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Market Access Approach to Urban Growth[†]

By YOON SANG MOON*

This paper studies urban growth in Korean cities. First, I document that population growth patterns change over time and that the current population distribution supports random urban growth. I confirm two empirical laws—Zipf’s law and Gibrat’s law—both of which hold in the period of 1995-2015, but do not hold in the earlier period of 1975-1995. Second, I find a systematic employment growth pattern of Korean cities in spite of the random population growth. I examine market access effects on employment growth. Market access, a geographical advantage, has a significant influence on urban employment growth. The market access effect is higher in the Seoul metropolitan area than in the rest of the country. This effect is stronger on employment growth in the manufacturing industry compared to employment growth in the service industry. These results are robust with various checks (e.g., different definitions of urban areas). The results here suggest that policymakers should consider geographical characteristics when they make policy decisions with respect to regional development.

Key Word: Urban Growth, Market Access, Agglomeration Economies,
City Size Distributions

JEL Code: R11, R12, J21

I. Introduction

This study aims to analyze urban population and employment growth,¹ among the indicators of regional development. Population dispersion is a direct goal of balanced regional development, but the distribution of a population cannot be changed rapidly in the short term. Therefore, I investigate how cities have grown over the long run by analyzing changes in population distribution and growth. I document that the population patterns of Korean cities follow well-known empirical laws, implying that

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¹As is typical in urban studies literature, urban growth refers to population or employment growth in this paper. Specifically, it refers to population growth in Chapter 2 and employment growth in the following chapters.

the historical evidence supports *random* urban growth. Although the urban growth patterns appear to be random, I find that the historical data show a *systematic* urban growth pattern with the concept of market access, a geographical advantage. With this, I argue that employment in cities with high market access has increased more rapidly than that in cities with low market access, as population and employment have changed for economic as well as geographical reasons.

Regional development policies in Korea have been implemented along with economic development policies. In order to advance, the industrial structure focused on light industry in the early stages of economic development, with heavy and chemical industries fostered in the southeastern region of the country. The government also provided various benefits to companies willing to move industrial infrastructure concentrated in the Seoul metropolitan area (SMA) to areas the outside of the SMA. These policies for regional development, dispersing industrial facilities and populations across the country, aim to lessen economic disparities across regions. The policy stance for resolving regional imbalances has become more prominent since the 2000s, and regional policies, such as the relocation of public organizations, have been implemented to achieve more balanced regional development.

For balanced regional development, many reports have made comparisons between the SMA and non-SMA regions. Figure 1 shows the population trends in the SMA, referring specifically to Seoul, Incheon, and Gyeonggi-Do, against non-SMAs. The graph shows that the population of SMA continues to increase, currently accounting for more than 50% of the total population of Korea as of the end of 2019. However, there is little research on the agglomeration in regional development, which drives the growth of regions and so the disparities across regions. The agglomeration effects of concentrated urban areas arise not only in Seoul but also in

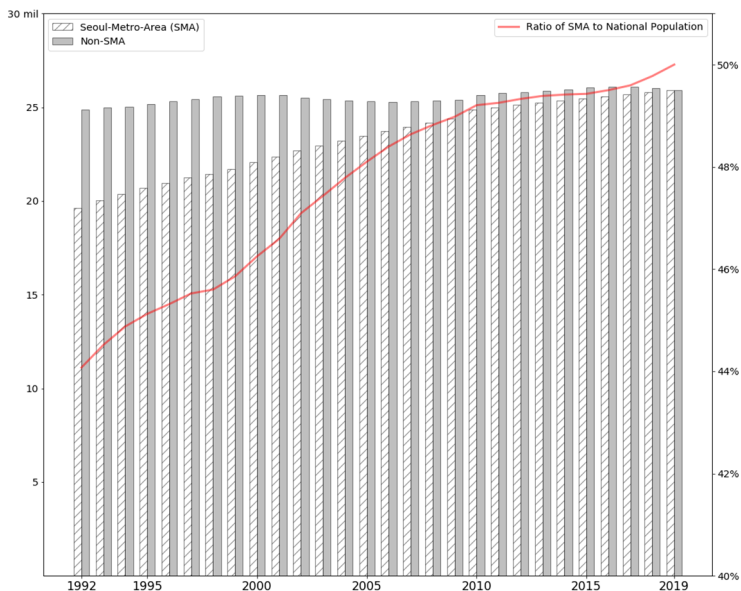


FIGURE 1. POPULATION TRENDS OF THE SEOUL METROPOLITAN AREA (SMA) AND NON-SMA

Source: Statistics of Residence Registration Population (1992~2019); Ministry of the Interior and Safety.

other large cities. In regional hub cities other than Seoul, however, the agglomeration effects appear to be reaching its limit.

Figure 2 shows the population trends of Korea’s metropolitan cities, in this case Seoul and six Gwangyeok-Si (metropolitan cities). All metropolitan cities except Incheon show decreases in terms of the population of registered residents. Busan experiences a population decline in all years except 1995 and 2010. In 1992, when data began to be collected, there were more than 3.8 million people in Busan, but in 2019, its population had declined to less than 3.5 million, showing nearly a 10% decline during that span. The population of Daegu, Korea’s third largest city in 1992, stagnated as it fell to the fourth largest city, behind Incheon, in 1999. Gwangju, the hub city of Jeollanam-Do, has been a smaller city than Daejeon since the late 1990s, showing a decline to less than 1.5 million. Daejeon had increased steadily, surpassing 1.5 million in 2010, but declined more recently, recording about 1.5 million inhabitants as of the end of 2019. Of the six metropolitan cities, Incheon alone sent positive news that it has recently exceeded 3 million. If the current trend remains, Incheon will become Korea’s second largest city in the next few decades.

The decreasing trend in the populations of local hub cities has more important implications than a population comparison between the SMA and non-SMAs. Population is the main cause of the agglomeration effect of consumption and is closely related to employment, which is the main source of the production of agglomeration. It would be very beneficial for metropolitan areas to maximize the agglomeration effect by exchanging positive interactions within regions. The populations of local metropolitan cities are, however, decreasing, and they are less likely to show their potentials in aggregation. This means that preventing the decline

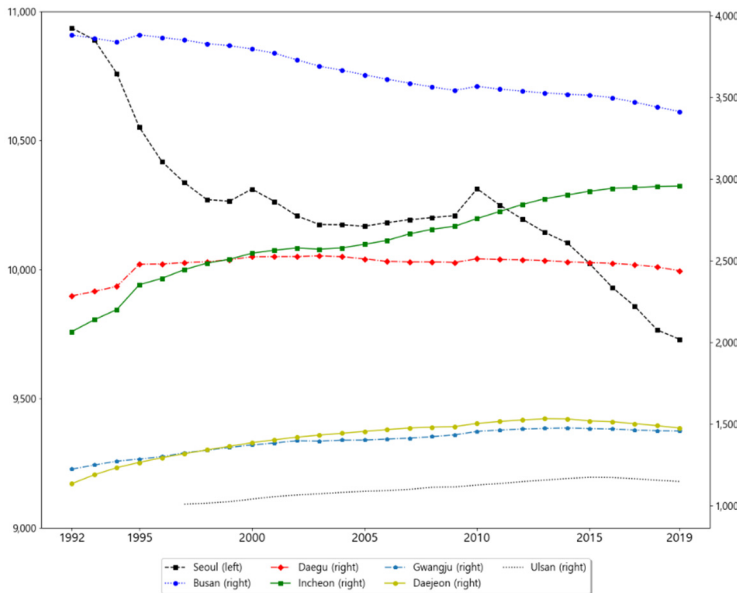


FIGURE 2. POPULATION TRENDS OF METROPOLITAN CITIES

Note: Seoul (dashed line with black dots) is on the left axis and the other cities are on the right axis. Ulsan (small dashed line) was promoted to Gwangyeok-Si status in 1997.

Source: Statistics of Residence Registration Population (1992~2019); Ministry of the Interior and Safety.

of local hub cities could be one of the most important starting points for balanced regional development, which is one of the government's main tasks. As shown in the following empirical analysis, if the populations of local hub cities continue to decrease, their agglomeration effects on the surrounding area will also lessen, which will in turn hamper regional development. It is necessary to promote the development of regional hub cities so as to disseminate the agglomeration effects to the surrounding areas.

To that end, we will examine the distributions of populations across cities and how these distributions have changed over time. Population size distributions and growth are known to follow Zipf's law and Gibrat's law. With historical population data, I will confirm these empirical laws. In addition, the effect of the population distribution on the growth of cities will be investigated through an empirical analysis. Changes in population distributions due to population growth or migration will affect economic activities in urban areas, and this effect will depend on several geographical factors. Among these, the concept of 'market access' is introduced, quantified and reflected in the empirical model. Based on this model, data from Korean cities in five-year periods will be constructed as panel data and analyzed more rigorously through a fixed-effect model.

Market access is an advantage of economic geography, first introduced in the field of international trade. However, some factors related to international trade, such as tariffs, do not apply between regions within a country. Therefore, market access is more simply applied to the movement of people and goods within a country. As discussed in more detail later, market access is associated with the size of the local market and the distances across regions. In other words, if there is a large local market nearby, the region has high market access. Assuming that the regional market is proportional to the population, it can be said that the population distribution affects market access. When there is such a populous city or large market, the surrounding areas are likely to develop. The main purpose of this study is to estimate an accurate measure of the impacts of these large markets on their surrounding areas.

This study is organized as follows. In Chapter 2, I discuss in detail the population distribution and growth of cities in Korea. Chapter 3 introduces the concept of market access and presents a model of market access and employment growth to examine the relationship between them. Chapter 4 explains the data used with the model. Chapter 5 analyzes the effect of market access on urban growth and shows that the agglomeration effect of hub cities on the growth of neighboring regions is significant. Finally, Chapter 6 concludes the study.

II. City Size Distribution and Urban Growth

This chapter examines the population distributions of Korean cities. According to Zipf's law, which is an empirical rule about population distributions, I analyze the distributions of urban populations over time and discuss the implications of population distributions. Section A discusses the characteristics of population distributions in Korean cities using Zipf's law. Second, Section B shows the relationship between changes in Korea's population distributions and urban growth according to Gibrat's law. The theory on random urban growth supports these laws

according to Gabaix and Ioannides (2004) and the references therein.

In order to check whether the empirical laws hold, I define the spatial scope of the cities using the Korean words ‘Si’ (city) and ‘Gwangyeok-Si’ (metropolitan city). This is distinguished from the normal definitions of cities. For the purpose of administration, ‘Si’ (city), ‘Gun’ (county), and ‘Gu’ (district) are mostly used. However, this normal classification is not appropriate for the empirical laws we discuss in this chapter. Appendix A describes in detail the definitions of urban areas and why I adopt these definitions.

A. City Size Distribution and Zipf's law

This section discusses the characteristics of the population distributions across Korean cities using Zipf's law (Zipf, 1949). This empirical law describes the relationship between population size and the rank of cities. Based on this law, I analyze how Korea's population is distributed across regions.

Figure 3 shows the distribution of population sizes of all cities in Korea over time. Using the Statistics Korea's Population Census, 85 cities are shown for every ten years from 1975 to 2015. After all cities are listed according to their population size, the ranks are plotted on the vertical axis and the population sizes are on the horizontal axis. Both are in log scale. Seoul is the most populous city, Busan is second and Incheon third. This graph illustrates Zipf's law, an empirical law which states that such a graph is linear and its slope is one. According to Gabaix and Ioannides (2004), the graphs of most countries are largely linear, but concave. That is, very large cities and small regions in fact fall short of this type of linear trend. This characteristic also

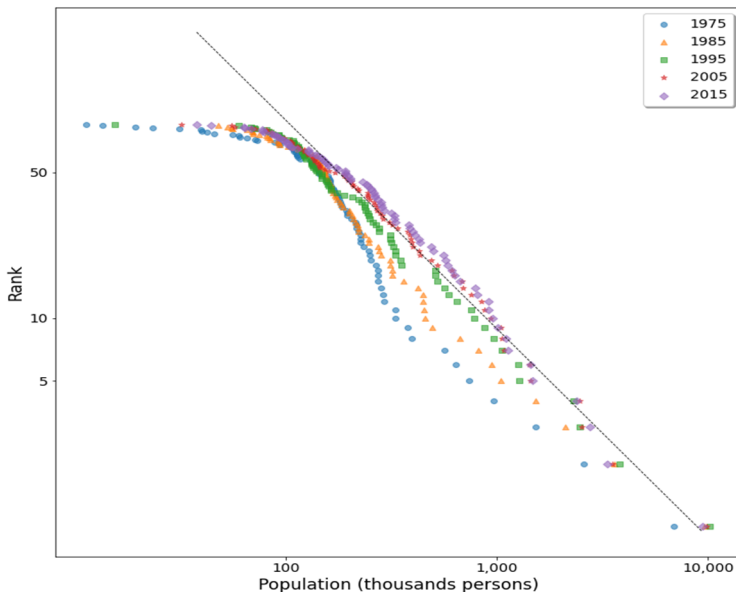


FIGURE 3. ZIPF'S LAW: POPULATION SIZE DISTRIBUTIONS OF CITIES

Note: Both axes are in log scale. The graph shows 85 cities and their ranks. The -45-degree line is also drawn.

Source: Population Census (1975~2015); Statistics Korea.

applies to Korea, where the population sizes of the second largest and the third largest cities are below the trend line. Additionally, some cities, from metropolitan cities such as the fifth largest city to cities with populations of 100,000 or more, are located above the trend line.

Looking at the past population distributions through the lens of Zipf's law, we see different patterns. Since 1995, the population distribution has not changed much, appearing to follow a linear pattern, as predicted by Zipf's law. The distributions in 2005 and 2015 follow nearly the same line, with concave distributions toward the origin. Before 1995, however, the overall population distributions are shown to be out of alignment. In particular, the population distribution in 1975, as far back as the data stretches, is far from a linear line.

In conclusion, large cities showed increases in populations in the early stages of industrialization such that their population distributions deviated from a linear line. However, as medium cities have grown since the 1980s, linearity has arisen. I add a quantitative analysis of Zipf's law to the Appendix. In that analysis, the Zipf's coefficient estimates are approaching one as time goes by.

B. *Urban Growth and Gibrat's law*

This section discusses population distributions and urban growth in Korea. More specifically, I examine Gibrat's law on population growth as it applies to Korean cities. Gibrat's law was advocated by Gibrat (1931), which states that the population growth of cities is independent of their size. Technically, the expected value and variance of population growth rates in any region are independent of the size of the region, meaning that both large and small cities have the same expected growth rate. This is related to random growth because urban growth is unrelated to the size of the city. This is also linked to Zipf's law, as discussed earlier. As noted in Gabaix and Ioannides (2004), the populations of cities growing randomly follow a log-normal distribution. This log-normal distribution is not very different from a power distribution when excluding small cities and focusing on the right side. Accordingly, Zipf's law appears to hold if Gibrat's law holds. Eeckhout (2004) actually showed that US city sizes follow a lognormal distribution, and Rossi-Hansberg and Wright (2007) proved this with a theoretical model.

However, Gibrat's law, a theoretical prediction, is not always confirmed empirically. Empirical results vary by the definitions of regions. Eeckhout (2004) mentioned above examined the law with data based on the core-based statistical areas (CBSAs) of the United States, confirming that population growth in these regions is independent of their population sizes. Holmes and Lee (2010) compare population growth at all locations by dividing the United States into equally sized grids, revealing that the growth rate at all grids forms an inverted U as the population increases. Michaels *et al.* (2012) find a U shape with county-level data. As such, the growth rates of populations are likely to differ depending on the regional unit and time period.

In Korea, I find that the relationship between population size and the growth rates of the cities forms a U shape in the early time period of 1975-1995, whereas this becomes blurred in the later period of 1995-2015. Figure 4 shows the results for these two periods. The graph on the left represents the first 20 years from 1975 to

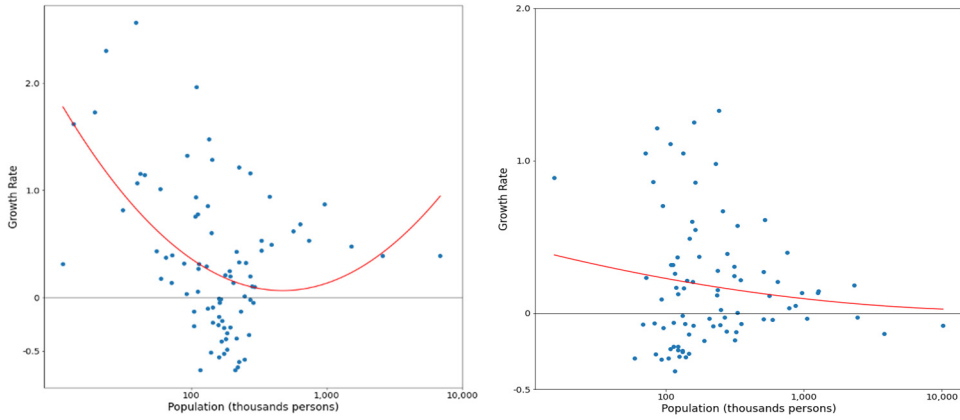


FIGURE 4. GIBRAT'S LAW: RELATIONSHIP BETWEEN POPULATION AND GROWTH RATE

Note: The x-axis denotes the population in the year 1975 for the graphs on the left, with that for 1995 on the right. They are in log scale. The y-axis is the annual growth rate over the 20-year period. The red lines are estimated in a parabola.

Source: Population Census (1975~2015); Statistics Korea.

1995, and that on the right is for the recent 20 years of 1995-2015. In these graphs, the horizontal axes indicate the population in log scale, and the vertical axes show the annual population growth rate for 20 years. If Gibrat's law holds and so urban populations grow independently of the population size, then the trend line would be horizontal with no slope. The graph on the left in Figure 4, however, shows a U-shaped pattern between 1975 and 1995. On the other hand, the trend tends to fade in the later period, suggesting that Gibrat's law holds. In the early period, the graph with the U shape implies that small and large cities showed greater increases in their populations between 1975 and 1995 compared to mid-size cities. Many medium-sized cities in fact underwent population decreases. However, there is no clear pattern between population size and population growth between 1995 and 2015. As a result, the population growth is independent of city size, which is consistent of what we have seen in the previous section. I add a quantitative analysis of Gibrat's law to the Appendix. In that statistical check, I confirm that the recent data support Gibrat's law.

III. Market Access and Urban Growth

In the previous chapter, I verify two empirical laws as well as random urban growth. In this chapter, I introduce market access to show a systematic urban growth pattern. Section A explains the concept of market access and quantifies market access as it pertains to Korean cities. Section B establishes an empirical model to clarify the relationship between market access and employment growth of Korean cities.

A. Market Access

In this section, we define market access, which plays an important role in the

analysis. People and businesses choose locations with good accessibility in which to live or engage in economic activities. Workers demand to live in areas where many jobs are available or where good transportation allows them to commute. Firms want to produce goods and services in places with good accessibility, close to large markets and many consumers. According to Fujita and Krugman (1995) and Fujita *et al.* (1999), moreover, many companies locate in urban areas with large numbers of consumers to compete and provide more diverse products. Such accessible regions provide both consumers and producers with more opportunities, and they promote economic activities (Hanson and Xiang, 2004; Head and Ries, 2001).

The concept of accessibility was recently examined by Davis (2003) and Donaldson and Hornbeck (2016) in an effort to analyze the effects of US railroad connections on the agricultural development of the central region in the US. They also provide a theoretical background showing that market access in this case stems from the model devised by Eaton and Kortum (2002), which is well known in international trade. Market access is also used in Lin (2017) and in Blankespoor *et al.* (2018) in their analyses of transportation development effects. It is also widely applied in various studies.

Market access is expressed as follows:

$$MA_i = \sum_{r \neq i} L_r \tau_{ir}^{-\theta},$$

where MA_i denotes market access of a city i , L_r represents the consumers or population of the city r , and τ_{ir} denotes the transport cost between city i and city r . That is, the market access of a city is a function of the populations of other cities and the transport costs between them for all cities in the country. Therefore, if a large city is close to city i , the market access of city i , MA_i , will then be large. A large city has a strong influence on the market access of surrounding cities, and that influence decays with greater distances at the rate of θ .

Regarding the transport elasticity of parameter θ , I set it to 8.22 according to Donaldson and Hornbeck (2016). According to Head and Mayer (2014), who performed a meta-survey of estimations of various estimated coefficients in many studies, including that by Eaton and Kortum (2002), the average value of this coefficient estimates is 6.74. The median value is 5.03. This study sets θ to 8.22 and checks a range of values between 4 and 10. The results are robust and not sensitive to this parameter.

The market access outcomes for Korea's cities are calculated and displayed as a map in Figure 5. In this figure, I show all of the cities and counties in Korea except Jeju and Ulleung because market access in these islands is exceptionally low. Higher market access is indicated by a darker color. I also list the cities sorted by market access in Table 1. In this table, I sort the cities into SMA and non-SMA categories, as cities in the SMA have very high levels of market access. Also, Appendix C contains a list with more cities. Here, we examine the market access of non-SMA cities. The city with the highest value is Gyeryong near Daejeon. The second and the fourth cities are respectively Kimhae and Gyeongsan, adjacent to Busan. The fifth city is Gyeongsan, neighboring Daegu. The sixth is Naju, next to Gwangju.

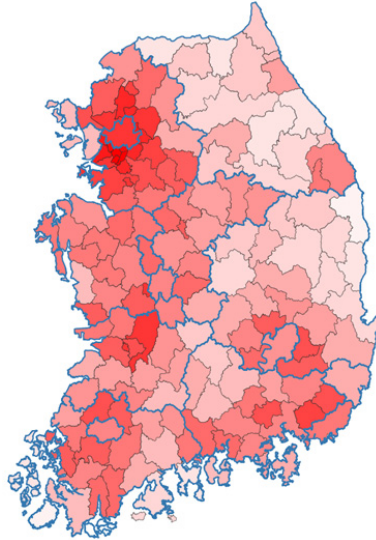


FIGURE 5. GEOGRAPHIC MAP OF MARKET ACCESS

Note: Market access levels in log scale are shaded in red. Darker red represents a higher value of market access, while lighter red areas have low market access. Jeju and Ulleung are excluded from this map because theirs are extremely low.

Source: Population Census (1975~2015); Statistics Korea.

TABLE 1—SI (CITIES) WITH THE HIGHEST MARKET ACCESS

Region	Si (Do)	Market Access	Population (rank)	Adjacent large city
Seoul Metropolitan Area (SMA)	Gunpo (Gyeonggi-Do)	0.1372	235,233 (33)	Seoul
	Uiwang (Gyeonggi-Do)	0.1287	108,788 (67)	Seoul
	Anyang (Gyeonggi-Do)	0.0878	591,106 (13)	Seoul
	Gwangmyeong (Gyeonggi-Do)	0.0571	350,914 (18)	Seoul
	Gwacheon (Gyeonggi-Do)	0.0544	68,077 (81)	Seoul
Non-SMA	Gyeryong (Chungcheongnam-Do)	0.0003285	15,495 (83)	Daejeon
	Kimhae (Gyeongsangnam-Do)	0.0000578	256,370 (28)	Busan
	Jeonju (Jeollanam-Do)	0.0000468	563,153 (14)	-
	Yangsan (Gyeongsangnam-Do)	0.0000352	163,351 (41)	Busan
	Gyeongsan (Gyeongsangbuk-Do)	0.0000255	173,746 (39)	Daegu

Source: Population Census (2015) and Census on Establishments (2015); Statistics Korea.

Note that these cities are all adjacent to a Gwangyeok-Si. Thus, I argue that metropolitan areas with many cities of many people show high market access. These are referred to as hub cities, which have much influence on the surrounding areas.

B. Model

This section provides a description of the model used here to illustrate the relationship between market access and urban growth. The model is simplified as much as possible to focus on the effects of market access on urban growth. The basic

framework of the model stems from Glaeser *et al.* (1992), which examines the effects of industry specialization and competition on urban growth. The study by Glaeser *et al.* (1992) does not consider growth factors outside of cities. Thus, the present study attempts to expand an urban growth model to include outside factors, specifically market access, discussed in the previous section. In this model, urban growth means employment growth rather than population growth.

The environment of the model is as follows. It is assumed that a representative firm in a city produces the final goods. This representative company employs only labor to produce the goods. In addition to the input factor of labor, the total factor productivity (TFP) determines the output. I assume that the TFP² is affected by not only internal factors in the city, such as labor skills, but also by external factors outside of the city, i.e., market access. This means that geographical factors of a city have impacts on production in the city.

The formula is as follows. The representative firm in a city has the following production function:

$$Y = AF(L_i)$$

where L_i represents labor in city i . Consumption goods are produced using the labor force in the city. Labor is the only input factor, and A is the total factor productivity. TFP can be divided into local components A_i within the city and those components outside of the city, A_{-i} , as follows:

$$A = A_i \times A_{-i}.$$

We can convert this equation into a form of growth account, with the result being

$$\ln\left(\frac{A_{t+1}}{A_t}\right) = \ln\left(\frac{A_{i,t+1}}{A_{i,t}}\right) + \ln\left(\frac{A_{-i,t+1}}{A_{-i,t}}\right).$$

This study is distinguished from Glaeser *et al.* (1992) in that the growth rate of total factor productivity of the external factors is determined by urban geography. That is, productivity depends on where the city is located. It is also assumed that external productivity is determined by market access, which is defined as before.

Next, we express external TFP as a function of market access, as follows:

$$\ln\left(\frac{A_{-i,t+1}}{A_{-i,t}}\right) = \ln f(MA_{i,t}) = \ln MA_{i,t}^\alpha.$$

This equation states that the change in the external TFP over time is assumed to

²TFP includes any factor other than the input factors—labor in this model—that is considered as related to production technology. Therefore, all factors, including external factors—market access in this model—must not be problematic to be a part of TFP. For example, the TFP may be higher with higher market access because firms in a city with a high market access can benefit from high productivity compared to firms in nearby cities.

be a function of market access with constant elasticity. Geographical factors, represented by market access, are as important channels in production technology.

In this study, we consider situations in which demand shocks are caused by population growth and population migrations within a country. This type of shock has different effects across regions. Given a population distribution, aggregate demand shocks as a national factor spread and have different effects depending on the geographical locations of cities. Because geographic locations do not change due to the unique characteristics of cities, the population distributions of the surrounding areas are relative to the characteristics of the cities. It is assumed that higher market access, determined based on the population distribution and the location of a city, leads to a greater demand shock, affecting production in that city. This assumption is interpreted to mean, according to the theory of new economic geography (Krugman, 1980), that high demand of the surrounding area makes the city's production more efficient. This has been proved in studies such as Baum-Snow and Pavan (2013) and Combes *et al.* (2012) on city sorting as well as Baldwin and Okubo (2005) and Behrens, Duranton and Robert-Nicoud (2014) on firm sorting, demonstrating that companies with higher productivity are located in larger cities.

Next, local components, A_i , also play a role in urban productivity. To this end, A_i is assumed to be related to a city's population density, education level, industrial structure, and other related factors. Population density is a typical variable for urban agglomeration, and education levels have been found to have a significant impact on productivity. Therefore, the density of the population can confirm the effect of agglomeration on urban production, and the level of education is indicative of the quality of human resources.

As such, the representative firm in a city solves the following profit maximization problem based on the production function discussed above. The problem of maximizing the profits of representative firms in cities is expressed as follows:

$$\max_L \Pi_i = A_i F(L_i) - w_i L_i,$$

where w_i is the wage for labor in the city. To solve this problem, we obtain the following first-order condition (FOC):

$$A_i F'(L_i) = w_i.$$

In addition, it is assumed that the production function is in the Cobb-Douglas form. That is, we can replace the production function with $F(L_i) = L_i^{1-\beta}$ in the FOC. Next, taking the natural log on both sides in the FOC above and expressing it in terms of growth account gives us the following linear empirical equation:

$$\beta \ln \left(\frac{L_{i,t+1}}{L_{i,t}} \right) = \ln \left(\frac{A_{t+1}}{A_t} \right) - \ln \left(\frac{w_{i,t+1}}{w_{i,t}} \right).$$

This equation means that the rate of increase in employment in the city is proportional to the rate of increase in the TFP, which includes market access and

local factors, and inversely proportional to the rate of increase in wages in the city. Moreover, we can replace TFP with the local and national factors previously assumed, and replace the national TFP with a function of market access. This results in the following equation:

$$\beta \ln \left(\frac{L_{i,t+1}}{L_{i,t}} \right) = \alpha \ln MA_{i,t} + g(X_{i,t}) - \ln \left(\frac{w_{i,t+1}}{w_{i,t}} \right).$$

where $g(X_{i,t}) = \ln(A_{i,t+1} / A_{i,t})$ is the rate of increase in the total factor productivity due to urban local factors. This will be replaced with the population density in the city, the level of education and the proportion of the service sector, which represents the industrial structure.

Finally, there may be an endogeneity problem in the wage term. Thus, we can replace the wage term with the initial level of wages, as was done with other terms. However, given that there is no available data on wages by cities, this is expressed here as a function of the education level and age according to the Mincer wage equation. According to Mincer (1974), the wage formula can be expressed as a function of years of education, and career years. In particular, the return of career years on wages is assumed to be a quadratic function of experience in the labor market:

$$\ln w = \ln w_0 + \rho School + \beta_1 x + \beta_2 x^2 + \varepsilon.$$

We then obtain the final equation for the empirical analysis. Because a balanced panel dataset is constructed, as will be discussed in the next section, a fixed-effect model will be adopted. As a result, how the employment growth rate is related to market access in cities is estimated with the following empirical model:

$$\begin{aligned} \ln \left(\frac{L_{i,t+1}}{L_{i,t}} \right) = & \alpha_0 + \alpha_1 \ln MA_{i,t} + \alpha_3 School_{i,t} + \alpha_4 Age_{i,t} + \alpha_5 Age_{i,t}^2 \\ & + \beta X_{i,t} + FE_i + FE_t + \varepsilon_{i,t}. \end{aligned}$$

IV. Data

Based on the model discussed in the previous section, I analyze a panel dataset to estimate the effect of market access on employment growth in the city.

The dependent variable is the growth rate of employment. The total number of employees in urban areas comes from Enterprise Survey by the National Statistics' survey for business operations in the nation. I construct panel data from the survey on a five-year basis from 1995. The national Enterprise Survey has been conducted every year since 1994, but for the sake of consistency with the Census, only five-year data is used here. The Population Census in Korea is a survey also conducted on a five-year basis. I harness the Census to construct market access variables and

the other variables. We also look at employment by industry. The total employment in the city can be divided into the manufacturing and service sectors to investigate different effects on the employment growth of each industry. Finally, the rate of change in the population will also be employed as a dependent variable to test the robustness of the model.

The explanatory variables include not only market access of all cities but also variables that influence urban growth among the factors within the cities. These factors control other factors that may affect dependent variables rather than market access. As such variables, population density, education level, and the service sector weight are selected. Since Ciccone and Hall (1996), who showed that there is a positive relationship between population density and productivity, population density has been a well-known variable used to estimate the urban aggregation effect. In general, the higher the population density is, the greater the agglomeration effect becomes.

Industrial structure is one of the main explanatory variables. I choose the share of the service industry as a variable by which to represent the industrial structure. The service share is the ratio of the number of employees engaged in the service sector to the total number of those employed in a city. Urban employment can largely consist of the manufacturing sector and the service industry. Because the manufacturing share is perfectly inversely related to the service share, the latter is used. This share will control for labor demand from the service sector. Wage is also an important explanatory variable. Because wage data is not available, wages are replaced by the Mincer equation, as discussed in the model specifications. In the Mincer wage model, education level and years of experience are the main variables, as derived from the Population Census. From this survey, I take the average of ages and education years the population between 15 and 65 years old to describe the labor force characteristics living in a city, after which these are inserted into the wage equation. The industry structure and the variables for wage are explanatory to isolate the effects of market access.

Furthermore, I conduct robustness checks in the Appendix with different samples of cities. There are 83 cities and 76 counties as of the end of 2018. For the first verification, the samples are classified into the Seoul metropolitan area (SMA) and non-SMAs. The SMA refers to 30 cities, including Seoul and Incheon and those in Gyeonggi-Do, and the non-SMAs consist of 53 cities outside of the SMA. We will observe the differences between these two samples. Second, the cities will be redefined as 'Si (cities)' as of 1995 given the endogeneity problem in the sample selection of the cities. There were 68 cities to analyze as of the end of 1995. Finally, the definitions of cities are expanded to all regions, including the 83 Si (cities) and 76 Gun (counties), totally 159 in Korea.

The time period in which to examine recent urban growth is 20 years, from 1995 to 2015. Because the main data source, the Population Census, is conducted in every five years, the data for the analysis is constructed into the format of the Census, using the five-year periods between 1995 and 2015. Basic statistics for the variables are shown in Table 2 without weights. The minimum population in 1995 is in Gyeryong-Si, at 15,495, and the maximum is the population of Seoul for every year, which declined from around 10 million in 1995 to 9.4 million in 2015. The minimum value of employment is also in Gyeryong-Si in 1995, and the maximum number of

TABLE 2—BASIC STATISTICS (UNWEIGHTED)

Variable	Year	Mean	Standard Deviation	Min	Max
Employment	1995	150,384	447,620	2,683	3,874,597
	2000	150,121	412,805	3,808	3,574,824
	2005	168,391	443,430	5,838	3,843,010
	2010	196,546	514,170	7,404	4,487,357
	2015	232,183	585,968	8,851	5,108,828
Employment growth	1995	1.46%	2.61%	-3.45%	11.12%
	2000	2.54%	2.73%	-1.67%	11.94%
	2005	3.24%	1.73%	-0.63%	8.84%
	2010	3.80%	2.68%	-1.02%	22.35%
	2015	-	-	-	-
Population	1995	481,125	1,222,665	15,495	10,231,217
	2000	502,626	1,189,460	27,122	9,895,217
	2005	521,356	1,180,106	31,699	9,820,171
	2010	538,827	1,177,133	41,528	9,794,304
	2015	535,372	1,136,265	37,690	9,394,807
Population density	1995	1,612	2,999	71	16,904
	2000	1,720	3,000	64	16,349
	2005	1,825	3,127	57	16,225
	2010	1,896	3,159	57	16,182
	2015	1,869	3,043	54	15,522
Market access	1995	0.0059	0.0238	0.0000	0.1372
	2000	0.0061	0.0246	0.0000	0.1383
	2005	0.0064	0.0260	0.0000	0.1506
	2010	0.0065	0.0261	0.0000	0.1490
	2015	0.0063	0.0253	0.0000	0.1437
Education years	1995	10.5	1.1	8.4	13.8
	2000	11.1	1.0	9.2	14.0
	2005	11.9	1.0	9.9	14.6
	2010	12.9	0.7	11.4	15.1
	2015	13.0	0.6	11.9	15.1
Age	1995	39.0	2.0	34.6	43.8
	2000	40.2	1.8	36.8	44.6
	2005	41.8	1.8	37.8	46.2
	2010	41.9	1.5	38.9	45.5
	2015	44.2	1.4	41.2	47.4
Service sector ratio	1995	65.6%	13.3%	33.1%	92.1%
	2000	70.4%	12.4%	40.4%	92.7%
	2005	71.0%	12.0%	41.8%	91.3%
	2010	70.1%	12.7%	39.6%	91.8%
	2015	70.2%	12.3%	42.6%	91.4%

Source: Population Census (1995-2015) and Census on Establishments (1995-2015); Statistics Korea.

employees is in Seoul for all years. In Seoul, employment has risen since 2000 unlike the population with the lowest being in 2000.

Although not shown in the table, the variables of population and employment are highly correlated. The correlation between the population and employment levels

reaches 0.9803 over the entire period. In cities with many people, there is much employment. Additionally, the correlation coefficient of the changes in these variables between periods is 0.8304. As observed in relation to the growth rate of employment, there are many variations affecting urban population growth.

Market access in the table is reported in log scale. As explained early, this is calculated using the population and the distances between regions. Thus, the interpretation is ambiguous. We will revisit this issue in the results section. Education years and age are calculated as the averages of the populations in the regions with micro-data from the Population Census. Based on the age variable, the youngest city among the 83 cities is Ansan, Gyeonggi-Do, in 1995. The region with the highest educational level based on schooling years is Gwacheon in Gyeonggi-Do.

V. Results

This section discusses the results of the analysis based on the empirical model described in Chapter 3 with the data above. The main result is how market access affects urban employment growth. As discussed with the empirical model, employment growth, our dependent variable, is used for the analysis, with market access being one of the explanatory variables. The change in employment is the annual growth rate over five-year periods for 20 years from 1995 to 2015. It should be noted that market access is calculated in the starting year of a period, i.e., 1995 for the period from 1995 to 2000. That is, variations of market access at the beginning of the periods will lead to differences in the annual change rates of employment over the periods.

As mentioned above, I apply various samples for robustness checks. First, panel data on 83 cities constructed as the main definitions of cities are adopted. With these data, two models are compared: pooled OLS and a fixed-effect model with city effects. In these two models, the yearly time effects are also included so as to control for compounding factors which have an influence on employment in all regions. For example, macroeconomic variables such as GDP or the consumer price level are identical for all areas in each period.

The results of this empirical analysis are shown in detail in Table 3. In addition to the OLS and fixed-effect models, model types (1) and (2) are classified according to whether or not the mean age squared is included in the explanatory variables. Market access, the most interesting result, was found to increase employment growth in both the pooled OLS and fixed-effect models. In the two types of regressions, a 1% change in market access increases employment growth by 0.00219%p or 0.00227%p, which is significant at the level of 1%. In the fixed-effect model, the magnitude of this effect is much larger, reaching 0.0196%p, or as small as 0.0178%p. All of these outcomes are significant at the level of 1%. In other words, the effect of market access is largely predicted in the fixed-effect model. This confirms what was discussed earlier. Cities with higher market access tend to experience higher employment growth due to geographical advantages. Most of the cities with high market access are located around regional hub cities, confirming that the agglomeration effect from hub cities is significant.

Moreover, the F-statistics in Table 3 show that more attention should be paid to

TABLE 3—RELATIONSHIP BETWEEN EMPLOYMENT GROWTH AND MARKET ACCESS

Dependent Variable: $\Delta \ln$ Employment	Pooled OLS		Fixed-effect model	
	(1)	(2)	(1)	(2)
Explainable Variables				
In Market Access	0.00219*** (0.000382)	0.00227*** (0.000385)	0.0196*** (0.00598)	0.0178*** (0.00565)
In Population Density	-0.00983*** (0.00147)	-0.0100*** (0.00146)	-0.0595*** (0.0101)	-0.0665*** (0.0115)
Education years	0.00708** (0.00313)	0.00665** (0.00313)	0.0163*** (0.00523)	0.0200*** (0.00614)
Age	-0.00351*** (0.00135)	0.0249** (0.0110)	0.00124 (0.00214)	0.0369 (0.0248)
Age ²	-	-0.0354** (0.0137)	-	-0.0445 (0.0309)
Ratio of Service	0.00675 (0.0116)	0.00511 (0.0116)	0.117*** (0.0215)	0.107*** (0.0227)
Cities	-0.0247*** (0.00803)	-0.0232*** (0.00796)	-0.00421 (0.00689)	-0.00276 (0.00657)
Constant	0.172** (0.0723)	-0.390* (0.223)	0.375*** (0.115)	-0.338 (0.504)
Year Fixed-effect	YES	YES	YES	YES
Citi Fixed-effect	NO	NO	YES	YES
F-statistics	-	-	177.51	183.65
R ²	0.601	0.605	0.722	0.726
# of Observations	332	332	332	332
# of Cites	83	83	83	83

Note: 1) The dependent variable is the average annual growth rate of employment over the 5-year period. *, **, and *** indicate the significance level of 10%, 5%, and 1%, respectively, 2) The robust standard errors are in parentheses, and clustered by cities, 3) Among 85 cities, Jeju and Seoguiipo are excluded.

Source: Population Census (1995~2015); Statistics Korea.

the results of the fixed-effect model. The fixed-effect models with city fixed-effect dummies control for unobservable and time-invariant factors in cities, thus reducing omitted variable bias. Any unobservable compounds that do not change over time are controlled by city fixed effects. These include time-invariant geographical conditions and environmental factors. The F-statistics of 177.51 and 183.65 reject the hypothesis that all city fixed-effect dummies are null, indicating that estimates of the pooled regression model are likely to be biased. Because the pooled OLS analysis does not reflect the unobservable individual characteristics of cities, these omitted factors cause bias. The fixed-effect model focuses on within-variation rather than between-variation factors, meaning that a 1% change in the market access of a specific city has an effect of approximately a 0.02%p change in the employment growth of that city. This does not stem from differences between cities but from the unobservable characteristics within a specific city.

Regarding the coefficients estimated, it is worth noting that the coefficient for population density is negative. As shown in the previous chapter, Gibrat's law is seen to hold in this period. That is, urban employment growth is independent of the city's population size without controlling for variables. If we assume that urban areas are

unchanged, the population density is directly associated with the population size. Thus, estimates of the population density should be close to zero according to Gibrat's law. In Chapter 2, when no other variables were controlled, the corresponding estimates were statistically null in the period of 1995 to 2015. As shown in Table 3, however, the population density is inversely related to employment growth in cities. The denser the city is, the slower employment grows. Furthermore, because population density is used as a proxy variable for the agglomeration effect, it can be interpreted as meaning that the agglomeration effect in the city is generally negative. As the size of a city grows, so does the population density. This implies that large cities have less potential to create additional jobs. This is a phenomenon that usually occurs in cities where growth has slowed. This negative external effect is due to traffic congestion, rising house prices, or increasing levels of crime. The negative coefficient estimates suggests that negative externalities are stronger than positive agglomeration effects. Because this hampers urban growth, it is good to minimize these side effects for urban areas to continue to grow.

Next, we examine education effects. In both models, schooling years are positively correlated with employment growth. The level of education is used as a proxy variable for the total factor productivity of the region in the empirical model and as one of the factors of wages in the Mincer model. Therefore, the effects through these two channels can be estimated together. First, it is assumed that the higher the education level is, the higher the human capital of the urban workforce becomes, thus leading to higher productivity. Conversely, in cities with high wage levels, the demand for employment can be reduced, leading to a small increase in employment. As such, the relationship between education level and employment growth rate can be interpreted as a composite of these two channels. As a result, positive coefficient estimates show that the productivity effect is greater than the employment effect, implying that the positive externalities of high human resources in productivity are more important.

Robustness checks are also important. Accordingly, here we examine the likelihood that the results discussed above are dominated by a faction of the sample regions. In particular, metropolitan cities showed high market access in that they are close to Seoul, the largest city in Korea. Therefore, there is a marked difference in population and employment growth levels in this region as compared to the other regions. It is possible that the market access effect would be great in the Seoul metropolitan area.

However, the results in Table 4 tell us that this is not the case. The table shows the results of the fixed-effect model with two samples, the SMA and the non-SMAs. SMA here refers to Seoul, Incheon and 28 cities in Gyeonggi-Do, i.e., 30 cities in total. On the other hand, non-SMA regions consist of 53 cities in all regions outside of the SMA. In the analysis of only the SMA, coefficients are estimated to be 0.0261 ~ 0.0276 and the effect of market access in the non-SMA regions is approximately 0.017. This suggests that the effect of market access on employment growth is greater in the SMA than in the non-SMA cities.

The results also show limitations. Nearly half of Korea's population lives in the SMA, but there are only 30 cities in the Seoul metropolitan area. Moreover, most of the cities in the metropolitan area are quite large. Therefore, the growth of employment is likely to be somewhat limited. This can be seen by examining the

TABLE 4—RELATIONSHIP BETWEEN EMPLOYMENT GROWTH AND MARKET ACCESS BY REGION (SMA AND NON-SMA)

Dependent Variable: $\Delta \ln$ Employment	Seoul Metropolitan Area (SMA)		Non-SMA	
Explainable Variables	(1)	(2)	(1)	(2)
In Market Access	0.0261** (0.00995)	0.0276** (0.0103)	0.0169** (0.00705)	0.0170** (0.00708)
In Population Density	-0.0804*** (0.0149)	-0.0792*** (0.0155)	-0.0456*** (0.0114)	-0.0450*** (0.0146)
Education years	0.0307** (0.0113)	0.0298** (0.0121)	0.00818 (0.00750)	0.00810 (0.00775)
Age	0.00771** (0.00371)	-0.00587 (0.0494)	-0.00462 (0.00296)	-0.00644 (0.0245)
Age ²	-	0.0174 (0.0632)	-	0.00229 (0.0323)
Ratio of Service	0.0963 (0.0647)	0.0983 (0.0659)	0.170*** (0.0431)	0.171*** (0.0415)
Cities	-0.00643 (0.00823)	-0.00677 (0.00824)	0.000821 (0.0114)	0.000744 (0.0114)
Constant	0.225 (0.191)	0.500 (1.018)	0.511** (0.211)	0.544 (0.478)
Fixed-effect	YES	YES	YES	YES
R ²	0.833	0.833	0.659	0.659
# of Observations	120	120	212	212
# of Cites	30	30	53	53

Note: 1) The dependent variable is the average annual growth rate of employment over the 5-year period. *, **, and *** indicate the significance level of 10%, 5%, and 1%, respectively, 2) The robust standard errors are in parentheses, and clustered by cities, 3) Year fixed-effect and city fixed-effect are included.

Source: Population Census (1995~2015); Statistics Korea.

variable of population density. The estimate for this is about -0.08, indicating steeper negative elasticity than the estimate of about -0.045 for the non-SMA cities. The larger the population of the city is, that is, the denser the population density, the more stagnant the growth is. This may occur because larger cities are concentrated in the Seoul metropolitan area. This is likely to offset the effects of greater market access. However, the impact of market access may be greater in the SMA because it is overestimated to offset the negative density externalities. Despite this concern, the results show that market access has a positive effect on employment in both the SMA and in non-SMA regions.

Next, we look at the growth of employment by industry. This is important because the impact of market access may differ by industry. Table 5 shows the impact of market access by industry. Employment growth, which is the dependent variable, is calculated in one industry among the manufacturing or service industries. Manufacturing represents the trading sector, and service denotes the non-trade sector. Although the statistical significance is lower than in the previous results for all industries, the market access effect is greater in the manufacturing than in the service sector. In cities with high market access, employment increases more in manufacturing than in services. This result implies that over the past two decades,

TABLE 5—RELATIONSHIP BETWEEN EMPLOYMENT GROWTH AND MARKET ACCESS BY INDUSTRIES

Dependent Variable: $\Delta \ln$ Employment	Manufacturing Sector		Service Sector	
	(1)	(2)	(1)	(2)
Explainable Variables				
In Market Access	0.0295* (0.0156)	0.0349** (0.0165)	0.0175** (0.00772)	0.0146** (0.00709)
In Population Density	-0.0614*** (0.0183)	-0.0479** (0.0193)	-0.0620*** (0.0152)	-0.0759*** (0.0168)
Education years	0.0250** (0.0116)	0.0163 (0.0108)	0.00815 (0.00714)	0.0145* (0.00775)
Age	-0.00140 (0.00445)	-0.0772* (0.0426)	-0.000795 (0.00241)	0.0656* (0.0359)
Age ²	-	0.0948* (0.0535)	-	-0.0825* (0.0441)
Ratio of Service	0.272*** (0.0573)	0.287*** (0.0562)	0.0102 (0.0259)	-0.00903 (0.0235)
Cities	-0.00650 (0.0101)	-0.00809 (0.0109)	-0.00598 (0.00798)	-0.00253 (0.00726)
Constant	0.370 (0.347)	1.921** (0.938)	0.637*** (0.167)	-0.672 (0.742)
Fixed-effect	YES	YES	YES	YES
R ²	0.407	0.412	0.437	0.453
# of Observations	332	332	332	332
# of Cites	83	83	83	83

Note: 1) The dependent variable is the average annual growth rate of employment over the 5-year period. *, **, and *** indicate the significance level of 10%, 5%, and 1%, respectively, 2) The robust standard errors are in parentheses, and clustered by cities, 3) Year fixed-effect and city fixed-effect are included.

Source: Population Census (1995~2015); Statistics Korea.

large cities with large populations have more strength in services than in manufacturing, causing manufacturing facilities to move to nearby high market access cities. According to Glaeser and Gottlieb (2006) and Couture and Handbury (2017), the growth of consumption in the service industry is the main reason for the stagnant growth of US metropolitan cities in the 2000s. Similar phenomena may have occurred in Korean cities. Greater importance of consumption for services leads to more employment in the services in large cities.

Next, the definition of a city will be tested for robustness. We define ‘cities’ by Si (city) in the current administrative district as of 2018. We will examine how the results of this study differ with other definitions of cities. First, Si (city) is examined as of 1995, the first year of the analysis. There were only 68 cities with the status of “Si (city)” in the administrative districts in 1995. In contrast, I extend the sample into all cities and counties to observe how the results change. The results are reported in the Appendix.

Finally, Table 6 reports the results of analysis on the population growth. Note that the dependent variable is the average annual rate of change in the population, and the explanatory variables are identical to those used before. Overall, the explanatory power is lower than in the model of employment growth. This implies that the impact of market access on population growth is smaller than on employment changes. This

TABLE 6—RELATIONSHIP BETWEEN POPULATION GROWTH AND MARKET ACCESS

Dependent Variable: $\Delta \ln$ Population	Pooled OLS		Fixed-effect model	
	(1)	(2)	(1)	(2)
Explainable Variables				
In Market Access	0.00128*** (0.000374)	0.00129*** (0.000373)	0.0104** (0.00444)	0.00784** (0.00345)
In Population Density	-0.00907*** (0.00150)	-0.00910*** (0.00151)	-0.0804*** (0.00904)	-0.0904*** (0.0101)
Education years	0.00803** (0.00341)	0.00796** (0.00340)	0.00328 (0.00445)	0.00768 (0.00505)
Age	-0.00596*** (0.00145)	-0.000362 (0.0159)	-0.00215 (0.00175)	0.0478*** (0.0169)
Age ²	-	-0.00692 (0.0192)	-	-0.0622*** (0.0210)
Ratio of Service	-0.0125 (0.0121)	-0.0130 (0.0124)	-0.00958 (0.0178)	-0.0249 (0.0183)
Cities	-0.0222*** (0.00705)	-0.0218*** (0.00717)	0.0208** (0.00962)	0.0236** (0.00928)
Constant	0.259*** (0.0796)	0.147 (0.334)	0.787*** (0.108)	-0.201 (0.335)
Year Fixed-effect	YES	YES	YES	YES
Citi Fixed-effect	NO	NO	YES	YES
F-statistics	-	-	25.66	24.29
R ²	0.461	0.461	0.548	0.566
# of Observations	332	332	332	332
# of Cites	83	83	83	83

Note: 1) The dependent variable is the average annual growth rate of employment over the 5-year period. *, **, and *** indicate the significance level of 10%, 5%, and 1%, respectively, 2) The robust standard errors are in parentheses, and clustered by cities, 3) Among 85 cities, Jeju and Seoguiipo are excluded.

Source: Population Census (1995~2015); Statistics Korea.

may occur because decisions by people about where to live are less responsive to market access than decisions by firms about where to produce. Although the explanatory power is low, the estimates are similar in terms of the directions. Market access appears to have a 0.01%p impact on population change. In addition, population growth is slow in densely populated cities. The effects of years of education and age are similar to those of employment, but these results are not as significant as before.

In sum, market access is closely associated with employment growth as well as population growth in Korean cities. Employment in cities with high market access tends to increase rapidly. On the other hand, regions with low market access, located far from hub cities, appear to have grown slowly or even to have declined. These results are more prominent in the Seoul metropolitan area than in non-SMA regions. In addition, employment growth in the manufacturing sector occurs more rapidly than in the service sector.

VI. Concluding Remarks

This study examines the relationship between market access and urban growth and analyzes the effect of market access, which is high with nearby large populations. Market access is a variable representing the aggregation effect of the nearby cities. The empirical results show that market access has a significant impact on regional employment development.

I also documented the urban population growth patterns of Korean cities, finding that the population distributions of cities in Korea follow Zipf's law. Moreover, it appears that Zipf's law holds very well with the recent population distribution, while this cannot be confirmed in the period of 1975 to 1995. Gibrat's law also has different implications because the relationship between population size and its growth varies over time. Population growth from 1975 to 1995 showed a different trend from that of 1995 to 2015. This appears to have major policy implications. Since the 1970s, industrialization policies had led people to move to large cities. In the 1990s, on the other hand, the policies aimed to ease overcrowding in metropolitan cities and to distribute industrial facilities nationwide. As a result, the growth of medium-size cities has been prominent. However, behind the population growth of these middle cities, there was a decline of small cities, recently referred to as extinction areas, raising awareness of this local crisis.

This study introduces the concept of market access as a factor that influences urban growth. Market access, a concept introduced in the international trade, measures the geographical and economic advantages of cities. The market access of a city is calculated from the population of and the distances from the surrounding regions. Therefore, cities located close to populated cities show high market access, and regions far from a large city or regional hub city have low market access.

An empirical analysis of the relationship between market access and urban growth using data from 1995 to 2015 shows that employment in cities with high market access has rapidly increased. On the other hand, regions with low market access appear to have undergone slower growth. These results are more prominent in the Seoul metropolitan area than in non-SMA regions. In addition, employment in the manufacturing sector has risen more prominently than that in the service sector.

Next, we discuss policy implications for balanced national development. Korea is striving for balanced national development, and various policies have been implemented with the goal of 'evenly developing regions'. As discussed in the introduction, however, the gap between the SMA and non-SMAs is broadening. Metropolitan cities in non-SMA regions are showing decreasing populations. As shown in this study, the gap between the SMA and non-SMA regions can be explained by differences in market access and agglomeration effects. In other words, cities with low market access in non-SMA regions have experienced little development in employment, whereas cities with high market access near Seoul have grown rapidly. Compared to non-SMA cities with low market access, cities with high market access near non-SMA metropolitan cities also benefited from nearby large cities, with employment rising. These are the agglomeration effects of large cities on regional development.

Currently, the shrinking populations of local metropolitan cities imply the

possibility that it is not merely a matter related to these cities but a risk that can impede the development of the corresponding regions. To prevent this trend, policies that help local hub cities find a starting point for development without causing a decline in the overall development of the region are needed. When investing in local areas via policies such as the relocation of public institutions, the relocation area selected should be an investment worthy as a place for regional development, not for political gains. If Korea's second city grows due to such an investment, it will contribute not only to the region but also to the growth rate of the whole country. Moreover, many regions with low market access should be compact, with investments to strengthen a network with neighboring hub cities.

Finally, it is important to discuss the limitations of this study. The analysis here focuses on quantitative growth of cities in terms of population and employment. Therefore, the study fails to analyze qualitative growth in order to improve the quality of life. Quantitative growth outcomes of employment and population cannot be achieved in non-urban areas with poor market access, but the qualitative growth of productivity and income per capita can improve. This can have a positive impact on the quality of lives of local residents. The analysis in this study does not take this into account, as it is limited to an analysis of quantitative growth.

APPENDIX

A. *Definition of Cities*

To look at the population distributions of cities, we need to define what a city is. In other words, we need to determine the spatial scope of a city. With this definition, we will study the population distribution of Korea by looking at how many people live in each geographically defined city.

A city is a place where people live and work, and a city can differ essentially from an administrative division. However, the literature has often defined spatial units of research as administrative divisions, as a variety of factors are needed for a strict definition of a city. Administrative divisions are used in many fields, including politics, and various types of statistical data are collected on this basis. Based on the administrative divisions, basic living zones are termed Si (city), Gun (county), and Gu (district) in Korea. Existing studies have utilized these distinctions as a spatial scope. In a metropolitan area, however, people's living zones are wider than administrative divisions. In this study, it is necessary to divide regions into those similar to people's living areas as precisely as possible.

Here, I define basic living zones as Si (city) and Gun (county) and define cities among living zones by using Si (city) and not Gun (county). To clarify this, we consider the administrative divisions in Korea. Table A1 shows the areas and populations of Korea's administrative divisions. Korea is divided into eight metropolitan cities, including Seoul and Sejong, and nine general and special autonomous provinces. Metropolitan cities as autonomous municipalities have autonomous districts (Gu) and autonomous counties (Gun), and such provinces have general administrative cities (Si) and counties (Gun). As shown in Table A1, Seoul has 25 Gu and Busan has 15 Gu and one Gun. There may be a general municipality which has general Gu and Gun, particularly when their populations exceed 500,000. This division is distinct from the autonomous districts of metropolitan cities. Suwon, the capital of Gyeonggi-Do, has four general Gu, and there are 17 general Gu in Gyeonggi-Do. Si (city), Gun (county), and Gu (district) refer to general cities, general counties, and autonomous districts, respectively. A city in this sense differs from a metropolitan city in a metropolitan municipality.

For the purposes of this study, cities are defined as metropolitan cities and general cities. This does not include the autonomous districts of metropolitan cities. In this regard, cities in this study are distinguished from a city as defined by Si (city), Gun (county), and Gu (district). Because general cities and metropolitan cities are regarded as the same types of cities, cities are also different from metropolitan economic zones in that the provinces are divided into cities and counties. Finally, cities are distinguished from Gun (county). Article 7 of the Local Autonomy Act provides the criteria for the promotion of a county or town to a city. Gun (counties) with population of 50,000 or more or Eup (towns) with population of 20,000 or more can be a Si (city). The Act states that a Gun or Eup should be in the form of a city, more than 60% of the population must live in the city's urban area, and a high proportion of people must be engaged in urban industries. Moreover, a city's population density is expected to be higher than the average population density of cities with populations of 100,000 or less. According to the Local Autonomy Act,

TABLE A1— ADMINISTRATIVE REGIONS IN SOUTH KOREA

Region	Area (km ²)	Population	Si	Gun	Gu
Seoul	605.23	9,857,426	-	-	25
Busan	770.04	3,470,653	-	1	15
Daegu	883.54	2,475,231	-	1	7
Incheon	1,063.10	2,948,542	-	2	8
Gwangju	501.18	1,463,770	-	-	5
Daejeon	539.46	1,502,227	-	-	5
Ulsan	1,061.18	1,165,132	-	1	4
Sejong	464.85	280,100	-	-	-
Gyeonggi-Do	10,186.29	12,873,895	23	3	(17)
Gangwon-Do	16,875.04	1,550,142	7	11	-
Chungcheongbuk-Do	7,407.66	1,594,432	3	8	(4)
Chungcheongnam-Do	8,227.45	2,116,770	8	7	(2)
Jeollabuk-Do	8,069.01	1,854,607	6	8	(2)
Jeollanam-Do	12,335.14	1,896,424	5	17	-
Gyeongsangbuk-Do	19,032.20	2,691,706	10	13	(2)
Gyeongsangnam-Do	10,539.83	3,380,404	8	10	(5)
Jeju-Do	1,850.16	657,083	(2)	-	-
Total	100,411.36	51,778,544	75	82	69

Note: The numbers in parenthesis are different types of divisions. For example, cities (Si) in a province (Do) cannot have autonomous districts (Gu) but can have general districts (Gu), which is a type of division for administrative purposes.

Source: Administrative division and population (2017); Ministry of the Interior and Safety.

there are 75 cities with current status of Si (city).

Next, I would like to compare Gun (county) with Si (city) defined as explained above. In Table A2, 162 Si (cities) and Gun (counties) in Korea are divided into 85 cities and 77 counties. Their differences are determined by their population, population density, employment, and industry structure. First, cities have on average approximately 12 times more people than counties. In addition, the population density is more than 20 times higher than that in counties, showing remarkable differences in terms of the population size and density. Similar to the population, there is a major difference in terms of the number of employees. It is important to note that the variations across cities are greater than those across counties. The standard deviations for population and employment were more than double in urban areas compared to those in rural areas. The maximum population and employment values for cities are 249 times and 577 times higher than the corresponding minimum values, while the respective differences are only 13 times and 15 times in the counties. In contrast, in terms of the industrial structure, cities and counties do not show much of a difference. On average, the share of manufacturing is higher in urban areas, and the service sector is higher in rural areas, but the differences are slight.

Figure A1 shows more clearly the differences in population and population densities between cities and counties. In all samples, the density of the population is

TABLE A2— COMPARISON BETWEEN SI AND GUN

Administrative Region	Variable	Mean	Standard Deviation	Min	Max
Si (cities)	Population	529,550	1,123,505	37,690	9,394,807
	Population Density	1,832	3,016	54	15,522
	Employment	229,661	579,270	8,851	5,108,828
	Ratio of Manufacture	22.7%	13.6%	1.1%	53.7%
	Ration of Service	70.5%	12.4%	42.6%	91.4%
Gun (counties)	Population	43,218	19,562	8,392	112,446
	Population Density	77	59	18	421
	Employment	17,753	11,120	4,073	64,542
	Ratio of Manufacture	19.0%	13.7%	3.8%	58.5%
	Ration of Service	71.1%	12.5%	37.3%	88.2%

Note: These basic statistics are from 85 Si (cities) and 77 Gun (counties). is a type of division for administrative purposes.

Source: Population Census (2015) and Census on Establishments (2015); Statistics Korea.

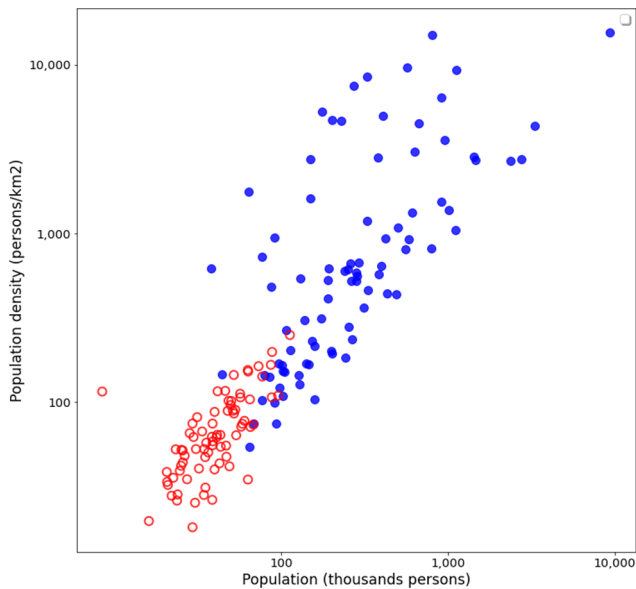


FIGURE A1. COMPARISON BETWEEN SI AND GUN: POPULATION VERSUS POPULATION DENSITY

Note: Both axes are in log scale. Si (cities) is represented by blue dots and Gun (counties) is denoted by red circles.

Source: Population Census (2015); Statistics Korea.

strongly correlated with the number of people, and counties in general have smaller populations than cities. However, the fact that some counties are larger than smaller cities that have nearly 100,000 persons and a density of 100 persons/km² suggests that the distinction between cities and counties does not simply reflect the size of the population. Therefore, if only urban areas are included in the analysis, such large counties will be excluded. In this regard, the analysis should be robust in terms of

sample selection among the 162 regions used. To this end, I will conduct an analysis with various samples.

Cities are defined as a part of a Si (city) and Gun (county) at the regional level because these criteria are actually most similar to people's living zones. In cities and counties with small populations, people rarely live and work beyond this administrative boundary, and people in large cities tend to extend their livelihoods across these boundaries due to the expanded transportation facilities. Therefore, the autonomous districts of Gu in metropolitan cities are too small to serve as a spatial unit. In particular, the Seoul metropolitan area, which includes the vicinity of Seoul in Gyeonggi-Do, can be seen as a living zone because many people commute to Seoul from various cities of Gyeonggi-Do, and people consider the entire metropolitan area as their living area. According to the Seoul Metropolitan Living Population in Seoul, the average population of those living in Seoul in the fourth quarter of 2017 was 11.5 million, which is about 1.7 million more than the 9.8 million registered residents in Seoul. When taking into account people who live in Seoul but work outside of Seoul, approximately two million people can be said to live near Seoul but work mainly in Seoul on weekdays.

However, it is not easy to define such living zones, as there is no information about where the living population of Seoul resides, either outside of Seoul or vice versa. In addition, other metropolitan cities apart from Seoul lack statistical data pertaining to the living population to define their living zones. I did not find any information about the living population of Busan, the second city of Korea, and where these people live and commute to or from the city center. On the other hand, even with this information, it is known that living zones tend to grow as the cities expand. Therefore, in this study I define cities using Si (cities) and Gun (counties).

It also should be noted that a considerable amount of the literature on regions defines regions as closely as possible to living zones. In the United States, a CBSA (core-based statistical area) is defined separately from administrative divisions and is used for statistics-based research. Most papers on Zipf's law, discussed in the next section, also find cities or statistical areas of administrative divisions based on these living areas. Accordingly, this study establishes cities as close to the living zone as the spatial units of research.

B. *Statistical Test of Empiric laws*

We estimate the coefficients of linear trends according to Zipf. Here, we denote the population of city i by S_i . According to Zipf's law, the city population has the following characteristics.

$$\ln(\text{rank}) = A - B \ln S_i.$$

In this equation, Zipf's law holds if B equals 1. To determine whether Zipf's law holds in Korea, we conduct a cross-sectional regression analysis. Table A3 shows the coefficient estimates for B in the equation for Zipf's law. From 1975 to 1985, the early data period, the estimates are between 1.1 and 1.3. This appears to be due to the fact that there are many medium-sized cities with relatively small populations at that time, before the population grew. Hence, the slope of the trend

TABLE A3—ZIPF'S LAW AND HHI OF CITIES' POPULATIONS

Year	Number of Cities	Estimates	p-value $H_0: \beta_1 = 1$	R^2	HHI
1975	67	1.291 (0.031)	0.0000	0.964	0.0943
1980	67	1.212 (0.024)	0.0000	0.974	0.1047
1985	67	1.150 (0.017)	0.0000	0.985	0.1092
1990	71	1.092 (0.010)	0.0000	0.995	0.1049
1995	72	1.037 (0.010)	0.0003	0.994	0.0909
2000	73	1.034 (0.013)	0.0101	0.989	0.0804
2005	71	1.029 (0.016)	0.0862	0.983	0.0750
2010	69	1.034 (0.020)	0.1039	0.975	0.0712
2015	70	1.037 (0.021)	0.0912	0.972	0.0675

Note: In the column of estimates, the standard errors are given in parentheses. The rank is technically defined by (rank-0.5). See Gabaix and Ibragimov (2011) in more details. The p-value is the probability of obtaining the observed results under the null hypothesis of $H_0: \beta_1 = 1$. HHI is the Herfindahl-Hirschman Index on urban populations.

Source: Population Census (1975~2015); Statistics Korea.

line appears to be steeper than a 45-degree line. After this point, however, the coefficient estimates become smaller, reaching 1 mostly due to the rapid growth of medium-sized cities. Table A3 also shows the statistical significance of the Zipf's law coefficient estimates. The null hypothesis that the coefficient for the slope of the line is 1 can be tested. The table shows the p -values of the test of the null hypothesis. From 1975 to 1990, the p -values are all close to zero, allowing rejection of the null hypothesis. In other words, there is no statistical significance until 1990 to support the contention that the estimated line has a slope of 1, which means that Zipf's law does not hold. Since 2000, the p -value increased until 2010, and the null hypothesis could not be rejected at the significance level of 1%. This means that the coefficient estimate recently approached 1. The recent populations distributions of Korean cities satisfy Zipf's law and show linearity with a slope of 1, which is consistent with the graph discussed above.

Moreover, I add a concentration indicator to the results table to highlight the change of the urban population distribution in Korea. The indicator is the Herfindahl-Hirschman Index (HHI), which is widely applied in the field of industrial organization. Similar to observing concentrations or competition in a market, this index for urban population indicates how much of a population is concentrated in a small number of cities. The index is calculated as follows:

$$HHI = \sum_{i=1}^N S_i^2,$$

TABLE A4—GIBRAT'S LAW: RELATIONSHIP BETWEEN POPULATION AND GROWTH RATE

Dependent Variable: $\Delta \ln$ Population	Year: 1975~1995		Year: 1995~2015	
	(1)	(2)	(1)	(2)
Explainable Variables				
ln Population	-0.215*** (0.072)	-3.218*** (0.774)	-0.055 (0.044)	-0.211 (0.664)
(ln Population) ²	- -	0.123*** (0.032)	- -	0.006 (0.026)
Constant	2.904*** (0.868)	21.095*** (4.738)	0.855 (0.546)	1.851 (4.266)
R^2	0.096	0.237	0.018	0.019
Number of Cities	85	85	85	85

Note: The dependent variable is the annual growth rate of population over the period described.

Source: Population Census (1975~2015); Statistics Korea.

where S_i is the population share of city i over the total population in the country. If all cities have the same population, this index will be $1/N$, where N is the total number of cities. On the other hand, the index would be close to one when the total population is clustered in one city. Thus, the index value must be between $1/N$ and 1. The index as calculated from census data varies over time. It increased until 1985, when the HHI showed its maximum value of 0.1092. Since 1985, the index has declined, reaching 0.0675 in 2015.

Gibrat's law can be confirmed through the regression analysis of population growth. Table A4 shows statistical results to verify the trends in Figure 4 in Chapter 2, Section B. I run regressions of the population growth on population size and the corresponding squared value. In the period between 1975 and 1995, the coefficient of the population squared is positive, implying a parabolic curve. All coefficients estimated are statistically significant at the 1% level. In the next two decades, on the other hand, the significance of the estimates falls, and it is difficult to identify any relationship between population and population growth. This suggests that population growth over the last 20 years is independent of the population size. As a result of analyzing the relationship between population and population growth through a basic regression analysis and graphs without any other explanatory variables, we can confirm the applicability of Gibrat's law here.

C. City List sorted by market access

TABLE A5—NON-SMA SI (CITY) LIST WITH THE HIGHEST MARKET ACCESS

Rank (of Non-SMA)	Si (Do)	Rank (of Non-SMA)	Si (Do)
1	Gyeryong (Chungcheongnam-Do)	11	Asan (Chungcheongnam-Do)
2	Kimhae (Gyeongsangnam-Do)	12	Gunsan (Jeollabuk-Do)
3	Jeonju (Jeollabuk-Do)	13	Taebaek (Gangwon-Do)
4	Yangsan (Gyeongsangnam-Do)	14	Mokpo (Jeollanam-Do)
5	Gyeongsan (Gyeongsangbuk-Do)	15	Gwangyang (Jeollanam-Do)
6	Naju (Jeollanam-Do)	16	Busan (Busan)
7	Gimjae (Jeollabuk-Do)	17	Iksan (Jeollabuk-Do)
8	Nonsan (Chungcheongnam-Do)	18	Cheonan (Chungcheongnam-Do)
9	Sejong (Sejong)	19	Samcheok (Gangwon-Do)
10	Sacheon (Gyeongsangnam-Do)	20	Gongju (Chungcheongnam-Do)

Source: Population Census (2015) and Census on Establishments (2015); Statistics Korea.

D. Robustness Checks

TABLE A6—RELATIONSHIP BETWEEN EMPLOYMENT GROWTH AND MARKET ACCESS BY CITY DEFINITION

Dependent Variable: $\Delta \ln$ Employment	Cities as of 1995		All Cities and Counties	
	(1)	(2)	(1)	(2)
Explainable Variables				
In Market Access	0.0197*** (0.00649)	0.0184*** (0.00656)	0.0204*** (0.00572)	0.0183*** (0.00586)
In Population Density	-0.0641*** (0.0129)	-0.0695*** (0.0149)	-0.0558*** (0.00897)	-0.0609*** (0.0104)
Education years	0.0117** (0.00562)	0.0140** (0.00575)	0.0139*** (0.00347)	0.0152*** (0.00362)
Age	0.00182 (0.00242)	0.0262 (0.0272)	0.00201 (0.00188)	0.0232 (0.0153)
Age ²	-	-0.0305 (0.0341)	-	-0.0260 (0.0179)
Ratio of Service	0.113*** (0.0282)	0.105*** (0.0316)	0.127*** (0.0174)	0.120*** (0.0195)
Cities	-	-	-0.00352 (0.00654)	-0.00161 (0.00664)
Constant	0.447** (0.180)	-0.0299 (0.535)	0.336*** (0.115)	-0.0857 (0.324)
Fixed-effect	YES	YES	YES	YES
R ²	0.787	0.788	0.677	0.679
# of Observation	272	272	636	636
# of Cites	68	68	159	159

Note: 1) The dependent variable is the average annual growth rate of employment over the 5-year period. *, **, and *** indicate the significance level of 10%, 5%, and 1%, respectively, 2) The robust standard errors are in parentheses, and clustered by cities, 3) Year fixed-effect and city fixed-effect are included.

Source: Population Census (1975~2015); Statistics Korea.

TABLE A7—RELATIONSHIP BETWEEN EMPLOYMENT GROWTH AND MARKET ACCESS
WITH DENSITY SQUARED

Dependent Variable: $\Delta \ln$ Employment	Pooled OLS		Fixed-effect model	
Explainable Variables	(1)	(2)	(1)	(2)
In Market Access	0.00234*** (0.000457)	0.00238*** (0.000456)	0.0189*** (0.00641)	0.0168*** (0.00614)
In Population Density	-0.00334 (0.00766)	-0.00502 (0.00789)	0.0124 (0.0693)	0.0131 (0.0648)
(In Population Density) ²	-0.0421 (0.0537)	-0.0323 (0.0549)	-0.508 (0.529)	-0.568 (0.491)
Education years	0.00679** (0.00310)	0.00646** (0.00311)	0.0156*** (0.00509)	0.0195*** (0.00591)
Age	-0.00316** (0.00129)	0.0234** (0.0116)	0.00173 (0.00242)	0.0410 (0.0260)
Age ²		-0.0331** (0.0145)		-0.0488 (0.0325)
Ratio of Service	0.00749 (0.0116)	0.00579 (0.0117)	0.111*** (0.0231)	0.101*** (0.0253)
Cities	-0.0253*** (0.00799)	-0.0237*** (0.00793)	-0.00802 (0.00707)	-0.00687 (0.00667)
Constant	0.140* (0.0750)	-0.379* (0.228)	0.127 (0.269)	-0.685 (0.603)
Year Fixed-effect	YES	YES	YES	YES
Citi Fixed-effect	NO	NO	YES	YES
F-statistics	-	-	177.51	183.65
R ²	0.603	0.606	0.725	0.729
# of Observation	332	332	332	332
# of Cites	83	83	83	83

Note: 1) The dependent variable is the average annual growth rate of employment over the 5-year period. *, **, and *** indicate the significance level of 10%, 5%, and 1%, respectively, 2) The robust standard errors are in parentheses, and clustered by cities, 3) Among 85 cities, Jeju and Seoguiipo are excluded.

Source: Population Census (1995~2015); Statistics Korea.

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