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The Role of Regional Innovation System Characteristics in Regional Growth in Korea

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Abstract

In recent times, local governments and policymakers in Korea have been strongly interested in sustainable growth or job creative growth locally, but how? The purpose of this study was to expand our understanding of the relationship between regional economic growth and the local characteristics of RIS. Of special interest are the determinants of regional economic growth, and also for policy makers, which policy should be first between population policy and employment policy? For solving the problems, this paper first identified the determinants of sources of innovation, knowledge spillovers, and regional spillovers as the principal characteristics of RIS in Korea through empirical review as well as literature review.

Through the model specification, Carlino-Mills models (CM models) with three-stage least square (3SLS) estimation are proposed as a conclusive model for the determinants of regional growth in a RIS framework. The findings from the extended CM models indicate a more focused role of RIS characteristics in population and employment growth rates than that in OLS models. The results from the simultaneous equation model (or 3SLS estimations) indicated that the innovative activity of local firms had positive spillovers with regards to increasing in employment growth rates in local areas. Another main conclusion of the analysis was that "jobs follow people." Thus, given this evidence, policymakers may well consider how to enhance their regions to stimulate innovation and regional growth according to the determinants of regional

population growth, and after that those of regional employment growth. Finally, in chapter V, I summarize the empirical findings and provide some conclusions emanating from this body of work, including some policy implications.

Ⅰ. Introduction

In recent times, local governments and policymakers in Korea have been strongly interested in sustainable growth or job creative growth locally, but how? One of the answers is from Baumolian or Schumpeterian "innovation" which was emphasized as "the engine of growth" (Baumol *et al.*, 2007; Schumpeter, 1947). In the past decades there has been increasing recognition that innovations contributed substantially to local economic growth. The positive relationship between innovation systems and regional economic growth has been good news for regional industry policymakers since introducing regional innovation systems (Barkley *et al.*, 2006). Given their purported importance as the sources of regional economic growth, innovation spillovers received considerable treatment in the economic literatures in both empirical and theoretical studies (Griliches, 1984).

This study explores the role of local characteristics of Regional Innovation Systems (RIS) in regional economic growth at the county level in Korea. Cooke and Morgan (1998, p. 71) defined RIS as "regions that possess the full panoply of innovation organizations set in an institutional milieu, where systemic linkage and interactive communication among the innovation actors is normal." The popularity of RIS is closely related to the apparent shortcomings of traditional regional development models and policies, the emergence of identifiable and successful clusters of innovative activity in many regions, and the increased use of regional development policy for stimulating innovative activity at the local level (Enright, 2001; Asheim and Isaksen, 1997).

This paper investigates the relationship between the characteristics of Korean RIS and regional growth rates (population and employment growth) in 234 Korean counties with 4 missing values from 2000 to 2009 period. The main goal of this study is to investigate the role of RIS in the regional growth at the county level in Korea, including both population growth and employment growth. Of special interest are the determinants of regional economic growth, and also for policy makers, which policy should be first among population and employment policies? Specifically, is the local characteristics of RIS associated with regional economic growth or population growth in the county, and if so, what characteristics of regional counties contribute to increased regional economic growth, especially for job creative factors?

For solving these problems, this paper is organized as follows. Chapter II provides a brief background of studies of RIS and regional development at the regional level and also literature reviews. These earlier works provide both the empirical and conceptual bases for the research on Korean county by using county patents from 2000 to 2009 as the measure of innovative activity. Chapter III describes the variables and data employed in this study, the hypotheses to be tested, and construction of the models. Chapter IV explores regional economic growth models such as the Glaeser OLS model and the Carlino-Mills model with three-stage least square (3SLS) estimation are estimated for the 230 counties in Korea. The principal goal of these estimations is to determine the influence of the characteristics of RIS in the growth rates of population and employment in Korean counties (*Si, Gun and Gu*). Lastly, Chapter V summarizes the empirical findings and provides some conclusions emanating from this body of work, including some policy implications.

Ⅱ. The Literature and Regional Innovation Systems[1)]

The concept of Regional Innovation Systems (RIS) has received much attention from policy makers and academic researchers as a framework for innovation policy making in recent years (Asheim *et al*., 2003; Cooke *et al*., 2000). The popularity of RIS is closely related to the apparent shortcomings of traditional regional development models and policies, the emergence of identifiable and successful clusters of innovative activity in many regions, and the increased use of regional development policy for stimulating innovative activity at the local level (Lee, 2007). A major issue is the development of an adequate empirical basis for conceptual work focusing on RIS. The goal of this chapter is to review and summarize the recent literature on RIS and regional development.

1. Sources of Innovation

The systemic approach to innovation and industry is founded upon the interactive model of innovation. It is important to promote interactions between different innovative actors that have reasons to

1) An earlier version of this chapter was published in the author's book, *Regional Innovation Activity: The Role of Regional innovation Systems in Korea* (Lee, 2010).

interact, such as interactions among small start-up firms, larger firms, universities and government agencies or institutions (Cooke, 2001). Baumol (2004) argued that there were four principal sources of innovation (small firms, large firms, government and universities R&D), and each source specialized in a part of the innovation process: "revolutionary breakthroughs" (small firms), "incremental improvements" (large firms) and basic research (government agencies and universities).

(1) Role of Entrepreneurs (Small Firms) in Innovation

Two recent studies (CHI Research, 2003, 2004) by the U.S. Small Business Administration (SBA) provided support for small firms as important sources of innovation. These reports examined technological change. The entrepreneur is naturally associated with the small startup-firm, and these reports found that small firms were more innovative per employee than larger firms. Moreover, the more recent study (CHI Research, 2004, p. ii) found that, "The technological influence of small firms is increasing. The percentage of highly innovative U.S. firms (those with more than 15 U.S. patents in the last five years) that are defined as small firms increased from 33 percent in the 2000 database to 40 percent in the 2002 database … Small companies represent 65 percent of the new companies in the list of most highly innovative companies in 2002."

Koo (2005) argued that a cluster of small firms could achieve economies of scale and flexible specialization through close cooperation among themselves. Many researchers hypothesized that a local economy's performance is linked to entrepreneurial activity if the entrepreneurs serve as a mechanism for knowledge spillovers

(Audretsch and Fritsch, 1996; Malecki, 1994). A rich empirical work also linked entrepreneurship to RIS and regional development. Feldman (2001) examined the formation of innovative clusters around Washington, D.C. and found that clusters formed not because resources were initially located in a particular region, but through entrepreneurial activity. Feldman noted that large firms had made important contributions to RIS and regional development, however, the smaller enterprises had specialized in the breakthroughs.

(2) Role of Large Firms in Innovation

Schumpeter (1947) argued that innovation increased more than proportionately with firm's size, so called "Schumpeterian Hypothesis," and that large firms had a natural advantage in innovation because there were scale and scope economies in the production of innovations. Firms with greater market power can more easily appropriate the returns from innovation and hence have better incentives to innovation and regional development (Baumol, 2004). According to data provided by the National Science Foundation (National Science Board, 2000), 46 percent of total U.S. industrial R&D funds was spent by 167 companies that employed 25,000 or more workers; 60 percent of these funds was spent by 366 companies with at least 10,000 employees; and 80 percent was spent by 1,990 firms of 1,000 or more employees. Alternatively, about 15 percent of total U.S. industrial R&D funds was spent by the 32,000 companies that employed fewer than 500 workers (Lee, 2007).

Acs *et al.* (1994) pointed out that the innovation output of all firms increased along with an increase in R&D expenditures, both in private enterprises and in university laboratories. Private enterprises' R&D expenditures played a particularly important role in generating innovation for large firms, while expenditures on government and university R&D played an important role in generating innovative activity for small firms (Audretsch and Feldman, 2003).

(3) Role of Universities and Government Agencies

The last two key developers of innovation are universities and government agencies. Baumol (2004) argued that basic research was difficult for a small or large firm to conduct because it was considered a wasteful investment. An additional contribution of universities and the public institutions to innovation includes the education of the innovator, and also one of the major purposes of research in the academy is the training of the researchers of the future (Baumol, 2004).

University research spillovers were investigated in several empirical studies. Jaffe (1989) and Jaffe *et al.* (1993) provided empirical evidence that university research had a significant effect on innovative activity at the state level. Acs (2002) found that academic research had a high-tech employment spillover at the city level. His results also suggested that spillovers from university research were greater than those from the private industrial R&D. Varga (2000) provided evidence of a positive effect of agglomerations of universities on high technology innovations. Anselin *et al.* (1997) found that regional university research stimulated regional high technology firms' innovative activities as well as regional development in the U.S. Black (2004) concluded that greater R&D activity in the local academic sector also contributed to more innovative activities for small firms, supporting previous evidence that small firms generated innovations from R&D at local universities.

Woodward *et al*. (2006) analyzed the connection between university proximity and the location of new-technology intensive firms. They used a conditional logit model for all counties in the U.S. for 1996. They found that a university's R&D impact on firm location choices varied by industry. These findings were supported by other research indicating that government and university research laboratories provided an important source of innovation to private enterprises (Jaffe, 1989; Feldman and Audretsch, 1998).

2. Knowledge Spillover Effects

There are three regional factors related to the availability of knowledge spillovers: industrial specialization, industrial diversity, and regional competitiveness.

(1) Industrial Specialization

The first theory of external economies was developed by Marshall, 1890; Arrow, 1962; and Romer, 1986, hereafter MAR. MAR assumed that for a given region, specialization in a limited number of economic activities would contribute to spillovers in innovative activity (Van Stel and Nieuwenhuijsen, 2004). In a regional innovation system, industrial specialization in a region refers to the geographic concentration of a particular industry within a specific region and may result from the interaction of increasing returns to scale, transportation costs savings, labor pooling, and local demand, generating additional externalities that enhance industrial innovation and regional development (Krugman, 1991). In the MAR theory, regional specific industry growth is maximized if an industry is dominant in the region, and if local competitiveness is not too strong (Koo, 2005).

Much empirical research focused on the effects of an economy's industrial structure on innovation and regional growth. Henderson *et al.* (1995) examined employment growth rates between 1970 and 1987 in five traditional capital goods industries located in 224 cities. They found that employment growth in these sectors was positively correlated with a high past concentration in the same industry, supporting the industrial concentration, or MAR view.

(2) Regional Competitiveness

A second theory of knowledge spillovers was proposed by Porter (1990). Porter assumed that regional competitiveness accelerated imitation and upgraded innovation. Although competitiveness decreased the relative benefits for the innovator due to large spillovers to competitors, the amount of innovative activity increased because competitiveness forced enterprises to innovate (Van Stel and Nieuwenhuijsen, 2004). Gleaser *et al.* (1992) provided an evidence of fierce competitiveness to innovate, resulting in regional growth as well, from the Italian ceramics industries. Thus, while MAR emphasized the negative effect of local competitiveness on the amount of innovative activity, Porter assumed that the positive effects dominated (Van Stel and Nieuwenhuijsen, 2004). The empirical research tends to favor the competitiveness view over the MAR view. Following Glaeser, *et al.* (1992), much of the empirical research found that regional competitiveness was more conducive to city growth than was regional monopoly. Feldman and Audretsch (1999) also found that local competitiveness was more beneficial to innovative activity than was local monopoly.

(3) Industrial Diversity

The third explanation on the availability and significance of local knowledge spillovers was developed by Jacobs (1969). Jacobs believed that the variety of local economic activities played a major role in the innovation process. In her theory, industry variety rather than specialization in the region promoted innovation and regional growth because many knowledge transfers occurred across industries. The availability of Jacobs externalities (*i.e.* spillovers) provided innovating firms with strong incentives to cluster together to take advantage of the various positive agglomeration economies resulting from cross-industry networking (Koo, 2005).

Glaeser *et al.* (1992), Feldman and Audretsch (1999), and Acs *et al.* (2002) examined the role of externalities associated with knowledge spillovers as an engine of regional economic growth. They tested models of knowledge externalities and found that regional competitiveness and industrial diversity, rather than industrial specialization and monopoly, encouraged innovative activities. Their evidence suggested that knowledge spillovers might occur predominately between, rather than within, industries, consistent with the theories of Jacobs (1969). Alternatively, Henderson *et al.* (1995) showed that either diversity or specialization might create external economies, depending on the industry.

3. Regional Spillover Effects

If knowledge spillovers are important, it follows that they will influence firms' location decisions. In particular, when knowledge is not easily exchanged due to a distance, firms tend to locate in the industry cluster to capitalize on the innovations (*e.g.* patents) in nearby firms, and innovative actors also utilize the favorable local characteristics in their region (Koo, 2005). Earlier research on RIS supported this view and showed that the innovative activity of firms was based on localized resources such as a specialized labor market, supplier systems, local learning processes, supporting agencies or organizations, and the size of the local economy (Asheim *et al.*, 2003; Cooke *et al.*, 2000). Innovating firms have strong incentives to cluster together to take advantage of the various positive agglomeration economies provided by geographic spillovers (Koo, 2005).

(1) Role of Agglomeration Effects in Innovative Activity

Henderson (1986) showed that agglomeration could affect the productivity levels of local firms through external economies and thereby boost the economic performance of a region, suggesting that such agglomeration effects arose from the diversity of deep local labor markets and information. Malecki (1991) also found that agglomerative economies took the form of two related effects such as localization and urbanization economies.

Localization economies occur largely from concentrations of labor and knowledge spillovers, particularly related to high-tech industries (Black, 2004). Rosenthal and Strange (2001) found that firms could benefit from reduced innovation costs generated by lower labor costs if the search for and acquisition of skilled labor was easier due to the proximity of a relevant labor pool, suggesting why many industries requiring certain types of skilled workers were clustered geographically. This labor pooling effect can be especially beneficial to high-tech industries requiring highly skilled and trained workers (Glaeser, 2000). Therefore, the innovative activity in a region may be greater with the presence of a relatively high-tech labor pool (Black, 2004).

Urbanization economies exist because of positive externalities primarily related to the size of a geographic area (large populations and employments), indicating the importance of the size of the local economy (Black, 2004; Jacobs, 1960). The size of a local economy can provide agglomerative economies through greater access to networks among workers, firms and institutions located in the area. Black (2004) also argued that the opportunity for increased communication and interaction among these agents could enhance the innovation process and the ability to perform innovative activity in the area.

(2) Geographical Spillovers of Innovative Activity

Several papers asserted that knowledge spillovers had clear spatial boundaries because the communication between firms and workers depended on their geographical proximity (Feldman and Audretsch, 1999). Baptista (2000) provided empirical evidence that innovations diffused faster within clusters. Lawson and Lorenz (1999) also gave an increased role for the importance of local institutions in encouraging spillovers. It was maintained that relational proximity played a prominent role along with geographical spillovers (Boanet, 1994).

A significant research effort was devoted to finding evidence of geographical spillovers. Jaffe *et al.* (1993) found evidence for both the existence of knowledge spillovers and their boundedness in space. They concluded that citations (1972 through 1980) to patents were more likely to come from the same region as the patents to which the citations were made, indicating a spatial phenomenon. It is indicated in several recent studies that companies were attracted to the close proximity of external knowledge inputs such as universities (Audretsch and Stephan, 1996; Zucker *et al.*, 1998). Thus, both theory and empirical findings pointed in the direction that geographical spillovers was critical for the spread of innovations as well as regional development (Feldman, 1994).

A popular approach to empirically model the local characteristics of RIS as well as to test for their influence on regional innovative activities is the knowledge production function framework initiated by Griliches (1979, 1984). This framework has been widely applied in empirical studies of regional innovation in the US (Jaffe, 1989; Anselin *et al.*, 1997, 2000), in Italy (Capello, 2002), in Austria (Fischer and Varga, 2003) and in Germany (Fritsch, 2001). The literature emphasized the importance of interaction between actors, and proximity among innovators was regarded as a core characteristic of RIS (Asheim and Isaksen, 1997).

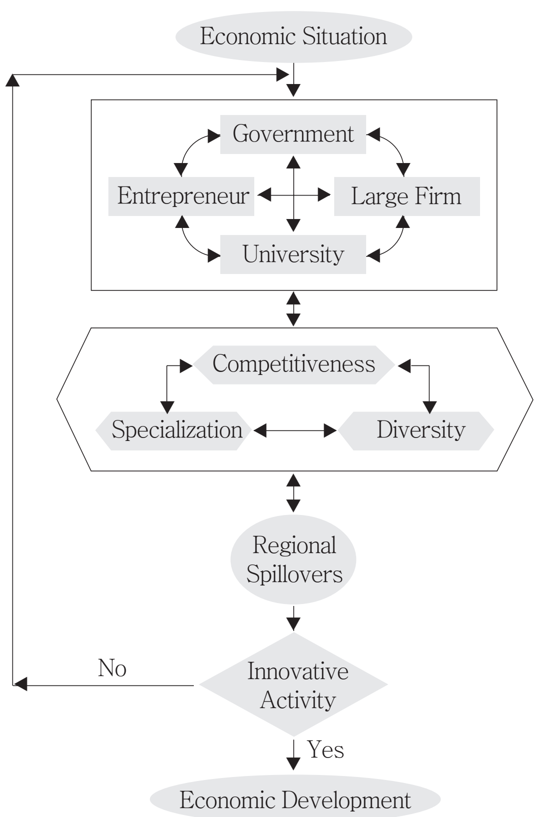
4. Identification of RIS and Regional Growth

(1) The Identification of RIS

Although the concept has no commonly accepted definitions, conceptualizations of RIS are provided by Cooke *et al.* (2000) and others (Asheim and Isaksen, 2002; Wolfe, 2003; Enright, 2001). According to these studies, all regions have some kind of RIS, including not only regions with strong preconditions to innovation, but also old industrial regions, peripheral regions, and even rural regions (Wigg, 1999). Cooke (2001) and Cooke *et al.*(1998) ranked RIS at different points on a scale from strong to weak, and Asheim and Isaksen (2002) distinguished between different types of RIS in order to capture some conceptual variety. Cooke and Morgan (1998, p. 71) defined RIS as "regions that possess the full panoply of innovation organizations set in an institutional milieu, where systemic linkage and interactive communication among the innovation actors is normal."

Three broad dimensions of the local characteristics of RIS are emphasized in this paper. First are the interactions among different sources of innovation in the RIS such as small firms, large firms, and the wider research community including university and public R&D institutions. Second is the role of knowledge spillovers to which innovation processes are institutionally embedded in the regional setting of systems of production. Third are regional spillovers, which are related to regional characteristics and may embody localized interactive learning with its proximity. Accordingly, policy strategies could be oriented towards the promotion of accessibility in the development of RIS (Andersson and Karlsson, 2002) and the development of local comparative advantages linked to specific local resources.

Figure Ⅱ-1. The Flow Chart of Regional Innovation System



Source : Lee (2010).

The context within which firms conduct innovative activities is highly important and may be modeled by analyzing the interrelationships between economic and technological systems at various scales. The RIS are comprised of the elements (small and large firms, universities and government R&D institutions) and relationships (knowledge spillovers and regional spillovers) that interact in the production, diffusion, and use of new knowledge or innovation. Figure Ⅱ.1 summarizes the concepts, and the following sections discuss the relationship between regional growth and the components of RIS in more detail.

(2) The Role of RIS in Regional Economic Growth

In the past decades there has been increasing recognition that innovations contributed substantially to local economic growth. According to the new growth theory (*i.e.* the endogenous growth theory), innovation spillovers are an engine of regional economic growth (Romer, 1986, 1990; Lucas, 1993; Porter, 1996). The positive relationship between innovation systems and economic growth has been investigated since the works of Schumpeter (1947). Given their purported importance as the sources of regional economic growth, innovation spillovers received considerable treatment in the economic literatures in both empirical and theoretical studies (Griliches, 1984 ; Lee, 2007).

Empirical support for the role of innovative activity in regional economic growth is provided in a study of county level differences in 2002 per capita incomes and 1997 to 2002 per capita income growth (Schunk *et al.*, 2005). Schunk *et al.* (2005) used county-level utility patents and university research and development expenditures as measures of local innovative capacity. Their findings indicated that roughly two-thirds of the variation in county-level per capita income across the U.S. could be explained by variations in these measures of innovation and innovative capacity. They also found that counties with higher levels of patents and university research and development had faster rates of growth (Schunk *et al*., 2005).

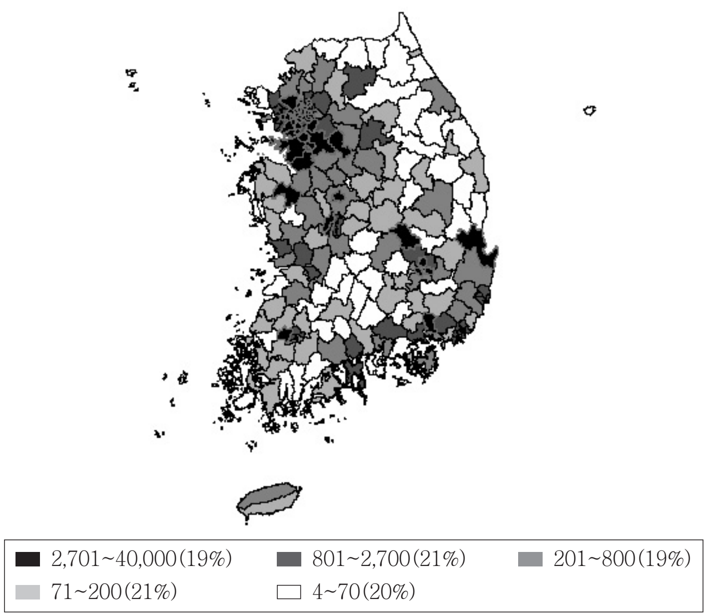
Although the literature on the role of innovative activity in regional economic growth is extensive (Enright, 2001; Porter, 1996; Barkley and Henry, 1997), there is limited evidence on the role of RIS in non-metro or rural areas (Barkley *et al*., 2006; Barkley *et al*., 1999). These studies indicated that nonmetropolitan innovative clusters contributed to higher wages and an increase in business start-ups, but employment was more volatile with industry concentrations. Barkley *et al*. (2006) found that rapid metropolitan growth would stimulate economic activity in hinterlands nearest the metro cores but little spillover of growth was evident in the more peripheral rural areas of the functional economic areas.

Barkley *et al*. (2006) also found a strong correlation between local indicators of RIS and measures of economic growth for metropolitan areas in the South. In this research, cluster analysis was used to divide the 107 metro areas in the South according to 16 indicators of innovative activity (e.g., patents, university R&D expenditures); innovative capacity (e.g., employment in high-technology manufacturing, employment in scientific and technical occupations); and entrepreneurial environment (e.g., venture capital investments, employment in business services). The cluster analysis identified six groupings of metropolitan areas, and only 21 of the metropolitan areas were classified as RIS based on relatively high levels for the selected measures of innovation. Their findings indicated that nonmetro counties near a metro regional innovation system experienced more rapid population and employment growth; however, nonmetro growth rates varied among the three types of metro RIS. In addition, proximity to a metro regional innovation system had a stronger impact on nonmetro population change than on nonmetro employment (Barkley *et al.*, 2006).

5. Overview of Innovative Activity in Korea

Although the popularity of the concept of RIS is increasing, the

Figure Ⅱ-2. Total Patents of Korean Counties (Si, Gun, Gu, 2000-2009)



basic argument is how to apply the systems to regions where innovative activities are visible. A potential shortcoming of the RIS strategy is that innovative capacity and activity are distributed very unevenly across space (Lee, 2010). For example, Figure II.2 illustrates how total patents (2000-2009) in counties in Korea (*Si, Gun, Gu*) are unevenly distributed.

(1) Patents as a Proxy Measure for Innovative Activity

Previous measures of the innovative activity in a region generally focused on inputs into the process, an intermediate output measure such as patents, or proxy measures for innovative capacity (Barkley, Henry, and Lee, 2006). Among these alternatives, patents have become a popular measure for innovative activity at the local level because annual data are readily available from Korean Intellectual Property Office (KIPO). Since data on innovations generally are not available at the local level, patents in metropolitan and county areas often are used as a measure of innovative activity.

This measure, however, has its disadvantages when used to represent innovative activity (Barkley, Henry, and Lee, 2006). First, all inventions are not patented, and all patented inventions are not of equal consequence with respect to innovative products or production processes (Griliches, 1984). Second, Zucker and Darby (2006) claimed that the key to new high-technology industries was the presence of "star scientists" and not the scientists' "disembodied discoveries." The authors noted that patents trended to diffuse over time, while the science and engineering stars became concentrated. Third, patenting activity is concentrated in manufacturing. Innovative activities in trade and service industries are less likely to be patented, and the use of patent data may over-represent the relative innovative activity of counties with significant manufacturing sectors. Finally, patents are credited to the home address of the lead scientist on the patent. This location may not be the same county where the research and development occurred or where the new product/process was implemented (Lee, 2007).

Nonetheless, patents remain a useful measure of the generation of ideas (Barkley *et al.*, 2006; Acs *et al.*, 2000). Acs *et al.* (2002) used the Knowledge Product Function (KPF) approach to test whether patent data was a reliable proxy measure of innovative output as opposed to innovation count data (as represented by SBA innovation counts). Preliminary analysis indicated that patent data and innovation count data had a positive correlation coefficient of 0.79. They concluded that patents were a reliable measure of innovative activity. However, Acs *et al.* (2002) suggested that patent data over emphasized the effects of localized interactions. Alternatively, the influences of university R&D were under represented in the model that used patent data.

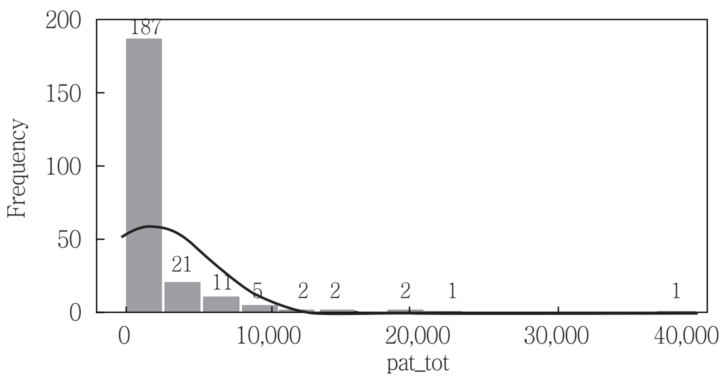
(2) Overview of Regional Innovation Activity in Korea

The innovative activity in Korea, as measured by utility patents 2000-2009, varied across the 232 counties and ranged from 4 (Ulleung-gun) to 39,242 (Suwon-si) in total patents in the time period. The average county had 1,902 patents from 2000 to 2009, especially for an average of 89 patents per 10,000 residents (patent intensity). Seventy counties (30.17%) averaged less than 10 patents per year for the time period. Thus over one-half (64.66%) of the counties had fewer than 100 average patents over the 10 year

Table Ⅱ-1. Counties that Averaged More than 1,000 Patents a Year, 2000-2009

County	Metropolitan City or Province	Patents
Suwon-si	Gyunggi-do	3,924
Yongin-si	Gyunggi-do	2,097
Yuseong-gu	Daejun-si	2,080
Seongnam-si	Gyunggi-do	1,874
Gangnam-gu	Seoul-si	1,513
Seocho-gu	Seoul-si	1,406
Anyang-si	Gyunggi-do	1,143
Songpa-gu	Seoul-si	1,076
Pohang-si	Gyungbuk-do	1,009
Total	9 Counties	161,216

Figure Ⅱ-3. Histogram for Patent Totals (PAT_TOT) of 232 Counties, 2000-2009



period (Table II-1). Alternatively, a relatively small number of counties were very active in innovative activity. Only nine counties averaged more than 1000 patents per year from 2000 to 2009.

These 9 counties accounted for 161,216 patents or 36.82% of the all patenting activity among the 232 counties for the period (See Figure Ⅱ-3), indicating that regional innovation activity was very unevenly distributed locally.

(3) The Determinants of Regional Innovation Activity in Korea

Lee (2010) and others developed the concept of a regional knowledge-production function (KPF) to help identify factors contributing to a regional innovative activity. He empirically estimated the existence of local characteristics of RIS in Korea by using the concept of a KPF model developed by Feldman (1994) to model the relationship between innovative activity and local characteristics of RIS such as sources of innovation, knowledge spillovers, and regional spillovers at the local level. This general relationship was provided in Equation (Ⅱ.1):

$$IA_r = IS_r^{\alpha} KS_r^{\beta} RS_r^{\delta} \qquad (\text{Ⅱ}.1)$$

where IA stands for innovative activity (in this research, the total number of patents from 2000 to 2008); IS stands for innovation sources (such as small and large firms, university and government); KS represents knowledge spillovers (as related to industry specialization, competitiveness, and diversity); RS represents regional spillovers (as reflected by patents in nearby counties, regional amenities, the size of local economy, high-tech employment, distances between a county and a metropolitan, and metro innovative activities); α, β, and δ are parameter coefficients;

Table Ⅱ-2. Variable Descriptions and Data Sources

Variable	Hypothesis	Description
% Knowledge Based Mfg., ***PR***	Positive	Percent of employment in knowledge based manufacturing to county population, 2000 (KIET)
% Higher Education, ***UR***	Positive	Percent of tertiary education population to county population, 2000 (KOSIS)
% Entrepreneurship Firms, ***KBIZ***	Positive	Percent of number of knowledge based manufacturing businesses to county business, 2000 (KIET)
MMfg LQ, ***S_MMFG***	Uncertain	LQ in major manufacturing industry, 2000 (KIET)
KMfg LQ, ***S_KMFG***	Positive	LQ in knowledge based manufacturing 2000 (KIET),
KSvc LQ, ***S_KSVC***	Positive	LQ in knowledge based service industry, 2000 (KIET),
Competitiveness, ***C***	Positive	The ratio of local to national businesses per worker, 2000 (KOSIS).
Diversity, ***D***	Positive	Inverse of Krugman Index, 2 digit KSIC, 2000 (KOSIS)
Employment Density, ***EMP_D***	Positive	Percent of county employment to county area, 2000 (KOSIS)
Distance, ***DIST***	Negative	Kilometers from capital or city hall in a province or metropolitan city, 2008 (GIS)
Road Pavements, ***ROAD***	Positive	County road pavements, 2000 (KOSIS)
Pupil-Teacher Ratio, ***PUPIL-T***	Positive	Ratio of pupils to teachers in a county, 2000 (KOSIS)
% Hospital Beds, ***HOSPB_P***	Positive	Percent of county hospital beds to a county population, 2000 (KOSIS)
Public Expenditures per Capita, ***PEXP_P***	Uncertain	County public expenditures per capita, 2000 (KOSIS)

Source : Lee (2010).

and r represents the less developed county area.

Decomposing Equation (Ⅱ.1) into specific sources of innovation, knowledge spillovers, and regional components yields the general-functional form represented in the following equation:

$$PAT\_TOT_r = f(PR_r, UR_r, KBIZ_r, S\_MMFG_r, S\_KMFG_r, S\_KSVC_r, C_r, C_r^2, D_r, EMP\_D_r, DIST_r, ROAD_r, PUPIL\_T_r, HOSPB\_P_r, PEXP\_P_r) \quad (\text{Ⅱ}.2)$$

where *PR, UR, KBIZ, S_MMFG, S_KMFG, S_KSVC, C,* C^2*, D, EMP_D, DIST, ROAD, PUPIL_T, HOSPB_P, and PEXP_P* are as defined earlier Table II-3; and r represent each county.

Lee (2010) defined the variables and hypothesis used in the empirical estimation (see Table II-2).

Finally he presented the appropriate model for the analysis of innovative activity at the county level in Korea by using Generalized Negative Binomial Model (GNBM) and Zero Truncation Negative Binomial Model (ZTNBM). Table Ⅱ-3 summarizes his results and the influences of RIS characteristics in regional innovative activity in Korea (Lee, 2010). Among the variables representing sources of innovation, the percent of tertiary educated population to county population (*UR*), the proxy variable for university R&D, was positively related to the total county patents or regional innovation activity at the significant level, 99%. The finding for university R&D is consistent with previous evidence of innovation research.

All the specialization of employment in major industry (*S_MMFG*), knowledge based manufacturing industry (*S_KMFG*) and knowledge based service industry (*S_KSVC*) had significant impact on regional innovation activity, indicating industrial specialization was more important than other factors of knowledge spillover effects just as MAR hypothesis. These findings are not consistent with the hypothesis that “manufacturing towns” were unattractive places for innovative activity (Acs *et al.*, 2002). However, county patent totals were not related to industry diversity (D) of the local economy at the significant levels. These results are not consistent with Jacob's hypothesis, which is that less specialization promotes innovation because most important knowledge transfers are from outside industries. County innovation activity was weakly related to Glaeser's U-shaped competitiveness measure (C, C^2). That finding was inconsistent with earlier research indicating that relatively high levels of innovation were associated with both a small number of large establishments as well as a large number of small establishments, indicating the role of local monopoly or the importance of large sized establishments.

The proxy variables for urbanization and regional proximity, *EMP_D* and *DIST*, were not significantly related to regional innovation activity. In the case of sensitive analysis, however, when Lee (2010) used each county employment for the proxy variable for urbanization, it was positively related to regional innovation activity significantly. Another proxy variable for regional proximity, the road pavement in a county (*ROAD*) was positively associated with innovative activity in a county at the significant level, 99%, indicating regional spillover effects.

The proxy variable for the availability of local amenities, *PUPIL_T*, was positively associated with the number of county patents. The elasticity of *PUPIL_T* was very high, 1.25, indicating the marginal

Table Ⅱ*-3. Estimation Results of Alternative Negative Binomial Models*

Variables	GNBM		ZTNBM	
	Coefficient	z-value	Coefficient	z-value
% Knowledge Based Mfg., *PR*	9.915435	1.32	9.991258	1.33
% Higher Education, *UR*	9.170252***	2.60	9.0904***	2.56
% Entrepreneurship Firms, *KBIZ*	.2688155	0.03	.1507849	0.02
Mfg LQ, *S_MMFG*	.2557742**	2.06	.2543163**	2.05
KMfg LQ, *S_KMFG*	.2203766*	1.83	.2187604*	1.81
KSvc LQ, *S_KSVC*	.6921503***	2.83	.6930764***	2.83
Competitiveness, *C*	.3065207	0.78	.297158	0.76
Competitiveness squared, C^2	-1.21933*	-1.74	-1.218763*	0.082
Diversity, *D*	-.0029311	-0.13	-.0027356	-0.12
Employment Density, *EMP_D*	-.0000526	-1.65	-.000053	-1.66
Distance, *DIST*	.001754	0.87	.0017586	0.86
Road Pavements, *ROAD*	.0021634***	3.31	.0021665***	3.31
Pupil-Teacher Ratio, *PUPIL-T*	.0598662***	2.66	.0599728***	2.67
% Hospital Beds, *HOSPB_P*	-31.64733***	-2.31	-31.56606**	-2.30
Public Expenditures per Capita, *PEXP_P*	-.9925919***	-4.75	-1.000677***	-4.71
Intercept	3.996609***	4.63	4.016334***	4.61
lnalpha	-.4473076*	-1.95	-.436685***	-4.97
Number of observations	229		229	

Source : Lee (2010).
Note : *, P-Value<0.1; **, P-Value<0.05; and *** P-Value<0.01

effect of *PUPIL_T* would be also high among the proxy variables for regional spillover effects (see Table Ⅱ-3). An increased presence of the ratio between teachers and students in a county had significant effect on the number of county patents in all the models.

An increase in amenity quality in a county contributed to an increase in the number of patents issued within a county. Another proxy variable for the quality of life, *HOSPB_P*, was negatively associated with regional innovation activity. Nevertheless, in his sensitive analysis, there was positive relationship between regional innovation activity and the total number of hospital beds. This finding may indicate that the quality of life in a county is associated with the quality of hospital, which means the bigger the size of hospital, the better. The final proxy variable of local quality of life, *PXEP_P*, is negatively related to innovative activity. The finding indicates that the higher taxes to support public services discourage locally innovative activity.

In sum, Lee (2010) concluded that the final empirical model in his empirical study captured the role of the local characteristics of RIS in the existence and volume of innovative activity at the county level. Given those evidences, regional policymakers may well consider how to build innovation systems in their regions to stimulate innovation and regional growth according to the situation of innovative activity case by case, but how? In the next chapter, I will empirically explore the relationship between the characteristics of RIS and regional economic growth in Korea.

Ⅲ. The Data

Korean counties are composed of 234 counties such as Si, Gun and Gu. The most of data used in this study is 2000 year data as basic year data and 10 years data from 2000 to 2009. The dependent variables and explanatory variables are as follows.

1. The Dependent Variable

This study hypothesizes that counties with significant innovative activity and RIS characteristics have more rapid economic growth than counties without significant innovative activity and characteristics of RIS. Thus, this study builds on the empirical framework of Glaeser and Saiz (2003) to determine the effects of local characteristics of RIS on regional economic growth. Two models are estimated for Korean counties according to the following specifications:

$$\ln\left(\frac{POP_{r,2009}}{POP_{r,2000}}\right) = \alpha_1 + \sum\alpha_{2i}CHR_r + \sum\alpha_{3i}RIS_r + \varepsilon_1 \quad (\text{Ⅲ}.1)$$

$$\ln\left(\frac{EMP_{r,2009}}{EMP_{r,2000}}\right) = \beta_1 + \sum\beta_{2i}CHR_r + \sum\beta_{3i}RIS_r + \varepsilon_2 \quad (\text{Ⅲ}.2)$$

where : POP=Population; *EMP*=Employment; 2000=Year 2000; *2009*=Year 2009; r=county; CHR_r=Characteristics of county r;

RISr=Characteristics of *RIS* of county *r*, 2000; α and β are the parameter coefficients; and ln stands for log transformation.

There are two variables selected as the dependent variables in the models, which are the growth rate of population and the growth rate

Figure Ⅲ-1. Histogram for the Growth of Population (POP)

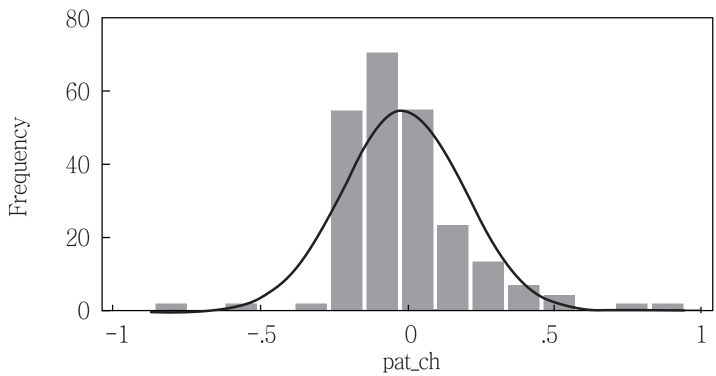
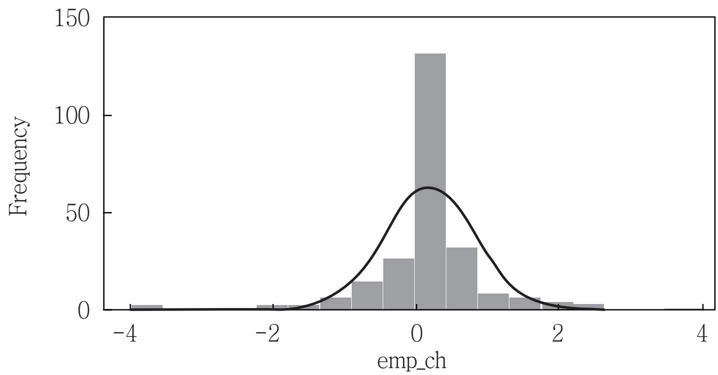


Figure Ⅲ-2. Histogram for the Growth of Employment (EMP)



of employment. All variables are expressed in log form. To gain some information about the dependent variables in the 234 counties including 2 missing data such as Bukjeju-gun and Namjeju-gun, it is useful to look at a histograms of the observed data in Figure Ⅲ-1 through Figure Ⅲ-2. Table Ⅲ-1 and Table Ⅲ-2 provide the definition and descriptive summary statistics for the two dependent variables, achieving from Korea Statistical Information Service (KOSIS) data.

2. The Explanatory Variables of RIS

(1) Sources of Innovation

In this study, the proxy variable selected for the industry R&D (*PR*) of small and large firms is the utility patents of firms issued from the Korean Intellectual Property Office (KIPO) 2000 because measures of private R&D expenditures by county are not available (see Table Ⅲ-1). Usually the proxy variable for the R&D of small firms is county establishments with fewer than 20 employees per capita in 2000, and the proxy measure of large firms is county establishments with greater than 500 employees per capita in 2000. However the data are not available at the county level. Thus the proxy variable for firms (*PAT_F*) is the utility patents of enterprises issued from the KIPO, as of the base year, 2000, and also is selected as the measure of innovative activity of firms.

Another independent variable for innovation sources is the proxy variable measured by the 2000 patent counts for public research institutes (*PAT_P*) and also as a proxy variable for government

R&D. The proxy variable for potential university R&D (*UR*) is the ratio of the number of individuals who has tertiary education (bachelor, master, and doctorate degree) to county population, which is provided by KOSIS. Measures of university R&D expenditures are available, but only for the larger universities. Thus, this research substituted number of college students as the measure for potential university R&D. All positive coefficients for firm, university and government or public R&D are hypothesized.

(2) Knowledge Spillovers

It is important how measures of industrial specialization, competitiveness, and diversity are defined because the estimation results may be sensitive to different variable measures. The measures employed in this study are discussed below.

Specialization of major manufacturing industry in region *r* is measured by the location quotient (LQ) which is defined as:

$$S\_MFG_r = \frac{EMP_{i,r} / EMP_r}{EMP_{i,KR} / EMP_{KR}} \qquad (Ⅲ.3)$$

where EMP_{ir} is manufacturing employment in county r; EMP_r is total employment in county r; $EMP_{i,KR}$ is Korea employment in manufacturing industry; and EMP_{KR} is total Korea employment.

Thus, the ***S_MFG*** is the ratio of the share of local manufacturing industry employment to the share of national manufacturing industry employment. If a value is greater than one, it means that manufacturing industry employment is more concentrated in county

r compared to the national level. The MAR and Porter theories of external economies suggested that industry specialization will stimulate innovative activities and regional growth rates in that region. Patenting among manufacturers, however is high relative to other sectors, but Glaeser and Saiz (2003) found that innovative firms avoided traditional manufacturing areas. Thus, the hypothesized coefficient on the variable representing specialization in manufacturing industry (*S_MFG*) is uncertain.

Following Glaeser *et al.* (1992), the degree of local competitiveness in region r is measured by the ratio of local to national establishments per worker:

$$C_r = \frac{EST_r / EMP_r}{EST_{KR} / EMP_{KR}} \tag{III.4}$$

where EST_r and EST_{KR} are establishments in county r and in Korea, respectively; and EMP_r and EMP_{KR} are employment in county r and in Korea, respectively.

Thus, more establishments per worker mean more competitiveness (Koo, 2005). Values of C greater than one indicate that there are more firms in county r relative to its employment compared to that of the nation.

According to MAR, intensive local competitiveness impeded economic growth and innovative activities. In case of intensive competitiveness, MAR assumed that enterprises limited their amount of innovative activities or regional growth because too much new knowledge spilled over to competitors. According to Jacobs and Porter, however, intensive local competitiveness benefited innovative activities or regional growth because enterprises were forced to innovate. Therefore, the effects of local competitiveness within industries on innovation are ambiguous. Specialization and competitiveness are different concepts in that specialization deals with the clustering of workers, while competitiveness deals with the clustering of businesses in this study.

Following Krugman (1991a), the diversity of region *r* is defined as:

$$D_r = \frac{1}{\sum_i \left(\frac{EMP_{ir}}{EMP_r} \right)^2} \qquad (Ⅲ.5)$$

where $EMP_{i,r}$ and EMP_r are industry *i* employment in county *r* and total employment in county *r*, respectively; $EMP_{i,us}$ and EMP_{us} are Korea employment in industry *i* and total Korea employment, respectively; and $\sum_i$ is the summation of 2 digit industries in KSIC.

The diversity index takes into account the industry diversity of the entire regional economy, so a local economy can have a few specialized industries as well as industry diversity (Koo, 2005). Research on innovative activity and regional growth in states and metropolitan areas indicated a positive association between area patent numbers and industrial diversity (*D*) of the local economy (Anderson *et al*., 2005).

(3) Regional Spillovers

County and regional characteristics found in earlier research to be associated with regional growth rates are the structure of the local characteristics of the local labor market and RIS in nearby communities (geographic spillovers). More specifically, research on RIS in local areas indicated a positive association between regional growth and (a) economic growth rates in nearby communities in the presence of RIS, indicating spillovers (Lim, 2004; Acs, 2002); (b) employment in high-tech industries (Riddel and Schwer, 2003); (c) size of the local economy (Anderson *et al*., 2005); and (d) the availability of local amenities (Deller *et al*., 2001).

First, a common way of modeling spillovers between regions is using spatial econometric models. A positive estimated coefficient on the spatially lagged dependent variable ($W \cdot y$), indicating a positive association between economic growth rates in a county and growth rates in surrounding counties (Boanet, 1994). Total county employment density in 2000 is the proxy variable for the urbanization economies, hypothesized to be positively associated with regional growth. The distance variable (*DIST*), kilometers from capital or city hall in a province or metropolitan city, reflects proximity to urbanization or population spillovers. A negative relationship between distance and county growth rates is hypothesized. The rate of road pavement in a county (*ROAD*) is also one of proxy variables for regional spillover effects, and positive sign of the coefficient for the rate is expected.

Second, the proxy variable selected for high-technology manufacturing industries (*KBIZ*) is the ratio of county business in knowledge based manufacturing industry to county population in 2000 set by Korea Institute for Industrial Economics and Trade (KIET). The percentage of county business in high-technology manufacturing industries is also hypothesized to be positively related to county growth rates.

Finally, the proxy variables of local quality of life and local economic size related to regional growth rate are considered simultaneously in the next section because those variables are the independent variables of regional characteristics as well.

3. The Explanatory Variables of Regional Characteristics

Deller *et al.* (2001) extended the Carlino-Mills model to explore the nature of amenity attributes on regional development. Their main hypothesis was that regional economic growth rates are conditional upon regional amenity factors. Their findings indicated that workers in low amenity regions were compensated by higher wages than workers that live in areas with high levels of amenities. Thus, this study mainly hypothesizes that local economic growth rates are positively related to the perceived local quality of life in Korea as well.

First, the ratio of private institutes to county population is used as a proxy for determining the effect of school quality in Korea on regional economic growth. It is also expected that the institute ratio will have a positive sign on local growth rates. Second, the percentage of hospital beds on local residences was used as a proxy for determining the effect of local quality of life on regional growth. Third, the cost and availability of public goods and service was used as a proxy variable by 2,000 per capita county public expenditures. The sign of the coefficient on the public expenditures variables will be positive if abundant public services attract providers of local labor market, or the sign will be negative if the higher taxes to support public services discourage the local market. Local school quality or the local educational environment is represented by the instrument housing value (lnHVAL), 2000. An increase in local housing value is associated with an increase in available funding for schools and a higher demand by residents for student performance (Barkely, Henry, and Nair, 2006). This research anticipates a positive relationship between county population or employment growth rate and median housing value if local school quality is an important determinant of residential location choice. Last, the proxy variables for the quality of life measures are the ratios of a) sports facility, b) pollution facility, and c) labor union to county population. I hypothesize that employers or residents are concerned to areas with a high quality of life because labor is less expensive in or more easily attracted to such locations (Roback, 1982).

Racial diversity is measured as the ratio of foreigners to the county population (*FRN*), and a positive relationship is hypothesized between racial diversity and regional growth rates. However, the ratio of old people (*OLDP*), over 60 years old, to local population is negatively associated with regional growth rate (Lee, 2010). Total county population (*POP*) and employment (*EMP*) in 2000 are variables are the proxy variables for the size of the county economy and for the availability of urbanization economies in the county, which are hypothesized to be positively associated with regional growth rate.

Table Ⅲ-1 and 2 provide the detailed variable definitions and data sources. The characteristics are selected based on the findings of previous research regarding regional characteristics associated with regional growth (Deller, *et al.*, 2001. Base year (2000) values of the explanatory variables are used to control for possible endogeneity

Table Ⅲ-1. Independent Variable Descriptions and Data Sources

Variable	Hypothesis	Description
Firm Patent per 10000 Pop., *PAT_F*	Positive	Firm patents per 10,000 population, 2000 (KIPO)
Higher Education Ratio, *ln_UR*	Positive	Ratio of tertiary education population to county population, 2000 (KOSIS)
Public Patent per 10000 Pop., *PAT_P*	Positive	Public patents per 10,000 population, 2000 (KIPO)
MMfg LQ, *S_MFG*	Uncertain	LQ in major manufacturing industry, Eq(Ⅲ.3), 2000 (KIET)
Competitiveness, *C*	Positive	The ratio of local to national businesses per worker, Eq. (Ⅲ.4), 2000 (KOSIS).
Diversity, *D*	Positive	Inverse of Krugman Index, Eq. (Ⅲ.5), 2 digit KSIC, 2000 (KOSIS)
W·Growth, W·Y	Positive	Spatially lagged dependent variable, W=contiguity matrix
Entrepreneurship Firm Ratio, *ln_KBIZ*	Positive	Ratio of number of knowledge based manufacturing businesses to county population, 2000 (KIET)
Distance, *ln_DIST*	Negative	Kilometers from capital or city hall in a province or metropolitan city, 2008 (GIS)
Road Pavement Ratio, *ln_ROAD*	Positive	Ratio of county road pavements to county population, 2001 (KOSIS)
Private Institute Ratio, *ln_PRVI*	Positive	Ratio of private institutes to population in a county, 2003 (KOSIS)
Hospital Bed Ratio, *ln_HOSB*	Positive	Ratio of county hospital beds to a county population, 2000 (KOSIS)
Public Expenditures per Capita, *ln_PEXP*	Uncertain	County public expenditures per capita, 2000 (KOSIS)
Foreigner Ratio, *ln_FRN*	Positive	Ratio of county foreigners to a county population, 2000 (KOSIS)
Pollution Facility Ratio, *ln_POLF*	Positive	Ratio of county pollution facilities to a county population, 2000 (KOSIS)
Union Ratio, *ln_UNION*	Positive	Ratio of county labor unions to a county population, 2000 (KOSIS)
Sports Facility Ratio, *ln_SPOF*	Positive	Ratio of county sports facilities to a county population, 2000 (KOSIS)
Old People Ratio, *ln_OLDP*	Negative	Ratio of local old people to a county population, 2000 (KOSIS)
Population, *ln_POP*	Positive	Total county population, 2000 (KOSIS)
Employment, *ln_EMP*	Positive	Total county employment, 2000 (KOSIS)
Land Value Change, *LVAL*	Uncertain	Land value change rate, 2003 (KOSIS)

Table Ⅲ-2. *Summary Statistics for Variables*

Variable	Obs	Mean	Std. Dev.	Min	Max
Population Change Rate, *POP_CH*	232	-0.015	0.206	-0.872	0.943
Employment Change Rate, *EMP_CH*	232	0.180	0.643	-3.979	2.586
Firm Patent per 10000 Pop., *PAT_F*	232	2.409	5.065	0.000	37.935
Higher Education Ratio, *ln_UR*	232	-2.823	0.615	-4.309	-1.274
Public Patent per 10000 Pop., *PAT_P*	232	0.000	0.000	0.000	0.004
MMfg LQ, *S_MFG*	232	0.827	0.924	0.003	6.186
Diversity, *D*	232	14.828	3.815	3.258	25.860
Competitiveness, *C*	232	1.139	0.258	0.389	1.713
Entrepreneurship Firm Ratio, *ln_KBIZ*	232	-8.814	1.532	-13.711	-5.655
Distance, *ln_DIST*	232	3.278	1.297	-0.734	5.613
Road Pavement Ratio, *ln_ROAD*	232	3.214	0.991	1.497	5.022
Private Institute Ratio, *ln_PRVI*	230	-6.844	0.459	-8.854	-5.552
Hospital Bed Ratio, *ln_HOSB*	232	1.893	0.400	-0.342	3.617
Public Expenditures per Capita, *ln_PEXP*	230	-0.026	0.805	-1.540	1.684
Foreigner Ratio, *ln_FRN*	232	3.539	0.759	0.668	5.842
Pollution Facility Ratio, *ln_POLF*	232	2.923	0.733	-0.844	4.642
Union Ratio, *ln_UNION*	232	-0.099	1.105	-4.605	2.454
Sports Facility Ratio, *ln_SPOF*	232	2.116	0.329	0.944	3.323
Old People Ratio, *ln_OLDP*	232	-2.428	0.495	-3.598	-1.564
Employment, *ln_EMP*	232	10.489	1.034	8.029	13.115
Population, *ln_POP*	232	11.835	0.931	9.234	13.762
Land Value Change, *LVAL*	232	1.953	2.118	-1.630	12.640

issues except for some variables unavailable in 2000 data set. The models are estimated for the 234 Korean counties with four missing values, which are *Si, Gun*, and *Gu*. All variables, if possible, were expressed in log transformation. As such, the estimated coefficients are elasticities. All the models were estimated with STATA 11.

Ⅳ. The Analysis of Regional Growth

This chapter investigates the relationship between the characteristics of Korean RIS and regional growth rates (population and employment growth) in 234 Korean counties with 4 missing values from 2000 to 2009 period. The main goal of this chapter is to investigate the role of RIS characteristics in the regional growth at the county level in Korea, including both population growth and employment growth with 3-stage least squares (3SLS) regression.

1. The Data Analysis with OLS Models

(1) The OLS Model for Population Growth

The OLS model for the growth rate in county population, 2000-2009, is as follows:

$$\ln(POP_{2009}/POP_{2000}) = \alpha_0 + \alpha_1 PAT\_F + \alpha_2 \ln\_UR + \alpha_3 PAT\_P + \alpha_4\ S\_MFG + \alpha_5 C + \alpha_6 D + \alpha_7 W \cdot POP\_CH + \alpha_8 \ln\_KBIZ + \alpha_9 \ln\_DIST + \alpha_{10} \ln\_ROAD + \alpha_{11} \ln\_PRVI + \alpha_{12} \ln\_HOSB + \alpha_{13} \ln\_FRN + \alpha_{14} \ln\_POLF + \alpha_{15} \ln\_UNION + \alpha_{16} \ln\_OLDP + \alpha_{17} \ln\_POP + \alpha_{18} \ln LVAL + \varepsilon_1 \quad \text{(IV.1)}$$

where ln stands for log transformation ; α_0, α_1, α_2, α_3, α_4, α_5, α_6, α_7, α_8,

α_9, α_{10}, α_{11}, α_{12}, α_{13}, α_{14}, α_{15}, α_{16}, α_{17} and α_{18} are estimated parameters; and the ε_1 is the error term.

RIS Characteristics

The findings of the OLS regression analysis for the population change are presented in Table Ⅳ-1. Several patterns are evident from the estimated equations. As hypothesized, the growth rate of county population is positively related to characteristics of innovation sources, but not at the significant levels. The elasticity of *ln_UR* is very high, 63.79, indicating the marginal effect of *ln_UR* will be also high (see Table Ⅳ-1). An increased presence of overall higher educated people has significant effect on the rate of county population change. The finding for university R&D is consistent with previous evidence of innovation research. Anselin *et al.* (1997, 2000) and Feldman (1994) found that academic R&D had a significant effect on the number of innovations (Jaffe *et al.*, 1993). Unfortunately, there is limitation to use appropriate data of the proxy variables for R&D of firms and universities because the data related to firm size and R&D expenditure of universities and private firms are not available at the county level in Korea.

All the specialization of employment in major industry (*S_MFG*), industry diversity (*D*) and industry competitiveness (*C*) has negative impact on regional population growth, and county population growth rates are not related to major industry specialization and industry competitiveness of the local economy at the significant levels, except for industry diversity. These results are not consistent with Jacob's hypothesis, which is that less specialization promotes regional population growth because most important knowledge transfers are from outside industries.

The proxy variables for urbanization and regional proximity, W·Y and *ln_KBIZ*, are significantly related to regional population growth, indicating regional spillover effects. The spatially lagged dependent variable (W·POP_CH) indicates a positive association between the population growth rate in a county and the rates in surrounding counties. That is, counties with low growth rates tend to cluster, and counties with high growth rates tend to locate near similar counties. Other proxy variables for regional proximity, the road pavement in a county (*ln_ROAD*) and distance (*ln_DIST*), are not significantly related to regional population growth at the traditional significant levels.

Regional Characteristics

As hypothesized, the availability of local amenities is positively associated with the rate of county population growth. An increase in amenity quality in local areas contributes to an increase in the county population growth rate. The growth rate of county population is related to good school quality as reflected in county land values (LVAL) and county private academic institutes (ln_PRVI). Thus an increase in amenity quality in a county contributes to the growth rate of county population. Another proxy variable for the quality of life, ln_HOSB, is negatively associated with county population growth. However, Lee (2010) showed opposite results in his sensitive analysis, indicating positive relationship between regional innovation activity and the total number of hospital beds. Thus this finding may indicate that the quality of life in a county is associated with the quality of hospital, which means the bigger the size of hospital, the better. Another proxy variable of local quality of life, *PXEP_P*, is positively related to county population growth, indicating that public services encourage local population growth. The proxy variable for racial diversity (ln_FRN) is positively related to the growth rate of county population, but the ratio of county old people (ln_OLDP) is negatively associated with the growth rate. Other variables for regional characteristics related to population growth are not related to the county population growth at the significant levels.

(2) The OLS Models for the Employment Growth

The OLS models for growth rates in county employment, 2000-2009, are as follows :

$$\ln(EMP_{2009}/EMP_{2000}) = \beta_0 + \beta_1 PAT\_F + \beta_2 \ln\_UR + \beta_3 PAT\_P + \beta_4\ S\_MFG + \beta_5 C + \beta_6 D + \beta_7 W \cdot POP\_CH + \beta_8 \ln\_KBIZ + \beta_9 \ln\_DIST + \beta_{10} \ln\_ROAD + \beta_{11} \ln\_PRVI + \beta_{12} \ln\_HOSB + \beta_{13} \ln\_FRN + \beta_{14} \ln\_POLF + \beta_{15} \ln\_UNION + \beta_{16} \ln\_OLDP + \beta_{17} \ln\_EMP + \beta_{18} \ln LVAL + \varepsilon_2 \quad \text{(IV.2)}$$

where β_0, β_1, β_2, β_3, β_4, β_5, β_6, β_7, β_8, β_9, β_{10}, β_{11}, β_{12} β_{13}, β_{14}, β_{15}, β_{16} β_{17}, and β_{18} are estimated parameters; and the ε_2 is the error term.

RIS Characteristics

The findings of the OLS regression analysis for the employment change are presented in Table Ⅳ-1. As hypothesized, the innovative activity of county firms (PAT_F) is positively related to the growth rate of county employment at the significant levels. The elasticity of

PAT_F, or the marginal effect of *PAT_F*, is 0.0235 (see Table Ⅳ-1). An increased presence of innovative activity of county firms will have significant effect on the rate of county employment change. All other variables for innovation sources are not associated with the county employment growth at the significant levels.

The only significant variable for knowledge spillover in RIS is industry diversity (D), indicating opposite result comparing to the OLS result of growth rate in population. This result is also consistent with Jacob's hypothesis, which is that less specialization promotes regional employment growth because most important knowledge transfers are from outside industries. All other variables for knowledge spillovers in RIS are not related to the county employment growth at the significant levels.

The proxy variable for regional proximity, W·Y, is only significantly related to regional employment growth. However, the spatially lagged dependent variable (W·EMP_CH) indicates a negative association between the employment growth rate in a county and the rates in surrounding counties. Alternatively, counties with low growth rates tend to cluster those with high growth rates, indicating 'spread effects' tend to locate near similar counties. Other proxy variables for regional proximity are not significantly related to regional employment growth at the significant levels.

Regional Characteristics

The regression results for the growth rate of county employment indicate that the employment growth rate is highest among counties with relatively low base year employment (ln_EMP). The proxy variable of local public expenditures, *ln_PEXP*, is negatively related

Table Ⅳ-1. OLS Results for Growth Rates in Population and Employment

Variables	Population Change, POP_CH		Employment Change, EMP_CH	
	Coefficient	t-value	Coefficient	t-value
PAT_F	0.0000	0	0.0235**	2.09
ln_UR	0.0404	0.96	0.1638	1.07
PAT_P	63.7909	1.31	-6.7607	-0.04
S_MFG	-0.0199	-1.06	-0.0669	-0.97
D	-0.0084*	-1.83	0.0335**	2.08
C	-0.0428	-0.54	0.4561	1.55
W·Y	0.3157**	2.5	-0.7796***	-6
ln_KBIZ	0.0230**	1.99	0.0112	0.27
ln_DIST	-0.0165	-1.4	0.0643	1.55
ln_ROAD	-0.0117	-0.41	0.0073	0.07
ln_PRVI	0.1137***	2.88	0.1357	0.96
ln_HOSB	-0.2170***	-4.57	-0.1480	-0.86
ln_PEXP	0.0661*	1.82	-0.3131**	-2.5
ln_FRN	0.0393*	1.8	0.1242	1.56
ln_POLF	0.0138	0.61	-0.0710	-0.85
ln_UNION	0.0007	0.06	0.0619	1.44
ln_SPOF	0.0396	0.92	-0.0757	-0.46
ln_OLDP	-0.1151*	-1.75	0.2588	1.11
ln_POP	0.0066	0.24		
ln_EMP			-0.3677***	-3.58
LVAL	0.0143**	2.24	0.0371*	1.67
Intercept	1.1241*	1.69	5.1745	2.18
R^2	0.498		0.291	
Obs. Number	230		230	

Note : *, P-Value <0.1; **, P-Value <0.05; and *** P-Value<0.01

to the growth rate of county employment. The finding indicates that the higher taxes to support public services discourage local employment growth. The growth rate of county employment is a little bit related to good school quality as reflected in county land values (LVAL). The coefficients of remaining variables of regional characteristics (ln_PRVI, ln_HOSB, ln_FRN, ln_POLF, ln_UNION, ln_SPOF, and ln_OLDP) are not significant at the traditional level.

2. The Data Analysis with the Carlino-Mills Models

(1) The Model

Model Specification

Many researchers have suggested that both firms' and households' location decisions are dependent upon each other (Lee, 2007). This extends itself to the argument of the direction of causality regarding whether "people follow jobs" or "jobs follow people" (Steinnes and Fischer, 1974). Carlino and Mills (1987) used a simultaneous equation systems model for population and employment change to address this problem. Since, several studies have used variations of this model to address various issues relating to population and employment growth in counties and metro areas. The Carlino and Mills model (CM model) defines the equilibrium population and employment in linear functional form as:

$$POP^* = f(EMP^*/\Omega^{POP}), \tag{IV.3}$$

$$EMP^* = g(POP^*/\Omega^{EMP}) \tag{IV.4}$$

where POP* and EMP* are population and employment of the county at equilibrium, respectively; and Ω^{POP} and Ω^{EMP} are the set of independent indicators to explain population and employment at initial level. The following equations are used to identify the direction of causality issue (Greene, 2003):

$$POP^* = b_0 + b_1 EMP^* + \sum d_{1i} \Omega_i^{POP} \tag{IV.5}$$

$$EMP^* = c_0 + c_1 POP^* + \sum d_{2i} \Omega_i^{EMP} \tag{IV.6}$$

where, *b*, *c* and *d* are the parameter coefficients. Under the assumption that population and employment are independent, the variables would return to their equilibrium values after an adjustment period. The basic assumption of the above model is that both households and firms adjust toward equilibrium levels of population and employment. Carlino and Mills (1987) assumed a lagged adjustment toward equilibrium population and employment as:

$$POP = POP_{-p} + v_{POP}(POP^* - POP_{-P}), \tag{IV.7}$$

$$EMP = EMP_{-p} + v_{EMP}(EMP^* - EMP_{-P}). \tag{IV.8}$$

where the subscript $-p$ refers to the indicated variable lagged p period, and v_{POP} and v_{EMP} are the speed of adjustments coefficients, with $0 \leq v_{POP}, v_{EMP} \leq 1$. By rearranging terms, the equations are expressed:

$$\varDelta POP = POP - POP_{-p} = v_{POP}(POP^{*} - POP_{-p}), \qquad (IV.9)$$

$$\varDelta EMP = EMP - EMP_{-p} = v_{EMP}(EMP^{*} - PEMP_{-P}) \qquad (IV.10)$$

where $\varDelta POP$ and $\varDelta EMP$ are the change in population and employment between 1990 and 2000; and POP_{-p} and EMP_{-p} are the initial condition, the 1990 levels. Substituting (IV.5) and (IV.6) into (IV.9) and (IV.10) gives:

$$\varDelta POP = v_{POP}b_{o} + \frac{b_1 v_{POP}}{v_{EMP}}\varDelta EMP - v_{POP}POP_{-p} + b_1 v_{POP}EMP_{-p} + \sum v_{POP}d_{1i}\Omega_i^{POP} \qquad (IV.11)$$

$$\varDelta EMP = v_{EMP}c_{o} + \frac{c_1 v_{EMP}}{v_{POP}}\varDelta POP - v_{EMP}POP_{-p} + c_1 v_{EMP}POP_{-p} + \sum v_{EMP}d_{2i}\Omega_i^{EMP} \qquad (IV.12)$$

Furthermore, the model can be expressed:

$$\varDelta POP = a_{POPo} + a_{POP1}\varDelta EMP + a_{POP2}POP_{-p} + a_{POP3}EMP_{-p} + \sum e_{1i}\Omega_i^{POP} + \varepsilon_1 \qquad (IV.13)$$

$$\varDelta EMP = a_{EMPo} + a_{EMP1}\varDelta POP + a_{EMP2}POP_{-p} + a_{EMP3}EMP_{-p} + \sum e_{2i}\Omega_i^{EMP} + \varepsilon_2 \qquad (IV.14)$$

where a_0, a_1, a_2, a_3, e_{1i} and e_{2i} are the estimated parameters; ε_1 and ε_2 are the random error terms. The above equations (IV.13) and (IV.14) are modeled to give short term equilibrium instead of long-term equilibrium so that it would be easier to determine the effects of RIS's on county economic growth rates. The Carlino-Mills framework in growth model form would be:

$$POP^* = A(EMP^*)^{b_1}\Omega_{POP}^{d_1}, \tag{IV.15}$$

$$EMP^* = B(POP^*)^{c_1}\Omega_{EMP}^{d_2} \tag{IV.16}$$

And the equilibrium condition would be,

$$\frac{POP}{POP_{-p}} = \left(\frac{POP^*}{POP_{-p}}\right)^{V_{POP}}, \tag{IV.17}$$

$$\frac{EMP}{EMP_{-p}} = \left(\frac{EMP^*}{EMP_{-p}}\right)^{V_{EMP}} \tag{IV.18}$$

Substituting (IV.13) and (IV.14) into (IV.15) and (IV.16), and using a log transformation will give,

$$\Delta \ln POP = a_{POP_0} + b_1 \Delta \ln EMP + a_{POP1}\ln POP_{-p} + a_{POP2}\ln EMP_{-p} + \sum e_{1i}\ln\Omega_i^{POP} + \varepsilon_1, \tag{IV.19}$$

$$\Delta \ln EMP = a_{EMP_0} + c_1 \Delta \ln POP + a_{EMP1}\ln POP_{-p} + a_{EMP2}\ln EMP_{-p} + \sum e_{2i}\ln\Omega_i^{EMP} + \varepsilon_2 \tag{IV.20}$$

Specifically, the estimated CM models are

$$\ln(POP_{2009}/POP_{2000}) = \alpha_0 + \alpha_1 PAT\_F + \alpha_2 \ln\_UR + \alpha_3 PAT\_P + \alpha_4 S\_MFG + \alpha_5 C + \alpha_6 D + \alpha_7 W \cdot POP\_CH + \alpha_8 \ln\_KBIZ + \alpha_9 \ln\_DIST + \alpha_{10} \ln\_ROAD + \alpha_{11} \ln\_PRVI + \alpha_{12} \ln\_HOSB + \alpha_{13} \ln\_FRN + \alpha_{14} \ln\_POLF +$$

$$\alpha_{15}\ln\_OLDP+\alpha_{17}\ln\_POP+\alpha_{17}\ln LVAL+\varepsilon_1, \qquad (IV.21)$$

$$\ln(EMP_{2009}/EMP_{2000}) = \beta_0+\beta_1 PAT\_F+\beta_2\ln\_UR+\beta_3 PAT\_P+ \beta_4\ S\_MFG+\beta_5 C+\beta_6 D+\beta_7 W\cdot POP\_CH+\beta_8\ln\_KBIZ+\beta_9\ln\_DIST+ \beta_{10}\ln\_ROAD+\beta_{11}\ln\_HOSB+\beta_{12}\ln\_FRN+\beta_{13}\ln\_POLF+ \beta_{14}\ln\_UNION+\beta_{15}\ln\_OLDP+\beta_{16}\ln\_EMP+\beta_{17}\ln LVAL+\varepsilon_1 \qquad (IV.22)$$

where all dependent variables are the same as earlier defined (Table Ⅲ-1); and ε_1, ε_2 are error terms.

The variables names and descriptive statistics are provided in Tables Ⅲ-1 and Ⅲ-2. The main purpose of these models is to investigate the role of RIS characteristics in regional economic development. Specifically, the models can test whether a county's innovative activities promote regional economic growth. The model can also be used to test whether employment growth or population growth rate is more important as regional development policies, indicating the direction of causality regarding whether "people follow jobs" or "jobs follow people."

The Three Stage Least Square (3SLS) Estimation

The three-stage least square (3SLS) method is preferred to two stage least squares (2SLS) method because there are several instruments common to both equations, and the 3SLS method will correct for the correlation occurring across equations (Greene, 2003). Thus, the above growth rate system of equations (Equation (Ⅳ.21) and (Ⅳ.22) is estimated using the 3SLS method. The dependent variables are first estimated using their sets of instrument variables. In the second stage, the estimated value from the first stage are used to run an OLS regression to derive the parameters, and the third stage takes into account the correlations among the error estimates between the equations to improve the regression estimates (Greene, 2003).

The growth rate systems of equations are used in this analysis, as it makes it easier to interpret the estimated coefficients. The equations are estimated for Korean counties (230 counties), for the time period of 2000-2009. Finally, the regression results are shown in Table Ⅳ-2. These empirical results provide evidence of the relationship between local RIS characteristics and the growth rates in employment and population. Estimations were made using STATA 11.

(2) The Data Analysis for Population Growth

RIS Characteristics

Table Ⅳ-2 provides the results for the county population growth rate model in the 3SLS analysis, indicating almost the same as the results of the OLS estimation. First, all the variables for innovation sources are not associated with the county employment growth at the significant levels.

Second, the only significant variable for knowledge spillover in RIS is industry diversity (D), indicating that D is negatively related to the growth rate of county population. This result is not consistent with Jacob's hypothesis. All other variables for knowledge spillovers in RIS are not related to the county employment growth at the significant levels.

Last, the proxy variables for urbanization and regional proximity, *W·Y, ln_KBIZ*, and *ln_DIST* are significantly related to regional population growth, indicating regional spillover effects. The spatially lagged dependent variable (W·POP_CH) indicates a positive association between the population growth rate in a county and the rates in surrounding counties. The only difference between the OLS and the 3SLS results is the significance of distance (*ln_DIST*), enhancing regional spillover effects.

Regional Characteristics

The availability of local amenities is positively associated with the rate of county population growth, just as the results of the OLS estimation. The growth rate of county population is related to good school quality as reflected in county land values (LVAL) and county private academic institutes (ln_PRVI). Thus an increase in amenity quality in a county contributes to the growth rate of county population. Another proxy variable for the quality of life, ln_HOSB, is negatively associated with county population growth, indicating that the bigger the size of hospital, the better. The proxy variable of regional public service, PXEP_P, is positively related to county population growth, indicating that public services encourage local population growth. The proxy variable for racial diversity (ln_FRN) is positively related to the growth rate of county population, but the ratio of county old people (ln_OLDP) is negatively associated with the growth rate. Thus young towns and foreign workers are recommended for population growth.

(3) The Data Analysis for Employment Growth

The last two columns of Table Ⅳ-2 provide the estimated results for the growth rate of county employment. The coefficient for change in population growth rate is positive and significant, suggesting that population growth rates are significantly related to employment growth rates. However, the coefficient of employment growth rate in the population growth equation, 0.038, is not significant at the traditional levels. Furthermore the coefficient of population growth rate in the employment growth equation is 1.498. Thus these findings support the view that “jobs follow people,” indicating the importance of local population policy.

RIS Characteristics

The growth rates in county employment are positively related to the innovative activity of local firms as one of determinants for regional employment growth. Other determinants for local economic growth are industrial diversity (D) and competitiveness (C), rather than industrial specialization. The other determinant for regional economic growth is a negative association between the employment growth rate in a county and the rates in surrounding counties, indicating ‘spread effects’ tend to locate near similar counties. All other remaining variables in the characteristics of RIS are not statistically significant.

Regional Characteristics

The regression results for the growth rate of county employment

Table Ⅳ-2. 3SLS Results for Growth Rates in Population and Employment

Variables	Population Change, POP_CH		Employment Change, EMP_CH	
	Coefficient	z-value	Coefficient	z-value
POP_CH			1.498*	1.92
EMP_CH	0.038	0.98		
PAT_F	-0.001	-0.24	0.023**	2.19
ln_UR	0.031	0.78	0.111	0.77
PAT_P	65.521	1.46	-101.555	-0.59
S_MFG	-0.019	-1.09	-0.038	-0.6
D	-0.010**	-2.16	0.045***	2.88
C	-0.070	-0.95	0.491*	1.82
W·Y	0.318***	2.75	-0.752***	-6.32
ln_KBIZ	0.024**	2.21	-0.020	-0.5
ln_DIST	-0.019*	-1.68	0.095**	2.41
ln_ROAD	-0.011	-0.44	0.032	0.35
ln_PRVI	0.106***	2.98		
ln_HOSB	-0.207***	-4.76	0.175	0.91
ln_PEXP	0.076**	2.13	-0.443***	-3.24
ln_FRN	0.035*	1.73	0.062	0.8
ln_POLF	0.016	0.76	-0.110	-1.38
ln_UNION			0.064	1.68
ln_SPOF	0.046	1.17	-0.140	-0.9
ln_OLDP	-0.126**	-2.1	0.536*	1.95
ln_POP	0.018	0.62		
ln_EMP			-0.371***	-4.01
LVAL	0.013**	2.22	0.008	0.32
Intercept	0.929	1.47	4.053***	2.71
R^2	0.5299		0.3456	
Chi2	245.02		104.67	
Obs. Number	230		230	

Note : *, P-Value<0.1; **, P-Value<0.05; and *** P-Value<0.01

indicate that the employment growth rate is highest among counties with relatively low base year employment (ln_EMP) because estimates for the coefficients for beginning period employment and population give an estimate of the speed of adjustment to equilibrium levels as shown in the CM model. The proxy variable of local public expenditures, *ln_PEXP*, is negatively related to the growth rate of county employment. Alternatively, the higher taxes to support public services discourage local employment growth. One of the unexpected results is the coefficients of old people (lnOLDP), which is not consistent with my hypothesis. The coefficients of remaining variables of regional characteristics (ln_PRVI, ln_HOSB, ln_FRN, ln_POLF, ln_UNION, ln_SPOF, and LVAL) are not significant at the traditional levels.

3. Summary of Findings

The main goal of this chapter was to investigate the role of RIS in the regional growth at the county level in Korea, including both population growth and employment growth with 3-stage least squares regression.

Through the model specification, Carlino-Mills models (CM models) with 3-stage least square estimation are proposed as a conclusive model for the determinants of regional growth in a RIS framework. The findings from the extended CM models indicate a more focused role of RIS characteristics on population and employment growth rates than that in OLS models. The CM models support a role for local firm innovative activity in employment growth but not population growth. Other results from the CM models are similar to those of the OLS models.

In sum, the main conclusion of the analysis is that "jobs follow people." Thus, given this evidence, policymakers may at first well consider how to enhance their regions to stimulate innovation and regional economic growth according to the determinants of regional population growth, and after that those of regional employment growth. For the characteristics of RIS, the innovative activity of local firms and industrial diversity should be considered. All the significant, positive coefficients of spatially lagged dependent variables indicates a positive association between the economic growth rates in a county and the growth rates in surrounding counties. Quality of life variables in a county were positively associated with all the economic growth rates in both the OLS and 3SLS models. In all the economic growth equations, county growth rates were related to local RIS characteristics such as source of innovation (industry R&D), knowledge spillovers (regional competitiveness, industry diversity) and regional spillovers (geographical proximity and local amenity), especially for educational quality of life.

V. Conclusion

The purpose of this study was to expand our understanding of the relationship between regional economic growth and the local characteristics of RIS. Of special interest are the determinants of regional economic growth, and also for policy makers, which policy should be first among population and employment policies? For solving the problems, this paper first identified the determinants of sources of innovation, knowledge spillovers, and regional spillovers as the principal characteristics of RIS in Korea through the empirical review as well as the literature review. And then it overviewed the Korean innovation activity at the county level (*Si, Gun and Gu*) by using county patents as the measure of innovative activity. In addition, it also examined the effects of the local characteristics of RIS on regional economic growth and explored whether the characteristics had a differential effect on regional economic growth rates.

Through the model specification, Carlino-Mills models (CM models) with 3-stage least square estimation are proposed as a conclusive model for the determinants of regional growth in a RIS framework. The findings from the extended CM models indicate a more focused role of RIS characteristics in population and employment growth rates than that in OLS models. The CM models confirmed that a role of local firm innovative activity in local employment growth is significant but not in local population growth. Other results from the CM models are similar to those of the OLS models.

The results from the simultaneous equation model (CM model) indicated that the innovative activity of local firms had positive spillovers with regards to increase in employment growth rates in local areas. Another main conclusion of the analysis was that "jobs follow people." Thus, given this evidence, policymakers may well consider how to enhance their regions to stimulate innovation and regional growth according to the determinants of regional population growth, and after that those of regional employment growth. For the characteristics of RIS, the innovative activity of local firms and industrial diversity should be considered. All the significant, positive coefficients of spatially lagged dependent variables indicate a positive association between the economic growth rates in a county and the growth rates in surrounding counties, implicating the effectiveness of local industrial cluster policies. Quality of life variables in county were positively associated with all the economic growth rates in both the OLS and 3SLS models. In all the economic growth equations, county growth rates were related to local RIS characteristics such as source of innovation (industry R&D), knowledge spillovers (regional competitiveness, industry diversity) and regional spillovers (geographical proximity and local amenity), especially for educational quality of life.

Given those empirical results, policymakers may well consider strengthening local R&D efforts as a potential road for stimulating innovation and economic development in their areas. The empirical results of this research also have important implications related to economic development policies. First, local economic development policies should not ignore the innovative activity in local researchers, hence population growth policy should be considered at first, including local quality of life. Policymakers should be directed to stimulating the interaction between local researchers and institutions or firms in the local economy because incentives to attract innovative firms may fall short unless sufficient regional spillovers and knowledge spillovers take place (Black, 2004).

Second, therefore, the quality of the local labor force and the entrepreneurial environment must improve if increases in innovative activity are to ultimately lead to significant new economic activity, supporting the policy of 'quality of working life (QWL)' by ministry of knowledge economy (MKE). Just as the result of this empirical study showed the importance of high quality of academic environments, local policymakers should consider how to enhance the quality of their school zones.

Third, moreover, insights into the spatial spillovers effects on innovative activity suggest that regional economic policymakers consider the specific geographies of knowledge spillovers, specifically how the RIS might promote regional economic growth, also indicating the usefulness of locally industrial cluster policies.

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