
Regional Potential Outputs and Output Gaps in Korea

Euijune Kim*, Brian H.S. Kim**, and Ayoung Kim***

Abstract

This paper analyzes whether economic growth of the Seoul Metropolitan Area (SMA) has a negative effect on other regional economies in Korea. The cause-effect relationship of economic growth between SMA and other regions in Korea (ROK) is analyzed with respect to regional potential outputs and output gaps. The regional potential output is derived from production function and NAIRU (Non-Accelerating Inflation Rate of Unemployment). The estimated results indicate that there are no significant cause-effect relationships on regional potential output between SMA and ROK. The output gaps, on the other hand, have a positive relationship between the two regions. The net population inflow to SMA increases the output gap of SMA and reduces the output gap of ROK.

JEL Classification : R10, R58
Keywords : CES Function, NAIRU, Output Gaps, Regional Potential Outputs

1. Introduction

Seoul Metropolitan Area (SMA) consists of only 11.8% of Korea’s total land area, but accounts 46% of the nation’s population, 88% of major enterprises’ headquarters and 85% of national government offices (KRIHS 2004). This one area concentrated growth caused large economic gaps between SMA and the rest of Korea (ROK) for past many years that a number of scholars and politicians have involved in the debate to support or against the notion of ‘balanced regional development.’ With the spreading national consensus that the growing regional inequality would be a big obstacle for Korea’s future, the government has launched a five-year national fiscal investment program for ‘balanced regional development’, where nearly 100 billion US$ will be invested. The program is committed to promote balanced growth, enhance quality of living and to improve the national competitiveness by guaranteeing equal opportunity of development and strengthening the growth potential in each region.

In order to validate the practicality of ‘balanced regional development’ program and implement relative spatial economic policy, regional potential rate of growth need to be estimated. The growth state of regional economy and regional inequality problems can be identified with the estimation of regional potential rate of growth. The concept of potential output is applied in this paper to address

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the regional potential rate of growth in SMA and ROK. Potential output is generally defined as a sus-
tainable maximum production level that is attained by utilizing all usable resources and does not accel-
erate inflation pressure.

One of the measures to account for regional growth patterns is the output gap. It is a difference
between actual output and potential output, and its measure can be applied to assess the regional eco-
nomic growth level of SMA and ROK. If the regional economy of SMA is in excess growth (actual
output is larger than potential output), then a control policy such as ‘balanced regional development’ is
needed. However, if it is in negative growth, then a policy to promote the economic activities should
give more priority to SMA.

In this paper, we try to validate the government’s argument of “regional economic growth of SMA
is at the cost of relative economic depression of ROK” by 1) estimating regional potential outputs and
output gaps of SMA and ROK and 2) identifying whether economic growth of SMA has a negative
effect on regional economy of ROK. This paper begins with a brief review of the estimation methods
of potential output and related literatures. We then propose models and estimate the regional poten-
tial outputs and output gaps for SMA and ROK. The policy implications and further research direc-
tions are discussed in the last section.

2. Literature Review

With respect to the previous studies in the estimation of potential output, Giorno et al. (1995)
reviewed the estimation methods of potential output in OECD countries and found that production
function approach provides a best method to estimate output gaps and to calculate structural budget
balances. Multhaup (1996) measured structural unemployment in North Rhine–Westphalia in Ger-
many based on traditional Okun’s Law approach. This paper is one of a few papers to implement the
concept of potential output into a regional level, estimating regional potential output and structural
level of unemployment. Bolt and Els (2000) estimated output gaps for 11 EU countries, US and
Japan. Output gaps are estimated by potential output derived from a CES production function. For
the cases in Korea, Jang (1996) estimated potential GNP in Korea using production function approach
and unobserved component model. He used Cobb–Douglas production function with the NAIRU
(Non-Accelerating Inflation Rate of Unemployment). According to his estimation result, the potential
rate of growth in Korea at 1996 was approximately 7%, showing a decreasing trend in the long
run. GNP gap has converted from a negative value to a positive value after the second half of
approach and evaluate inflation pressure in Korea. The potential rate of GDP growth was maintained
6 to 7% until the foreign exchange crisis but decreased to 4% in 1998 and 1999. The rate of GDP gap
was closely related to the business cycle and affected inflation for about three years in prior to 2 to 3
quarters of year. Park (2002) estimated potential GDP in Korea using production function approach of
OECD. According to his paper, potential rate of GDP growth in Korea during 2002 was more than
5%, which is lower than the level of growth prior to foreign exchange crisis (6~8%). Choi (2003)
estimated the growth potential of Korea using production function approach, state-space model and fil-
tering method.

3. Models

There are three types of estimation methods for the potential output: univariate, multivariate,
and production function. Among these methods, the production function method is most widely used in OECD and US and demonstrated as a best method to estimate the potential output (Giorno et al. 1995). The potential output can be derived from this method by substituting labor of natural employment rate (1–natural unemployment rate) and capital of natural utilization rate. This approach has various advantages. The use of a production function makes it possible to analyze the underlying components of potential output and to explain output gap fluctuations in terms of changes in factor inputs and total factor productivity. Although the production function method is a structural approach and has a strong intuitive appeal it can be criticized on several grounds. Given its popularity and advantage for economic implications, the production function method is used in this paper.

1) Regional Production Functions of SMA and ROK

Regional production function is used to estimate the regional potential outputs of SMA and ROK. The regional output measured by gross regional domestic product (GRDP), $Y_t$, can be described by the following production function:

$$Y_t = AF(L_t, γK_{t-1} | θ),$$

where $L_t$ and $γK_{t-1}$ are the factor inputs of labor and capital ($K_{t-1}$ is a capital stock at the end of previous year and $γ$ is a capital utilization rate), respectively. The capital utilization rate can be obtained from the annual operating ratio in manufacturing sectors. $A_t$ is total factor productivity and determined by time variable $t$, and $F(L_t, γK_{t-1} | θ)$ is a production technology follows by CES production function. The total factor productivity and production technology are described as follows:

$$A_t = Ae^{βt + ϵ}$$

(2)

$$F(L_t, γK_{t-1} | θ) = [δL_t^{-ρ} + (1-δ)(γK_{t-1})^{-ρ}]^{-ρ/δ}, ρ > -1$$

(3)

where $θ = {δ, ρ, ν}$, $δ$ is a distribution parameter indicating the labor intensity of output, $ρ$ is a substitution parameter indicating the elasticity of substitution, and $ν$ is a scale parameter indicating the return to scale. The technology parameter $β$ of Equation (2) reflects the trend growth rate of total productivity. Rewriting the Equation (1) in logarithms (represented by lower case letters) gives:

$$y_t = a_t + f(L_t, γK_{t-1} | θ) = a_i - \frac{ν}{ρ} \ln(δL_t^{-ρ} + (1-δ)(γK_{t-1})^{-ρ}) + ϵ_t$$

$$= a_i + 1 + \frac{ν}{ρ} \ln(δL_t^{-ρ} + (1-δ)(γK_{t-1})^{-ρ}) + ϵ_t.$$

(4)

The log of total factor productivity is as follows:

$$tfp_t = y_t - f(L_t, γK_{t-1}) = a_t = a + βt + ϵ_t,$$

(5)

where the technology parameter $β$ reflects the trend growth rate of total productivity and $ϵ_t$ is a stochastic component. From Equation (5), it follows that the description of $Y_t$ can be divided into an explained part, $f(L_t, γK_{t-1})$, and an unexplained part, $tfp_t$. The unexplained part is also known as the Solow Residual.¹

The non-linear nature of the CES function makes the estimation of parameters considerably more difficult. The restriction of $δ$ (e.g. $0 < δ < 1$) complicates the non-linear optimization of the estimation problem even further for convergence of the parameters. In order to alleviate these technical problems, the parameters are estimated by Taylor series approximation (Greene 2000). Applying Taylor series approximation to Equation (4) gives:
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2) The Natural Unemployment Rate

In order to estimate the regional potential output using estimated production function, we need regional potential labor and capital inputs. The natural unemployment rate is a key variable to calculate these inputs. There are two different types of methods in calibrating the natural unemployment rate: NAWRU (Non-Accelerating Wage Rate of Unemployment) and NAIRU (Non-Accelerating Inflation Rate of Unemployment). The NAWRU (non-accelerating wage rate of unemployment) is calculated on the basis of a simple equation which relates unemployment and fluctuations in wage inflation. It measures the structural unemployment simply by relating unemployment to wage inflation. The stock of potential capital is simply replaced by the actual stock of capital goods. The concept of NAIRU goes beyond the older notion of a Phillips curve trade-off between inflation and unemployment to imply that unemployment below the "natural" rate will lead not just to inflation, but to accelerating inflation. The NAIRU theory holds that the natural rate of unemployment is, in turn, determined primarily on the supply side of the labor market (Setterfield, 1996). In this paper, we estimate NAIRU of SMA and ROK since it is a convenient way to estimate the likelihood function for unobserved component models.

The NAIRU is the unemployment rate that is consistent with the steady inflation. The following model is a general form of the NAIRU based on Gordon (1997)’s “Triangle Model”. It shows the dependence of inflation rate on three basic determinants: inertia, demand and supply (Richardson et al., 2000):

\[ \Delta \pi_t = \alpha(L)\Delta \pi_{t-1} + \beta(L)(u_t - u^*_t) + \gamma(L)z_t + e_{it} \]
\[ u^*_t = u^*_{t-1} + \epsilon_{it} \]

(7)

where \( \Delta \) is the first difference operator, \( \pi_t \) is the inflation rate, the growth rate of output (GRDP) deflator, and \( \Delta \) is a vector of temporary supply shock variables. \( \alpha(L) \), \( \beta(L) \), and \( \gamma(L) \) are polynomials of the lag operator and \( e_{it} \) are white noise error terms.

According to Equation (7), inertia of the inflation is expressed by the lagged rate of inflation, \( \alpha(L) \Delta \pi_{t-1} \), unemployment gap, \( \beta(L)(u_t - u^*_t) \), and vector of supply shock variables, \( u^*_t \). The NAIRU, \( u^*_t \), is a stochastic trend and assumed to follow the random walk behavior. The degrees of polynomials used in Equation (7) are first degree of \( \alpha \), first degree of \( \beta \), and second degree of \( \gamma \). Rewriting Equation (7) in the degrees of polynomials gives:

\[ \Delta \pi_t = \alpha \Delta \pi_{t-1} + \beta(u_t - u^*_t) + \gamma_1 \Delta i_t + \gamma 2 \Delta i_{t-1} + \epsilon_{it} \]
\[ u^*_t = u^*_{t-1} + \epsilon_{it} \]

(8)

where \( i_t \) is the rate of change in importing commodity price.

There are two types of inflation models for SMA and ROK. First model is the regional price inflation of SMA (ROK) estimated with the lagged rate of inflation, the unemployment gap of SMA (ROK), and the rate of change in the import prices, as in Equation (8). It implies that each region acts as “an independent island without explicit economic linkage with other regions.” Second model is the regional inflation of SMA (ROK) determined by three variables used in the first model and the changes in unemployment rate of ROK (SMA). This specification takes into account the indirect effect of interregional migration of labors on the regional price inflation. The following equation describes the

\[ y_t = a + \beta t + \nu \delta \ln L_t + \nu (1 - \delta) \ln \left( \gamma L_{t-1} \right) + \rho \nu \delta (1 - \delta) \left[ -\frac{1}{2}(\ln L_t - \ln (\gamma L_{t-1}))^2 \right] + \epsilon_t \]  

(6)
second inflation models, where S and R stand for SMA and ROK, respectively.

\[
\Delta S \pi_t = \alpha_1 (S_{t-1} - Su^*_t) + \beta_1 \Delta u_t + \gamma_1 \Delta \pi_t + \delta_1 \Delta R \pi_t + \epsilon_{u_t}
\]

\[
Su^*_t = Su^*_{t-1} + \epsilon_{Su}
\]

\[
\Delta R \pi_t = \alpha_1 (R_{t-1} - Ru^*_t) + \beta_1 \Delta u_t + \gamma_1 \Delta \pi_t + \delta_1 \Delta S \pi_t + \epsilon_{Ru}
\]

\[
Ru^*_t = Ru^*_{t-1} + \epsilon_{Ru}
\]

(9)

The NAIRU, \( u^*_t \), is used in the estimation of potential labor input \( (L^*_t) \) as follows:

\[
L^*_t = E^*_t (1 - u^*_t),
\]

(10)

where \( E^*_t \) is the trend of labor supply, which is the H-P filtered economically active population. The natural capital utilization rate, \( \gamma^*_t \), is estimated by the method used in Jang (1996), which is based on putty-clay hypothesis:

\[
\gamma^*_t = \frac{1 - u^*_t}{1 - u^*_t},
\]

(11)

The potential capital input is represented by multiplying the capital stock at the end of previous year \( K_{t-1} \) and natural capital utilization rate \( \gamma^*_t \). In addition to potential labor input \( (L^*_t) \) in Equation (10) and potential capital input \( (\gamma^*_t K_{t-1}) \) in Equation (11), potential total factor productivity is measured by H-P filtered as follows:

\[
\text{tfp}^*_t = \text{HPF}(\text{tfp}_t)
\]

(12)

If the three determinants of potential output are substituted in the second degree Taylor series approximation of the production function, we can estimate the potential output \( (Y^*_t) \) as follows:

\[
\ln Y^*_t = \text{tfp}^*_t + \nu \ln L^*_t + \nu (1 - \delta) \ln (\gamma^*_t K_{t-1}) + \rho \nu \delta (1 - \delta) \left[ -\frac{1}{2} (\ln L^*_t - \ln (\gamma^*_t K_{t-1}))^2 \right]
\]

(13)

4. Estimation Results

In order to estimate the actual output and potential output, we need the data of Total Factor Productivity (tfp), Labor (L), Capital (K), Potential Total Factor Productivity (tfp*), Potential Labor (L*), and Potential Capital (K*). Among these variables, L* and K* are derived from the estimation of NAIRU using State-Space model. The data used to estimate the actual output and potential output variables are from 1985 to 2000. GRDP and inflation data are obtained from Korea National Statistical Office, and employment data are from labor statistics provided by Ministry of Labor. The capital stock data are from capital stock estimation data by Pyo et al. (2003).

1) CES Production Function and NAIRU

The estimation results of regional CES production functions for SMA and ROK are presented in Table 1. It is difficult to examine the significance of each parameter due to non-linearity in regression estimation. However, the model could be acceptable in a sense that ratios of residual sum of squares to total for two regions are quite low; 0.20% (=0.0030/1.4876) for SMA and 0.11% (=0.0015/1.3238) for ROK. It is meaningful use these results that the estimated output is very close to the actual output of log GRDP in SMA and ROK (shown in Figure 1 and 2).

In order to estimate an unobserved variable \( u^*_t \) (NAIRU) in Equation (8), Kalman filter is applied
in the state-space models using the data from 1985 to 2000. As the estimated results showed in Table 2, the signs of coefficients of all four models are generally consistent with the previous empirical studies, and most variables are statistically valid at 5 to 10% significant level. The results indicate that the positive unemployment gap ($b^h$ (actual unemployment rate - natural unemployment rate)) reduces the speed of inflation. The change in the inflation rate ($a^h$) increases with the supply shock, such as a rise in import prices ($c^h$), and the unemployment rate of other regions ($d^h$).

2) Potential Outputs and Output Gaps

Estimates on potential outputs and output gaps of SMA and ROK from 1993 to 2000 are summarized in Table 3 and Table 4, respectively. The data used to estimate the actual output and potential output variables is from 1985 to 2000 (16 years), however, due to the characteristics of Kalman filter, the estimation can be done only for the period of 8 years (from 1993 to 2000). The model 1 assumed that the change of inflation rate in SMA do not depend on the unemployment rate of ROK. The model
2, however, assumed that the unemployment rate of ROK is associated with the change of inflation rate in SMA.

The estimated results of Model 1 showed that the economies of SMA were negative growth right after 1997 (beginning of foreign currency crisis period). The actual outputs during 1998 and 1999 were smaller than the potential outputs. The proportions of output gaps to potential output in 1998 and 1999 were \(-9.67\%\) (\(-10.10\) billion US$) and \(-3.85\%\) (\(-24.37\) billion US$), respectively. During the excess growth period (1996 and 2000), however, the proportions in 1996 and 2000 were 3.8\% (9.09 billion US$) and 0.3\% (0.83 billion US$), respectively. The results from model 1 and model 2 showed similar potential output levels and average growth rate, even though the applied assumptions between two models are different. The average annual growth rate of potential output in SMA is 5.60\% (Model 1) and 5.75\% (Model 2). These are reasonable levels in a sense that the national growth rate of potential output is around 4.8\% in the early 2000s.

The results in Table 4 showed that ROK achieved higher actual outputs than potential outputs in

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Seoul Metropolitan Area (SMA)</th>
<th>Rest of Korea (ROK)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Model 1</td>
<td>Model 2</td>
</tr>
<tr>
<td>(a)</td>
<td>(-0.254^*) (-2.450)</td>
<td>(-0.396^*) (-2.665)</td>
</tr>
<tr>
<td>(b)</td>
<td>(-5.755^*) (-8.302)</td>
<td>(-3.596^*) (-3.180)</td>
</tr>
<tr>
<td>(\gamma)</td>
<td>1.562* 6.759</td>
<td>1.209* 4.746</td>
</tr>
<tr>
<td>(\delta)</td>
<td>0.076 1.498</td>
<td>0.058 1.013</td>
</tr>
</tbody>
</table>

Log Likelihood: \(-53.956\) \(-35.257\) \(-47.243\) \(-39.693\)

Note. * significant at 5\% level.

Figure 2: Actual and estimated output of log GRDP in ROK
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1994, 1996 and 1997, but suffered negative growth in 1998 and 1999. In Model 3, the proportion of output gaps to potential outputs during the foreign currency crisis were $-4.63\%$ (−12.57 billion US$) in 1998 and $-2.51\%$ (−7.29 billion US$) in 1999. The negative growth level is greater in Model 4, where the proportion in 1998 were $-6.24\%$ (−17.23 billion US$) and in 1999 were $-3.24\%$ (−9.47 billion US$).

Comparing the results of SMA and ROK for the period of 1993~2000, SMA had more years of positive output gaps than ROK. SMA had six years (1993 to 1997 and 2000) of positive output gaps,
whereas ROK had only three years (1994, 1996 and 1997). Although the results in the above indicated that the regional economies of SMA and ROK during 1990s have been both in excess growth and negative growth, we are not able to find systematic and statistically significant cause-effect relationship between SMA and ROK in terms of output gaps. To confirm whether the excess growth of SMA results in less development or negative growth of ROK, the causality between two regional output gaps needs to be modeled as follows:

Note: 1) one US dollar = 1,000 Korean Won. 2) Foreign currency crisis periods in Korea

Figure 4: Potential output and actual output of ROK

Table 4: Potential Output and Output Gap of ROK (unit: billion US$, %)

<table>
<thead>
<tr>
<th>Year</th>
<th>Actual output (A)</th>
<th>Potential output</th>
<th>Output gap (billion US$)</th>
<th>Output gap (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Model 3 (B)</td>
<td>Model 4 (C)</td>
<td>Model 3 (D=B-A)</td>
<td>Model 4 (E=C-A)</td>
</tr>
<tr>
<td>1993</td>
<td>210.48</td>
<td>210.81</td>
<td>-0.33</td>
<td>0.10</td>
</tr>
<tr>
<td>1994</td>
<td>230.96</td>
<td>229.79</td>
<td>0.18</td>
<td>0.99</td>
</tr>
<tr>
<td>1995</td>
<td>247.38</td>
<td>250.17</td>
<td>-2.61</td>
<td>-2.79</td>
</tr>
<tr>
<td>1996</td>
<td>268.05</td>
<td>254.21</td>
<td>13.12</td>
<td>13.84</td>
</tr>
<tr>
<td>1997</td>
<td>281.24</td>
<td>269.34</td>
<td>11.36</td>
<td>11.90</td>
</tr>
<tr>
<td>1998</td>
<td>258.63</td>
<td>271.20</td>
<td>-12.57</td>
<td>-17.23</td>
</tr>
<tr>
<td>1999</td>
<td>282.64</td>
<td>292.11</td>
<td>-7.29</td>
<td>-9.47</td>
</tr>
<tr>
<td>2000</td>
<td>301.45</td>
<td>302.04</td>
<td>-0.58</td>
<td>0.82</td>
</tr>
</tbody>
</table>

Average of growth rate (1993-1997) 6.37% 6.37% 6.40%

Note: 1) one US dollar = 1,000 Korean Won. 2) Foreign currency crisis periods in Korea
\[ \Delta OG_S = \alpha_1 + \beta_1 OG_R + \gamma_1 \text{PRICE} + \delta_1 NP_S + \epsilon_1 \]
\[ \Delta OG_R = \alpha_2 + \beta_2 OG_S + \gamma_2 \text{PRICE} + \delta_2 NP_R + \epsilon_2 \]  
(14)

where \(OG_{SR}\) is an output gap for SMA (ROK), PRICE is producer price index (set 100 at year of 2000), and \(NP_{SR}\) is a share of net population inflow to total population of SMA (ROK). The output gap of one region is assumed to be determined by the output gap of another region, the inflation rate and the net population inflows. The sign of the output gap variable should be negative in order to validate the government’s policy on balanced regional development. That is, in an indirect way, it would be possible to find out spatial interactions between two regions if we examine magnitudes of output gap variable and their signs for both SMA and ROK equations. The estimated results for regression equation of regional output gaps for SMA and ROK are presented in Table 5. As shown in Table 5, the positive signs of parameter \(\beta\) indicate that there are complementary (and not competitive) relationships between two regions in terms of output gaps. This implies that the economic growth of SMA has led an increase in regional outputs of ROK in the 1990s, which may not agree with the government’s claim that the excess growth of SMA has caused the negative growth of ROK. The marginal effect of output gap from ROK to SMA (\(\beta = 0.676\)) is larger than from SMA to ROK (\(\beta = 0.533\)).

The output gaps are also influenced by the price inflation and net population change. As expected, the parameters of price inflation are negative for both regions, and the parameters of net population inflow are positive for SMA and negative for ROK. The results indicate that the output gaps are reduced in ROK due to inflation and net population outflow, and SMA’s output gaps are increased due to persistent net population inflow from ROK. Therefore, if the government wants to achieve a balanced regional development, it needs to focus on the cause of population movement from ROK into SMA. The major causes of persistent population outflows from ROK to SMA are quality of education and employment opportunities. Most of the migration is made by young generations (20s and 30s) to gain more opportunities in education and employment. Park (2006) has found that as specific region’s per capita GNP and education opportunities increase, more inflow of population into that region. Therefore, the government must put consistent efforts and investments to provide high quality educational services and employment opportunities in ROK rather than direct control of the population in SMA.

Table 5: Regression Equation of Regional Output Gap (Equation 14)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Seoul Metropolitan Area (SMA)</th>
<th>Rest of Korea (ROK)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimate</td>
<td>t-value</td>
</tr>
<tr>
<td>(a)</td>
<td>40.355</td>
<td>0.640</td>
</tr>
<tr>
<td>(\beta)</td>
<td>0.676**</td>
<td>4.590</td>
</tr>
<tr>
<td>(\gamma)</td>
<td>-0.843</td>
<td>-1.210</td>
</tr>
<tr>
<td>(\delta)</td>
<td>0.007*</td>
<td>2.220</td>
</tr>
<tr>
<td>Adjusted R(^2)</td>
<td>0.548</td>
<td></td>
</tr>
<tr>
<td>D-W stat</td>
<td>2.214</td>
<td></td>
</tr>
</tbody>
</table>

Note. * significant at 5% level.
** significant at 1% level.
5. Conclusions and Future Research Directions

Estimating potential output is one of the good alternatives to understand the growth patterns of regional economies. It can also contribute to the development of spatial economic plan for mid- to long-term goals. In this paper, we estimated the potential outputs and output gaps of SMA and ROK in Korea to assess the validity of current regional policies that are favorable to the ROK. The empirical results show that both SMA and ROK have suffered significant under-growth for two years (1998 and 1999) right after foreign currency crisis in 1997. During the period of 1993 to 2000, SMA had six years of excess growth and ROK had three years of excess growth. Even though regional economies of SMA and ROK during 1990s have been in excess growth and under growth respectively, it is difficult to determine the cause of less development of ROK by the excess growth of SMA. However, due to larger marginal effect of the output gap from ROK to SMA than from SMA to ROK and persistent net population outflows to SMA, the government needs to focus on the cause of population movement from ROK into SMA. In order to achieve balanced regional development, the government must put consistent efforts and investments to provide high quality educational services and employment opportunities in ROK in the long run. However the major findings are derived from the state space model with small number of sample sizes, so it should be cautious to interpret them.

In the future research, additional work on market analysis of factor inputs, such as labor and capital, is needed. What is the relationship of the change in unemployment rate of one region to the changes in wages of another region? Do land inputs with cheaper land rent in ROK promote more potential outputs than the case in SMA? More emphasis should be put on the calibration of factor inputs and total factor productivities at the regional level for accuracy of the results. For example, the capital inputs can be disaggregated into transportation and energy infrastructures, communications equipments, non-residential structures, inventories, and land in the non-farm business sector and measure the flow of available capital services for the production. The labor inputs can take into account the different labor productivity by segregating educational backgrounds, skill levels, employment types, and average weekly hours. The total factor productivity also can be estimated with regional R&D and infrastructure investments and the qualities of labor inputs.

Acknowledgement

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Endnotes

1. Strictly speaking, $\varepsilon$ is the Solow Residual.
2. Putty Clay hypothesis, defined by Klein and Preston (1967), stated that substitution between capital and labor is possible before the actual investment; however the substitution is not possible after the equipment is installed. In other words, the capital equipment ratio is constant after the investment. Using Putty-clay hypothesis on equation $\frac{K^m}{L^m} = \frac{\gamma^m C}{(1-\mu_c)E_c} = \frac{\gamma^m}{\gamma_c} \frac{1-\mu_c}{1-\mu_c} \frac{K}{L}$, the natural capital utilization rate $\gamma^m$ can be derived (assuming that the capital equipment ratio $\frac{K}{L}$ is constant and equal to natural capital equipment ratio $\frac{K^m}{L^m}$), as $\gamma^m = \frac{1-\mu_c}{1-\mu_c} \gamma_c$. 
References


