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Abstract

Active creation of jobs and start-ups in high-tech clusters like Silicon Valley has drawn a lot of attentions from policy makers and analysts around the world. We empirically investigate the geography of Korea's high tech jobs and start-ups using the combined data set of Korea's Local Employment Survey and Korea's R&D Activities Survey. Although we identified significantly positive agglomeration effects of higher wages of highly educated employees and bigger probability of start-ups in locations with more highly educated people, we could not find the empirical evidence of high-tech clusters with active technology transfers from universities and public R&D institutions to start-ups in Korea.

I. Introduction

In technology frontier countries such as the United States, it has been observed that new jobs are being actively created in high-tech industries while the opposite has been happening in traditional counter-parts. For instance, in 1985, there were over 20 million manufacturing jobs in America, but the number has dwindled down to about 1.1 million in 2010. In contrast, high-tech industries such as pharmaceuticals, internet, research and development (R&D), and software have been showing rapid increases in number of jobs. Furthermore, it is clear that new geography of jobs are emerging since inequalities in jobs not only appear between industries but also appear greatly between regions as well (Moretti, 2012).

Based on analyses of geography of high-tech clusters in Korea, the current study aimed to show whether agglomeration of high-tech jobs and start-ups in high-tech clusters, as evident in developed countries including the United States, has also been occurring in Korea, which is approaching technology frontier.

In the age of new geography of jobs and technological changes drastic enough to be called the Fourth Industrial Revolution (Klaus, 2016), research outputs and ideas generated by newly discovered scientific technologies from private and public research institutions, and universities get transferred quickly to industries. As a result, high-tech clusters have been active centers of start-ups engaging in creations of new products and even new industries. As is the case, many scholars have been paying much attention to innovation ecosystem where technology transfers, start-up activities, and agglomerations occur actively around high-tech clusters through bridging of outputs from knowledge economy, such as universities and research institutions, to commercial economy (Jackson, 2014).

Here, high-tech clusters can be defined as industry complexes in large and small sizes where factors essential to innovations, including relevant industries and research personnel, are agglomerated in close geographical proximity (Lee, 2014). That is to say, in addition to clustering of various industries, existence and agglomeration of entrepreneurs, intermediate industries, venture capitals, research institutes, and universities contribute positively to innovation capacity of a cluster in a region (Engle, 2014). For example, the most well-known high-tech cluster in the United States is Silicon Valley (Bresnahan & Gambadella, 2004; Engel, 2014) whereas Seoul Digital Valley and Pangyo Techno Valley are recognizable cases in Korea (Lee, 2014).

The current study examines whether start-ups alongside high-tech jobs in Korea show convergence on high-tech clusters and whether regional R&D outputs from universities and public research institutions have been actively contributing to creations of high-tech jobs and start-ups through technology transfer to industries. In other words, from the angle of geography of jobs, it attempts to empirically investigate whether Korea shows similar signs of the emerging trends that stand out in innovation ecosystems of developed countries.

Rest of chapters are organized as follows. In chapter 2, review of literatures on high-tech clusters and descriptions of data utilized in the study are presented. In chapter 3, we overview the geography of high-tech jobs and start-ups by region with city/county-level regional data set. In addition, analyses of clustering trends from 2008 to 2014 in Korea are investigated. In chapter 4, we investigate effects of market force and government policy in determining the geography of high-tech jobs and start-ups in Korea through number of methodologies including OLS estimations of regional number of high-tech jobs and start-ups and regional average wage in 163 cities and counties, logit estimations of factors affecting individuals' decision to engage in start-ups, and instrumental variable estimations of wage equations. Finally, in chapter 5, conclusions are presented based on the results obtained.

II. High-Tech Clusters and Data

According to Spencer, Vinodrai, Gertler, and Wolfe (2010), when agglomeration of related industries within a city reaches a threshold, level of income across industries and growth rate of employment within a cluster tend to be larger than those outside of the cluster. Furthermore, among cities, size of high-tech clusters was positively related to their income level and employment growth rate.

Indeed, despite high cost of living and doing businesses, evidence is overwhelmingly positive that large cities in general tend to offer competitive advantages over relatively less concentrated areas (Bettencourt, Lobo, Helbing, Kuhnert, & West, 2007). More specifically, it is well established that urban cities tend to display strong innovative activities than less populated ones (Agrawal, Kapur, & McHale, 2008; Gerlach, Ronde, & Stahl, 2009; Simonen, & McCann, 2008).

General consensus is that there are three possible explanations for the positive agglomeration effect on regional economy (Duranton & Puga, 2004; Moretti, 2012; Puga, 2010). Firstly, one of the strongest advantages offered by urbanization is the access to efficient and active labor market, especially for high skilled workers. Because high skilled workers are characterized by low substitutability with unskilled workers or capital (Correa, Lorca, & Parro, 2014; Krusell, Ohanian, Rios-Rull, & Violante, 2000) as well as by high degree of specialization, it is a necessary for both firms and high skilled workers to find employments that better match their specialized set of needs (Moretti, 2012). In this regard, urbanized city facilitates the match because clustering of potential employers and employees within one area create a large pool of accessible human resources, improving the chance and quality of matches between firms and workforce (Moretti, 2012; Puga, 2010). In other words, city offers an advantage to both firms and employers in terms of giving access to thick labor market, which produces better matching of skills and needs that translate in turn to high productivity and eventually innovation (Moretti, 2013).

In addition to thick labor market, another key advantage provided by agglomeration is the rich set of specialized intermediate services that accompany the core cluster industry (Moretti, 2012). These intermediate inputs can range from advertisement and management consultancies to technical assistances such as legal and engineering supports, and their existence allows the core cluster industries to focus even further on their specializations by drawing on local expertise (Holmes, 1999). This in effect creates positive productivity feedback as having a specific industrial cluster attracts intermediate services to a city, generating a relatively thick market for intermediate services, which in turn further increases productivity of the core cluster (Ellison, Glaeser, & Kerr, 2010). Thus, clustering of core industry in a city can create a virtuous cycle of thick markets which ultimately contribute towards productivity gains, innovative capacity, and ultimately growth of economy.

Finally, Moretti (2012) argues that urbanized cities tend to show higher productivity because university-educated high skilled workers attracted to cities generate positive externalities such as knowledge spillovers. The human capital spillovers can raise productivity and creativity of less skilled workers because formal and informal interactions among workers facilitate transfer of knowledge and skills from highly educated peers to less skilled ones. This spillover effect is arguably one of the most significant drivers of economic growth (Arzaghi & Henderson, 2007; Glaeser & Resseger 2010; Moretti, 2004; 2014), which may be large enough to explain not only city-wise differences in development but also between developed and developing countries (Lucas, 1988).

Extreme concentration of start-ups towards large cities has been noted by many scholars already. One of most well-recognized determinant of entrepreneurship (or start-up) is human capital or more simply education. The argument is that those with higher level of education are better positioned to take advantage of existing inventions and knowledge to generate innovative products and processes; as such, they are more likely to go into start-ups and generate more successful businesses (Doms et al., 2010; Robinson & Sexton, 1994). The implication is that areas with large share of educated individuals will likely to have more entrepreneurial activities purely based on their propensity to enter start-ups.

Indeed, looking at the results from existing empirical evidence, having a large share of university graduates (Acosta, Coronado, & Flores, 2011) as well as of entrepreneurial activities tend to generate more start-up businesses in the region (Glaeser & Kerr, 2009; Glaeser, Ker, & Ponzetto, 2010), indicating that through a chain of events, a share of educated individuals in a region is deeply linked to amount of entrepreneurial activities in that region. Similarly, examinations of innovation activities suggest that nations with higher level of human capital tend to show greater innovation capacities and activities as represented by number of patents, proportion of R&D expenditure, and proportion of high-tech exports (Dakhli & Clercq, 2004). Likewise, some researches indicate that cities endowed with highly educated populace are likely to show strong growth in their size (Henderson & Wang, 2007) and form local economies that have great deal of innovations (Duranton, 2013). These indicate that having an existence of ecosystem that attracts highly educated individuals tend to propagate entrepreneurial activities even further.

In addition to its direct impact, human capital has number of other channels through which it can affect entrepreneurships in a region. The first is through knowledge spillover effect. Evidence points to the fact that entrepreneurial activities thrive better in places where existing knowledge can be accessed and appropriated (Acs, Baunehjelm, Audretsch, & Carlsson, 2009). Similarly, evidence does indicate that cluster of related industries within a given region promotes more start-ups than otherwise, meaning that within industry spillovers can foster entrepreneurships. (Delgado, Porter, & Stern, 2010).

In addition, another way through which entrepreneurship can be fostered is input-sharing. Helsley and Strange (2002) argued that innovation can result from dense network of input sharing as realization of ideas can be achieved more easily by having lower costs of inputs. Empirically, greater concentrations of inputs and specialized set of workers positively contributes to the likelihood of firm entry to the region (Glaeser and Kerr, 2009). Hence, whereas knowledge spillover affects innovation through creation of ideas, input-sharing fosters innovation through realization of ideas. A common point in these channels is that they are critically hinged on regional clustering of innovation start-up capacity, meaning that innovation and activities of entrepreneurs are affected by regional characteristics and that cities, in particular, take the central role.

The focus of the current study is the fact that high-tech clusters are related to fostering start-up creations. For example, Gilbert, McDougall, and Audretsch (2008) showed that in America, newly established venture firms in IT industry clusters achieved more innovations, and Feser, Renski, and Goldstein (2008) reported a positive effect of Appalanchia region high-tech clusters on formation of technology-focused industry start-ups with closer distance to university and innovation activities displaying strong links to more start-up activities.

Similarly, another key aspect of the current study is to determine whether agglomeration of R&D activities could affect high-tech jobs and start-up activities in Korea as has already been confirmed by a number of studies in developed countries[1]. For instance, analyses by Woodward, Figueiredo, and Guimaraes (2006) indicated that university R&D capacity of a region was associated with the likelihood of attracting high-tech manufacturing plants. Similarly, it has been reported that university start-ups tend to stay in the vicinity of their parent universities, suggesting that presence of research universities can positively contribute to formation of start-up community (Heblich & Slavtchev, 2013).

Considering that most of research findings on high-tech clusters presented thus far have been the cases of the United States, it still remains uncertain as to whether such findings could be applied directly to Korea as well. To this end, we attempted empirical investigations.

Firstly, definition of high-tech industry may vary depending on time period and nations. As is the case, the current study largely adopted the definition used in Jang et al. (2014) who most recently defined 'creative industry[2]' based on an extensive survey of domestic and foreign literatures. The current study, however, differs from Jang et al. in that the definition we used

[1] As one aspect of high-tech clusters, venture capital also acts as a catalyst promoting innovation start-ups. Florida and Kenny (1988) explained that venture capitals tend to converge on locations with high concentration of technology-intensive businesses because there are reductions in opportunity costs and gains from information spillovers by not needing to invest in long distances. Although, data regarding venture capitals were not included in the current study, this may be an area to be explored further in the future.

[2] The term 'creative industry' appears to have been named in a reaction to the priority policy objective set by Park administration to foster creative economy.

classified industries at the division-level of Korean Standard Industrial Classification (KSIC) whereas Jang et al. utilized the group-level classifications. According to Jang et al., in addition to the existing classification rules such as *proportion of creative workers by industry* and *intellectual property*, they also incorporated new rules derived from the perspectives of input, process, and output to their classification system, including *investment in creative activities*, *start-up characteristics*, *IT investment and utilization*, and *innovation*. More specifically, at the division-level of KSIC, high-tech industries were classified as shown in Appendix 1. For instance, high-tech manufacturing industries included pharmaceuticals, electronics, and motor vehicles whereas industries such as publishing, research and development, and computer programming were included in high-tech service industries.

For the empirical analyses, the current study utilized the Local Area Labor Force Survey from labor area and the Survey of Research and Development in Korea from the science and technology area. Since 2008, statistics department in Korea has been conducting the Local Area Labor Force Survey to create and to provide basic statistics concerning administrative level employment conditions and structure with detailed information on industries and job types of those who employed. In the case of 2014 data used in the current study, the survey was conducted biannually in April and October with the final sample including 399,579 people aged 15 and over who were part of 199,000 sample households across the nation. Because the survey did not include district level data, the present study utilized data from 163 areas including 156 cities and counties, and 7 metropolitan cities[3]. The time frame of data was from 2008 to 2014, and we used data from October samples. Additionally, as a proxy variable for the number of start-ups, the current study used number of self-employed individuals from the Local Area Labor Force Survey[4].

The Survey of Research and Development in Korea is conducted in accordance with the Framework Act on Science and Technology. It collects information regarding current state of R&D in Korea from a number of indicators such as R&D expenditures and R&D manpower to provide basic information necessary in planning national R&D policies and to be used as a

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[3] The survey has been collecting general labor statistics that can be classified by the level of cities and counties in nine provinces other than 7 metropolitan cities, but cannot be classified by the level of districts in 7 metropolitan cities As of July 1st, 2012, parts of Cheongwon-county (Chungbuk) and Gongju-city (Chungnam) as well as the whole area of Yeongi-county (Chungnam) have been incorporated into the Sejong-city due to the launching of Sejong-city. However, because Sejong-city has neither a population estimate nor a sampling design needed for statistics at the time, Cheongwon-county, Gongju-city, and Yeongi-county have been used instead.

[4] It is not uncommon to rely on self-employment data to proxy for entrepreneurial activities. Acs et al (2009), for instance, used self-employment statistics from OECD countries to investigate impact of knowledge stock on rate of entrepreneurial activities. Likewise, Schiller and Crewson (1997) used self-employment data from National Longitudinal Surveys of Youth to identify characteristics that determine entrepreneurship. Georgellis and Wall (2000) used number of self-employed ratio as a representative variable for regional entrepreneurship to investigate the effect of labor market conditions on regional entrepreneurship in UK. In the case of Parker, Congregado, and Golpe (2012) examined relationships between business cycle and innovation start-ups with number of self-employed as the proxy variable. Notably, Faggio and Silva (2014) showed in their region level analysis with self-employed variable from the Labour Force Survey in England that ratio of self-employed was highly related to entrepreneur activities such as innovation and start-ups in cities, indicating that self-employed can act as a valid proxy variable of innovative start-ups.

reference by experts in various fields. Moreover, the data is supplied to OECD to improve trust and to be utilized as comparative statistics among nations among nations[5]. Targets of the survey includes public research institutes, universities, medical institutions, and businesses across the nation. Personnel and capital related data are surveyed at the end of the survey year while sales and R&D related data are surveyed throughout the year. More specifically, items surveyed include current state of research personnel (sex, education level, major, and so on) and R&D expenditures (R&D stage, finance, and expenditures by items)[6]. The current study utilized 2014 data.

Additionally, information from the “Higher Education in Korea” website was also used. “Higher Education in Korea” contains information disclosed by universities as accorded by the article 6 of the “Act on Special Cases Concerning Disclosure of Information of Education Related Institutions” to facilitate citizens’ utilizations of information regarding universities[7]. The current study used number of patent (domestic and foreign patent applications in 2013) applied by 4-year universities as obtained from the website.

Empirical analyses in the current study can largely be divided into city/county-level regional and individual-level analyses. To construct regional dataset, the raw Local Area Labor Force Survey data from the Statistics Korea were processed to create city/county-level region data. Specifically, variables such as regional number of high-tech jobs, high-tech start-ups, and university graduates were generated by aggregating all surveyed individuals residing in cities and counties. Similarly, the data provided by public research institutes, universities, medical institutions, and businesses for the Survey of Research and Development in Korea were also restructured by aggregating them into city/county-levels. Furthermore, school-level data from “Higher Education in Korea” employed location of schools to aggregate them into city/county-levels to create regional data. Then, the three generated regional data were linked based on the year of survey, and city/county-level area codes to produce the final regional-level data set. For the individual-level data set, the regional-level dataset constructed above were linked to the raw Local Area Labor Force Survey data from the Statistics Korea through area code in which each individual resided.

[5] The scope of survey follows the FRASCATI Manual of OECD, which covers various areas from natural sciences and engineering to humanities and social sciences (humanities and social sciences were included from the 2008 survey). Survey employed the mail and online self-enumeration method through and used telephone survey where necessary.

[6] It is important to note that due to methodological constraints, city/county level R&D manpower, expenditure, and so on used in the current study were based on addresses of respondents. This means that there may be some disparities between surveyed R&D manpower and expenditure and actual figures in respective areas.

[7] More specifically, it aims to (c) achieve qualitative improvement in university education, (a) improve transparency in university management, (b) strengthen accountability of education performance, (d) encourage the government to take rational and scientific approach to education policy making, (e) assist students and parents in making decisions regarding universities and majors, and (f) to aid discovery and hiring of high-quality employees. Main agents of information disclosure are accredited universities and colleges in accordance with related laws such as the article 2 of Higher Education Law. Disclosed information includes 63 items in 14 areas.

III: Geography of High-Tech Jobs and Start-Ups

Firstly, using the constructed city/county-level region data, quintile distributions of high-tech jobs and start-ups by region are displayed on the map of Korea (Figure 1). The most notable phenomenon that can be seen in Figure 1 is concentration on Seoul or on metropolitan areas. In particular, Seoul as a capital city confirmed its high concentration of workers as it accounted for 22% and 32% of all of high-tech jobs and start-ups in the nation. Next in line is Incheon Metropolitan City which, alongside Seoul Metropolitan City, is a part of the larger capital metropolitan area. Incheon holds about 6% of high-tech jobs and 7% of high-tech start-ups in its region. Although Incheon Metropolitan City was far smaller in size compared to Busan and Daegu Metropolitan Cities, it has expanded rapidly to overcome Daegu Metropolitan City and is placed third next to Busan Metropolitan City in terms of population size, and has become second overall from the perspectives of high-tech job and start-up numbers. In contrast, all of the counties were included in the lowest 20% regions (first quintile) of high-tech jobs and start-ups proportions.

Figure 1. The Quintile Distributions of High-Tech Jobs and Start-Ups by Region

From Figure 1, it is apparent that in Korea, number of high-tech start-ups in particular show stronger clustering in Seoul and the Metropolitan Area, even more so than that of high-tech jobs. Although there is no doubt about the existence of market forces accelerating agglomeration of high-tech jobs and start-ups towards Seoul or capital metropolitan areas in Korea, from the balanced regional growth perspective, there also exists counter forces attempting to break out of increasing concentration on Seoul or capital metropolitan areas. More specifically, a number of government policies such as industrial site policy, R&D policy, and recent innovation policy (Sohn & Kenny, 2007) have been acting against agglomeration forces.

Figure 2. The Quintile Distributions of University Graduates by Region and Regional Distribution of Government-Led Clusters

As can be seen in Figure 2 (a), the tendency of university graduates to cluster in Seoul and capital metropolitan areas is likely to be the result of market forces as pointed out in agglomeration economics rather than intended government policy outcomes. In contrast, Figure 2 (b) shows that government-led clusters are scattered across whole regions of Korea as they include not only cities but also counties. Government has been implementing various Location Support Policies to foster R&D and innovation activities and to eventually bridge such activities to actual realization of businesses. However, it can be seen that compared to market driven clusters of highly educated people, the government-led clusters are far more varied and spread out. The reasons for such outcome are partly due to explicit push for balanced regional growth initiatives. In some cases, agglomeration could not be achieved as originally planned due to political pressures exerted by excluded regions at the implementation stage, which, in effect, negated the initial selection process and agglomeration intentions.

Government-led clusters including Science and Research Complex, Technopark, and National Industrial Cluster are analyzed in the current study. More specifically, Science and Research Complex is intended to organically build linkages and facilitate cooperation among industries, academics, and researchers by assembling them in one location. Through this, government expects greater competitiveness in regional research and development and better commercialization of research outputs. By making investments in areas such as regionally appropriate science and technology infrastructures and shared equipment, it supports chosen areas to act as regional centers of science and technology that lead science and technology innovations and develop of respective regions. Among the 12 industry complexes (excluding capital metropolitan areas), the policy targeted areas with the most potential to grow as a regional base of research and development.

Technopark is a base of regional industry cultivation which builds organic cooperation networks among regional innovation organizations including industry, academics, research institutes, and government. Furthermore, it also establishes strategies and policies appropriate for regional characteristics and circumstances to best discover and nurture knowledge-based high-tech firms. As of 2014, there are 18 locations across the country.

National Industry Cluster is one of the industrial clusters designated by a minister of Ministry of Land, Infrastructure, and Transport in accordance with the Industrial Sites and Development Act to raise key national industry and cutting-edge science and technology industry. Where it deems necessary, a head of central administrative agency may request to the minister of Ministry of Land, Infrastructure, and Transport to assign the targeted region as a National Industry Cluster. Because the cluster is constructed as a part of national strategy by government, it is relatively cheap to acquire land and is easy to attract connecting roads and agencies including R&D infrastructures. 27 places are currently designated as of 2014.

Figure 3. The Quintile Distribution of R&D Expenditures and University Patents by Region

From Figure 3 that presents regional distribution of research and development, market forces driving convergence of innovative activities on Seoul or capital metropolitan areas and counter forces by the government can be observed at the same time. For example, as can be seen in Figure 3 (b), the fact that private sector R&D is concentrated in Seoul and Suwon in capital metropolitan areas seems to indicate existence of strong market forces. Seoul holds 29% of all private R&D expenditure while 25% is concentrated in Suwon where Samsung Electronics Company Ltd. resides in. In contrast, Figure 3 (c) shows that public sector and university R&D expenditure is largely focused in Daejeon where Daedeok Science Town is located. Finally, regional distribution of university patents indicates concentration in Seoul (38%) which has a cluster of prestigious universities. Meanwhile, in capital metropolitan areas other than Seoul has long been under the regulation of the Seoul Metropolitan Area Readjustment Planning Act that inhibits establishment of universities and restricts student quota. As a result, only 11% of university patents exist in the area, and the rest are sparsely distributed to places such as regional national universities. Therefore, it is apparent that public sector and university R&D expenditures and university patents are strongly affected by governmental forces that scatter rather than concentrate them into high-tech clusters as is the case with private sector R&D driven by market forces.

A question arises then as to whether regional concentration of high-tech jobs and start-ups are becoming intensified in recent years like developed countries such as the United States or whether no such clustering exist due to government policies mentioned previously.

First of all, the current study examined overall changes in high-tech jobs and start-ups for the last six years from 2008 to 2014. As shown in Figure 4, high-tech jobs as a whole grew at much higher rate than other jobs in the last six years, but the total number of high-tech start-ups actually declined during that period. Moreover, the amount of decline was even greater for high-tech start-ups than for traditional industry start-ups. In the case of highly educated people, the total number of university graduates increased with far greater pace than that of 2-year college graduates or lower, consistent with the current trend for higher education. As for wage, high-tech jobs on the whole had relatively better increase from 2008 to 2014 than other jobs. Conversely, rate of wage growth for university graduates was actually lower than that of people with college degree or lower. This reflects the fact that quality of higher education could not be guaranteed in the face of so-called education bubble or rapid expansion of higher education (Lee, Jeong, & Hong, 2014).

From these perspectives, although it is true that high-tech jobs in general showed relatively faster rate of job and wage expansions than other sectors, in the case of high-tech start-ups, their number declined more rapidly than traditional start-ups. Similarly, the number of university graduates increased faster than lower education group, but it was the opposite for wages since their wage grew slower than that of lower education group.

Figure 4. Percentage Change in Employment and Wage from 2008 to 2014

Then, do high-tech jobs and start-ups in Korea also show intensifying regional clustering as in the United States? Through inspection of Figure 5, it can be examined whether regional agglomerations have been intensifying. Firstly, as pointed by previous researches, a factor closely related to agglomeration of high-tech jobs and start-ups is university graduates. As such, the question is whether regional clustering of university graduates intensified over the last six years. According to Figure 5, it can be seen that regional distribution of university graduates has become dispersed lately. From 2008 to 2014, the percentage change in university graduates was highest in the first quintile containing all the counties. However, considering that there exist a wide gap in qualities between universities in capital metropolitan areas and regional universities, it is difficult to say with certainty that decentralization of human capital is actually being realized.

Next, in the case of high-tech jobs, the fifth quintile (Seoul) or first quintile (counties) do not show much differences in rates of high-tech job growth in the last six years. Furthermore, because Incheon, Busan, Daegu, and Ulsan in fourth quintile exhibited the lowest rate of increase from 2008 to 2011, it is also difficult to say that regional clustering of high-tech jobs have been intensifying.

On the contrary, in the case of high-tech start-ups, third to fifth quintiles show far greater growth rates than first and second quintiles; especially, Incheon, which is the fourth quintile region displays the highest growth rate. In fact, many IT firms in Seoul Gangnam high-tech cluster have been relocating to Pangyo Techno Valley in Seongnam, Gyeonggi province for the reasons such as high rent; the above results seem to reflect this phenomenon. In other words, clustering of high-tech start-ups has been occurring in cities surrounding Seoul rather than in the fifth quintile region Seoul which has the highest concentration of high-tech start-ups at the moment.

Next, it was examined in Figure 5 (b) whether growth of regional wage is related to greater concentration of high-tech jobs or university graduates. If wage increase faster in regions where certain groups cluster, it is highly probable that such wage gains may act as an incentive to cluster, further accelerating the agglomeration process. Figure 5 indicates that for case of the high-tech jobs, the quintile areas with the highest growth in regional average wage was third quintile, including Incheon, Daejeon, Yongin, Gwangju, Seongnam, and Goyang, and for the case of university graduates, it is the fourth quintile containing Busan and Daegu.

To summarize, from 2008 to 2014, Figure 5 reveals that regional clustering of high-tech jobs and high-tech start-ups were very limited. Furthermore, it was noteworthy for high-tech start-ups that rather than Seoul in the fifth quintile, the fourth quintile areas such as Incheon and Seongnam in the outskirts of Seoul showed least decline in the number of high-tech start-ups during the time period. Such observations consistently confirm the notion pointed out earlier that in addition to market forces agglomerating high-tech jobs, start-ups, and university graduates inside high-tech clusters, there also exist countervailing governmental forces scattering them out of high-tech clusters in Korea.

Figure 5. Percentage Change in Employment and Wage from 2008 to 2014 by Quintile Region

Based on the geographical data of high-tech jobs and start-ups, analyses so far examined whether high-tech jobs and start-ups are agglomerated around high-tech clusters and how such regional concentration have intensified from 2008 to 2014. The current chapter concludes that although clustering of highly educated people into innovation regions, as pointed out by economics of agglomeration, also occur in Korea, there also exist the offsetting forces to the market forces arising from government-led clusters, and public sector and university R&D expenditure emphasizing balanced regional growth. In addition, regional agglomerations of high-tech jobs and start-ups from 2008 to 2014 were revealed to be very limited. In the next chapter, we consider other key control variables in analyses, and to approach and confirm causal interpretations beyond mere correlations, regression analyses were conducted with both individual- and regional-level data sets.

IV: Regression Analysis

From the results of investigating Korea's geography of high-tech jobs and start-ups in the previous chapter, it became apparent that the role of government deserved as much attention as the market forces known as agglomeration effect. That is, since high-tech clusters are influenced by activities such as technology transfer from universities and public research institutes to start-ups, we named those influential activities as 'innovation ecosystem effect.' As such, regression analyses were aimed at confirming agglomeration effect and innovation ecosystem effect in relation to high-tech cluster in Korea.

To conduct regression analyses, raw data from second half of 2014 Local Area Labor Force Survey and 2014 Survey of Research and Development in Korea were combined to create a regional dataset containing 163 city/county-level data and another with individual-level data from 399,579 respondents. Descriptive statistics of key variables are presented in Table 1.

Table 1. Descriptive Statistics

To begin with, the current study uses regression analyses to examine how numbers of high-tech jobs and start-ups are determined at the 163 city/county-level in Korea. As explanatory variables, key factors of innovation ecosystem were included. In estimating Equation 1, 2, and 3, it was assumed that number of high-tech jobs and start-ups and average wage in each region are affected by agglomeration effect variable (A), representing concentration of talented individuals, by innovation ecosystem effect variable (I), representing strength of innovation ecosystem, and by other region-level control variables (C).

$$ln(E_j) = \alpha_0 + \beta_1 A_j + \beta_2 I_j + \beta_3 C_j + \varepsilon_j \tag{1}$$

For Equation 1, dependent variable $ln(E_j)$ is log number of high-tech jobs of a region *j*. For agglomeration effect variable A_j, log number of university graduates in region *j* is included. As for the innovation ecosystem effect I_j, it is measured by log number of patents applied by universities in region *j*, by log R&D expenditures from private, public, and university of each region *j*, and by dummy variables each indicating existence of Science and Research Complex, Technopark, National Industrial Cluster, or Regional Specialized Industry Zones in each region *j* for inspecting effectiveness of the government-led clusters. C_j contains control variables including city dummy variable indicating status of region *j*, proportion of female in region *j*, and average age of region *j*. Finally, ε_j is the error term in the equation.

$$ln(S_j) = \alpha_0 + \beta_1 A_j + \beta_2 I_j + \beta_3 C_j + \varepsilon_j \quad (2)$$

$$ln(W_j) = \alpha_0 + \beta_1 A_j + \beta_2 I_j + \beta_3 C_j + \varepsilon_j \quad (3)$$

Equation 2 and 3 are the same except for dependent variables where $ln(S_j)$ of Equation 2 is log number of high-tech start-ups in region j, and $ln(W_j)$ of Equation 3 is log average wage of region j. Since estimated coefficients may be biased due to inter-correlations among explanatory variables, various specifications from model A to E are attempted. The results for Equations 1, 2, and 3 are presented in Table 2, 3, and 4, respectively.

Followings are results of regression analyses. First of all, number of university graduates in a region very consistently affects the number of high-tech jobs and start-ups in a region, and average regional wage. The estimated coefficients indicate that elasticity of number of high-tech jobs by number of university graduates is about 0.85 whereas that of start-ups is at around 0.95. In other words, we could affirm stable agglomeration effect.

On the other hand, innovation ecosystem effect variables have negligible impact on high-tech jobs, high-tech start-ups, and average regional wage. In the case of regional R&D expenditure, it does not have any influence on number of start-ups, suggesting that high-tech cluster akin to Silicon Valley, where ideas from R&D are actively commercialized, has not been established in Korea.

Moreover, because number of patents by universities located in a region neither contribute to number of high-tech jobs nor start-ups, technology transfer of university patents have minimal at best on regional economy. Only regional private R&D expenditure could be confirmed to have statistically significant positive influence on regional number of high-tech jobs (Table 2). Conversely, the results show that regional public or university R&D expenditures have no influential impact not only on high-tech start-ups but also on high-tech jobs and average regional wage.

Similarly, government-led clusters in general does not show positive impact on number of high-tech jobs or start-ups in a region. Since Technopark and Regional Specialized Industry Zone have even negative relationships to the jobs and start-ups, it can be interpreted that government policies counteracted the agglomeration of market. An exception to this is the Science and Research Complex by which high-tech jobs are statistically affected.

Table 2. OLS Estimates of High-Tech Jobs in a Region

Table 3. OLS Estimates of High-Tech Start-Ups in a Region

Table 4. OLS Estimates of Average Wage in a Region

Next, as shown below in Equation 4, we estimated individuals' probability to engage in a start-up.

$$Pr(Startup_{ij} = 1) = \alpha_0 + \beta_1 A_j + \beta_2 I_j + \beta_3 C_j + \beta_4 X_{ij} + \varepsilon_{ij} \tag{4}$$

By utilizing data on employed people in 2014, logit models with start-up dummy as dependent variable (start-up = 1, not start-up = 0) was estimated to determine factors affecting decisions of individual *i* in region *j* to engage in start-ups (Table 5). As was the case in the previous analyses, regional R&D expenditures (private, public, and university) and university patents as well as dummy variables representing government-led clusters in region *j* are included as innovation ecosystem effect variables (I_j). Importantly, agglomeration effect variables (A_j) such as regional number of university graduates, high-tech jobs, and high-tech start-ups in region *j* are included. Finally, city status of region *j* is included as a region control (C_j), and sex, age, education, and major of individual *i* in region *j* are included as individual controls (X_{ij}).

The results of logit analyses on determinants of start-up likelihood is presented in Table 5. In Korea, an individual is more likely to engage in a start-up if the person is male, older, and have more than high school education. One interesting finding is that those with Master's degree or higher have lower likelihood of start-up than 4-year university graduates despite their higher education level. This indicates that general start-ups in Korea are not founded on the basis of higher level scientific knowledge or R&D skills, and for these highly educated individuals, being employed rather than engaging in start-ups are relatively more common practice.

Next, to find impact of major in start-up likelihood, science and engineering dummy variable is included, but no statistically significant effect could be seen. Because those in science and engineering major can relatively easily obtain knowledge, skill, and experience needed for high-tech start-ups through university education, they should be in better position than those in arts and humanities majors to open high-tech start-ups. This is backed up by the fact that many CEOs leading venture booms in Korea were from science and engineering majors including IT related majors and that many science and engineering graduates in US and China have been actively attempting start-ups. However, in Korea, because there is definitive preference for employment over start-ups, and because demand for science and engineering graduates are relatively plentiful, there are only few science and engineering graduates attempting to launch start-ups. The findings in the current study reflects such prevailing conditions in Korea.

Key factor that we particularly note with interest in start-up likelihood analyses is the presence of agglomeration effect or how the number of high-tech jobs and start-ups in a region influence the decisions of individuals to engage in start-ups. We could empirically confirm that agglomeration effect exists in start-ups in Korea. The results suggest that numbers of university graduates, high-tech jobs, and high-tech start-ups all have statistically significant impacts on individuals' start-up likelihood. Therefore, this shows that agglomerations of highly educated people and high-tech jobs as well as start-ups are functioning properly to propel start-ups in

Korea and that to have flourishing start-up community, it is critical to have knowledge sharing and networking at the regional level.

Moreover, a question of interest is to confirm whether new ideas generated from universities or public research institutes through R&D processes lead to technology transfer and eventually to launching of start-ups as observed in high-tech clusters such as Silicon Valley. However, no significant effect is observed for university patents[8] and even for R&D expenditures (private and public sectors, and university). More specifically, considering that R&D expenditure supplied to universities and university patents had negligible effect on raising the number of high-tech start-ups in a region, it becomes apparent that universities have not been acting as a regional innovation hub to lead R&D activities linked to start-ups, suggesting the need for restructuring of R&D support system for university from industry-university cooperation perspectives. Furthermore, Science and Research Complex, Technopark, National Industry Cluster, and Regional Specialized Industry Zones show insignificant impact on raising start-up likelihood. This indicates only limited impact on start-up and innovation activities may be expected from pushing forward start-up support policies centered around regions that have been receiving start-up related policy supports.

As such, through the logit analyses on factors affecting individuals' start-up decisions, we could verify presence of market forces reflected by agglomeration effect and also confirm the problem of not being able to develop innovation ecosystem through government policies. More specifically, we could confirm market forces through which innovation activities, such as high-tech start-ups that take increasingly central role in overall economy, are becoming more regionally agglomerated also in Korea. In contrast, it can be seen that the balanced regional growth policy of the government or public sector and university R&D activities are not supporting innovation ecosystem of those high-tech clusters.

Table 5. Logit Estimates of High-Tech Start-Ups by Individuals

As presented below in equation 5, another way in which we can verify the effects of agglomeration towards high-tech cluster is through wage equations estimating wage differences depending on whether individuals live in areas with high concentration of high-tech jobs, high-tech start-ups, or university graduates while all else remain the same.

$$ln(W_{ij}) = \alpha_0 + \beta_1 A_j + \beta_2 I_j + \beta_3 C_j + \beta_4 X_{ij} + \beta_5 Edu_{ij} * A_j + \beta_6 Major_{ij} * A_j + \varepsilon_{ij} \qquad (5)$$

We use log hourly wage of individual *i* in region *j* as a dependent variable of wage Equation 5, and as individual control variables (X_{ij}), we include sex (dummy variable), age, age-squared, education (2-year college, 4-year college, university, and high school or lower), major (science

[8] As universities located in Seoul own less than 7000 domestic and foreign patents, number of patents in a region does not have practical significance on start-ups. This means patents as university R&D outputs have low linkage to start-ups, reflecting the fact that university R&D outcomes has only little utility from industry perspective in Korea.

and engineering or other majors), weekly working hours, employment status (part-time or full-time), and job type (professional/managerial, white collar, or blue collar) of individual *i* in region j. In addition, we also include agglomeration effect (A_j) and innovation ecosystem variables (I_j) as in previous analyses, and importantly, interactions between education dummies and agglomeration effect variable ($Edu_{ij} * A_j$) and between major dummy and agglomeration effect variable ($Major_{ij} * A_j$) are included as well. Equations 5, 6 and 7 were the same except for agglomeration effect variable where log number of graduates, of high-tech jobs, or of high-tech start-ups in region *j* is included, respectively.

In addition to OLS method, instrumental variable approach is employed to estimate wage equations. In general, because OLS estimations contain limitations due to endogeneity bias, causal interpretation of relationships is difficult. For instance, there is a possibility that competent people with high wages may be simply attracted to so called high-tech clusters rather than the improvement in productivity of individuals due to them residing in areas with agglomeration of highly educated people. Considering that such areas tend to be large cities, this effect could be the result of having better life and work infrastructures, and relatively well structured labor markets (Duranton & Puga, 2004; Moretti, 2012; Puga, 2010). Therefore, if such effect is not controlled, causal interpretation of relationship between agglomeration of highly educated people and wage is not possible.

To ameliorate this problem, population of 163 cities and counties in 1960 are used as an instrument for the number of highly educated (including high-tech jobs and high-tech start-ups) in a region. It is a common instrument in researches investigating agglomeration of cities and productivity (Ciccone & Hall, 1996; Abel, Dey, & Gabe, 2012). Underlying assumptions according to these previous researches are that number or density of population in a particular area in the past is positively related to current population in that region due to favorable regional characteristics such as weather or other geographical reasons contribute positively to productivity and higher wages, which in turn resulted in agglomeration of population in the past, and such preference for living is maintained until present. More specifically, because industry structures are far different today and the reasons for agglomeration in the past do not have direct relations in today's conditions, the past number (or density) of population as an instrument satisfies both the relevance condition of relating to agglomeration of cities and the exogeneity condition of not relating to individual productivity (Ciccone & Hall, 1996). Based on this ground, the current study employs city/county-level population number of 1960 in Korea[9] as an instrument.

In detail, populations in 1960s are positively correlated to regional number of highly educated (high-tech job or high-tech start-up) in present day. This is related to the existences of life infrastructure attracting these work forces and of industry infrastructure acting as a synergy to development of high-tech industry (Moretti, 2014). Considering that these are common characteristics of major cities in Korea, it is easy to see that the number of highly educated (high-

[9] Population census administrative level/sex, age, marriage status, education, economic activity in 1960 data from Statistics Korea is used.

tech jobs or high-tech start-ups) may be correlated positively and strongly with current day large cities.

Furthermore, since large cities in the past generally stay as big cities, it is likely that regional number of population in 1960s and current high-tech clusters would have positive relationships. However, it is difficult to imagine that factors contributed to productivity in 1960s are the same as ones driving agglomeration of innovation activities in the present day. Therefore, the population in 1960s as an instrument should not have direct relationship with the dependent variable of the current study which is wages of individuals. As such, exogeneity of population in 1960s can be safely assumed.

As for the details of the instrument, in the cases of disappeared regions existed in the 1960 due to integration such as Daedeok-county, they are modified with respect to 2014 regional levels. Specifically, for Daedeok-county, its population is added to that of Daejeon-city in 1960. In contrast, for the cases such as Yangju-county, which has itself separated into a number of different administrative regions, the number of population in the mother region is divided by the number of areas newly separated out. For the Yangju-city (area code: 3126), because it is separated into Uijeongbu-city (3103), Dongducheon-city (3108), Guri-city (3112), and Namyangju-city (3113), the population of Yangju-county in 1960 is divided by five and is assigned to areas 3103, 3108, 3112, 3113, 3126, which are current administrative areas.

Firstly, when looking at the OLS Model A in Table 6, the log number of university graduates in a region, which the current study has the most focus on, show statistically significant impact on wages of individuals (elasticity = 0.015). To further examine this detail, Model B and C conduct interaction between log regional number of university graduates in which respondent residing and education level of respondents. Interestingly, respondents with high school and 2-year college diplomas do not benefit from number of university graduates in a region. In contrast, 4-year university graduates show that doubling the number of university graduates in a region is related to 1.6% higher wages, and for those with Master's degree or higher, the wage effect is at 3.7% per doubling the regional number of university graduates. Combined, the findings indicate that higher the individual's education, the greater the wage benefits following agglomeration of highly educated individuals in a region.

As pointed out previously, because OLS estimations lack causal interpretations, instrumental variable (IV) analyses are conducted. In model D containing interactions, doubling the regional number of university graduates causes 1.7% higher wages for individuals with 4-year university degree and 3.1% higher wages for those with Master's degree or higher, indicating that even after controlling for potential endogeneity biases, the results are largely consistent with those from Model C.

Next, models in Table 7 and 8 include the same dependent and control variables as in Table 6, but instead of having log number of university graduates in a region, log number of high-tech jobs and start-ups are included to examine whether agglomeration of high-tech jobs or high-tech start-ups would have positive impact on wages of individuals, respectively. The IV analysis in the Model D of Table 7 suggest that with doubling the regional number of high-tech jobs, 4-year university and Master or higher degree graduates enjoy about 1.8% and 3.2% higher wages, respectively. In the case of IV Model D in Table 8, results indicate that for every twofold increase in the number of high-tech start-ups, those with a 4-year university degree have wage effect of 1.4%, those with Master's degree or higher receive 2.7% higher wages, and finally, those with science and engineering major have additional 1.1% higher wage effect.

As a whole, above results suggest that although regional agglomeration of university graduates, high-tech jobs, and start-ups all have statistically significant wage increasing impact in Korea, it is also empirically confirmed that such benefits are limited only to highly educated people. One potential explanation may be that productivity effect of high-tech cluster in Korea has not yet spread out to reached those with lower level of education in a region. However, to establish validity of such explanation, further researches with finely detailed analysis will be required. However, the fact that wage effects of high-tech cluster agglomeration are focused around highly educated individuals contrast sharply with findings reported in foreign countries indicating existence of positive wage effects even for those with high school diploma (Moretti, 2014)[10].

In fact, while agglomeration effect has consistent impact on individuals' wages, innovation ecosystem effect show no statistical significance or even estimated negative coefficients with an exception of regional private R&D expenditure, which is statistically significant in Table 6 and 7. This means that government R&D expenditure, government-led clusters, or university R&D expenditure and patents in a place of an individual's residence does not affect a person's wage positively.

Table 6. Hourly Wage of Individuals and University Graduates in a Region- OLS and IV Estimates

Table 7. Hourly Wage of Individuals and High-Tech Jobs in a Region - OLS and IV Estimates

Table 8. Hourly Wage of Individuals and High-Tech Start-Ups in a Region- OLS and IV Estimates

V: Conclusion

From the angle of geography of jobs, the current study attempted to empirically investigate whether existence of two important trends prominent in innovation ecosystem of developed

[10] Rosenthal and Strange (2004) summarized in their review of literatures that doubling up of city population has productivity increase of 3 to 8% in general. Similarly, Combes, Duranton, and Gobillon (2008) indicated 3% increase in wages for every twofold increase in local employment, and Abel and Deitz (2015) showed that wage of university degree holders were 4% higher when population doubled in a city. Echeverri-Carroll and Ayala (2011) estimated that individual wage was raised by 0.12% for every additional 100,000 local population.

countries could also be verified in Korea. First, does agglomeration effect that drive convergence of high-tech jobs and start-ups on high-tech cluster also exist in Korea? Second, does Korea also have innovation ecosystem fostering creation of start-ups through technology transfer of regional R&D outputs from universities and public research institutes to industries? For the first question, the empirical evidence, albeit limited, is positive, but for the second question, the answer is mostly negative.

First of all, while not as strong as those observed in the United States, it is still apparent that high-tech jobs and start-ups do indeed agglomerate in high-tech clusters. Following are detailed summary of results.

First, Seoul as a capital city of Korea hold 22% and 32% of all high-tech jobs and start-ups in Korea, respectively. Next to Seoul is Incheon, which forms the capital metropolitan area alongside Seoul, contain 6% and 7% of all high-tech jobs and start-ups, respectively (Figure 1).

Second, regional concentration tendencies of high-tech jobs and high-tech start-ups were confirmed to be severely limited from 2008 to 2014. Only notable feature here is the fact that fourth quintile cities such as Incheon and Seongnam around outskirts of Seoul showed least decline in high-tech start-ups from that period (Figure 5).

Third, OLS regression investigating determinants of number of high-tech jobs and start-ups in 163 cities and counties in Korea indicated that regional number of university graduates very consistently affected regional number of high-tech jobs and start-ups. Specifically, elasticity of regional number of university graduates on regional number of high-tech jobs is at around 0.85 while that on regional number of high-tech start-up is estimated to be somewhat greater at about 0.95. Moreover, it has positive influence on average regional wage with an elasticity of 0.05 (Table 2, 3, and 4).

Fourth, the results from the logit analyses on determinants of individuals' decision to engage in high-tech start-up show that regional number of university graduates, high-tech jobs, and high-tech start-ups all have significantly positive impact on probability of engaging in start-ups. From these, it can be interpreted that agglomeration of highly educated people, high-tech jobs, and high-tech start-ups proper function in raising start-up likelihood (Table 5).

Fifth, IV estimations of wage equations suggest that clustering of highly educated, high-tech jobs, or high-tech start-ups through increases in their number in a region can have statistically positive impact on wages of employees. However, in Korea, such wage effect is limited to employees with high education level (Table 6, 7 and 8). More specifically, for every twofold increase in number of university graduates in a region, wages of employees with 4-year university degree, with Master's degree of higher, and with science and engineering major correspondingly show 1.4%, 2.7%, and 1.1% increases, respectively (Table 8).

Next, the findings reported in the current study indicate that in contrast to the United States with well-established innovation ecosystem, R&D outputs from regional universities and public research institutes in Korea could not foster high-tech jobs and start-ups through technology transfers. Detailed summaries of analyses results are presented below.

First, government-led clusters such as Science and Research Complex, Technopark, National Industry Cluster, and Regional Specialized Industry Zone are scatter not only across cities but also across counties in Korea (see Figure 2). Furthermore, even in the case of R&D, private sector is focused in Seoul and capital metropolitan areas while public sector is concentrated in Daejeon where Daedeok Science Town is located. For university R&D expenditure and patents, they are far more scatter around regionally than in the case of public R&D (Figure 3).

Second, OLS estimations are conducted to examine factors determining number of high-tech jobs and start-ups, and average regional wage across 163 cities and counties in Korea. The results reveal that university patents and all forms of R&D expenditures (private, public, and university) have negligible impact. Moreover, Science and Research Complex, Technopark, National Industry Cluster, or Regional Specialized Industry Zone, all do not contribute to increasing regional number of high-tech jobs and start-ups (Table 2, 3, and 4).

Third, logit analysis on probability of individuals to engage in start-up suggest that Science and Research Complex, Technopark, National Industry Cluster, or Regional Specialized Industry Zone have no statistically significant impact on likelihood of creating a start-up. Likewise, amount of regional R&D funding supplied to university and regional number of university patents do not affect start-up likelihood as well. Finally, specializing in a science and engineering major also do not influence the probability of engaging in start-ups (Table 5).

Fourth, compared to the consistent positive impact of agglomeration effect on individuals' wages, it is verified that all innovation ecosystem effect variables show no statistical impact or even have statistically negative influences except for private R&D expenditures, which show statistically positive coefficient. In short, government expenditure, government-led clusters, or university R&D expenditure and patents of a region in which people live have no perceptible impact on individual wages (Table 6, 7, and 8).

In conclusion, the current study confirm the simultaneous existences of market forces driving convergence on high-tech clusters and counteracting governmental forces in Korea. That is to say, as innovation activities such as high-tech start-ups begin to agglomerate in Korea, increasingly stronger market forces could be verified. Conversely, because balanced regional growth policy of government, and public sector and university R&D activities actually act in the direction of dispersing agglomerating tendencies, it is apparent that the policies has not been properly supporting the innovation ecosystem (Table 6, 7, and 8).

For policy makers in Korea, the empirical evidence presents the need to readjust the role of government in order to nurture innovation ecosystem actively creating high-tech jobs and start-ups through technology transfer between R&D outputs of university and public research institutes to industry. In other words, our empirical evidence suggests that the role of government should be changed fundamentally to fully utilize the market forces agglomerating high-tech start-ups in areas where highly educated people are concentrated and, at the same time, to facilitate construction of innovation ecosystem where R&D outputs of university and public research institutions actively create high-tech jobs and start-ups through technology transfers.

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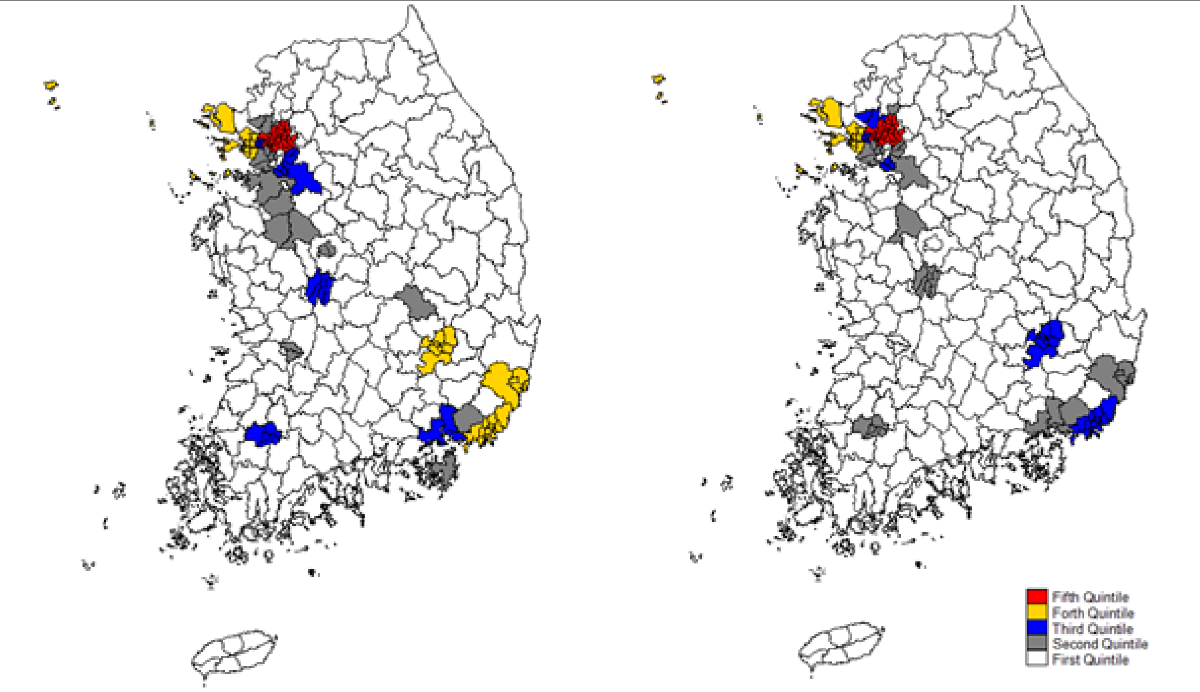
Figure 1. The Quintile Distributions of High-Tech Jobs and Start-Ups by Region

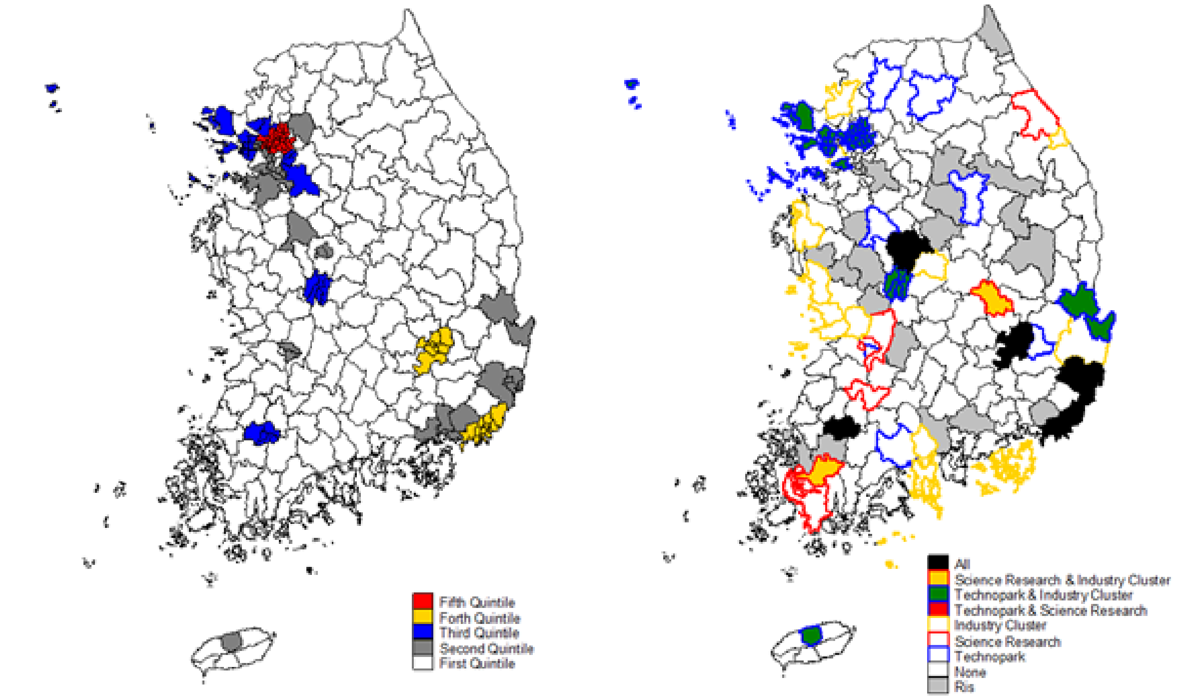


(a) High-Tech Jobs (b) High-Tech Start-Ups

Notes: Due to data constraint, high-tech start-ups are proxied by number of self-employed in high-tech jobs. Areas included in each quintile: (a) *fifth* (Seoul), *fourth* (Incheon, Busan, Daegu, and Ulsan), *third* (Suwon, Changwon, Daejeon, Gwangju, Seongnam, Yongin, and Bucheon), *second* (Ansan, Goyang, Cheonan, Hwaseong, Geoje, Anyang, Gimhae, Gumi, Cheonju, Pyeongtaek, Jeonju, Asan, and Gwangmyeong), *first* (the rest); (b) *fifth* (Seoul), *fourth* (Incheon), *third* (Busan, Daegu, Goyang, Suwon, and Bucheon), *second* (Gwangju, Daejeon, Seongnam, Ansan, Changwon, Ulsan, Siheung, Yongin, Cheonan, Anyang, Gimhae, Uijeonbu, and Gwangmyeong), *first* (the rest);

Source: Local Area Labor Force Survey 2014.

Figure 2. The Quintile Distributions of University Graduates by Region and Regional Distribution of Government-Led Clusters

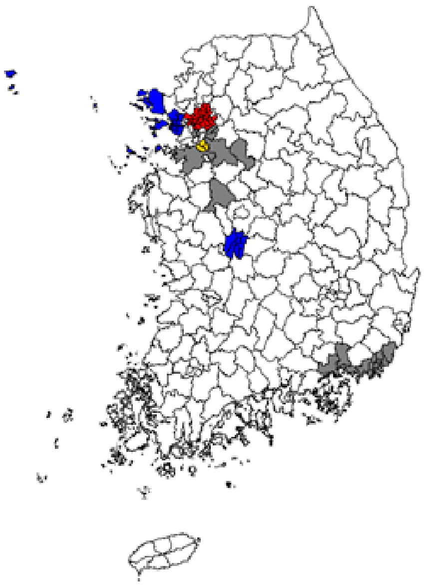


(a) University Graduates (b) Government-Led Clusters

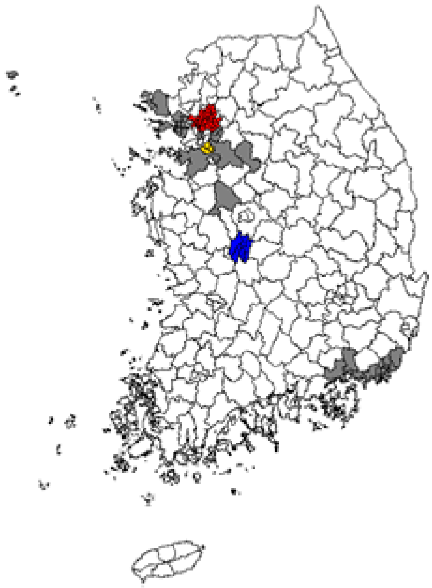
Notes: (a) Areas included in each quintile: *fifth* (Seoul), *fourth* (Busan, Daegu), *third* (Incheon, Daejeon, Yongin, Gwangju, Seongnam, and Goyang), *second* (Suwon, Changwon, Ulsan, Bucheon, Anyang, Jeonju, Cheonan, Cheongju, Hwaseong, Namyangju, Ansan, Gimhae, Pohang, Gwangmyeong, Gunpo, and Jeju), *first* (the rest); university graduates included those with four or more years of higher education. (b) Areas included in each category: *Ris only* (Goseong-gun, Gongju, Goesan-gun, Gimhae, Naju, Nonsan, Muan-gun, Bucheon, Suwon, Asan, Andong, Yeongwol-gun, Yeongju, Yongin, Wonju, Jinan-gun, Jinju, Cheongyang-gun, Cheongju, Chungju, Hadong-gun, and Hongseong-gun), *Technopark only* (Gyeongsan, Suncheon, Jeonju, Jecheon, Cheonan, Chuncheon, and Pocheon), *Science & Research Complex only* (Gangneung, Mokpo, Sunchang-gun, Wanju-gun, and Haenam-gun), *Industry Cluster only* (Geoje, Gyeongju, Gwangyang, Gunsan, Donghae, Boeun-gun, Seosan, Seocheon-gun, Siheung, Yeosu, Iksan, Tongyeong, and Paju), *Technopark and Science & Research Complex* (none), <u>*Technopark and Industrial Cluster*</u> (Daejeon, Seoul, Ansan, Incheon, Jeju, and Pohang), *Science & Research Complex and Industrial Cluster* (Gumi and Yeongam-gun), and *areas that include all three* (Busan, Daegu, Ulsan, Gwangju, and Cheongwon-gun).

Source: Local Area Labor Force Survey 2014.

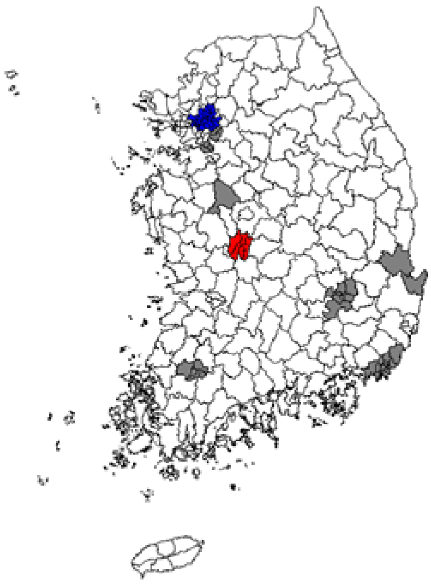
Figure 3. The Quintile Distribution of R&D Expenditures and University Patents by Region



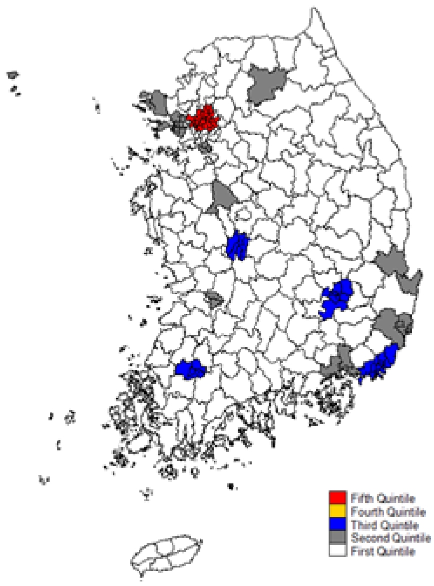
(a) Total R&D Expenditure



(b) Private R&D Expenditure



(c) Public and University R&D Expenditure

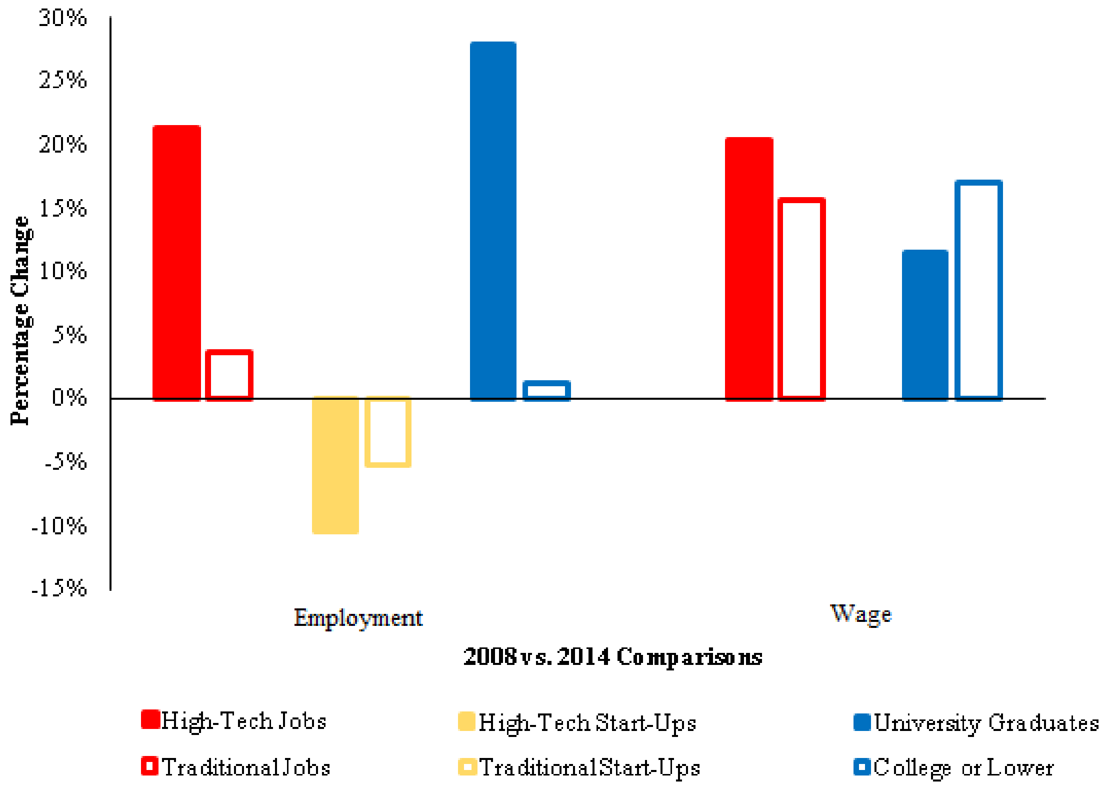


(d) University Patents

Notes: Total R&D expenditure includes those of private and public sectors, and universities. University patents include domestic and foreign patents. Areas included in each quintile: (a) *fifth* (Seoul), *fourth* (Suwon), *third* (Daejeon and Incheon), *second* (Yongin, Seongnam, Hwaseong, Icheon, Busan, Changwon, Anyang, and Cheonan), *first* (the rest); (b) *fifth* (Seoul), *fourth* (Suwon), *third* (Daejeon), *second* (Incheon, Yongin, Seongnam, Hwaseong, Icheon, Busan, Changwon, and Anyang), *first* (the rest); (c) *fifth* and *fourth* (Daejeon), *third* (Seoul), *second* (Suwon, Busan, Pohang, Cheonan, Daegu, Gwangju, and Seongnam), *first* (the rest). (d) *fifth* and *fourth* (Seoul), *third* (Daejeon, Busan, Daegu, and Gwangju), *second* (Pohang, Incheon, Cheonan, Ulsan, Jeonju, Chuncheon, Suwon, and Changwon), *first* (the rest);

Sources: Survey of Research and Development in Korea 2014. Higher Education in Korea 2013

Figure 4. Percentage Change in Employment and Wage from 2008 to 2014



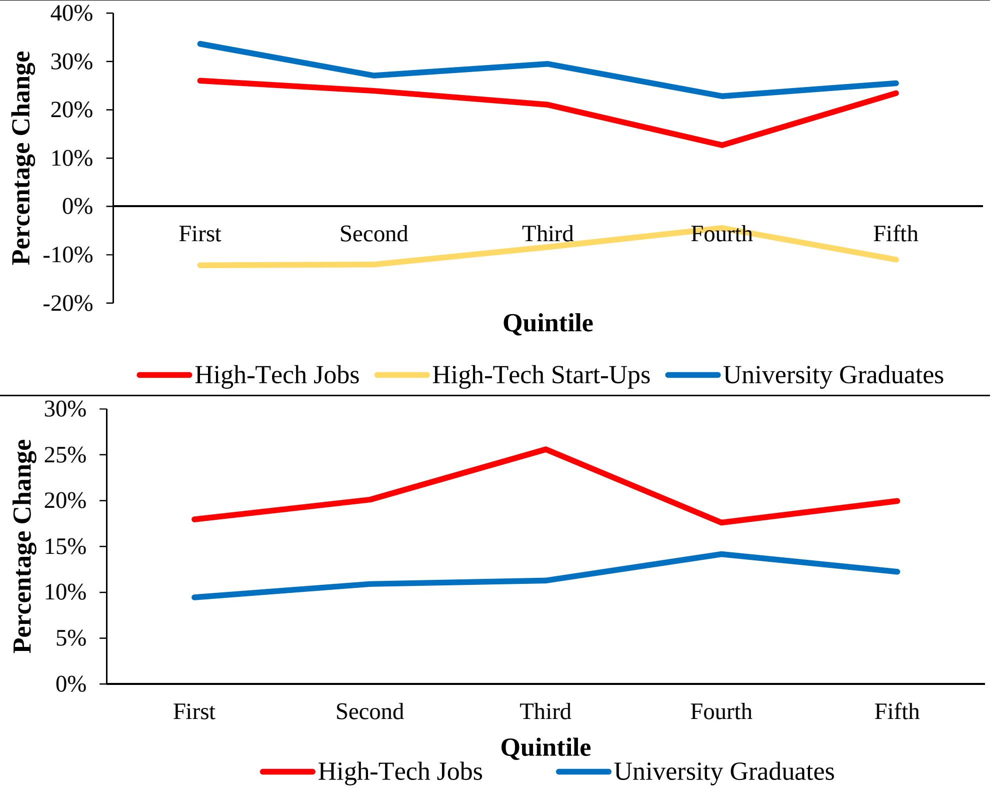
Notes: Traditional jobs and start-ups are those that are not high-tech as defined by the classification in Table 1. University graduates include 4-year university degree and over.

Source: Local Area Labor Force Survey 2008, 2014.

Figure 5. Percentage Change in Employment and Wage from 2008 to 2014 by Quintile Region

(a) Changes in Numbers by Quintile Region

(b) Changes in Wage by Quintile Region



Notes: Due to data constraint, high-tech start-ups are proxied by number of self-employed in high-tech jobs. See Figure 1a, 1b, and 2a for regions in each quintile.

Source: Local Area Labor Force Survey 2008, 2011, 2014.

Table 1. Descriptive Statistics

(a) Individual Variables

Variable	Observations	Mean	Std. Dev.	Min	Max
Start-up	167,738	0.012	0.111	0	1
Hourly wage (Won)	137,734	11606.500	7911.357	42.735	576923.1
Employed	399,579	0.594	0.491	0	1
Female	399,579	0.534	0.499	0	1
Age (years)	399,579	49.928	18.578	15	105
High school graduate	399,579	0.733	0.442	0	1
2-year college degree	399,579	0.082	0.275	0	1
4-year university degree	399,579	0.160	0.366	0	1
Master degree or higher	399,579	0.024	0.154	0	1
Major-in-Engineering	399,579	0.047	0.211	0	1
Hours worked (hours)	236,738	43.120	13.528	1	119
Part-time	236,166	0.200	0.400	0	1
Managerial/professional job	237,536	0.153	0.360	0	1
White-collar job	237,536	0.327	0.469	0	1
High-tech job	237,536	0.133	0.339	0	1

(b) Regional Variables

Variable	Observations	Mean	Std. Dev.	Min	Max
City	399,579	0.683	0.465	0	1
High-tech jobs in a region (1,000 people)	399,579	152.867	301.889	0.263	1045.345
High-tech start-ups in a region (1,000 people)	399,579	13.618	30.234	0	104.283
University graduates in a region 2008 (1,000 people)	399,579	326.811	704.931	0.67	2436.583
University graduates in a region 2014 (1,000 people)	399,579	411.998	883.829	1.078	3058.194
Private R&D expenditure (one billion Won)	399,579	6809.05	16367.95	0.00	62054.48
Public R&D expenditure (one billion Won)	399,579	1182.71	3288.82	0.00	19285.53
University R&D expenditure (one billion Won)	399,579	1372.39	3267.72	0.00	11249.21
University patents (1,000 patents)	399,579	0.853	1.993	0	6.862
Technopark	399,579	0.340	0.474	0	1
Science & Research Complex	399,579	0.163	0.369	0	1
Industrial Cluster	399,579	0.379	0.485	0	1
Regional Specialized Industry Zone	399,579	0.451	0.498	0	1
Population in 1960 (1,000 people)	399,579	448.785	701.746	17.91	2445.402

Notes: Unless noted, variables are from 2014 data. University graduates in a region 2008 and 2014 variables represent regional numbers of individuals with 4-year university degree or higher in 2008 and 2014, respectively. University patents in a region variable include domestic and foreign patents owned by universities in a region.

Source: Local Area Labor Force Survey 2008, 2014; Survey of Research and Development in Korea 2014; Higher Education in Korea 2013; Population Census in 1960: by Administrative Level, Sex, Age, Marriage Status, Education, and Economic Activity Status

Table 2. OLS Estimates of High-Tech Jobs in a Region

Dependent Variable: Log High-Tech Jobs in a Region (1,000 people)	Model A	Model B	Model C	Model D	Model E
Log university graduates 2008 in a region (1,000 people)	0.878***	0.854***	0.843***	0.856***	0.836***
	(0.066)	(0.070)	(0.071)	(0.066)	(0.070)
Log Private R&D expenditure in a region (one billion Won)	0.040**	0.043**	0.041**	0.040**	0.040**
	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)
Log Public R&D expenditure in a region (one billion Won)	-0.004	-0.004	-0.002	-0.004	-0.001
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Log University R&D expenditure in a region (one billion Won)	0.013	0.010	0.013	0.018	0.014
	(0.014)	(0.013)	(0.013)	(0.014)	(0.013)
Log university patents in a region (1,000 patents)	0.02	0.008	0.005	0.033	0.048
	(0.029)	(0.028)	(0.029)	(0.027)	(0.029)
Technopark	-0.164				-0.257**
	(0.108)				(0.115)
Science & Research Complex		0.274*			0.285
		(0.159)			(0.177)
Industrial Cluster			0.174		0.156
			(0.125)		(0.132)
Regional Specialized Industry Zone				-0.215**	-0.216**
				(0.093)	(0.095)
Observations	163	163	163	163	163
R-squared	0.935	0.936	0.936	0.936	0.94

Notes: University graduates in a region 2008 variable represents regional numbers of individuals with 4-year university degree or higher. University patents in a region variable includes domestic and foreign patents owned by universities in a region. Variables controlled include city dummy, proportion of female population in a region, and mean age of a region. Robust standard errors in parentheses. * $p<0.1$, ** $p<0.05$, *** $p<0.01$.

Source: Local Area Labor Force Survey 2008, 2014; Survey of Research and Development in Korea 2014; Higher Education in Korea 2013.

Table 3. OLS Estimates of High-Tech Start-Ups in a Region

Dependent Variable: Log High-Tech Start-Ups in a Region (1,000 people)	Model A	Model B	Model C	Model D	Model E
Log university graduates 2008 in a region (1,000 people)	0.965***	0.978***	0.935***	0.953***	0.940***
	(0.127)	(0.127)	(0.133)	(0.132)	(0.141)
Log Private R&D expenditure in a region (one billion Won)	-0.027	-0.029	-0.027	-0.027	-0.031
	(0.031)	(0.031)	(0.031)	(0.031)	(0.032)
Log Public R&D expenditure in a region (one billion Won)	0.012	0.012	0.014	0.012	0.016
	(0.023)	(0.023)	(0.023)	(0.023)	(0.024)
Log University R&D expenditure in a region (one billion Won)	0.040	0.044	0.040	0.043	0.047
	(0.034)	(0.036)	(0.034)	(0.036)	(0.038)
Log university patents in a region (1,000 patents)	-0.029	-0.031	-0.036	-0.011	-0.018
	(0.049)	(0.049)	(0.052)	(0.060)	(0.063)
Technopark	-0.031				-0.068
	(0.186)				(0.218)
Science & Research Complex		-0.313			-0.388
		(0.420)			(0.470)
Industrial Cluster			0.198		0.283
			(0.224)		(0.281)
Regional Specialized Industry Zone				-0.175	-0.124
				(0.298)	(0.316)
Observations	163	163	163	163	163
R-squared	0.738	0.74	0.739	0.739	0.742

Notes: University graduates in a region 2008 variable represents regional numbers of individuals with 4-year university degree or higher. University patents in a region variable includes domestic and foreign patents owned by universities in a region. Variables controlled include city dummy, proportion of female population in a region, and mean age of a region. Robust standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Source: Local Area Labor Force Survey 2008, 2014; Survey of Research and Development in Korea 2014; Higher Education in Korea 2013.

Table 4. OLS Estimates of Average Wage in a Region

Dependent Variable: Log Mean Wage in a Region (one million Won)	Model A	Model B	Model C	Model D	Model E
Log university graduates 2008 in a region (1,000 people)	0.054***	0.050***	0.047***	0.048***	0.048***
	(0.013)	(0.014)	(0.014)	(0.014)	(0.013)
Log Private R&D expenditure in a region (one billion Won)	0.002	0.003	0.003	0.002	0.002
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Log Public R&D expenditure in a region (one billion Won)	0.003	0.002	0.003	0.003	0.003
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Log University R&D expenditure in a region (one billion Won)	0.000	0.000	0.000	0.001	0.001
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Log university patents in a region (1,000 patents)	-0.012*	-0.017**	-0.017***	-0.013**	-0.008
	(0.007)	(0.007)	(0.006)	(0.006)	(0.006)
Technopark	-0.063**				-0.075**
	(0.030)				(0.034)
Science & Research Complex		0.001			0.004
		(0.028)			(0.029)
Industrial Cluster			0.022		0.035
			(0.025)		(0.026)
Regional Specialized Industry Zone				-0.035*	-0.030
				(0.021)	(0.021)
Observations	163	163	163	163	163
R-squared	0.665	0.655	0.657	0.660	0.674

Notes: University graduates in a region 2008 variable represents regional numbers of individuals with 4-year university degree or higher. University patents in a region variable includes domestic and foreign patents owned by universities in a region. Variables controlled include city dummy, proportion of female population in a region, and mean age of a region. Robust standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Source: Local Area Labor Force Survey 2008, 2014; Survey of Research and Development in Korea 2014; Higher Education in Korea 2013.

Table 5. Logit Estimates of High-Tech Start-Ups by Individuals

Dependent Variable: Start-Up	Model A	Model B	Model C	Model D
Female	-1.368***	-1.359***	-1.365***	-1.364***
	(0.211)	(0.209)	(0.208)	(0.210)
Age (years)	0.131***	0.132***	0.133***	0.132***
	(0.027)	(0.028)	(0.027)	(0.028)
Age-squared divided by 100	-0.104***	-0.103***	-0.105***	-0.104***
	(0.026)	(0.026)	(0.026)	(0.026)
2-year college degree	0.971***	0.974***	0.972***	0.978***
	(0.088)	(0.087)	(0.088)	(0.087)
4-year university degree	1.240***	1.251***	1.226***	1.231***
	(0.096)	(0.095)	(0.092)	(0.096)
Master degree or higher	1.052***	1.067***	1.032***	1.044***
	(0.122)	(0.121)	(0.119)	(0.123)
Major-in-Science and Engineering	-0.068	-0.062	-0.056	-0.054
	(0.126)	(0.127)	(0.127)	(0.129)
City	0.101	0.022	-0.138	-0.004
	(0.141)	(0.137)	(0.131)	(0.161)
Log university graduates in a region	0.168***			0.291***
(1,000 people)	(0.016)			(0.058)
Log high-tech jobs in a region		0.183***		
(1,000 people)		(0.016)		
Log high-tech start-ups in a region			0.197***	
(1,000 people)			(0.021)	
Log Private R&D expenditure in a				0.012
region (one billion Won)				(0.019)
Log Public R&D expenditure in a				-0.017
region (one billion Won)				(0.013)
Log University R&D expenditure in a				0.001
region (one billion Won)				(0.017)
Log university patents in a region				-0.043
(1,000 patents)				(0.049)
Technopark				0.067
				(0.186)
Science & Research Complex				-0.079
				(0.090)
Industrial Cluster				-0.127
				(0.157)
Regional Specialized Industry Zone				-0.135
				(0.164)
Observations	167738	167738	167738	167738
Pseudo R-square	0.100	0.101	0.106	0.101
Log pseudolikelihood	-10075.6	-10063.3	-10008.1	-10055.1

Notes: University graduates in a region variable represents regional numbers of individuals with 4-year university degree or higher. University patent variable includes domestic and foreign patents owned by universities in a region. Cluster robust standard errors in parentheses (clustered at the region level). * p<0.1, ** p<0.05, *** p<0.01.
Source: Local Area Labor Force Survey 2014; Survey of Research and Development in Korea 2014; Higher Education in Korea 2013.

Table 6. Hourly Wage of Individuals and University Graduates in a Region- OLS and IV Estimates

Dependent Variable: Log Hourly Wage	OLS Model A	OLS Model B	OLS Model C	IV Model D
Log university graduates in a region (1,000 people)	0.015*	0.008	0.003	-0.009*
	(0.008)	(0.008)	(0.004)	(0.005)
2-year college degree x		-0.001	-0.002	0.000
Log university graduates in a region (1,000 people)		(0.003)	(0.003)	(0.003)
4-year university degree x		0.016***	0.016***	0.017**
Log university graduates in a region (1,000 people)		(0.005)	(0.005)	(0.007)
Master degree or higher x		0.037***	0.037***	0.031***
Log university graduates in a region (1,000 people)		(0.004)	(0.004)	(0.008)
Major-in-Science and Engineering x		-0.001	-0.001	0.002
Log university graduates in a region (1,000 people)		(0.002)	(0.002)	(0.002)
Log Private R&D expenditure in a	0.006***	0.007***		
region (one billion Won)	(0.002)	(0.002)		
Log Public R&D expenditure in a	-0.001	-0.001		
region (one billion Won)	(0.001)	(0.001)		
Log University R&D expenditure in a	0.002	0.003		
region (one billion Won)	(0.002)	(0.002)		
Log university patents in a region	-0.006	-0.007		
(1,000 patents)	(0.004)	(0.004)		
Technopark	-0.031	-0.030		
	(0.022)	(0.022)		
Science & Research Complex	-0.012	-0.008		
	(0.028)	(0.028)		
Industrial Cluster	0.026	0.026		
	(0.019)	(0.019)		
Regional Specialized Industry Zone	-0.027**	-0.028**		
	(0.013)	(0.013)		
Observations	137734	137734	137734	137734
R-squared	0.501	0.502	0.500	

Notes: Control variables include female dummy, age (years), age-squared, 2-year college degree dummy, 4-year university degree dummy, Mater degree or higher dummy, major-in-science and engineering dummy, hours worked (hours), part-time dummy, managerial/professional job dummy, white-collar job dummy, high-tech job dummy, and city dummy. Instrument used was population of each region in 1960. Cluster robust standard errors in parentheses (clustered at the region level). * p<0.1, ** p<0.05, *** p<0.01.

Source: Local Area Labor Force Survey 2014; Survey of Research and Development in Korea 2014; Higher Education in Korea 2013. Population Census in 1960: by Administrative Level, Sex, Age, Marriage Status, Education, and Economic Activity Status

Table 7. Hourly Wage of Individuals and High-Tech Jobs in a Region - OLS and IV Estimates

Dependent Variable: Log Hourly Wage	OLS Model A	OLS Model B	OLS Model C	IV Model D
Log high-tech jobs in a region (1,000 people)	0.026***	0.022***	0.009*	-0.009*
	(0.006)	(0.006)	(0.005)	(0.005)
2-year college degree x		-0.002	-0.003	0.000
Log high-tech jobs in a region (1,000 people)		(0.003)	(0.003)	(0.004)
4-year university degree x		0.012**	0.011*	0.018**
Log high-tech jobs in a region (1,000 people)		(0.006)	(0.006)	(0.008)
Master degree or higher x		0.031***	0.030***	0.032***
Log high-tech jobs in a region (1,000 people)		(0.005)	(0.006)	(0.009)
Major-in-Science and Engineering x		-0.001	-0.001	0.002
Log high-tech jobs in a region (1,000 people)		(0.002)	(0.002)	(0.002)
Log Private R&D expenditure in a	0.003	0.003		
region (one billion Won)	(0.002)	(0.002)		
Log Public R&D expenditure in a	-0.001	-0.001		
region (one billion Won)	(0.002)	(0.002)		
Log University R&D expenditure in a	0.002	0.002		
region (one billion Won)	(0.002)	(0.002)		
Log university patents in a region	-0.009**	-0.010**		
(1,000 patents)	(0.004)	(0.004)		
Technopark	-0.028	-0.028		
	(0.021)	(0.021)		
Science & Research Complex	-0.016	-0.012		
	(0.027)	(0.027)		
Industrial Cluster	0.018	0.017		
	(0.019)	(0.019)		
Regional Specialized Industry Zone	-0.020	-0.020		
	(0.014)	(0.014)		
Observations	137734	137734	137734	137734
R-squared	0.502	0.502	0.500	

Notes: All control variables are the same as in Table 6. Instrument used was population of each region in 1960. Cluster robust standard errors in parentheses (clustered at the region level). * p<0.1, ** p<0.05, *** p<0.01.

Source: Local Area Labor Force Survey 2014; Survey of Research and Development in Korea 2014; Higher Education in Korea 2013. Population Census in 1960: by Administrative Level, Sex, Age, Marriage Status, Education, and Economic Activity Status

Table 8. Hourly Wage of Individuals and High-Tech Start-Ups in a Region- OLS and IV Estimates

Dependent Variable: Log Hourly Wage	OLS Model A	OLS Model B	OLS Model C	IV Model D
Log high-tech start-ups in a region (1,000 people)	0.003	-0.001	0.001	-0.008*
	(0.004)	(0.004)	(0.003)	(0.005)
2-year college degree x		-0.001	-0.002	-0.002
Log high-tech start-ups in a region (1,000 people)		(0.002)	(0.002)	(0.004)
4-year university degree x		0.013***	0.012***	0.014**
Log high-tech start-ups in a region (1,000 people)		(0.004)	(0.004)	(0.007)
Master degree or higher x		0.029***	0.029***	0.027***
Log high-tech start-ups in a region (1,000 people)		(0.004)	(0.004)	(0.008)
Major-in-Science and Engineering x		0.000	0.000	0.011***
Log high-tech start-ups in a region (1,000 people)		(0.002)	(0.002)	(0.004)
Log Private R&D expenditure in a	0.008***	0.008***		
region (one billion Won)	(0.002)	(0.002)		
Log Public R&D expenditure in a	-0.001	-0.001		
region (one billion Won)	(0.002)	(0.002)		
Log University R&D expenditure in a	0.002	0.002		
region (one billion Won)	(0.002)	(0.002)		
Log university patents in a region	-0.003	-0.004		
(1,000 patents)	(0.004)	(0.004)		
Technopark	-0.028	-0.028		
	(0.021)	(0.021)		
Science & Research Complex	-0.012	-0.008		
	(0.027)	(0.027)		
Industrial Cluster	0.032	0.030		
	(0.020)	(0.020)		
Regional Specialized Industry Zone	-0.030**	-0.030**		
	(0.013)	(0.013)		
Observations	137734	137734	137734	137734
R-squared	0.501	0.502	0.500	

Notes: All control variables are the same as in Table 6. Instrument used was population of each region in 1960. Cluster robust standard errors in parentheses (clustered at the region level). * p<0.1, ** p<0.05, *** p<0.01.

Source: Local Area Labor Force Survey 2014; Survey of Research and Development in Korea 2014; Higher Education in Korea 2013. Population Census in 1960: by Administrative Level, Sex, Age, Marriage Status, Education, and Economic Activity Status

Appendix 1. The Definition of High-Tech Industry by the Industry Code

(a) Manufacturing Industries

Code	Classification
10	Manufacture of Food Products
11	Manufacture of Beverages
12	Manufacture of Tobacco Products
13	Manufacture of Textiles, Except Apparel
14	Manufacture of wearing apparel, Clothing Accessories and Fur Articles
15	Tanning and Dressing of Leather, Manufacture of Luggage and Footwear
16	Manufacture of Wood and of Products of Wood and Cork; Except Furniture
17	Manufacture of Pulp, Paper and Paper Products
18	Printing and Reproduction of Recorded Media
19	Manufacture of Coke, hard-coal and lignite fuel briquettes and Refined Petroleum Products
20	Manufacture of chemicals and chemical products except pharmaceuticals and medicinal chemicals
21	Manufacture of Pharmaceuticals, Medicinal Chemicals and Botanical Products
22	Manufacture of Rubber and Plastic Products
23	Manufacture of Other Non-metallic Mineral Products
24	Manufacture of Basic Metal Products
25	Manufacture of Fabricated Metal Products, Except Machinery and Furniture
26	Manufacture of Electronic Components, Computer, Radio, Television and Communication Equipment and Apparatuses
27	Manufacture of Medical, Precision and Optical Instruments, Watches and Clocks
28	Manufacture of electrical equipment
29	Manufacture of Other Machinery and Equipment
30	Manufacture of Motor Vehicles, Trailers and Semitrailers
31	Manufacture of Other Transport Equipment
32	Manufacture of Furniture
33	Other manufacturing

(b) Service Industries

Code	Classification
35	Electricity, gas, steam and air conditioning supply
36	Water Supply
37	Sewage, Wastewater and Human Waste Treatment Services
38	Waste Collection, Disposal and Materials Recovery
39	Remediation activities and other waste management services
41	General Construction
42	Special Trade Construction
55	Accommodation
56	Food and beverage service activities
58	Publishing activities
59	Motion picture, video and television programme production, sound recording and music publishing activities
60	Broadcasting
61	Telecommunicationst
62	Computer programming, consultancy and related activities
63	Information service activities
64	Financial Institutions, Except Insurance and Pension Funding
65	Insurance and Pension Funding
66	Activities Auxiliary to Financial Service and Insurance Activities
68	Real Estate Activities
69	Renting and leasing; except real estate
70	Research and Development
71	Professional Services
72	Architectural, Engineering and Other Scientific Technical Services
73	Professional, Scientific and Technical Services, n.e.c.
74	Business Facilities Management and Landscape Services
75	Business Support Services
84	Public Administration and Defence ; Compulsory Social Security
85	Education
86	Human Health
87	Social Work Activities
90	Creative, Arts and Recreation Related Services
91	Sports activities and amusement activities
94	Membership Organizations
95	Maintenance and Repair Services
96	Other Personal Services Activities
97	Private Households with Employed Persons
98	Undifferentiated goods- and services-producing activities of private households
99	Extra-Territorial Organizations and Bodies

Notes: Two-digit Korean Standard Industry Classification Code adapted from Jang et al. (2014). Shaded areas indicate high-tech industries.

Source: Jang et al. (2014)

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