**The Empirical Research on Role of primacy on Income convergence across region in South Korea**

Jinwoo, Dong[[1]](#footnote-1)\*ㆍYoungduk Kim[[2]](#footnote-2)\*\*

This paper examines the effect of primacy on gap of convergence using regional panel data in South Korea during 2000- 2014. We employ heterogeneity convergence model with various version of primacy to estimate the speed of income convergence in South Korea. We then analyze the difference in the speed of convergence between SMA (Seoul metropolitan area) and ROR (rest of regions). The findings follow as: first, the speed of convergence of SMA is more rapidly than that for ROR. Second, primacy is more relevant to income growth for ROR. Finally, the speed of income convergence for ROR is gradually reduced with increasing primacy. From estimation of convergence rate, we find that inequality income growth is more deepened with reinforced primacy.

**JEL classify: O18, O43, O53**

**Key word: speed of convergence, parameter heterogeneity, primacy**

**Ⅰ. Introduction**

Incheon is located nearby Seoul which is capital city in South Korea, and Daegu is the largest city among the neighborhood. In 2000, population size of Incheon reversed that of Daegu. Their difference in size henceforth has been maintained. It is associated with inequality income growth across regions

In the economic development literature, the gap of income growth across region is to be less than across countries (Lucas, 1988; Barro, 1991). However, the example of Incheon and Daegu illustrates that difference in income could sustainedly appears across regions. Another strand of literature has tended to focus on the issue of inequality growth across regions. In the spatial equilibrium context, Increasing urban size enhances knowledge spillover effect and may changes industrial composition (Au and Henderson, 2006a, 2006b; Henderson, 2009). Theses imply agglomeration effect with growth of urban scale (Behrens and Robert-Nicoud, 2014; Ahrend et al., 2017). Second, due to various barriers of factor mobility, the growth rate across region can be similar to that across countries (Gennaioli et al, 2014; Kim, 2015).

In addition, we propose that primacy is also related to inequality income growth between regions. Primacy represents the share of the largest city in national population, and has been shown agglomeration effect and barriers of factor mobility. First, concentration of primacy means that Individual with skills and human capital, economic infrastructure, and political institutions in countries may migrate to primate city and suburb (Lucas, 1988; Henderson, 2009). Therefore, primacy may describe asymmetric factor mobility. Second, primacy has more agglomeration effect than the other larger cities in countries since primate city is the biggest city in country, and enhances productivity growth (Henderson, 2003, 2009). Furthermore, disproportionately more skilled workers choose to live in primate city due to earning higher wage (Eeckhout et al., 2010; Behrens and Robert-Nicoud, 2014; Davis and Dingel, 2014). Eventually, concentration of primacy may generate reinforced inequality income growth between primate city and the other regions.

In South Korea, representative primate area is Seoul Metropolitan Area (SMA). Incheon is included in SMA compared with Daegu which is noted as one of local big cities in rest of regions in South Korea (ROR). Therefore, the reversal of size and income between Incheon and Daegu can be associated with primacy of SMA. We show how primacy of SMA effects on inequality income growth between SMA and ROR. Our empirical analysis firstly finds out whether heterogeneous convergence reveals across regions, such as SMA and ROR. In addition, we investigate that increasing primacy of SMA leads the gap of income growth between them.

There are many previous paper associated with primacy. While theses have proposed how to the degree of primacy effect on economic growth in countries or what to role of primacy on urban economic, It has less to say about linking primacy to convergence rate. Wheaton and Shishido (1992) and Junius (1999) estimate Bell-shaped relationship between primacy and economic growth in countries using cross-section data. Henderson (2003) also shows inverse U-shaped between productivity growth and primacy using panel data. Kim el al. (2013) investigates How impact magnitude of SMA concentration impact on economic growth in South Korea. With respect to regional economic growth, Dong and Kim (2015) propose that SMA concentration is more significantly correlated to growth rate than local biggest cities in South Korea.

The main contribution of this research is to examine whether speed of convergence between regions is shown differently depending on primacy of SMA. We empirically present heterogeneous convergence model between SMA and ROR based on Durlauf et al. (2001) which proposed heterogeneity parameter of convergence rate across countries.

In economic growth context, furthermore, primacy is accompanied by outcome growth (Hederson, 2003, 2010). It means that estimates of OLS are biased due to correlated between primacy and income growth in regions. For treating these potential endogeneity, we estimate fixed effect-2SLS, FE2SLS and fixed effect-GMM, FEGMM to utilize instrument variables.

In previous studies related to urban scale, primacy is typically defined to share of largest city on national population (Henderson, 2003). According to Ahrend et al. (2016) and Kerr et al. (2017), workers with higher skill or human capital should migrate to larger city due to agglomeration economies and knowledge spillover. Hence, primacy may be more appropriately defined as human capital or worker than population. We estimate our regression to use various version of primacy measured by, such as, population, worker, and worker with human capital.

The rest of paper is organized as follows. Section 2 presents the basic model of convergence regression, characterizes heterogeneity parameter depended on concentration of SMA and propose treatment of endogeneity problem using instrument variables. Section 3 we show results of estimates. Section 4 concludes.

**Ⅱ. Method**

**2.1. Convergence Model**

In this section we study regional parameter heterogeneity model in context to the neoclassical growth model or Solow growth model. According to Barro (1991) we consider the canonical Solow growth regression with labor-augmenting technological change as follows:

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|  | (1) |

Where is growth rate in capita in province in year, is output per, is initial condition, is steady-state in province , and is error term. The parameter indicates speed of -convergence, defined as . Following Barro and Sala-I-Martin (1995), we note that is , is, and is unobserved fixed effect across regions.

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|  | (2) |

In equation (2), if the data for economic structure and environment differs considerably between countries, then, issue of heterogeneity parameter is raised (Harbeger, 1987). Durlauf et al. (2001) and Mamunease et al. (2006) find evidence of this parameter heterogeneity using countries data. We examine parameter heterogeneity across regions within country. While previous studies has much to say about that convergence rate across regions is similar than across countries (Lucas, 1988; Barro 1991), there are several reasons, as to why parameter heterogeneity may emerge across regions. They are related to agglomeration economies in primate area.

First, convergence rate is heterogeneous due to factor mobility barriers between regions (Gennaioli et al, 2014; Kim, 2015). Since these barriers have influenced transition to polices, financial and social structures across regions, there are different to structure across regions.

Second, we consider role of primacy accounting for inequality income growth between regions. Primacy is defined as the degree of concentration for population in metropolitan area or primate area, for instances, capital city and suburbs (Henderson, 2003). Key feature of primacy is referred to location of agglomeration effect and changing industrial composition (Au and Henderson, 2006a, 2006b; Henderson, 2003, 2010). Furthermore, it is noted that city size and density is endogenously determined by individuals choice according to trade off benefits and cost in city; called ‘sorting city’ (Davis and Dingel, 2014; Behrens and Robert-Nicoud, 2014). According to sorting city, disproportionately more skilled workers choose to locate in primate city or metropolitan area due to earning higher wage and to acquiring high-skill. Therefore, primacy by sorting city also means that primate area has knowledge spillovers by concentrated skilled workers (Eaton and Eckstein, 1997; Henderson, 2003; Davis and Dingel, 2014). Therefore, income growth for primate area is more increasing at a time compared with non-primate area.

Finally, primacy is described as that workers, firms, and financial resources may move to primate area. It can be noted as asymmetric factor mobility. In particular, asymmetric pattern of factor mobility leads to increasing income and productivity growth in primate area due to concentrated resources to primate area. (Gennaioli et al, 2014; Kerr el al., 2016; Ahrend, R., et al., 2017),

In the example of Incheon and Daegu above, the gap between two cities may be associated with geographic concentration of primate area such as SMA. While steady-state across regions is similar, the speed of convergence across regions may be different with primacy. These patterns may generate that the inequality income growth between regions is deepened. We develop equation (2) to the heterogeneity convergence regression, as following Durlauf et al. (2001).

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|  | (3) |

Where describes whether province is included in primate area: sma is SMA (Seoul Metropolitan Area) such as primate area and ror is ROR (Rest Of Regions). Since we assume that convergence rate differ between SMA and ROR with the degree of primacy, is given as function by.

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|  | (4) |

When indicates primacy defined degree of SMA concentration. We give equation (4) linear function, as follow:

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|  | (5) |

To construct a proxy for steady-state, , we use GDP per capita, . Supposing free factor mobility, path of income growth for regions tends to be converged to path of income growth for the country (Gennaioli et al, 2014). This paper assumed that relationship between and is defined as . is barriers for factor mobility in province within region In addition, when same factor mobility across provinces holds (), which means barriers of factor mobility exist across region such as, SMA and ROR, the relationship function can be illustrated as . To be plugged equation (5) and this function, our regression can be written as equation (6) rearranging equation (3).

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|  | (6) |

In equation (6), coefficients for speed of convergence are , , , . We expect that beta-convergence across regions is present, according to Solow regression context, as follows: , and for all .

A key feature of our study is that the gap of convergence rates depends on the coefficients of primacy (,). When beta convergence across regions holds, there are two results that income growth for SMA is faster than ROR with increasing primacy. First, under to be shown and for all , and means that reinforced primacy allow to be faster the speed of convergence for SMA than that for ROR. Second, given and for all , and indicates that primacy may has role of barrier accounting for convergence rate of ROR.

**2.2. Empirical strategy**

We concern two econometric tasks to estimate equation (6). Our first task is to deal with fixed effects, within . If is correlated with any of the covariates, pooled OLS estimation (POLS) would yield biased. To examine F-test, we show which estimator is more reliable between fixed effect estimation (FE) and POLS.

Our second econometric task is potential endogeneity. While urban scale and income growth is correlated, the ‘causal effect’ of primacy on income growth is ambiguous (Henderson, 2003). Due to these correlation, estimation POLS of convergence could be also biased. Therefore, we should identify the causality between primacy and GRDP.

Firstly, dependent variable or the error terms, is exogenous to predetermined covariates. According to Henderson (2003), we utilize lagged variables for primacy (,) to estimate our equation as follow:

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|  | (7) |

Arguably, using predetermined covariates, however, is not strictly exogenous. We examine 2SLS and GMM estimation using instrument variables in order to take account of this potential endogeneity. It is important issue to choose good instrument variables. The validity of instruments take account of two conditions: first, good instruments are strictly correlated by covariates. Second, they are not shown correlation with the error-term, . These conditions imply that our instruments should be associated with primacy, and should not be related to regional income growth.

We consider factors for sorting city as instruments satisfied above conditions. In urban economic literature, sorting city is referred why workers migrate to larger cities or primate areas. It means that city or region size is endogenously determined by individuals choice according to trade off benefits and cost in city (Combes et al, 2008; Behrens and Robert-Nicoud, 2014; Davis and Dingel, 2014). In free mobility, workers with heterogeneity skill want to earn higher wages, acquire knowledge accumulation, consume amenities, and take a good job. Due to agglomeration effect for knowledge, workers with high human tend to seek these things above in larger cities (Lucas, 1988; Behrens and Robert-Nicoud, 2014)

In this paper, we present that instruments related sorting SMA are wages and job quality. Workers choose where they live according to expected earning in region. In addition, big firms which provide high wages and better working environments also tend to locate in larger cities in order to seek workers with high human capital (Davis and Dingel, 2014). We utilize, therefore, that wages of primate area called primacy wage, and job quality in SMA called primacy job as instrument variables.

The validity test of these instruments can be examined using Hansen J test which shows that correlation between instruments and error-term. According to Anderson-Rubin test, moreover, we test whether our instruments are weak instrument variables which is instruments are not correlated with primacy.

**Ⅲ Results**

**3.1. Data**

For the empirical analysis in this paper, we mainly gather regional panel data for 16 provinces from 2000 to 2014 in South Korea from KOSIS (Korea statistical information service). According to KOSIS, regional output is measured using GRDP (Gross regional domestic product) and population for 16 provinces. Our proxy variables for steady-state are GDP per capita in South Korea. Instrument variables are collected also from KOSIS. We note that primacy wage is average wage rate for SMA calculated by labor income and operating surplus in provinces from KOSIS primacy job is noted share of large size firms (i.e. above 1000 workers) in SMA on the other regions.

Our mainly focus is the degree of primacy for SMA, . The first issue for primacy is how to define SMA (Seoul Metropolitan Area). In this paper, we suggest that definition of SMA includes Seoul which is capital city in South Korea and neighborhood, such as Incheon, and Gyeonggi-do. It is consistent of legislation for SMA in South Korea. Except SMA, the others regions is indicated as ROR (Rest of Region).

The second issue is definition of primacy. In the urban economic context, primacy for SMA can be noted the degree of population concentration in SMA (Henderson, 2003). Agglomeration effect is associated with why many literatures suggest that population concentration is referred as primacy. There are two sources. First, abundant labor market is located in large size cities. Second, high population concentration easily occur knowledge spillover (Duranton and Puga, 2003; Davis and Dingel, 2012). Therefore, population concentration for SMA is available to use how primacy effects on regional income growth (Henderson, 2003).

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| [Table 1] Index for variables |
| variables | definition | period |
|  | GRDP per capita in regions | 2000~2014 |
|  | GDP per capita | 2000~2014 |
| Instrument variables | Primacy wage | Labor income for provinceoperating surplus in provinces | 2000~2014 |
| Primacy job quality | share of large size firms in SMA on the other regions. | 2000~2014 |
|  | Primacy | Concentration of population | 2000~2014 |
| Worker primacy | Concentration of workers  | 2000~2014 |
| Primacy of human capital (1) | Average year of education for worker graduated high school, collage, and university. | 2000~2014 |
| Primacy of human capital (2) | Average year of education for worker graduated collage, and university.. | 2000~2014 |
| Source: KOSIS(Korea statistical information service: <http://kosis.kr/> 2017.01.16.) |

Arguably, we consider what aspects of population are effects on income growth. As we know above, transforming industrial composition from manufacturing to financial services and to R&D tasks takes place with increasing population in larger cities (Au and Henderson, 2006a, 2006b; Henderson, 2003, 2010). These industries are required abundant labor market with high human capital (Lucas, 1988; Black and Henderson, 1999; Davis and Dingel, 2014). Consequently, we should note primacy measured by not only population concentration, but also concentration of worker and of human capital.

The final issue is how to measure primacy. There are two measures that previous studies use. First, urban primacy is available to be measured typically to share of SMA in national population (Junius, 1999; Henderson, 2003). Second, Hirschman-Herfindahl index of primacy concentration (HHI) is used, which is defined the sum of squared shares of SMA in national population (Wheaton, W.C., and H. Shishido, 1981). We use both urban primacy and HHI for robustness estimation.

Our primacy variables are gathered by KOSIS using measurement of urban primacy and HHI. In addition, primacy of worker is concentration of worker for SMA. Primacy of human capital is two types to be calculated by average education year of workers (Yu and Park, 2004). Human capital (1) is average year of high school, college, and university of workers. Human capital (2) is average year of college, and university of workers.

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| <Figure 1> Trend of primacy |
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| Note: Human capital (1) is measured by average education year of worker included high school, collage, and universityHuman capital (2) is measured by average education year of worker included collage, and university Source: KOSIS(Korea statistical information service: <http://kosis.kr/> 2017.01.16.) |

<Fig. 1> is shown trend of primacy at time. It is shown that primacy of population is increasing gradually during 2000-2014. In 2014, share of population in SMA is 50% while primacy of population is 46% in 2000. It is similar primacy of worker. The difference in trend between them is that worker of primacy is a little faster than population primacy. In addition, above 50% of workers is concentrated in SMA from 2011 to 2014. In trend of primacy of human capital, it is densified in SMA. First, It is concentrated above 50% in SMA after 2000. Second, It is shown that that worker graduated such as high school, and university is more densely than worker graduated such as high school, college, and university. Consequently, primacy of SMA for all types is increasing, and more related to human capital is bigger degree of primacy.

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| <Figure 2> Trend of gap between regions |
| Panel (a) |
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| Panel (a) |
|  |
| Source: KOSIS(Korea statistical information service: <http://kosis.kr/> 2017.01.16.) |

<Fig. 2> illustrates the economic gap between SMA and ROR. In panel (a) we show the gap of wage rate between SMA and ROR. Their gaps are maintained constantly from 2000 to 2014. Panel (b) presents the gap of the number of bigger firms which have above 1000 workers in SMA compared with ROR. We show bigger firms are more located to SMA than ROR. Moreover, their difference has been increasing since 2000. According to panel (a) and (b), we find that many bigger firms tend to be concentrated in SMA since have advantage to seek workers with high human capital.

**3.2. Empirical results**

**3.2.1. Speed of convergence by population primacy**

According to estimation of equation (7) utilizing POLS, FE, FE2SLS, and FEGMM, we investigate the gap of convergence rate between SMA and ROR with increasing primacy. <Table 2>, and <Table 3> shows the results of estimation for population primacy of SMA measured urban primacy and HHI index. <Table 2> presents estimation of SMA, and <Table 3> illustrates estimation of ROR.

In particular, our instruments tests for <Table 2> and <Table 3> indicate that Hansen J test does not reject null hypothesis which is not correlated between instruments and residuals at significant 10%, and both Anderson-Rubin F-test, and -test are significant at 1 %, which implies our instruments are not weak instruments variables. Following results for test, instruments are empirically appropriate. In addition, p-value of F-test for unobserved time invariant effect is significant. Consequently, FE2SLS and FEGMM are more reliable than OLS, and FE. In addition, GMM estimated standard errors in small samples are consistently low is referred (see Arellano and Bond, 1991; see Henderson, 2003). As <Table 2> and <Table 3> indicated standard errors of GMM is lower than that of 2SLS, our mainly results is noted from FEGMM.

Following columns (7) and (8) in <Table 2> using FEGMM, while results of coefficients such as is negative and is positive, significant of column (7) measured urban primacy differ from that of column (8) measured HHI index. Coefficients in column (7) are not significant in contrast column (8) since limitation of data. Second, coefficients of convergence rate with primacy () are shown negative and insignificant. Therefore, reinforced primacy of SMA is irrelevant to speed of convergence for SMA. Third, which is response of GDP growth is larger than which is response of GRDP growth. It implies that barriers for factor mobility occur within SMA.

In the results for column (7)-(8) in <Table 3>, we find is negative and is positive. It is similarly <Table 2> described. Our mainly results are that coefficients of convergence rate with primacy () in ROR are statistically significant. We find that response of GRDP growth with primacy, is negative and response of GDP growth with primacy, , Findings illustrate that increasing primacy reduces the speed of convergence for ROR.

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| [Table 2] Results of population primacy: SMA |
| Variables | OLS | FE | FE2SLS | FEGMM |
| (1) primacy | (2)HHI | (3) primacy | (4)HHI | (5) primacy | (6)HHI | (7) primacy | (8)HHI |
|  | -0.141 | -0.086 | -0.584\*\*\* | -0.611\*\*\* | -0.721 | -0.683\*\* | -0.579 | -0.584\*\* |
| (0.118) | (0.064) | (0.033) | (0.118) | (0.481) | (0.287) | (0.421) | (0.276) |
|   | 0.509\*\*\* | 0.416\*\* | 0.770\*\* | 0.777\*\*\* | 0.987\*\*\* | 0.905\*\*\* | 0.967\*\*\* | 0.920\*\*\* |
| (0.180) | (0.171) | (0.085) | (0.180) | (0.247) | (0.164) | (0.220) | (0.160) |
|  | 0.241 | 0.263 | -0.113 | -0.111 | 0.147 | 0.153 | -0.056 | -0.071 |
| (0.231) | (0.239) | (0.439) | (0.215) | (0.887) | (0.897) | (0.758) | (0.825) |
|  | -0.492\*\* | -0.540\*\* | -0.029 | -0.048 | -0.364 | -0.381 | -0.223 | -0.225 |
| (0.193) | (0.203) | (0.471) | (0.212) | (0.833) | (0.830) | (0.709) | (0.760) |
| constant | -4.144 | -4.463 | -1.998\* | -2.206 |  |  |  |  |
| (2.919) | (2.954) | (0.665) | (2.668) |  |  |  |  |
| Obs | 45 | 45 | 45 | 45 | 36 | 36 | 36 | 36 |
| AR-F |  |  |  |  | 6.23\*\*\* | 6.23\*\*\* | 6.23\*\*\* | 6.23\*\*\* |
| AR- |  |  |  |  | 49.34\*\*\* | 49.34\*\*\* | 49.34\*\*\* | 49.34\*\*\* |
| Hansen J |  |  |  |  | 5.164 | 4.909 | 5.164 | 4.909 |
| Notes: The number in parentheses are standard errors\*\*\* Significant 1%, \*\* Significant 5%,\* Significant 10%.Primacy and HHI implies SMA concentration F-test is supported FE modelAR-F and AR- is Anderson-Rubin Wald test |

In <Table 4>, we calculate both convergence rate, and between SMA and ROR. Since coefficients of convergence rate with primacy measured by urban primacy are not significant, we do not note the results of them. Results of <Table 4> show that is negative, and is positive. These imply beta-convergence for regions. Second, The findings indicate difference compared to the response of GRDP, , and the response of GDP, . It is consistent to assumption of barriers of factor mobility. The most important evidences describe that reinforced primacy for population may reduce the speed of convergence for ROR. Hence, the difference in income growth between SMA and ROR may be deepened with primacy.

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| [Table 3] Results of population primacy: ROR |
| Variables | OLS | FE | FE2SLS | FEGMM |
| (1) primacy | (2)HHI | (3) primacy | (4)HHI | (5) primacy | (6)HHI | (7) primacy | (8)HHI |
|  | -0.027 | -0.015 | -0.222\*\*\* | -0.209\*\*\* | -0.601\*\*\* | -0.460\*\*\* | -0.655\*\*\* | -0.495\*\*\* |
| (0.065) | (0.033) | (0.071) | (0.040) | (0.165) | (0.092) | (0.154) | (0.087) |
|   | 0.280\*\*\* | 0.244\*\* | 0.428\*\*\* | 0.395\*\*\* | 0.976\*\*\* | 0.763\*\*\* | 1.028\*\*\* | 0.792\*\*\* |
| (0.104) | (0.096) | (0.089) | (0.091) | (0.172) | (0.131) | (0.165) | (0.129) |
|  | 0.058 | 0.068 | 0.061 | 0.070 | 0.583\* | 0.605\* | 0.662\*\* | 0.686\*\* |
| (0.134) | (0.138) | (0.102) | (0.104) | (0.325) | (0.331) | (0.299) | (0.310) |
|  | -0.227\* | -0.255\*\* | -0.197\* | -0.220\*\* | -0.880\*\*\* | -0.908\*\*\* | -0.968\*\*\* | -0.998\*\*\* |
| (0.120) | (0.125) | (0.091) | (0.097) | (0.331) | (0.335) | (0.304) | (0.313) |
| constant | -2.864\* | -3.103\* | -2.345\* | -2.540\* |  |  |  |  |
| (1.547) | (1.581) | (1.278) | (1.407) |  |  |  |  |
| Obs | 195 | 195 | 195 | 195 | 156 | 156 | 156 | 156 |
| AR-F |  |  |  |  | 4.07\*\*\* | 4.07\*\*\* | 4.07\*\*\* | 4.07\*\*\* |
| AR- |  |  |  |  | 25.90\*\*\* | 25.90\*\*\* | 25.90\*\*\* | 25.90\*\*\* |
| Hansen J |  |  |  |  | 6.452 | 6.471 | 6.452 | 6.471 |
| Notes: The number in parentheses are standard errors\*\*\* Significant 1%, \*\* Significant 5%,\* Significant 10%.Primacy and HHI implies SMA concentration F-test is supported FE modelAR-F and AR- is Anderson-Rubin Wald test |

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| [Table 4] Convergence rate between SMA and ROR: population primacy  |
| model | Urban primacy | HHI |
|  |  |  |  |
| SMA | FE2SLS | . | 0.987 | -0.683 | 0.905 |
| FEGMM | . | 0.967 | -0.584 | 0.920 |
| ROK | FE2SLS | -0.312 | 0.539 | -0.311 | 0.539 |
| FEGMM | -0.326 | 0.547 | -0.326 | 0.546 |
| Notes: we do not use value of significant below at 10% level. degree of primacy is maximum value.  |

**3.2.2. Speed of convergence by primacy for workers**

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| [Table 5] Results of primacy for workers: SMA |
| Variables | OLS | FE | FE2SLS | FEGMM |
| (1) primacy | (2)HHI | (3) primacy | (4)HHI | (5) primacy | (6)HHI | (7) primacy | (8)HHI |
|  | -0.011 | -0.021 | -0.594\*\*\* | -0.602\*\*\* | -0.590\*\* | -0.539\*\* | -0.606\*\*\* | -0.554\*\* |
| (0.087) | (0.051) | (0.050) | (0.120) | (0.229) | (0.226) | (0.211) | (0.218) |
|   | 0.379\*\* | 0.342\*\* | 0.721\*\*\* | 0.721\*\*\* | 1.036\*\*\* | 0.941\*\*\* | 1.013\*\*\* | 0.910\*\*\* |
| (0.146) | (0.148) | (0.024) | (0.164) | (0.234) | (0.190) | (0.218) | (0.187) |
|  | -0.034 | -0.029 | -0.042 | -0.048 | 0.151 | 0.161 | 0.171 | 0.178 |
| (0.150) | (0.149) | (0.055) | (0.122) | (0.346) | (0.356) | (0.310) | (0.342) |
|  | -0.173 | -0.187\* | -0.055 | -0.060 | -0.427 | -0.456 | -0.443 | -0.465 |
| (0.112) | (0.110) | (0.072) | (0.097) | (0.436) | (0.447) | (0.390) | (0.429) |
| constant | -4.512 | -4.554\* | -1.370 | -1.588 |  |  |  |  |
| (2.691) | (2.696) | (0.914) | (2.540) |  |  |  |  |
| Obs | 45 | 45 | 45 | 45 | 36 | 36 | 36 | 36 |
| AR-F |  |  |  |  | 6.23\*\*\* | 6.23\*\*\* | 6.23\*\*\* | 6.23\*\*\* |
| AR- |  |  |  |  | 49.34\*\*\* | 49.34\*\*\* | 49.34\*\*\* | 49.34\*\*\* |
| Hansen J |  |  |  |  | 2.883 | 2.742 | 2.883 | 2.742 |
| Notes: The number in parentheses are standard errors\*\*\* Significant 1%, \*\* Significant 5%,\* Significant 10%.Primacy and HHI implies SMA concentration F-test is supported FE modelAR-F and AR- is Anderson-Rubin Wald test |

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| [Table 6] Results of primacy for workers: ROR |
| Variables | OLS | FE | FE2SLS | FEGMM |
| (1) primacy | (2)HHI | (3) primacy | (4)HHI | (5) primacy | (6)HHI | (7) primacy | (8)HHI |
|  | 0.043 | 0.021 | -0.151\*\* | -0.169\*\*\* | -0.314\*\*\* | -0.303\*\*\* | -0.334\*\*\* | -0.312\*\*\* |
| (0.036) | (0.018) | (0.059) | (0.054) | (0.075) | (0.057) | (0.074) | (0.057) |
|   | 0.281\*\*\* | 0.270\*\*\* | 0.431\*\*\* | 0.421\*\*\* | 0.805\*\*\* | 0.738\*\*\* | 0.853\*\*\* | 0.770\*\*\* |
| (0.083) | (0.084) | (0.077) | (0.080) | (0.133) | (0.118) | (0.131) | (0.117) |
|  | -0.088 | -0.088 | -0.075 | -0.074 | 0.041 | 0.048 | 0.077 | 0.081 |
| (0.074) | (0.074) | (0.070) | (0.072) | (0.124) | (0.126) | (0.120) | (0.122) |
|  | -0.083 | -0.094\* | -0.070 | -0.079 | -0.304\*\* | -0.321\*\* | -0.362\*\*\* | -0.377\*\*\* |
| (0.055) | (0.055) | (0.053) | (0.053) | (0.144) | (0.146) | (0.139) | (0.140) |
| constant | -4.064\*\*\* | -4.177\*\*\* | -3.539\*\* | -3.624\*\* |  |  |  |  |
| (1.424) | (1.447) | (1.347) | (1.398) |  |  |  |  |
| Obs | 45 | 45 | 45 | 45 | 36 | 36 | 36 | 36 |
| AR-F |  |  |  |  | 6.23\*\*\* | 6.23\*\*\* | 6.23\*\*\* | 6.23\*\*\* |
| AR- |  |  |  |  | 49.34\*\*\* | 49.34\*\*\* | 49.34\*\*\* | 49.34\*\*\* |
| Hansen J |  |  |  |  | 2.883 | 2.742 | 2.883 | 2.742 |
| Notes: The number in parentheses are standard errors\*\*\* Significant 1%, \*\* Significant 5%,\* Significant 10%.Primacy and HHI implies SMA concentration F-test is supported FE modelAR-F and AR- is Anderson-Rubin Wald test |

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| --- |
| [Table 7] Convergence rate between SMA and ROR |
| model | Primacy | HHI |
|  |  |  |  |
| SMA | FE2SLS | -0.590 | 1.036 | -0.539 | 0.941 |
| FEGMM | -0.606 | 1.013 | -0.554 | 0.910 |
| ROK | FE2SLS | -0.314 | 0.652 | -0.303 | 0.657 |
| FEGMM | -0.334 | 0.671 | -0.312 | 0.674 |
| Notes: we do not use value of significant below at 10% level. degree of primacy is maximum value.  |

<Table 5> and <Table 6> is shown the results of estimation for primacy of SMA for workers, which is also measured urban primacy and HHI index. Results of <Table 5> are estimation of SMA, and Results of <Table 3> are estimation of ROR.

Test of instrument variables is shown consistent above. For <Table 5> and <Table 6>, Hansen J test is passed, and the value of Anderson-Rubin tests are statistically significant at 1% level. In addition, standard errors of estimation using FEGMM are the lowest, hence results of FEGMM using instruments are reliable among all estimations.

 We compare findings of column (7)-(8) in <Table 5> and in <Table 6>. It is similar estimates of and to <Table 2> and <Table 3>. One difference is that all coefficients of and are significant. For both SMA and ROR, the coefficients of convergence with primacy () show that is negative, and is positive. While their coefficients are shown consistently direction between SMA and ROR, level of significant is different. is only significant for ROR. These evidences present that increasing primacy for workers tend to decrease response of GDP growth in ROR.

According to <Table 7>, beta convergence occurs in SMA and ROR, and the difference in convergence between them is shown. As can be seen, the gap of income growth is increasing with primacy for worker. In particular, more concentration of worker to SMA means income growth in ROR is slowly.

**3.2.3. Speed of convergence by primacy for human capital (1)**

<Tale 8> and <Table 9> illustrates the results of estimation using primacy for human capital (1) for SMA which is measured by average year of education for worker graduated high school, collage, and university. All FEGMM estimations in this section pass Hansen J test and Anderson Rubin test, and show the low standard errors compared with the other estimations. In addition, FEGMM estimations of column (7)-(8) in <Table 8>, <Table 9> and <Table 10> are similar to <Table 5> and in <Table 6>. The primacy for human capital (1) reduced gradually convergence rate in ROR. In particular, increasing primacy for SMA decreases to the response of GDP growth.

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| [Table 8] Results of primacy for human capital (1): SMA |
| Variables | OLS | FE | FE2SLS | FEGMM |
| (1) primacy | (2)HHI | (3) primacy | (4)HHI | (5) primacy | (6)HHI | (7) primacy | (8)HHI |
|  | 0.002 | -0.014 | -0.613\*\*\* | -0.632\*\*\* | -0.611\*\* | -0.609\*\* | -0.541\*\* | -0.550\*\* |
| (0.073) | (0.046) | (0.027) | (0.117) | (0.280) | (0.236) | (0.249) | (0.229) |
|   | 0.138 | 0.116 | 0.649\*\*\* | 0.649\*\*\* | 0.831\*\*\* | 0.777\*\*\* | 0.773\*\*\* | 0.725\*\*\* |
| (0.091) | (0.089) | (0.053) | (0.132) | (0.169) | (0.168) | (0.155) | (0.162) |
|  | -0.061 | -0.055 | -0.070 | -0.066 | -0.004 | -0.002 | -0.047 | -0.045 |
| (0.112) | (0.104) | (0.111) | (0.088) | (0.283) | (0.267) | (0.223) | (0.226) |
|  | -0.076 | -0.073 | -0.005 | -0.006 | -0.205 | -0.197 | -0.179 | -0.169 |
| (0.072) | (0.067) | (0.094) | (0.062) | (0.251) | (0.236) | (0.196) | (0.198) |
| constant | -1.105 | -1.079 | 0.049 | 0.033 |  |  |  |  |
| (1.625) | (1.622) | (0.733) | (1.466) |  |  |  |  |
| Obs | 45 | 45 | 45 | 45 | 36 | 36 | 36 | 36 |
| AR-F |  |  |  |  | 6.23\*\*\* | 6.23\*\*\* | 6.23\*\*\* | 6.23\*\*\* |
| AR- |  |  |  |  | 49.34\*\*\* | 49.34\*\*\* | 49.34\*\*\* | 49.34\*\*\* |
| Hansen J |  |  |  |  | 3.628 | 3.556 | 3.628 | 3.556 |
| Notes: The number in parentheses are standard errors\*\*\* Significant 1%, \*\* Significant 5%,\* Significant 10%.Primacy and HHI implies SMA concentration F-test is supported FE modelAR-F and AR- is Anderson-Rubin Wald test |

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| --- |
| [Table 9] Results of primacy for human capital (1): ROR |
| Variables | OLS | FE | FE2SLS | FEGMM |
| (1) primacy | (2)HHI | (3) primacy | (4)HHI | (5) primacy | (6)HHI | (7) primacy | (8)HHI |
|  | 0.057\* | 0.028\* | -0.147\*\* | -0.171\*\*\* | -0.336\*\*\* | -0.326\*\*\* | -0.344\*\*\* | -0.333\*\*\* |
| (0.032) | (0.017) | (0.057) | (0.035) | (0.088) | (0.070) | (0.083) | (0.068) |
|   | 0.098\* | 0.091\* | 0.286\*\*\* | 0.279\*\*\* | 0.651\*\*\* | 0.575\*\*\* | 0.660\*\*\* | 0.581\*\*\* |
| (0.051) | (0.050) | (0.057) | (0.055) | (0.104) | (0.095) | (0.101) | (0.094) |
|  | -0.105\* | -0.096\* | -0.089 | -0.082\* | 0.038 | 0.037 | 0.038 | 0.037 |
| (0.059) | (0.055) | (0.053) | (0.046) | (0.108) | (0.102) | (0.099) | (0.095) |
|  | -0.023 | -0.024 | -0.020 | -0.021 | -0.285\*\*\* | -0.270\*\*\* | -0.291\*\*\* | -0.274\*\*\* |
| (0.038) | (0.035) | (0.037) | (0.032) | (0.107) | (0.100) | (0.097) | (0.092) |
| constant | -1.431\* | -1.405 | -1.343 | -1.318\* |  |  |  |  |
| (0.855) | (0.855) | (0.775) | (0.772) |  |  |  |  |
| Obs | 195 | 195 | 195 | 195 | 156 | 156 | 156 | 156 |
| AR-F |  |  |  |  | 4.07\*\*\* | 4.07\*\*\* | 4.07\*\*\* | 4.07\*\*\* |
| AR- |  |  |  |  | 25.90\*\*\* | 25.90\*\*\* | 25.90\*\*\* | 25.90\*\*\* |
| Hansen J |  |  |  |  | 3.236 | 3.195 | 3.236 | 3.195 |
| Notes: The number in parentheses are standard errors\*\*\* Significant 1%, \*\* Significant 5%,\* Significant 10%.Primacy and HHI implies SMA concentration F-test is supported FE modelAR-F and AR- is Anderson-Rubin Wald test |

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| --- |
| [Table 10] Convergence rate between SMA and ROR |
| model | Primacy | HHI |
|  |  |  |  |
| SMA | FE2SLS | -0.611 | 0.831 | -0.609 | 0.777 |
| FEGMM | -0.541 | 0.773 | -0.550 | 0.725 |
| ROK | FE2SLS | -0.336 | 0.496 | -0.326 | 0.428 |
| FEGMM | -0.344 | 0.501 | -0.333 | 0.432 |
| Notes: we do not use value of significant below at 10% level. degree of primacy is maximum value.  |

**3.2.4. Speed of convergence by human capital primacy (2)**

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| [Table 11] Results of primacy for human capital (2): SMA |
| Variables | OLS | FE | FE2SLS | FEGMM |
| (1) primacy | (2)HHI | (3) primacy | (4)HHI | (5) primacy | (6)HHI | (7) primacy | (8)HHI |
|  | -0.038 | -0.035 | -0.660\*\*\* | -0.665\*\*\* | -0.754\*\* | -0.676\*\* | -0.707\*\*\* | -0.630\*\* |
| (0.037) | (0.026) | (0.063) | (0.112) | (0.289) | (0.290) | (0.248) | (0.259) |
|   | -0.003 | -0.015 | 0.624\* | 0.618\*\*\* | 0.732\*\* | 0.640\*\* | 0.665\*\* | 0.576\*\* |
| (0.069) | (0.067) | (0.148) | (0.120) | (0.292) | (0.289) | (0.266) | (0.275) |
|  | 0.011 | 0.011 | -0.017 | -0.015 | 0.284 | 0.260 | 0.278 | 0.254 |
| (0.065) | (0.058) | (0.070) | (0.040) | (0.276) | (0.253) | (0.249) | (0.244) |
|  | -0.040 | -0.036 | -0.023 | -0.021 | -0.319 | -0.290 | -0.308 | -0.279 |
| (0.046) | (0.042) | (0.011) | (0.039) | (0.293) | (0.267) | (0.258) | (0.251) |
| constant | 1.003 | 1.008 | 0.981 | 0.982 |  |  |  |  |
| (0.903) | (0.900) | (1.103) | (0.663) |  |  |  |  |
| Obs | 48 | 48 | 48 | 48 | 69 | 276 | 69 | 276 |
| AR-F |  |  |  |  | 6.23\*\*\* | 6.23\*\*\* | 6.23\*\*\* | 6.23\*\*\* |
| AR- |  |  |  |  | 49.34\*\*\* | 49.34\*\*\* | 49.34\*\*\* | 49.34\*\*\* |
| Hansen J |  |  |  |  | 1.851 | 1.817 | 1.851 | 1.817 |
| Notes: The number in parentheses are standard errors\*\*\* Significant 1%, \*\* Significant 5%,\* Significant 10%.Primacy and HHI implies SMA concentration F-test is supported FE modelAR-F and AR- is Anderson-Rubin Wald test |

In this section, we concern estimation of primacy for human capital (2) for SMA which is measured by average year of education for worker graduated collage, and university. The results are shown in <Table 10>, <Table 11>. As can be seen, Hansen J test and Anderson Rubin test is passed, and show the standard errors of FEGMM estimation are low compared with the other estimations. According to results of FEGMM in column (7)-(8) in this section, we find that the direction of is consistent to our expected. Moreover, the coefficients of convergence with primacy () are insignificant in SMA. However, estimations of and in ROR are significant, which is also difference compared with primacy for workers and for human capital (1). Our findings mean that reinforced primacy for human capital (2) for SMA reduce the response of GRDP growth and GDP growth in ROR.

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| --- |
| [Table 12] Results of primacy for human capital (2): ROR |
| Variables | OLS | FE | FE2SLS | FEGMM |
| (1) primacy | (2)HHI | (3) primacy | (4)HHI | (5) primacy | (6)HHI | (7) primacy | (8)HHI |
|  | -0.001 | -0.000 | -0.204\*\*\* | -0.203\*\*\* | -0.566\*\*\* | -0.473\*\*\* | -0.560\*\*\* | -0.471\*\*\* |
| (0.017) | (0.010) | (0.049) | (0.033) | (0.116) | (0.094) | (0.113) | (0.094) |
|   | -0.027 | -0.034 | 0.182\*\*\* | 0.176\*\*\* | 0.395\*\*\* | 0.325\*\*\* | 0.378\*\*\* | 0.313\*\*\* |
| (0.026) | (0.024) | (0.055) | (0.041) | (0.130) | (0.113) | (0.124) | (0.111) |
|  | 0.003 | 0.003 | 0.006 | 0.005 | 0.338\*\*\* | 0.306\*\*\* | 0.326\*\*\* | 0.295\*\*\* |
| (0.028) | (0.025) | (0.023) | (0.022) | (0.122) | (0.110) | (0.117) | (0.107) |
|  | -0.025 | -0.022 | -0.020 | -0.018 | -0.242\*\* | -0.218\*\* | -0.224\*\* | -0.202\*\* |
| (0.022) | (0.020) | (0.019) | (0.021) | (0.116) | (0.104) | (0.107) | (0.097) |
| constant | 0.715\* | 0.720\* | 0.536 | 0.541 |  |  |  |  |
| (0.375) | (0.375) | (0.343) | (0.360) |  |  |  |  |
| Obs | 195 | 195 | 195 | 195 | 156 | 156 | 156 | 156 |
| AR-F |  |  |  |  | 4.07\*\*\* | 4.07\*\*\* | 4.07\*\*\* | 4.07\*\*\* |
| AR- |  |  |  |  | 25.90\*\*\* | 25.90\*\*\* | 25.90\*\*\* | 25.90\*\*\* |
| Hansen J |  |  |  |  | 0.658 | 0.653 | 0.658 | 0.653 |
| Notes: The number in parentheses are standard errors\*\*\* Significant 1%, \*\* Significant 5%,\* Significant 10%.Primacy and HHI implies SMA concentration F-test is supported FE modelAR-F and AR- is Anderson-Rubin Wald test |

|  |
| --- |
| [Table 13] Convergence rate between SMA and ROR |
| model | Primacy | HHI |
|  |  |  |  |
| SMA | FE2SLS | -0.754 | 0.732 | -0.676 | 0.640 |
| FEGMM | -0.707 | 0.665 | -0.630 | 0.576 |
| ROK | FE2SLS | -0.373 | 0.257 | -0.374 | 0.254 |
| FEGMM | -0.374 | 0.250 | -0.375 | 0.247 |
| Notes: we do not use value of significant below at 10% level. degree of primacy is maximum value.  |

<Table 13> also reveals that the difference in convergence rate with increasing primacy for human capital (2). For ROR, we find that more concentration of human capital (2) to SMA tend to reduce both response of GRDP, , and of GDP, . In other words, It shows that the inequality income growth between SMA and ROR is more deepened according to concentration of workers with higher human capital.

We summarize our findings as follows: while beta convergence holds in both SMA and ROR, the gap of convergence rate is shown between them. In addition, reinforced primacy is relevant to income growth in ROR compared with SMA. These evidences imply that income growth in ROR may be slower enhanced than SMA when productivity growth or technological progress is improved. Therefore, inequality of income growth should be deepened between SMA and ROR. Finally, we consider what implies that higher human capital is concentrated to SMA. With more migrating worker for higher human capital, the difference in coefficients is decreasing between response of GRDP growth and GDP growth. It means that higher skilled worker more easily can move to SMA than unskilled worker.

In other word, workers with high human capital have little barriers for mobility, and they have advantage to sorting city (Behrens and Robert-Nicoud, 2014; Gennaioli et al, 2014; Ahrend, R., et al. (2017) also argued that higher human capital could easily move to larger cities. The concentration of human capital is eventually deepened gradually inequality income growth between SMA and ROR.

**Ⅳ Conclusion**

To this paper, we have considered inequality income growth between SMA and ROR using regional paper data in South Korea. Parameter heterogeneity convergence between regions based on Durlauf et al. (2001) has been presented. Our key feature is that the relationship between primacy of SMA and disparities of convergence rate between SMA and ROR. Increasing primacy of SMA has aspects of not only agglomeration effects for SMA, but also of asymmetric factor mobility, such as, worker, financial resources, and human capital, which is directed to SMA. Therefore, primacy tends to be associated with how to occur gap of convergence across regions.

In particular, potential correlation between primacy and income growth across regions tents to lead biased estimation. We have estimated to use FE2SLS and FEGMM for treating this endogeneity. In addition, lagged sorting variables which are Average wage rate and job quality in SMA are presented as instrument variables for primacy. These variables have been not directly related with income growth but primacy since population concentration is resulted from sorting city by workers and firms. According to results from instrument tests, we find that our instrument variables are appropriate empirically.

Our main results are follows as: first, parameter heterogeneity between regions is shown. The convergence rate of SMA is faster than ROR. Second, primacy is more empirically relevant to convergence rate for ROR in contrast to SMA. Furthermore, increasing primacy tends to reduce convergence rate for ROR gradually. It implies that inequality income growth between SMA and ROR reveals with primacy of SMA. Third, workers with high human capital more easily migrate to SMA. Consequently, these findings indicate that the gap of income growth across regions such as, SMA and ROR is more increasing with reinforced primacy for human capital.

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1. \* Oral presenter, The Department of Economics, Pusan National University, orkai@naver.com [↑](#footnote-ref-1)
2. \*\* Corresponding author, The Department of Economics, Pusan National University, ydkim@pusan.ac.kr [↑](#footnote-ref-2)