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Regional Economic Gap in Korea

Sung Tai Kim*
Cho See Jung*
and
Keun Ho Roh**

Korea recorded a rapid economic growth since 1962. However its remarkable economic growth has been possible at the cost of deepening the economic gap between rural and urban areas and that between specific regions. This paper deals with the problem of unbalanced economic growth across the 11 regions in Korea in terms of Gross Regional Product. The purposes of this paper are twofold. First, we characterize the development of the unequal income distribution across the regions. Second, we try to find the economic factors that explain the regional economic gap by estimating the regional aggregate production function.

I. Introduction

It is indisputable that Korean economy has succeeded in implementing the five consecutive five-year economic plans since 1962 to achieve 8.5% annual growth rate in real GNP. The growth of Korean economy is remarkable in various aspects as shown in (Table 1). During the 1962-87 period per capita GNP has been increased by 5.9 times and export has been increased by 672 times.

A quantitatively remarkable economic growth has been possible at the cost of deepening the economic gap between urban and rural areas and that between specific regions. This paper deals with the problem of unbalanced economic growth across the 11 regions in Korea in terms of per capita Gross Regional Product (GRP).

* Department of Economics, Chongju University, Korea.
** Chungbuk Economic Research Institute, Korea.

The purposes of this paper are twofold. First, we characterize the development of the unequal income distribution across the regions along the economic growth. Second, we try to find the economic factors that explain the regional economic gap.

In section 2 we provide the GRP and per capita GRP (PGRP hereafter) data during 1970-86 period. It is shown that the regional economic gap has persisted during that period.

In section 3 we adopt the absolute and the relative inequality indices to measure the economic gap across the regions and estimate those indices during 1970-86 period. In particular we examine the relationship between income inequality and economic development empirically. We test the validity of the Kuznets hypothesis in the context of GRP. Kuznets hypothesis states that inequality tends to increase in the early stages of economic development and to decrease in the later stages tracing out an inverted U-curve. We find that the absolute inequality indices have increased steadily since 1970 while the relative inequality indices have decreased steadily.

Table 1

THE GROWTH OF KOREAN ECONOMY*

year	GNP (billion $)	current account surplus	export (million $)	import	per capita GNP ($)
1962 (A)	12.7	−60	50	390	395
1987 (B)	97.1	4,500	33,600	29,300	2,344
B/A	7.7	—	672	75.1	5.9

Source: Major Statistics of Korean Economy, Economic Planning Board.
*: 1980 constant price.

In section 4 we estimate the regional aggregate production function to figure out the economic factors explaining the differential economic growth. We categorize the 11 regions into three groups — the metropolitan area, the outlying metropolitan area, and the remote hinterland area following Park (1988). We adopt the random effect model for panel data estimation. We also discuss the empirical results. In section 5 we conclude the paper.

II. Development of Regional Economic Gap in Korea

A. GRP

We use the GRP data of 11 regions[1] — Seoul (SE), Busan (BS), Kyunggi (KG), Kyungbuk (KB), Kyungnam (KN), Chungbuk (CB), Chungnam (CN), Junbuk (JB), Junnam (JN), Kangwon (KW), and Jeju (JJ) in studying the regional economic gap.

In (Table 2) GRP's of 11 regions are shown. The data of 10 regions except SE during 1970-78 are obtained from the Yearbook of Residents Income and the data during 1980-86 period are obtained from the income data of the Ministry of Home Affairs. The missing data in 1979 are estimated based on 1970-78 data.[2] For SE only 1980-86 data are available from the Yearbook of Citizen Income. Therefore we use the following identity to estimate the missing data.

$$(1) \qquad \text{SE GRP} = \text{GDP} - \left(\sum_{i \neq SE} \text{GRP}_i + \text{Residual} \right)$$

where GDP is Gross Domestic Product and Residual measures the portion of GDP that does not belong to GRP's and the statistical discrepancy.[3]

We can find several characteristics of GRP growth pattern shown in (Table 2). First the ranking of 11 regions in terms of GRP has been almost unchanged except a couple of cases. The metropolitan area (SE and BS) and the outlying metropolitan area (KG, KB, KN) have kept the top five places.

Second, the concentration of the economic power and the population into the capital circle (SE and KG) has been accelerated along the growth of Korean economy as shown in (Table 3).

1 11 regions include Inchon, Taegu, Taejun, and Kwangju which have become administratively independent cities during 1970-86 period.

2 Since Korea recorded a negative economic growth in 1980 that is out of normal trend in its economic growth path, the intrapolation technique is not appropriate for obtaining the missing data for 1979 GRP's. Instead, we use the extrapolation technique. Thus, we get the forecasts of 1979 GRP^i from the following equation for obtaining the missing data.

$$GRP_t = a_0 + a_1 \, GRP_{t-1} + \varepsilon_t \qquad t = 1970, 1978.$$

where GRP_t denotes region i's GRP in year t.

3 Because the concept of the GRP data the Ministry of Home Affairs provided is more or less close to that of "National Income" in national income accounting, the sum of GRP's is not equal to GDP. The discrepancy is total amount of indirect taxes paid. Residual in equation (1) takes into account that discrepancy.

Table 2

GRP'S IN KOREA: 1970-86

1980 constant price (million won)

	SE	BS	KG	KW	CB	CN
1970	4,135,842	1,412,297	1,619,886	759,165	655,456	1,156,728
1971	4,235,922	1,458,989	1,776,111	773,872	704,700	1,271,828
1972	4,816,052	1,486,095	1,854,052	794,924	733,886	1,320,633
1973	5,830,782	1,871,181	2,355,294	847,042	804,929	1,427,424
1974	6,772,494	1,968,711	2,548,649	889,571	842,166	1,504,981
1975	6,484,278	2,007,562	3,008,271	994,773	967,642	1,578,273
1976	7,543,974	2,539,468	3,567,002	1,026,856	1,026,856	1,747,193
1977	8,607,177	2,685,502	4,039,921	1,195,035	1,058,908	1,903,928
1978	8,368,132	3,046,169	4,653,752	1,359,800	1,186,634	2,157,694
1979	8,845,099	3,392,644	5,333,558	1,550,623	1,282,660	2,410,744
1980	10,060,800	3,155,558	5,093,800	1,319,236	1,058,938	2,012,791
1981	10,601,037	3,306,867	5,361,674	1,401,750	1,087,361	2,212,600
1982	11,559,403	3,361,779	5,576,844	1,479,481	1,134,666	2,289,143
1983	13,280,784	3,787,858	6,336,063	1,555,414	1,220,101	2,451,093
1984	14,461,521	4,134,732	7,670,062	1,851,284	1,456,396	2,693,233
1985	15,613,314	4,884,355	8,872,941	2,141,407	1,719,033	3,184,473
1986	17,622,984*	5,248,540	10,031,946	2,405,943	1,862,999	3,493,704

	JB	JN	KB	CN	JJ
1970	945,070	1,432,475	1,778,665	1,453,433	151,918
1971	1,062,433	1,618,700	1,985,417	1,752,433	171,489
1972	1,146,243	1,682,776	2,051,033	1,770,743	181,048
1973	1,111,983	1,804,761	2,297,004	2,035,206	217,197
1974	1,200,156	1,823,942	2,461,627	2,309,828	224,562
1975	1,320,876	2,088,183	2,938,327	2,485,410	283,995
1976	1,395,386	2,356,056	3,154,399	2,798,612	256,994
1977	1,490,421	2,430,576	3,430,814	3,010,910	305,046
1978	1,691,480	2,887,831	3,948,661	3,823,275	345,617
1979	1,867,313	3,264,388	4,549,180	4,581,799	382,044
1980	1,418,470	2,756,100	3,769,196	3,809,364	330,022
1981	1,470,825	2,932,948	4,338,598	4,347,406	348,540
1982	1,514,828	3,006,997	4,492,596	4,414,155	379,341
1983	1,639,856	3,278,096	4,939,101	4,975,727	405,354
1984	1,917,309	3,969,655	5,336,414	4,944,978	454,376
1985	2,333,714	3,960,170	6,285,373	5,560,233	595,591
1986	2,596,725	4,440,289	7,030,709	6,441,238	674,500

Source: The data from the Ministry of Home Affairs, the *Yearbook of Residents Income,* and the *Yearbook of Citizen Income.*

Table 3

THE CONCENTRATION OF ECONOMIC POWER AND THE POPULATION INTO CAPITAL CIRCLE

Year	1970	1975	1980	1986
$\frac{\text{capital circle GRP}}{\text{GDP}} \times 100\%$	32.6	35.6	39.8	41.8
$\frac{\text{capital circle pop.}}{\text{total pop.}} \times 100\%$	27.6	31.0	34.9	39.6

Source: Major Statistics of Korean Economy, EPB.

Third, the existing regional economic gap in 1970 has been widened by the differential economic growth rate. The metropolitan area and the outlying metropolitan area recorded higher economic growth rate than the average while the remote hinterland area recorded lower economic growth rate.

B. Per Capita GRP

For welfare or standard of living comparisons across the regions PGRP is more appropriate than GRP. Also when we examine the equality and/or the equity aspects of the distribution of income we must consider PGRP rather than GRP.

The PGRP's of 11 regions during 1970-86 are provided in (Table 4). In terms of PGRP ranking the metropolitan area and the outlying metropolitan area have kept the top five places while the remote hinterland area have kept the last six places since 1979.

The gap between the top and bottom in 1970 which was 409 thousand won had been widened to reach its maximum 730 thousand won in 1983. Not only GRP but also PGRP show us that the regional economic gap has been deepened as Korean economy grows. However it seems that the gap between the top and the bottom in terms of PGRP relative to the mean of regional PGRP has been smaller. We need more rigorous measures to evaluate the regional economic gap more precisely. In next section we suggest the absolute inequality indices and the relative inequality indices for that purpose.

Table 4

PER CAPITA GRP's IN KOREA: 1970-86
(1,000 won, 1980 constant price)

	SE	BS	KG	KN	KB	CB
1970	749	767	482	456	390	451
1971	724	751	515	564	431	473
1972	793	738	520	561	438	487
1973	927	904	642	636	481	530
1974	1,035	854	657	696	505	549
1975	941	818	745	758	605	636
1976	1,040	987	860	855	643	679
1977	1,144	996	941	905	694	705
1978	1,070	1,058	1,046	1,150	796	806
1979	1,090	1,118	1,129	1,356	913	886
1980	1,203	999	1,033	1,147	761	744
1981	1,222	1,018	1,051	1,272	863	755
1982	1,296	1,006	1,043	1,267	884	787
1983	1,443	1,116	1,136	1,414	971	857
1984	1,522	1,183	1,313	1,384	1,047	1,026
1985	1,620	1,390	1,436	1,581	1,247	1,236
1986	1,799	1,467	1,540	1,832	1,371	1,335

	CN	KW	JJ	JB	JN
1970	404	407	416	388	358
1971	445	418	460	440	403
1972	455	427	476	469	413
1973	488	457	557	454	440
1974	511	477	550	486	442
1975	535	534	689	538	524
1976	590	558	612	571	589
1977	638	647	708	612	605
1978	720	734	780	705	718
1979	804	841	838	791	815
1980	681	737	716	620	729
1981	737	777	746	640	767
1982	754	818	802	654	779
1983	795	853	850	712	859
1984	881	1,019	943	838	881
1985	1,061	1,241	1,220	1,060	1,057
1986	1,161	1,375	1,363	1,185	1,176

III. Absolute and Relative Inequality Indices

A. Definitions

The absolute inequality indices measure the degree of regional economic gap regardless of the economy scale while the relative inequality indices take into account the economy scale.

We suggest the standard deviation of PGRP as the Absolute Inequality Index 1 (A1 hereafter) and the range of PGRP as the Absolute Inequality Index 2 (A2 hereafter). Both A1 and A2 measure the degree of dispersion of PGRP's each year. They are however scale-variant (Lambert, 1989). We may well expect both A1 and A2 increase as the economy grows even if the degree of dispersion of PGRP's stays the same.

Considering the weakness of A1 and A2 we suggest the relative inequality indices that take into account the scale variation. The Relative Inequality Index 1 (R1) is defined to be the coefficient of variation. The Relative Inequality 2 (R2) is defined to be the sum of the relative mean deviations. The Relative Inequality Index 3 (R3) is defined to be the standard deviation of the logarithm of PGRP.

(2) $$R1 = \sigma / \mu$$

$$R2 = \sum_{i=1}^{N} |X_i - \mu| / \mu$$

$$R3 = STD\ (\log(PGRP))$$

where σ denotes the standard deviation of PGRP, μ denotes the mean of PGRP, X_i denotes the PGRP of region i, and STD denotes the standard deviation.

B. Numerical Values

We calculate A1 and A2 as well as R1, R2, and R3 for each year from (Table 4). The numberical values of A1 and A2 are given in (Table 5).

We may observe that both A1 and A2 had increased steadily to reach its maximum in 1983 and started to decrease since 1984. But we cannot tell yet whether they would keep decreasing.

The numerical values of R1, R2 and R3 are given in (Table 6). On the contrary to A1 and A2 all of the relative inequality indices have decreased more or less steadily. It is interesting to see that R1, R2 and R3 decreased very rapidly in mid 80's.

Table 5

THE NUMERICAL VALUES OF ABSOLUTE INEQUALITY INDICES

(1,000 won)

year	A1 = standard deviation of PGRP	A2 = range of PGRP
1970	135	409
1971	115	348
1972	116	380
1973	166	487
1974	176	593
1975	131	417
1976	169	482
1977	175	539
1978	163	445
1979	175	565
1980	194	583
1981	203	632
1982	201	642
1983	235	730
1984	216	684
1985	190	563
1986	219	671

Note: PGRP denotes per capita GRP.

C. *The Income Inequality — Economic Development Relationships in Korea*

In section C we observed that the absolute gap in terms of PGRP has been deepened while the relative gap has been alleviated. The next question we can raise is whether the measures of inequality in terms of PGRP have increased or decreased as the economy grows. So we will regress the measures of inequality on the mean of PGRP. Then we will interpret our empirical results in the context of the Kuznets Hypothesis.

Kuznets (1955) proposed that income inequality tends to increase in the early stages of economic development and to decrease in the later stages tracing out an inverted-U curve (see Kuznets and Lewis (1954), Fei and Ranis (1964) for theoretical reasonings for an inverted-U curve).

Subsequently this theoretical underpinning came to be widely ac-

Table 6

THE NUMERICAL VALUES OF RELATIVE INEQUALITY INDICES

year	$R1 = \frac{\sigma}{\mu}$	$R2 = \sum_{i=1}^{N} \frac{\lvert X_i - \mu \rvert}{\mu}$	R3 = STD of log PGRP
1970	0.28	2.33	0.012
1971	0.23	1.99	0.008
1972	0.23	1.96	0.008
1973	0.28	2.49	0.012
1974	0.29	2.55	0.012
1975	0.20	1.87	0.006
1976	0.23	2.31	0.010
1977	0.22	2.20	0.008
1978	0.19	1.93	0.006
1979	0.18	1.76	0.005
1980	0.23	2.29	0.008
1981	0.23	2.19	0.008
1982	0.22	2.06	0.008
1983	0.24	2.21	0.010
1984	0.20	1.87	0.006
1985	0.15	1.37	0.004
1986	0.15	1.36	0.004

Notes: μ denotes the mean of PGRP each year,
σ denotes the standard deviation of PGRP each year,
Xi denotes the PGRP of region i, and STD denotes standard deviation.

cepted: see, for instance, Swamy (1967), Knight (1976), Robinson (1976), Lecallion at al. (1984), and Anand and Kanbur (1984).

In order to test the Kuznets Hypothesis empirically we regress A_i's (i = 1,2) and R_i's (i = 1,2,3) on various functional forms of the mean of PGRP, $\overline{PGRP}$.

(1) The relationship between A_i's and economic development

First, we regress A1 and A2 on the linear and the quadratic function of PGRP respectively as follows.

(3) $A_i = a + b\ \overline{PGRP} + c\ \overline{PGRP}^2$

$A_i + a + b\ \overline{PGRP} \qquad i = 1,2.$

The results of the regression analysis are shown in (Table 7).

We adopt the Akaike Information Criterion (AIC) as the criterion to find the model that fits the data best. The AIC is deinfed by

$$AIC = -2 \text{ (maximum log-likelihood)} + 2\text{(number of independent parameters)}.$$

The first term of the formula is a goodness-of-fit criterion, and the second is a penalty for complexity. By minimizing the entire form, a trade-off is made between goodness-of-fit and complexity.

Table 7

THE ABSOLUTE INEQUALITY INDICES AND ECONOMIC DEVELOPMENT: REGRESSION ANALYSIS

Dependent Variable	A1		A2	
Explanatory Variable	linear function	quadratic function	linear function	quadratic function
PGRP	0.102*** (4.86)	0.357*** (3.08)	0.311*** (4.13)	1.124*** (2.60)
$PGRP^2$		−0.0001** (−2.22)		−0.0004* (−1.91)
Constant	90.079*** (4.90)	−15.839 (−0.31)	279.107*** (4.23)	−58.75 (−0.31)
R^2	0.61	0.71	0.53	0.62
D.W.	1.42	1.88	1.41	1.74
AIC	0.6792	0.6189	0.7462	0.7048

Notes: t-value is in parenthesis, D.W. denotes Durbin-Watson statistic
AIC denotes standardized Akaike statistic
the significance level: * = 10%, ** = 5%, *** = 1%.
PGRP denotes the mean of per capita GRP.

According to the AIC criterion the quadratic function is chosen as the best model for A1 and A2. Furthermore the estimates of coefficients, a, b, and c indicate that only the left part of an inverted-U curve are relevent since $\overline{PGRP}$ in 1986 was 1,413 thousand won.

Therefore in terms of the absolute inequality indices Korea has gone through increasing regional income inequality.

(2) The relationship between R_i's and economic development

We regress R_i's (i = 1,2,3) on the liner and the quadratic functions of PGRP respectively. The results of the regression analysis are provided in (Tale 8).

According to (Table 8) the linear functions fit the data best except R2. R1 and R2 are the negative linear functions of $\overline{PGRP}$. Even though for R2 the quadratic function fits the data best, the linear function fits the data as well. Also R2 decreased steadily since 1974 when R2 hit its maximum. Notice that the coefficient of $\overline{PGRP}$ in linear function for R2 is negative.

Therefore we conclude that the relative income inequality across the regions has decreased as the economy grows.

IV. Economic Factors of Regional Economic Gap

A. Regional Aggregate Production Function

Table 8

THE RELATIVE INEQUALITY INDICES AND ECONOMIC DEVELOPMENT: REGRESSION ANALYSIS

Dependent Variable	R_1		R_2		R_3	
Function	linear	quadratic	linear	quadratic	linear	quadratic
Explanatory Variable						
PGRP	−0.0001***	−0.00005	−0.0009***	0.0018	-7×10^{-6}***	-5×10^{-6}
	(−4.84)	(−0.36)	(−3.92)	(1.41)	(−3.90)	(−0.41)
$PGRP^2$		−0.0		-1×10^{-6}**		−0.0
		(−0.39)		(−2.15)		(−0.19)
constant	0.319***	0.293***	2.793***	1.668***	0.013***	0.012***
	(14.99)	(4.36)	(13.92)	(3.01)	(8.85)	(2.60)
R^2	0.61	0.61	0.50	0.62	0.50	0.50
D.W	1.89	1.93	1.76	2.34	2.22	2.25
AIC	0.6810	0.7182	0.7669	0.7051	0.7680	0.8135

Notes: t-value is in parenthesis, D.W. denotes Durbin-Watson statistic,
AIC denotes standard Akaike statistic,
the significance level: * = 10%, ** = 5%, *** = 1%.
PGRP denotes the mean of per capita GRP.

The regional economic gap can be explained by economic and non-economic factors. Non-economic factors include political, social, cultural, and historical factors which we do not consider here. In this section we focus on economic factors.

Furthermore we assume that the performance of regional economy entirely depends on the supply side of the economy. Thus GRP is determined by the factor inputs and technology through the regional aggregate production function (RAPF). Factor inputs include labor, capital, and social indirect capital.

We already classify 11 regions into three groups according to economic environments — the metropolitan area, the outlying metropolitan area, and the remote hinterland area. We assume that all provinces in the same group have the same technology. Thus we will estimate three different RAPF's.

The RAPF takes a Cobb-Douglas form and neutral technical progress is imbedded as follows.

$$(4) \qquad Y_t = Q(K_t,\ L_t,\ SK_t,\ t)$$
$$= A_t\ K_t^{\alpha} L_t^{\beta} SK_t^{\gamma}$$

where subscript t denotes year t, Y denotes outputs, L denotes labor input, K denotes capital, SK denotes social indirect capital, and A denotes technology coefficient which is assumed to be unobservable.

We include social indirect capital as input factor since we believe it played a crucial role in the early stae of economic development at aggregate level. Notice that we do not restrict a priori that the production function shows constant returns to scale technology. That is different from a conventional neoclassical production function. Because, we expect that the RAPF's show differential technologies depending on economic environments.

Taking the natural logarithm in equation (4) we obtain

$$(5) \qquad \log Y_t = \log A_t + \alpha \log K_t + \beta \log L_t + \gamma \log SK_t$$

A_t is unobservable and the actual Y_t is also determined by other unknown factors so that we introduce the disturbance term for estimation equation. We will have three estimation equations as follows.

$$(6a) \qquad \log Y_{it} = \alpha_{mt} \log K_{it} + \beta_{mt} \log L_{it} + \gamma_{mt} \log SK_{it} + u_{it}$$

$i = SE, BS, \quad t = 1970, \ldots, 1987.$

(6b) $\text{Log } Y_{it} = \alpha_{om} \log K_{it} + \beta_{om} \log L_{it} + \gamma_{om} \log SK_{it} + u_{it}$

$i = KG, KB, KN, \quad t = 1970, \ldots, 1987.$

(6c) $\log Y_{it} = \alpha_{rh} \log K_{it} + \beta_{rh} \log L_{it} + \gamma_{rh} \log SK_{it} + u_{it}$

$i + CB, CN, JB, JN, KW, JJ, \quad t = 1970, \ldots, 1987.$

where the subscripts mt, om, and rh denotes the metropolitan area, the outlying metropolitan area, and the remote hinterland area respectively.

In the case of panel data the disturbance term u_{it} may be decomposed as follows.

(7) $u_{it} = \eta_i + \varepsilon_{it}$

η_i represents the individual effect and ε_{it} represents the residual term. The two alternative specifications of the model are possible in their treatment of the individual effect. The so-called fixed effect model treats η_i as a fixed but unknown component differing across individual regions. The alternative is known as the random effect or variance component model, in which η_i is assumed to be drawn from an i.i.d. distribution.

In this paper we postulate the random effect model for estimation since η_i represents the individual regional characteristics in each region such as weather, regional customs, and the characteristics of people that are more or less randomly determined independent of time. Also the fixed effect model is only a special case of the random effect model where the distribution of η_i is degenerate.

We assume that η_i follows the normal distribution with mean zero and variance σ_η^2. We also assume that η_i is independent of ε_{it} that has zero mean and common variance σ_ε^2. Both η_i and ε_{it} are serially independent and independent across the regions. These assumptions can be written as

$$
\begin{aligned}
& E(\eta_i) = 0,\ E(\eta_i \eta_j) && = \sigma_\eta^2 && \text{for } i = j \\
& && = 0 && \text{otherwise} \\
(8) \quad & E(\varepsilon_{it}) = 0,\ E(\varepsilon_{it} \varepsilon_{js}) && = \sigma_\varepsilon^2 && \text{for } i = j \text{ and } t = s \\
& && = 0 && \text{otherwise} \\
& E(\eta_i \varepsilon_{jt}) = 0 && && \text{for all } i, j, t.
\end{aligned}
$$

For group j (j = MT, OM, and RH) the complete system may be written out in matrix form as

$$(9)\quad \begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_N \end{bmatrix} = \begin{bmatrix} X_1 0 & \cdots & 0 \\ 0\, X_2 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0\ 0 & \cdots & X_N \end{bmatrix} \begin{bmatrix} b_j \\ b_j \\ \vdots \\ b_j \end{bmatrix} + \begin{bmatrix} u_1 \\ u_2 \\ \vdots \\ u_N \end{bmatrix}$$

where $y_i = \begin{bmatrix} y_{i1} \\ y_{i2} \\ \vdots \\ y_{iT} \end{bmatrix}$ $X_i = \begin{bmatrix} X_{i1} \\ X_{i2} \\ \vdots \\ X_{iT} \end{bmatrix}$ $u_i = \begin{bmatrix} u_{i1} \\ u_{i2} \\ \vdots \\ u_{iT} \end{bmatrix}$ $y_{it} = \log Y_{it}$,

$X_{it} = (\log K_{it}, \log L_{it}, \log SK_{it})$, and $b_j = (\alpha_j, \beta_j, \gamma_j)$.

B. Data

(1) Regional outputs: Y

Y is measured by regional total outputs in mining and manufacturing.[4]

(2) Labor: L

L is measured by yearly total employees in mining and manufacturing. The data Y and L are obtained from a series of the Report on Mining and Manufacturing (1970-87) issued by the Economic Planning Board in Korea.

(3) Capital stock: K

K is measured by the won value of fixed capital assets at the end of each year. The data source is the same as Y and L. The fixed capital assets data is available only during 1978-87 period. For the rest of periods only 1973 data is available. Thus for 1974-77 period we compute K_t using the following identity.

$$(10)\qquad K_t = K_{t-1} + I_t - D_t$$

[4] We exclude the other industries such as agriculture and service industries for lack of the data.

where K_t is the fixed capital assets at the end of year t and $D_t = \sigma_t K_{t-1}$ where σ_t is the depreciation rate in year t. I_t is the net investment in year t and D_t is the capital depreciation in year t. I_t for 1974-78 period can be calculated from the data set. But the data for D_t for the same period is missing. Thus we use the Benchmark Method as Pyo (1988) to get the constant depreciation rate σ^* and D_t during 1974-78 period.

For 1970-72 period the data for D_t is also missing while I_t can be obtained from the data set. In order to get K_t for 1970-72 period we apply σ^* to estimate D_t

(4) Social indirect capital: SK

Social indirect capital includes highways, harbor facilities, water supply system and sewers, and other public goods that play a crucial role in determining gross regional outputs at earlier stage of regional economic development. For lack of data measuring SK directly we assume that the sum of industrial economic expenditures and regional development expenditures in year t represent the net investment SI_t. Then SK_t can be estimated as follows.

(11) $$SK_t = SK_{t-1}\ (1-\sigma_t) + SI_t.$$

where σ_t denotes the depreciation rate in year t which is assumed to be equal to the capital depreciation rate in year t.

C. Estimation Method

The following estimation procedure is applied to estimating the RAPF's of the MT area, the OM area, and the RH area respectively.[5] So we drop the subscript j that indicates area j.

The estimation equation (9) can be represented more compactly as

(12) $$Y = X\ b + u$$

where Y is a vector of length NT, X is (NTxNk) matrix, where k is a number of explanatory variables, N is a number of cross-section units, and T is a number of years.

Let V be the covariance matrix of u_{it}. Then we may write V as

5 In this section we mostly follow the expositions shown in Kim (1989).

(13)
$$V = \begin{bmatrix} V_1 & 0 & \cdots & 0 \\ 0 & V_2 & \cdots & 0 \\ \vdots & & \ddots & \vdots \\ 0 & 0 & \cdots & V_N \end{bmatrix} \text{ where } V_i = \begin{bmatrix} \sigma_\eta^2 + \sigma_\varepsilon^2 & \sigma_\eta^2 & \cdots & \sigma_\eta^2 \\ \sigma_\eta^2 & \sigma_\eta^2 + \sigma_\varepsilon^2 & \cdots & \sigma_\eta^2 \\ \vdots & & & \\ \sigma_\eta^2 & \sigma_\eta^2 & \cdots & \sigma_\eta^2 + \sigma_\varepsilon^2 \end{bmatrix}$$

In estimating equation (12) if we know σ_η and σ_ε we can use Generalized Least Square (GLS) method. If we find the orthogonal matrix P such that $P'P\,\theta^{-2} = V^{-1}$ where θ is a scale parameter, premultiplying both sides of equation (12) by P gives

(14)
$$P\,Y = P\,X\,b + P\,u$$
$$\text{or } \tilde{Y} = \tilde{X}\,b + \tilde{u}$$

where $\tilde{Y} = P\,Y$, $\tilde{X} = P\,X$, and $u = P\,\tilde{u}$. For the new disturbance term $\tilde{u}$ its covariance matrix is

$$E(\tilde{u}\,\tilde{u}') = \theta^2 I$$

where I denotes a NTxNT identity matrix. Therefore we can apply Ordinary Least Squares (OLS) to the transformed data in equation (14). The orthogonal matrix P is a block diagonal matrix.

$$P = \begin{bmatrix} P_1 & 0 & \cdots & 0 \\ 0 & P_2 & \cdots & 0 \\ \vdots & & \ddots & \\ 0 & 0 & \cdots & P_N \end{bmatrix} \quad \text{where all } P_i\text{'s are (TxT) matrix for } i = 1,N.$$

Since we do not know σ_η^2 and σ_ε^2, the question is how to estimate them. In the estimation procedure we do not estimate them directly. Instead we will develop the maximum likelihood estimation method.

Assuming the normality of η and ε, we can find the likelihood function for region i,

(15)
$$L_i = (2\pi)^{-T/2}\,|V_i|^{-1/2} \exp(-1/2\; u_i'\,V_i\;\; u_i)$$

Then the likelihood function for the all regions will be $L = \prod_{i=1}^{N} L_i$.

Finding P requires us to find each P_i such that

(16)
$$P_i'\,P_i\,\theta^{-2} = V_i^{-1}, \qquad i = 1, N.$$

Motivated by the form of matrix V_i we may set

(17) $$P_i = I_T - \frac{\rho}{T} 1\,1'$$

where $1 = (1,1,\ldots,1)'$ is a (Tx1) column vector. The column vector of $\tilde{u}_{it}$ then can be written as

(18) $$[u_{it}] = P_i[u_{it}]$$
$$= [(1-\rho)\ \eta_i + \varepsilon_{it} - \rho\ \bar{\varepsilon}_i]_{(T\times 1)}$$

where $\bar{\varepsilon}_i = \frac{1}{T} \sum_{i=1}^{T} \varepsilon_{it}$ and the term in the bracket represents a typical term in the vector. Thus finding P_i is equivalent to finding ρ.

Using the fact that $E(u_{it}\ u_{is}) = 0$ for $t \neq s$. We can derive

(19) $$E(u_{it}\ u_{is} \mid t \neq s) = (1-\rho)^2\ \sigma_\eta^2 + 2\rho\ \frac{\sigma_\eta^2}{T} + \rho^2\ \frac{\sigma_\varepsilon^2}{T} = 0$$

Let $\delta = \frac{\sigma_\eta^2}{\sigma_\eta^2 + \sigma_\varepsilon^2}$. Then equation (19) can be rearranged as

(20) $$(\delta + \frac{1}{T}\ (1-\delta))\ \rho^2 - 2\ (\delta + \frac{1}{T}\ (1-\delta))\ \rho + \delta = 0.$$

Equation (20) is the quadratic equation of δ. Solving for ρ in equation (20) we can find

(21) $$\rho = 1 - \left(\frac{\frac{1}{T}(1-\delta)}{\delta + \frac{1}{T}(1-\delta)}\right)^{1/2}$$

Thus finding ρ is equivalent to finding δ. The MLE comes down to finding the optimal δ that gives the maximum likelihood.

Substituting $V_i^{-1} = P_i'P_i\ \theta^{-2}$ and $|V_i|^{-1/2} = |P_i|\theta^{-T}$ which is implied by equation (16) into the likelihood function (15) for region i we obtain

(22) $$L_i = (2\pi)^{-T/2}\,\theta^{-T}\ (1-\rho)\ \exp\ (-\frac{1}{2\theta^2}\ \tilde{u}_i'\ \tilde{u}_i)$$

Since $\hat{\theta}^2 = \frac{\tilde{u}_i'\tilde{u}_i}{T}$ where $\hat{\theta}$ is an estimated θ, $\hat{\theta}^2$ is $\hat{\sigma}^2$ that is the standard error of transformed OLS. Finally equation (22) can be written as

(23) $L_i = (2\pi)^{-T/2} \, (\hat{\sigma}^2)^{-T/2} \, (1-\rho) \exp\left(-\frac{T}{2}\right).$

or $\log L_i = -\frac{T}{2} \log \hat{\sigma}^2 + \log (1-\rho) - \frac{T}{2} - \frac{T}{2} \log 2\pi.$

Summing up L_i we find

(24) $L = \sum_{i=1}^{N} \log L_i = \log \frac{(1-\rho)}{\hat{\sigma}^{NT}} - \frac{TN}{2} (\log 2\pi + 1)$

Therefore the estimation procedure is to search over the value of δ between 0 and 1 that maximizes the likelihood function (24). Let us summarize the estimation procedure.

(i) Suppose a certain value of δ is chosen then compute ρ in equation (21).
(ii) Next calculate P_i in equation (17) and get P.
(iii) Given P transform the data by premultiplying P and apply OLS to the transformed data.
(iv) Compute the log likelihood in equation (24). This procedure will be repeated given different values of δ. A grid search is very useful in finding the optimal δ.

This result of grid search for the RH area is presented in (Table 9). We find that the optimal δ that maximizes the log-likelihood is 0.71. The results of grid search for the MT area and the OM area are presented in (Table 10) and (Table 11) repsectively.

Table 9

THE GRID SEARCH RESULT FOR THE REMOTE HINTERLAND AREA

σ	0	0.2	0.4	0.6	0.7	0.71*	0.8	0.9
log-likelihood	140.12	146.55	147.98	148.80	148.95	148.96*	148.79	147.95

Table 10

THE GRID SEARCH RESULT FOR THE METROPOLITAN AREA

σ	0	0.2	0.4	0.5	0.53*	0.6	0.8	0.9
log-likelihood	80.66	88.39	89.51	89.641	89.648*	89.61	89.14	89.51

Table 11

THE GRID SEARCH RESULT FOR THE OUTLYING METROPOLITAN AREA

σ	0	0.2	0.4	0.6	0.8	0.9	0.9999*
log-likelihood	64:1	79.6	83.3	84.8	85.5	86.2	101.7*

* indicate the otpimal σ and the maximum likelihood.

D. *Empirical Results*

The estimates of the RAPF are summarized in (Table 12).

First, from the Table we may note that technological differences across the areas explain the regional output gap. In other words the metropolitan area ($\alpha+\beta+\gamma=1.11$) and the outlying metropolitan area ($\alpha+\beta+\gamma=1.38$) show increasing returns to scale technology while the remote hinterland area ($\alpha+\beta+\gamma=0.97$) shows decreasing returns to scale technology. The technological gap also exists when only two factor inputs — capital and labor — are taken into account (see the second last column in (Table 12)).

Table 12

THE ESTIMATION RESULTS OF THE REGIONAL AGGREGATE PRODUCTION FUNCTION $\log Y_t = \alpha \log K_t + \beta \log L_t + \gamma \log SK_t$

area	α	β	γ	α+β	α+β+γ
MT: Metropolitan	0.162***	0.880***	0.068	1.04	1.11
(SE, BS)	(4.48)	(16.6)	(0.91)		
OM: Outlying					
Metropolitan	0.227***	0.856***	0.304***	1.08	1.38
(KG, KB, KN)	(5.57)	(9.37)	(4.21)		
RH: Remote					
Hinterland	0.343***	0.322***	0.301***	0.67	0.97
(CB, CN, JB, JN,	(5.54)	(4.08)	(5.96)		
KW, JJ)					

Notes: t-value is in parenthesis. ***: 1% significance level.
Y_t denotes the utput in year t,
K_t and L_t denote the capital and labor inputs in year t, and
SK_t denotes the social indirect capital in year t.

Second, the differential input factor growth rates also capture the output growth differentials. As shown in (Table 13) for all factor inputs except for capital the remote hinterland area shows lower growth rate than other areas.

Therefore we conclude that the output gaps across the regions are explained by the differences in the factor input growth as well as the absolute level of factor inputs.

Table 13

THE ANNUAL GROWTH RATES OF OUTPUT AND FACTOR INPUTS: 1970-87 (%)

area	output ($\dot{Y}/Y$)	capital ($\dot{K}/K$)	labor ($\dot{L}/L$)	social indirect capital ($\dot{SK}/SK$)
MT	9.5	9.0	5.4	18.4
OM	17.8	13.0	10.6	17.7
RH	10.5	11.1	3.4	17.5

Third, we consider technical progress as one of the important factors that explain differential output growth across the regions. However we cannot observe the data measuring regional technical progress. Thus we will estimate them using the following equation which is obtained from equation (5).

$$\frac{\dot{A}}{A} = \frac{\dot{Y}}{Y} - \alpha \frac{\dot{K}}{K} - \beta \frac{\dot{L}}{L} - \gamma \frac{\dot{SK}}{SK} \tag{25}$$

From the estimates of α, β, and γ in (Table 12) and $\frac{\dot{Y}}{Y}$, $\frac{\dot{K}}{K}$, $\frac{\dot{L}}{L}$, and $\frac{\dot{SK}}{SK}$ in (Table 12) we can obtain the estimates of $\frac{\dot{A}}{A}$[6] as shown in (Table 14).

According to (Table 14) the RH area falls behind other areas even in terms of technical progress.[7]

6 Since basic model is a continuous model, $\frac{\dot{A}}{A}$ must be the instantaneous growth rate of technical progress. Here, $\frac{\dot{A}}{A}$ is represented by the yearly growth rate of technical progress.

7. We must be a little bit careful about the interpretation of (Table 14). For the right-hand side of equation (25) is the residual of estimation so that it includes other factors such

Table 14

THE ESTIMATES OF ANNUAL TECHNICAL PROGRESS RATE: 1970-87 (%)

area	MT	OM	RH
	2.0	0.4	0.3

Notes: MT denotes the metropolitan area
OM denotes the outlying metropolitan area
RH denotes the remote hinterland area.

Therefore we conclude that the differences in technologies, the absolute level and the growth rates of factor inputs, and technical progress have deepened the regional economic gap acceleratedly. None of the above factors has favored the RH area.

Finally, there are a couple of interesting findings in the RAPF estimation results. First, the estimate of coefficient γ for the MT area which represents returns to social indirect capital input is very small (0.068) relative to other areas (0.301-0.304) and statistically insignificant. We suspect that the congestion caused by the economic and population concentration into the MT area lowered the productivity of social indirect capital. It also implies that the equal amount of social indirect capital investment for the MT area will not be as efficient as other areas.

Second, the RH area shows lower returns to labor input than other areas. The economic explanation for that is that for lack of capital stock per capita capital equipment has been lower resulting in lower productivity of labor.

V. Conclusions

Using per capita GRP data we estimated the absolute and the relative regional income inequality indices. We found that the absolute inequality indices had increased until mid 80's while the relative inequality indices have decreased steadily.

In the context of per capita GRP we examined the relationship be-

as political factor. In that case we must interpret the results such that the MT area and the OM area have been favored politically more than the RH area in the Korean economic growth path.

tween regional income inequality and economic development. We found that the absolute regional income inequality has increased while the relative regional income inequality has been alleviated as Korean economy grows. The economic gap across the regions still persist however.

We estimated the regional aggregate production function to figure out the economic factors that explain the regional economic gap. We found that technological differences as well as the differential growth rates of factor inputs have been responsible for the regional gap. Finally we confirm that the role of social indirect capital is very crucial in earlier stage of Korean economic development.

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