others require low level of knowledge as expected. Due to the inconsistency between knowledge and technology in the knowledge-based economy, there is a possibility that the low technology industry can move toward knowledge-based industry with applying new knowledge. These two dimensions of knowledge and technology will be more elaborated in the following section with regard to Figure 1.

Revolution of ICT has contributed to lessen the gaps of knowledge and technology among countries and regions as well as among firms in the global economy. The development of ICT accelerates radical changes in the way knowledge is produced, stored, and diffused. With communication costs plummeting, especially in the optical fiber transmission cost, during the last two decades, the cost of sending information and knowledge is cheaper than ever (THE WORLD BANK, 1998). Because of the radical reduction of communication costs, rapid narrowing knowledge gaps and then a surge in economic growth and well-being in developing economies may be expected. The development of ICT and the accelerated use of ICT in the

long-term can contribute to the evolution of the following three paths. 1) the increasing speed and decreasing cost of developing tools and instruments for basic research and R&D; 2) the increasing ability to generate technological options; and 3) the extending power of electronic networks as research tools (OECD, 1996). In this respect, the realization of a new potential of productivity gains in the process of generation, distribution and exploitation of knowledge and in the knowledge-based industries is the major concern of the long-term effects of ICT.

In reality, however, while ICT is pervasive in all sectors of industry and economic life, it does not seem to have produced the expected rise in productivity in all the sector of economy, resulting productivity paradox. The productivity paradox, which refer to the apparent contradiction between the investment on ICT and industrial productivity, can be easily found in the less developed regions because of the relatively lower capacity to absorb the investment on ICT for productivity growth, compared to advanced regions. Furthermore, the investment on ICT may not directly linked to the improvement of regional productivity in some regions because the ICT can not be easily applied to region's specialized traditional industries at first to improve productivity. In addition, the application of ICT stuck to a certain sector such as high tech and information industries which are not well developed in that region.

In addition, even though the knowledge gaps are decreased with the development of ICT, developing countries would still be at a disadvantage in the respect of knowledge about attributes (THE WORLD BANK, 1998). There are information problems resulting from the difficulties posed by incomplete knowledge of attributes such as the quality of product, the creditworthiness of a firm, etc. in addition to the knowledge gaps in poor countries. For example, financial crises of the East Asian countries in 1997 were surely related to the incomplete knowledge of attributes in those countries. Moreover, tacit knowledge is usually sticky in a certain place and can not be easily transferred across the space, even though the development of ICT has contributed to the diffusion of information or codified knowledge across the countries (HIPPEL, 1998; MALMBERG, SOLVELL AND ZANDER, 1996). However, in the long-term perspectives, the investment and spread of ICT will improve the productivity even in the traditional sector of industry and in peripheral areas.

Because of the uneven distribution of knowledge in the space and uneven increase of productivity by sectors and regions, appropriate regional policy with regard to knowledge-based economy is urgently needed, especially in the less favored regions. Considering the complexity in creating, acquiring, and using

knowledge, more detail examination of the knowledge-based industries and regions is necessary to understand the process of promoting regional growth.

3 Knowledge, Knowledge-Based Industry and Region

3.1 Knowledge Production Function and Knowledge Spillover

Based on empirical studies, the most important source of new economic knowledge is considered to be R&D. High degree of human capital, a skilled labor force, and a high presence of scientists and engineers are included to additional important factors generating new knowledge. Because of this close link between knowledge inputs and innovative output, empirical evidence supports more strongly the model of knowledge production function as the unit of observation becomes increasingly aggregated (AUDRETSCH, 1999). However, knowledge can be generated by the diverse learning modes. In some activities, knowledge is accumulated by informal mechanisms, such as learning-by-doing and learning by interacting with customers and suppliers. While in others, it is generated by more formalized activities of R&D. Knowledge is generated not only from firm's internal R&D activities but also from university research and scientific advances. Because of this diversity of learning modes, if the model of the knowledge production function is examined at the unit of observation of the firm, the link between knowledge inputs and innovative outputs become weak or non-existent (AUDRETSCH, 1999). This weak relationship or no relationship is resulting from the fact that many firms, especially the small firms, have considerable innovative outputs in spite of low level of or even no R&D expenditures.

Then where do the innovative small firms or new firms with little or no R&D expenditure get the knowledge inputs? Recent studies suggest that knowledge spillover from other firms conducting the R&D or research institutions such as universities is the major source of the knowledge inputs for those innovative small firms (AUDRETSCH, 1995; BAPTISTA, 1997; COHEN AND LEVINTHAL, 1989). There are three major mechanisms for knowledge spillover. First, firms can develop the capacity to adapt new technology and innovation developed in other firms. Then the firms can appropriate some of the returns accruing to investments in innovative outputs made by other firms or research institutions (COHEN AND LEVINTHAL, 1989). Most of leading large firms in the newly industrializing countries may belong to this category. Most of the NIEs had considerable benefits from this mechanism of knowledge-spillover during the rapid industrialization stage

Second, inter-firm networks, collaboration with public institutions and universities can provide synergy effects for participating firms with greater innovative outputs than expected from the given knowledge inputs. Firms can develop new ideas and knowledge through interactions with customers and suppliers, workshops or forums provided by public institutions or universities and can appropriate some of the returns accruing to the new ideas or knowledge made externally.

Third, knowledge worker may leave the firm or university where the knowledge was created in order to establish a new firm. If the knowledge worker can pursue the new idea within the organizational structure of the firm developing the knowledge and appropriate the expected value of that knowledge, he can continue to work at the firm. However, if the scientist or engineer places a greater value on his ideas than the decision-making bureaucracy of the incumbent firm, he may decide to start a new firm to appropriate the value of his idea (AUDRETSCH, 1999). In this mechanism of knowledge spillover the knowledge production function is reversed and the knowledge is exogenous and embodied in a knowledge worker.

There is, in general, spatial limitation in these knowledge spillovers. According to MALMBERG, SOLVELL AND ZANDER (1996), three elements are involved in the local creation and accumulation of knowledge and in the sustainability of competitiveness in the space as follows. First, locally confined innovation processes are favored because of the trial and error process of problem solving, the repeated interaction between related firms, and the need to exchange knowledge through face-to-face contacts. Second, there are barriers to diffusion of locally embedded knowledge to other areas. The ability to gain access to local informal and formal networks of knowledge exchange and accumulation is mostly limited to insiders of milieu. Third, both knowledge resources brought in by outsiders and initiatives taken by incumbents to tap knowledge resources from outside can enhance the process of knowledge accumulation within the local milieu. Because of these elements, the knowledge spillover effects have spatial dimension.

There are some empirical evidences of spatial links in exploiting knowledge spillover. Some recent studies (AUDRETSCH AND FELDMAN, 1996; FELDMAN, 1994; JAFFE, 1989) modified the model of knowledge production function to include explicit specification for the spatial and product dimensions[2]. The empirical evidences

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[2]) The model is as follows: $I_{ri} = PRD^{a1} \cdot (UR_{ri})^{a2} \cdot UR_{ri} \cdot (GCri)^{a3} \cdot e_{ri}$

where I is innovative output, PRD is private corporate expenditure on R&D, UR is the research expenditures undertaken at Universities, and GC measures the geographic coincidence between

consistently support the notion that knowledge spills over for the use of third party from university research laboratories as well as firm's R&D laboratories. The empirical results suggest that proximity to university research labs or industry R&D labs is important in exploiting knowledge spillover. Especially, the propensity of innovative activity to cluster geographically tends to be greater in industries where new economic knowledge plays a more important role such as bio-technology industry (AUDRETSCH AND FELDMAN, 1996). This finding suggests that industry life cycle of knowledge-based industry have relationship with spatial location.

3.2 Knowledge-Based Industry and Region

The models of product life cycle and global commodity chains suggest that key location factors are different by the stage of product life cycle and by the degree of the importance of new knowledge inputs. The concept of life cycle at the product level can also be applied to the level of industry. Industries in the early stage of industry life cycle in which new knowledge inputs are critical factor for the development of the industries tend to cluster geographically in a few locations. On the other hand, old industries in which new knowledge is less important than the earlier stage may tend to disperse with mass production and standardization. For example, firms in bio-technology, which is an industry based mainly on new knowledge, tend to cluster in just a handful of locations (PREVENZER, 1997). In the Newly Industrialized Economies (NIEs), relatively new and knowledge intensive industries such as computer and medicines are mostly concentrated in a few clusters (PARK, 1995; PARK AND NAHM, 1998).

Location patterns are also different by the stage of commodity chains of same industry (GEREFFI AND KORZENIEWIEZ, 1994). Even the old industries like textile and apparel, early stage of commodity chains may require considerable knowledge resources and tend to cluster in some areas. For example, development of design or new materials in these industries is knowledge intensive process and usually concentrate in major metropolitan areas. Producer services in the commodity chains, which are mainly regarded as knowledge intensive activities, also tend to concentrate to major metropolitan areas.

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university and corporate research. The unit of observation for estimation is at the spatial level, r, a state, and industry level, i.

Such differences in industrial location by product cycle and commodity chains reveal that the importance of knowledge as input resources is a critical factor for patterning industrial location instead of by just sectoral type of industries. That is, industries or a certain stage of industrial production in the commodity chains in which the knowledge input is a critical factor are in general clustering in a specific region rather than decentralizing throughout the space.

Those industries or a certain stage of commodity chain which require considerable knowledge inputs can be identified as "knowledge-based industry" in this study. In the knowledge-based industry "new knowledge" is more important production factor than the traditional production factors of labor, capital and land inputs. The products of the knowledge-based industries are strongly based on new techno-scientific knowledge. The knowledge-based industry represents comparatively high degree of knowledge intensity, measured in terms of the variables of R&D expenditure, scientists and engineers, and high skilled labor. The locational pattern of the knowledge-based industry shows, in general, a regional clustering trend, but may reveal a quite complex pattern by degree of technology intensity or industry life cycle.

Considering knowledge and technology are important dimension for development as reviewed in section II, industries/activities can be classified based on the degree of knowledge and technology as Figure 1. In (Figure 1), knowledge intensive industries can be identified in two cells. Industries in cell 1 of the (Figure 1) are highly knowledge-intensive and high technology-based ones, and belong to typical knowledge-based industry. Innovative activities are very active in this type of industries. Innovative new industries such as biotechnology and new ICT are the examples of this type of the knowledge-based industry.

The creation and accumulation of new knowledge is critical for the innovation activities in these industries. As reviewed in the previous section, the new knowledge needed for these industry are generated by the strong local networks among firms, research institutions, and university research labs. Tacit knowledge and codification of the knowledge are very important for the process of innovation. The innovative ideas and knowledge are, in general, sticky in local milieu and clustering of this type of the knowledge-based industries are natural. In order to develop such type of industries or activities, well development of social capital, learning mechanism and external economies of scale through networking are required. Advanced high technology regions such as Silicon Valley are a typical example of the cell 1.

(Figure 1) Intensity of knowledge and level of technology in industries

		Intensity of knowledge inputs	
		High	Low
Level of Technology	High	(1) Innovative new products	(3) Scale-based products
	Low	(2) Product design and advanced services	(4) Scale-based low skill products

Industries in cell 2 of (Figure 1) are low technology but require intensive knowledge inputs. High value added craft industries and advanced producer services such as product design, finance, market research, firm management, coordination, etc. are belong to this category. Even low technology or traditional sector like textile or apparel, designing part of the industry belongs to this type. Product design is very important because new products can be developed continuously. Knowledge is an important input for product design, firm management, coordination, market research, finance and other advanced services, and accordingly the industries in this cell can be regarded as the knowledge-based industry. In some aspect, the activities of firm management such as functions of headquarter and regional headquarter, market research, finance, and design are more knowledge intensive than the R&D activities (ENLIGHT, 2000). This type of the knowledge-based industry can be clustered in certain part of the large metropolitan areas or in industrial districts. Face-to-face contacts for exchange of information and tacit knowledge, division of labor, skill formation in local area, and collaboration and cooperation among firms are important factors for regional clustering of this type of knowledge-based industry. In the large metropolitan areas, some clusters of this type of industries/activities can be emerged in the era of globalization and knowledge-based economy even in the newly industrializing countries. Along with the globalization, Hong Kong has been specialized with knowledge intensive activities even though R&D activities are not strong compared to other newly industrialized economies (ENLIGHT, 2000). Hong Kong can be regarded as a typical example of cell 2.

Industries in cell 3 of (Figure 1) are high technology sector, but belong to mature stage of industry life cycle and are oriented toward mass production. Generally these industries decentralized to peripheral areas of industrialized countries or to newly industrialized countries. Production of electrical appliances such as TV, refrigerator, air conditions, and so on are the good example of this type of industries. In the initial stage of the industry life cycle, these industries were mainly located in industrialized countries. These industries are now matured and decentralized to the newly industrialized or developing countries because priority is given to reduction of production costs with severe competition and product standardization. Development of ICT and globalization of MNE's production have contributed to the decentralization of the industries. Even though modern new technologies are applied for the production in these industries, the production is relatively standardized with mass production and less required new knowledge. Accordingly, these industries can not be regarded as the knowledge-based industry.

However, in recent years, application of new knowledge to these mature industries makes different story. Application of new ICT and new knowledge to these mature industries provide possibilities of product innovation or improvement and process innovation. Product improvement and new product development in this sector in recent years have contributed to growth of certain regions with agglomeration of the industries, especially in the newly industrialized countries. Technology catch-up and leapfrogging in these high technology mature industrial sectors has been successfully performed in some of the newly industrialized countries such as Korea (LEE AND LIM, 1998). New industrial districts based on the application of new technology are emerging in the newly industrialized countries (PARK AND MARKUSEN, 1995; FROMHOLD-ELISEBETH, 1998; WANG, 1999). In the process of industrial restructuring of these industries in recent years, there are some possibility of local creation and accumulation of knowledge in those new industrial districts. Traditional agglomerated region of these industries has been undergoing creative destruction and regaining competitive advantages (FLORIDA, 1996). The changes of these industries in recent years reflect that these scale-based high technology sectors tend to become the knowledge-based industry in some region with the application of new knowledge. High tech parks in NIEs such as Kumi in Korea and Silicon Glen in UK can be regarded as good examples of cell 3.

Industries in cell 4 of (Figure 1) are low technology and scale-based standardized products. These industries can be regarded as typical traditional mature industries in which production technology is stabilized and new knowledge input is not important. Mass production of textile, apparel and shoes in the low cost location

are some examples of these industries. However, high value-added products of textile and apparel, in which new knowledge of design and products are important, can not be regarded as this type because knowledge input is very important in these activities. Since priority is given to lowering production cost, the industries decentralize to areas of low labor cost. In recent years these industries tend to disperse even to the peripheral areas of developing countries without any specific agglomeration. This type of industries is no more clustered in the advanced economies.

In sum, four types of industries or activities examined above are clearly related with region. It should be noted that two major aspects be found in recent years. Firstly, types of industries in cell 2 and 3 shows more the tendency to cluster than before with more emphasis on new knowledge creation and accumulation. Knowledge spillover effects in local milieu are becoming more important than before in these industries even though they are weaker than the case of innovative products in cell 1. Accordingly, those industries of cell 2 and 3 are more shifting toward the knowledge-based industries along with the development of ICT. Secondly, regions are dynamically changing with industrial restructuring and industry life cycle. Industrial clustering can be reemerged in some of the traditional industrial regions with application and creation of new knowledge on the one hand. Because of the dynamics, in some large metropolitan areas all the four types of industries or activities can be found with reemergence of new high tech sector and knowledge intensive activities along with the traditional specialized industries. Especially in some of the large metropolitan areas like Chicago, all the four types can coexist (See chapter of Felsenstein), even though a dominant type of activities/industries will be advanced over time. On the other hand, new innovation centers can emerge in new place with a congestion effect of maturing industry in the traditional innovation centers. The maturing industry in the traditional innovation center may lock-in with respect to new ideas in the region (AUDRETSCH, 1999). In this maturing industry of the old innovation center, the congestion refers to intellectual lock-in, contrasting to the traditional congestion factors with regard to rents, commuting, and pollution.

3.3 Knowledge-Based Economy and New Industry

The evolution of the knowledge-based economy in recent years contributed to the emergence of new industries and progress of new industrialization. Along with this new industrialization, new regional motors of growth seem to appear in the modern industrialized countries. Two major directions of the emergence of new industries and

new motors of growth can be identified: one is the expansion and new emergence of knowledge intensive industries; the other is knowledge intensive service-oriented industry.

As discussed in the previous section, knowledge input becomes more important even in the mature industries. This trend of growing the knowledge-based industries is not limited to the modern industrialized countries. Knowledge-based industries are expanding even in the newly industrialized and industrializing countries with the trend of globalization of MNE's activities. The development of ICT has promoted the globalization and expansion of the knowledge-based industries (DUNNING, 1998; SOLVELL AND ZANDER, 1998). In the process of expansion of the knowledge-based industries, the trend of localization or local clustering of the new industries has been conspicuous. In Europe, this clustering of the knowledge-based industries are identified as "*Islands of Innovation*" and about 90% of the *Islands of Innovation* are in the old or traditional industrial regions (HILPERT, 1992; 1996). These clusters of the existing or newly emerged knowledge intensive industries contributed to the regional growth. In the newly industrialized countries the local clusters of the industries can be identified as new industrial districts (MARKUSEN, ET. AL, 1999; PARK AND MARKUSEN, 1995). The new industrial districts are developed by clustering of the new industries, which are not actually new for the industrialized countries but newly introduced to the newly industrialized countries. These new industrial districts have taken a role of regional growth in these countries.

Knowledge inputs are also important in, what we call, the new industries such as health, tourism/leisure, and culture industries. With the increase of per capita income, people become more interested in health products and good health services which are mostly high value added and knowledge-based. Location of health service centers in good environment contributes to the regional development on the one hand, development of new health products and production of the products contributes to the local development on the other hand. Culture and image industries are also rapidly growing with regional clustering, like agglomeration of Los Angeles (SCOTT, 1996). Local clustering of these knowledge intensive activities are also appearing in the newly industrialized and even in the developing countries. The growth of new industries in recent years is related with the growing importance of knowledge as input resources. For example, recent growth of health industries is related with the new scientific knowledge. Recent growth of the culture and image industries is also mainly based on the integration of ideas, historical knowledge and modern information technology. Even modern tourism and leisure industry are changing toward intensive use of knowledge with the development of new tourism

goods such as theme tour and ecological tour, which are different from the traditional sightseeing. The notable evolution of the new industry in the modern industrialized countries are, therefore, based on the intensive use of new knowledge and expected to be the next motor of regional growth in some regions in the knowledge-based economy of this 21st century.

Knowledge is also being more important for service sector in the knowledge-based economy. Knowledge is a critical factor for producer services such as firm management and coordination, market research, product design, engineering, computer software and finance. In recent years many new products are developed based on new knowledge even in finance sector. The rapid growth of the producer services in the industrialized countries has been obvious during the last two decades. Rapid employment growth in the R&D activities, engineering service and computer software industries are well recognized in the newly industrialized countries as well as in the modern industrialized countries (MEYER-KRAHMER, 1996; FROMHOLD-EISEBITH, 1998; WANG, 1998). These activities are mostly clustering in a few regions and promoting regional economic growth and change (MALECKI AND OINAS, 1998).

4 Policy Directions for Promoting Regional Growth

In the knowledge-based economy, linkage between research and industry is one of the key elements. It is argued that learning firms in the knowledge-based economy intends to build non-price competitive advantages from creative use of information whose cost is rapidly decreasing with the ongoing ICT revolution, contrasting with "neo-classical" firms which are obsessed by scale and cost and produce standardized and homogeneous goods (GUINET, 1996). Competitive advantages of the firms in the knowledge-based economy is not in the low-cost production based on low-wage employment, but in the production of non-standardized, non-routinized tradeable goods with generation of high-wage employment. In this context, the learning firm can be the source of employment and growth in the knowledge-based economy (GUINET, 1996). The knowledge-based economy, however, does not mean that all the employment in the society are from the learning firms of the knowledge-based industries. Employment of low-wages from the "neo-classical" firms is coexist, but their significance in the economy is reducing and high-wage employment generated by learning firms become major source of employment and economic growth in the knowledge-based economy. Such changes require new policy or strategy for promoting growth in the knowledge-based economy. In this paper,

human resources and institution are regarded as the most important factors for the shift toward the knowledge-based economy and these factors will be more emphasized in the policy issues.

Key economic activities in the knowledge-based economy are the knowledge industries and the knowledge-based industries. It is non-disputable that the role of knowledge and learning firms in these industries are critical. Successful creation, acquisition, absorption, and accumulation of the knowledge are important for these industries. Then, ultimately, human resources are the most critical factor for benefiting from creation, acquisition, absorption, and accumulation of the knowledge. Accordingly, the government policy in the knowledge-based economy should be focused on the development of the human resources. R&D activities, inter-firm networks of customer-supplier relationships, innovative manufacturing and knowledge-intensive advanced services are constantly increasing the stock of knowledge that is required for the success of enterprises and promoting regional growth in the knowledge-based economy.

Government policies in the knowledge-based economy can not replace the firm as a learning organization, but can create a climate or soft infrastructure that is favorable for knowledge-based development (HILPERT, 1996). The distribution of technology and knowledge is uneven over space even though the ICT is prevalent. Government policy should be more focus on the less favored regions with regard to knowledge and technology with promoting the diffusion and application of the new knowledge to the less favored regions. Development of qualified and flexible labor forces is important and required for the knowledge-based industries. Educational systems and vocational training systems should be come into meeting these new demands of the knowledge-based economy, especially in the less favored regions. Lifelong process of learning should be developed and promoted to practice for both individuals and enterprises. Training the workforce in technology-related fields becomes more important for industrial and labor policy in the knowledge-based economy.

Policy directions regarding the development of human resources, however, should be different by countries or regions. In the modern industrialized countries, speeding up change with emphasis on the product innovation and development of new promising technologies is important for profit gaining. Strategies of strong networking among firms, universities, and research institutions for collaborative R&D activities will be important for the regional clustering like cell 1 in the (Figure 1) in the highly innovative regions. In the old industrial regions or newly industrialized

countries, however, application of new technology to mature industries, diffusion of knowledge, and knowledge spillover are more important for regional development. Accordingly, skill formation and development of incremental knowledge is more important for these countries. Strategies for labor training with collaboration of universities, firms, and trade unions, and local governments are more promising for the newly industrializing countries. In addition, training system and provision of infrastructure of ICT in order to reduce the proportion of workers excluded from the labor market should be emphasized in the newly industrializing countries.

Recent studies have emphasized the importance of institutional factors for the formation of industrial clustering and innovation in the knowledge-based economy (GUINET, 1996; STORPER, 1996; 1999; STORPER AND SALAIS, 1997). Institutions are "persistent and connected sets of rules, formal and informal, that prescribe behavioral roles, constrain activity. and shape expectations" and overlap with conventions (Storper, 1996: 265). In order to promote regional growth, in the knowledge-based economy, institutional reform is required. GUINET (1996: 210) summarized the main objectives of institutional reform as follows.

- improving the coordination between training and research institutions, or between training and research functions within any given institutions;
- reinforcing the institutional mechanisms for labor and firm competency assessment, as a means to increase workers' incentives to learn as well as financial institutions' propensity to invest in innovation;
- promoting the development of those networks which enable producer/user and basic research/development interactions;
- improving physical (e.g. information infrastructure) and legal conditions of access to existing stocks of knowledge;
- stimulating demand for innovative services and products, through the removal of trade and regulatory obstacles to market access and development; and
- removing structural impediment to technological entrepreneurship.

The directions of the institutional reforms identified above emphasize the production system-oriented policy rather than the firm-oriented one. Based on these objectives some of policy directions can be identified, especially for the newly industrialized or industrializing countries. First, networking between large and small firms, among large firms and among small firms should be encouraged and supported (PARK, 1996). Second, industry specific or region-specific labor training should be provided by public institutions in order to help workers to secure jobs in the

face of flexibility in specific, regionally-concentrated sectors (STORPER, 1996). Third, in order to promote knowledge spillover effects, support for venture business, technology incubator function, and spin-offs are needed. Fourth, technopoles or science parks in the newly industrialized countries should be promoted with emphasis of relations between research and industry, collaborative R&D activities, and skill formation in order to encourage clusters and regional growth. Lastly, service centers for providing producer services such as design, software industry, legal, managerial and marketing services should be developed for successful progress of the knowledge-based industries.

This paper has not intended to deal with all the policy directions to promote regional growth in the knowledge-based economy. Rather, the focus is given to the human resource and institution factors which are regarded as promising factor for regional growth in the knowledge-based economy. The above directions of institutional reforms and policy are not independent, but interrelated with each other. Even though there are some differences in the emphasis of the policy ingredients by the regions and countries, the basic directions can be commonly applied to the knowledge-based economy or toward the knowledge-based economy.

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