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Regional Income Inequality in the Post War Japan

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Abstract

The objective of this study is to measure regional income inequalities in Japan in the postwar period by using the weighted coefficient of variation and the Theil T index and explore factors determining regional income inequalities by using several inequality decomposition techniques. Regional inequality in per capita GDP, as measured by the weighted coefficient of variation, first increased and reached a peak in 1958 at 0.38. It then declined steadily and hit the bottom at 0.25 in 1979. After 1979, it rose again and reached a peak in 1990 at 0.37. There is a declining trend after 1990. To a considerable extent, regional inequality in per capita GDP is determined by regional inequality in labor productivity. Regional inequality in labor participation rate is not significant in the determination. A rapid rise in primary sector's inequality in per capita GDP is attributable to a rise in its inequality in employment share. On the other hand, a decrease in secondary sector's inequality in per capita GDP until the middle of the 1970s is due mainly to a fall in its inequality in employment share, while a decrease in tertiary sector's inequality in per capita GDP until the middle of 1960s is attributable to a fall in its inequality in both labor productivity and employment share. Finally, a rise and a fall in secondary and tertiary sectors' inequalities in per capita GDP in the 1980s and the 1990s are determined by their inequalities in labor productivity, since their inequalities in employment share were low and stable in the period.

1. Introduction

In his seminal work on national development and regional inequality, Williamson (1965) predicted that regional income inequality could be divided into three distinct phases as a nation moves from a less developed to a more developed economy. In the early stages of economic development, regional income inequality will increase, largely because of the disequilibrating effects of factor mobility. This will be followed by a period of stability, characterized by a relatively high level of inequality between regions. Finally, regional inequality will decrease as the national economy matures and equilibrating forces take effect. This overall process, if plotted against national economic development, will result in a bell-shaped or inverted U-shaped curve.

The early stages of development are also associated with rapid urbanization; in contrast, as the economy matures, there is a shift toward population dispersion. Other stylized facts in the process of development include industrialization, demographic transition, and changing income inequality among population subgroups (Alonso, 1980). The concentration of population in and around large cities is usually accompanied by an increase in regional income inequality. Some researchers have argued that this type of population concentration and the concurrent increase in regional inequality does not per se impede economic development and may in fact facilitate it. Nonetheless, many national governments have introduced policies of balanced regional development.

Regional income inequality in Japan has often been the subject of theoretical discussions and empirical economic research due to the fact that Japan has been able to decrease large regional income differentials while achieving remarkable economic growth. There are various studies on regional income inequality in Japan, and most of these examined the speed of convergence, the relationship of interregional migration with income inequality, and the role of public investment allocation on regional income disparity. For example, Mutlu (1991) described broad policy orientations and the resulting change in regional inequalities. Sala-i-Martin (1996) examined empirical evidence of a negative relationship between initial regional income and the subsequent growth rate, so-called β-convergence, with an estimated convergence rate of 2% per year. Tabuchi (1988) demonstrated, using Sims' causality test, that regional income differentials determines net migration in the period between 1954 and 1982, but not conversely. Fujita and Tabuchi (1997) documented two significant changes in the Japanese economy: (a) the shift from light to heavy industries, which transformed the regional structure of the economy from the Tokyo-Osaka bipolar system to the Pacific industrial belt system, and (b) the shift from heavy to high-tech and service industries, which further transformed the regional structure into the Tokyo Monopolar system. Yamano and Ohkawara (2000) examined the effects of the regional allocation of public capital on national growth and regional inequality through simulations of several policy alternatives.

The objective of this study is to measure regional income inequalities in Japan in the postwar period by using the weighted coefficient of variation and the Theil T index and explore factors determining regional income inequalities by using several inequality decomposition techniques.

This paper is organized as follows. The next section discusses national and regional economic development in postwar Japan. The third section presents the method and the data used in this study. The fourth section then discusses the findings based upon these data and methods.

2. National and Regional Economic Development in Postwar Japan

Postwar Japan has had notable economic success as indicated by average annual GDP and GDP per capita growth rates of 5.3% and 4.5%, respectively. GDP per capita in 2000 was 3.84 million yen, which is equivalent to US$37,549 (IMF, 2002). This is one of the highest levels of GDP per capita among developed countries, despite losing one-third of its industrial base in World War II (Vestel, 1994).

It can be said that the Japanese miracle started from the Five Year Economic Rehabilitation Plan in 1948, the first genuine economic plan in the postwar period. The main goal of this plan was to raise production and living standards to prewar levels by promoting the industrial shift from light to heavy industry. Soon after the attainment of this goal, the National Income Doubling Plan of 1960 was formulated – its aim was to double per capita national income in real terms. It adopted the Pacific Coast Belt Scheme, which proposed dispersing industrial bases throughout the Pacific Coast Belt, a region that would connect the four overcrowded industrial areas of Tokyo, Nagoya, Osaka, and Kitakyushu. In 1962, the Comprehensive National Development Plan was formed in response to the problems of overcrowding, depopulation and regional inequality; it attempted to disperse industrial and urban development throughout the country, especially outside the Pacific Coast Belt. In order to maximize the plan’s effectiveness, the Growth-Pole Scheme was adopted, which proposed allocating more investment in selected strategic areas (growth poles) outside the Pacific Coast Belt in the hope of generating the benefits of development in the surrounding areas. Under this scheme, two laws were formulated: (a) the Law for the Promotion of New Industrial Cities designated 15 new industrial cities, and (b) the Law for the Promotion of Special Industrial Development Areas designated 6 special industrial development areas. Until the early 1970s, these policy packages contributed to a rapid economic growth at a very high rate of approximately 10% annually.

In the 1960s, public pressure changed the objectives of economic plans from income growth to the correction of economic distortions caused by rapid economic growth (Tabb, 1995). The Second Comprehensive National Development Plan of 1969 focused on solving problems such as overcrowding, depopulation and regional inequality by diffusing development opportunities and benefits over the entire nation. In accordance with this plan, the Law on the Promotion of Industrial Development (1971) and the Law on the Promotion of Industrial Relocation (1972) were enacted to induce manufacturing firms to relocate their factories from the Tokyo, Nagoya, and Osaka areas to relatively less developed areas and underdeveloped remote areas. Table 2.2 and 2.3 show that the regional concentration of population and GDP into the three major metropolitan areas (Tokyo, Nagoya, and Osaka) tapered off in the mid-1970s.

In the 1970s, the sudden increase in energy prices and the rapid appreciation of the yen marked the end of rapid economic growth (see Figure 2.1) while concurrently the Japanese industrial structure started to shift from heavy and chemical industries to high technology-oriented industries. These drastic changes in the economic structure diverted development policies away from a focus on industrialization to a focus instead on population stabilization. The Third Comprehensive National Development Plan was devised in 1977, and its fundamental objective was to develop favorable integrated environments, balanced land use, and better living conditions by dealing with the issues of over-centralization, depopulation and regional inequalities. This plan also promoted the development of diversified economies and public investments on municipal levels. This seems to have resulted in staunching the flow of population away from rural areas in the mid-1970s (See Table 2.1).

The government instituted fiscal reconstruction in response to budgetary problems that were a result of the decrease in tax revenue and the increase in bond expenditures after the first oil shock. The consequential policies completely froze new public expenditures and severely affected rural economies. These conditions triggered increases in exports, especially to the U.S.; however, Japan's large trade surplus with the U.S. and other countries eventually led to the Plaza Accord of 1985, an international agreement among five major developed nations, which set a higher exchange rate for the yen vis-à-vis the U.S. dollar. In 1986, the Report of the Advisory Group on Economic Structural Adjustment for International Cooperation was submitted to Prime Minister Nakasone; it recommended a reorientation of Japan's growth strategy away from export dependence to domestic-led growth (Tabb, 1995). In 1987, the Fourth National Development Plan was formulated; its goal was to form a multi-polar system of national land use through an integrated network of exchange among major urban / industrialized areas and surrounding localities. Simultaneously, controversial objectives were added as a result of political pressure: Tokyo was to become a world-class metropolitan center for the entire country. As a part of this plan, a series of industrial development laws[1] were enacted in the late 1980s that engendered redevelopment booms all around Japan. Comprehensive financial deregulation led to excessive credit expansion and an increase in investment opportunities in the financial and real-estate sectors. The result was overheated speculation in land and equity shares. Figure 2.1 and Tables 2.2 and 2.3 show the higher national economic growth rate and the regional concentration of population and GDP in large cities.

Confidence in the financial system continued to be weak due to the increasing number of non-performing loans, which were the result of bad investments during the financial and real estate bubble of the late 1980s. This loss of confidence in the financial system has prolonged the recession of the 1990s. In response, the government has taken several stimulus measures in supplementary budgets that included special tax reductions, increases in government expenditures, and public works spending especially for rural development projects (Flath, 2000). Table 2.3 shows that regional distribution of output was dispersed away from urban regions in the 1990s – the regional distribution of GDP in the 3 major metropolitan areas declined from 54.3 % to 51.7%. However, these policies did not succeed in generating a full economic recovery as the average annual growth rate remained at 0.9 % in the 1990s (see Figure 2.1).

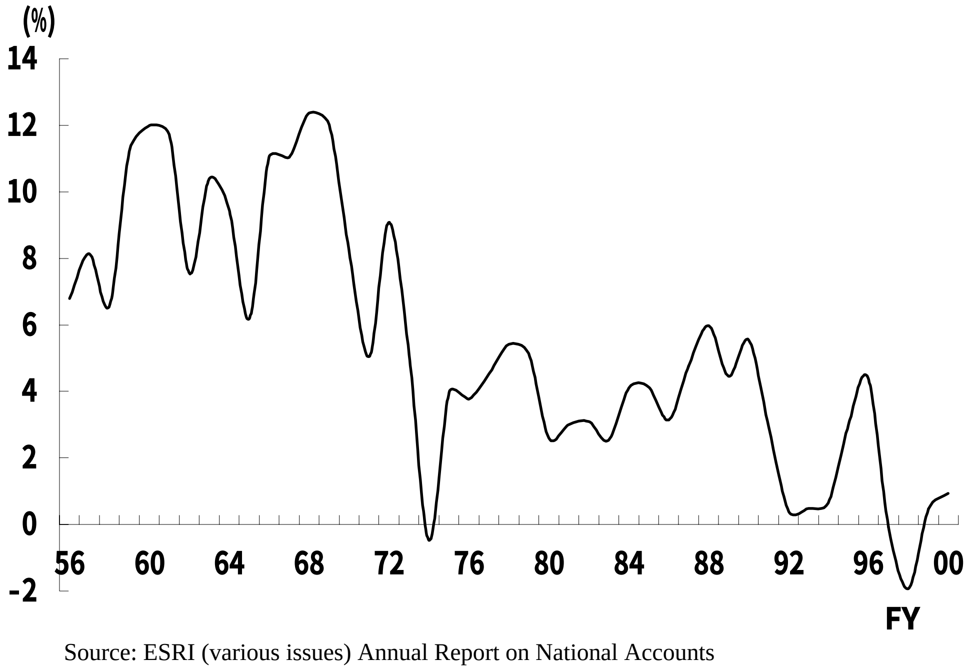
The problems afflicting Japan in the 1990s, including the prolonged recession, government budget deficits, and a low fertility and an aging society, signaled that the Japanese economy had entered a new stage of development. In 1998, the 5th Comprehensive National Development Plan was formulated and provided new guidelines for national land development through participation and mutual cooperation among the different entities - central and local government, private sector, and NGOs. This plan placed greater emphasis on autonomous regional development based upon each region's decision and responsibilities.

Table 2.1
Major Economic Indicators in Japan: 1955-2000

	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000
Real GDP (Trillion Yen)	47.9	73.5	113.4	190.4	237.3	292.7	345.4	436.0	469.4	486.9
Per capita GDP (Million Yen)	0.54	0.79	1.15	1.83	2.12	2. 50	2.85	3.53	3.74	3.84
Population (in Million People)	89.3	93.4	98.3	103.7	111. 9	117.1	121.1	123.6	125.6	126.9
Urban Population (% of Total)	56.1	63.3	67.9	72.1	75.9	76.2	76.7	77.4	78.1	78.7
Employment (in Million Employees)	39.6	44.0	48.0	52.6	53.1	55.8	58.3	61.7	64.1	63.0
Employment Share (in %)										
Primary Sector	41.2	32.7	24.7	19.3	13.9	10.9	9.3	7.2	6.0	5.1
Secondary Sector	23.4	29.1	31.5	34.1	34.2	33.6	33.2	33.5	31.8	29.8
Tertiary Sector	35.5	38.2	43.7	46.6	52.0	55.4	57.5	59.4	62.2	65.1

Notes: The data of Real GDP and per capita GDP are 1990 constant prices.
Population prior to 1975 excluded that of Okinawa prefecture whereas employment does not.
Sources: ESRI (various issues) Annual Report on National Accounts
Statistics Bureau (various issues) Population Census
Statistics Bureau (various issues) Japan Statistical Yearbook

Figure 2.1
Growth Rate of Real GDP in Japan in 1990 Constant prices



Source: ESRI (various issues) Annual Report on National Accounts

Table 2.2
Change in Regional Distribution: Population

	Regional Share of Total (%)										AGR
	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000	(%)
Hokkaido・Tohoku	15.7	15.8	14.4	13.6	13.0	12.9	12.7	12.4	12.4	12.2	0.2
Kanto	26.6	28.8	29.6	31.2	32.2	32.6	33.1	33.9	34.2	34.5	1.4
Chubu	15.0	15.5	15.0	15.1	15.1	15.1	15.0	15.1	15.2	15.2	0.8
Kinki	15.1	16.2	16.7	17.3	17.5	17.4	17.3	17.2	17.1	17.1	1.0
Chugoku	7.8	7.6	6.9	6.7	6.6	6.5	6.4	6.3	6.2	6.1	0.2
Shikoku	4.7	4.5	4.0	3.7	3.6	3.6	3.5	3.4	3.3	3.3	0.0
Kyushu・Okinawa	15.3	15.2	13.4	12.4	12.0	12.0	11.9	11.7	11.7	11.6	0.2
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.8
3 Major M.A.	34.3	38.4	40.7	43.5	44.9	45.1	45.4	46.1	46.3	46.7	1.5
- Tokyo	17.1	19.6	21.2	23.0	24.2	24.5	25.0	25.7	25.9	26.3	1.7
- Nagoya	5.8	6.3	6.4	6.6	6.7	6.8	6.8	6.9	6.9	7.0	1.2
- Osaka	11.3	12.5	13.2	13.9	14.0	13.8	13.7	13.5	13.4	13.4	1.1

Notes: AGR is short for annual average growth rate from 1955-2000.
M.A is short for metropolitan area.
Hokkaido・Tohoku： Hokkaido, Aomori, Iwate, Miyagi, Akita, Yamagata, Fukushima
Kanto： Niigata, Ibaraki, Tochigi, Gunma, Saitama, Chiba, Tokyo, Kanagawa, Yamanashi
Chubu： Nagano, Shizuoka, Toyama, Ishikawa, Gifu, Aichi, Mie
Kinki： Fukui, Shiga, Kyoto, Osaka, Hyogo, Nara, Wakayama
Chugoku：Tottori, Shimane, Okayama, Hiroshima, Yamaguchi
Shikoku：Tokushima, Kagawa, Ehime, Kochi
Kyushu・Okinawa：Fukuoka, Saga, Nagasaki, Kumamoto, Oita, Miyazaki, Kagoshima, Okinawa
Tokyo metropolitan area: Saitama, Chiba, Tokyo-to, Kanagawa
Nagoya metropolitan area: Aichi, Mie
Osaka metropolitan area: Kyoto, Osaka, Hyogo
Sources: Statistics Bureau (various issues) Population Census

Table 2.3
Change in Regional Distribution: Real GDP

	Regional Share of Total (%)										AGR
	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000	(%)
Hokkaido・Tohoku	14.0	13.3	12.1	10.6	11.3	11.2	10.8	10.0	10.6	10.7	4.7
Kanto	32.5	32.9	34.6	36.0	35.9	36.3	38.2	40.0	38.5	37.8	5.7
Chubu	14.7	15.6	14.7	15.6	15.3	15.4	15.8	15.8	15.9	16.6	5.6
Kinki	16.2	16.7	18.6	19.1	17.9	17.8	17.2	17.1	17.4	17.1	5.5
Chugoku	7.0	6.8	6.5	6.5	6.5	6.3	6.0	5.7	5.8	5.7	4.8
Shikoku	3.8	3.6	3.3	3.1	3.1	3.0	2.8	2.6	2.8	2.8	4.5
Kyushu・Okinawa	11.9	11.0	10.2	9.2	9.9	10.1	9.4	8.8	9.1	9.3	4.8
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	5.3
3 Major M.A.	43.6	45.8	49.6	52.8	51.1	51.0	52.2	54.3	52.7	51.7	5.7
- Tokyo	25.1	25.8	27.6	29.1	28.8	28.6	30.3	32.2	30.4	29.7	5.7
- Nagoya	6.2	6.8	6.7	7.7	7.5	7.6	7.8	8.1	8.0	8.2	6.0
- Osaka	12.3	13.2	15.3	16.0	14.9	14.8	14.1	14.0	14.2	13.8	5.6

Notes: As for Table 2.2.
Sources: ERI (1991) Retroactive Estimation of Prefectural Accounts, 1955-1974
ESRI (2002) Annual Report on Prefectural Accounts
ESRI (2003) Annual Report on Prefectural Accounts

3. Method and The Data

3.1. Methods

This section presents several indices of regional inequality that are employed in this study. Since this study uses regional per capita GDP to measure disparities in regional income levels, we start with a multiplicative decomposition of per capita GDP, which relates per capita GDP to labor productivity and labor participation rate. In a three-sector economy consisting of the primary, secondary, and tertiary sectors, we also show that labor productivity in a region is additively decomposed into three sectoral labor productivity components, where each component is the product of sectoral labor productivity and employment share. Therefore, regional inequality in per capita GDP can be ascribed to regional disparities in labor participation rate, sectoral labor productivities, and sectoral employment shares.

There are several indices that are used to measure regional income inequalities. Among them are the Gini coefficient, the coefficient of variation, the weighted coefficient of variation, the variance of logarithmic income, and Theil indices. This study employs the weighted coefficient of variation and a Theil index, called the Theil T index, to measure regional inequalities. This section first presents the Theil T index, which is defined in terms of both per capita GDP and labor productivity. We show that the Theil T index for labor productivity using sectoral GDP and employment figures can be decomposed into the within-sector inequality and between-sector inequality components. Based on the Theil T index, we also present the linear relationship between regional inequalities in per capita GDP and labor productivity.

This section next presents the weighted coefficient of variation, which is defined in terms of per capita GDP and labor productivity. In the three-sector economy, we show that the square of the weighted coefficient of variation is additively decomposed into six components: three components refer to the sectoral weighted coefficient of variation and the other three components denote the weighted coefficient of covariation between sectors. By using this method, we can analyze the extent to which each component contributes to the square of the overall weighted coefficient of variation.

Multiplicative Decomposition of Per Capita GDP into Labor Productivity and Labor Participation Rate

Let $Y_i, E_i, \text{and } P_i$ be GDP, employment, and population in region i, respectively, where there are n regions in the nation. Then per capita GDP in region i is given by $y_i = \frac{Y_i}{P_i}$, and can be multiplicatively decomposed into two components: labor productivity and labor participation rate.

$$y_i = x_i e_i \tag{1}$$

where $x_i = \frac{Y_i}{E_i}$ is labor productivity in region i and

$e_i = \frac{E_i}{P_i}$ is labor participation rate in region i.[2]

Suppose that the economy is divided into the following three sectors: primary, secondary, and tertiary sectors. Then total GDP is the sum of GDP from these three sectors, i.e.,

$$Y_i = Y_{1i} + Y_{2i} + Y_{3i} \tag{2}$$

where $Y_{1i}, Y_{2i}, \text{and } Y_{3i}$ are GDP from the primary, secondary, and tertiary sectors in region i, respectively. Similarly total employment is the sum of employment in these three sectors, i.e.,

$$E_i = E_{1i} + E_{2i} + E_{3i} \tag{3}$$

where $E_{1i}, E_{2i}, \text{and } E_{3i}$ are region i's employment in the primary, secondary, and tertiary sectors, respectively.

Let $y_{ji} = \frac{Y_{ji}}{P_i}$ be per capita GDP from sector j in region i. Then, we have

$$y_i = y_{1i} + y_{2i} + y_{3i}.$$

y_{ji} can be multiplicatively decomposed into three components as follows

$$y_{ji} = q_{ji} e_i = x_{ji} s_{ji} e_i \quad \text{for } j = 1, 2, \text{and } 3, \tag{4}$$

where $q_{ji} = \frac{Y_{ji}}{E_i}$ is sector j's GDP in region i per regional total employment,

$x_{ji} = \frac{Y_{ji}}{E_{ji}}$ is the labor productivity of sector j in region i, and

$s_{ji} = \frac{E_{ji}}{E_i}$ is the share of sector j in employment in region i.

Using equations (2) and (4), equation (1) is reduced to

$$y_i = \left(\frac{Y_{1i} + Y_{2i} + Y_{3i}}{E_i}\right)e_i = (q_{1i} + q_{2i} + q_{3i})e_i = (x_{1i}s_{1i} + x_{2i}s_{2i} + x_{3i}s_{3i})e_i \, . \qquad (5)$$

Therefore, regional inequality in per capita GDP can be attributed to regional disparities in labor participation rate, sectoral labor productivities, and sectoral employment shares.

Theil T Index and Its Decomposition into Between-Sector and Within-Sector Components

Theil indices are used to measure regional inequality (Theil, 1967). Using GDP and population figures, the Theil T index is given by

$$T = \sum_{i=1}^{n} \frac{Y_i}{Y} \log\left(\frac{Y_i/Y}{P_i/P}\right)$$

Let $\bar{y} = \frac{Y}{P}$ be national per capita GDP, where Y and P are, respectively, total national GDP and population. Then this equation is rewritten as

$$T = \sum_{i=1}^{n} \left(\log(y_i) - \log(\bar{y})\right)\frac{Y_i}{Y}, \qquad (6)$$

and thus the Theil T index measures regional inequality in per capita GDP. It uses GDP shares as weights, while another Theil index, the Theil L index, uses population shares as weights as follows

$$L = \sum_{i=1}^{n} \frac{P_i}{P} \log\left(\frac{P_i/P}{Y_i/Y}\right) = \sum_{i=1}^{n} \left(\log(\bar{y}) - \log(y_i)\right)\frac{P_i}{P}.$$

Using the Theil T index, we can measure regional inequality in labor productivity as follows.

$$T = \sum_{i=1}^{n} \frac{Y_i}{Y} \log\left(\frac{Y_i/Y}{E_i/E}\right) = \sum_{i=1}^{n} \left(\log(x_i) - \log(\bar{x})\right)\frac{Y_i}{Y}. \qquad (7)$$

In this equation, $\bar{x} = \frac{Y}{E}$ is national labor productivity, where E is national total employment. This equation compares sector j's labor productivity with the national labor productivity.

Next, in a three-sector economy, regional inequality in labor productivity for sector j can be measured by

$$T_j = \sum_{i=1}^{n} \frac{Y_{ji}}{Y_{jt}} \log\left(\frac{Y_{ji}/Y_{jt}}{E_{ji}/E_{jt}} \right) = \sum_{i=1}^{n} \left(\log(x_{ji}) - \log(\bar{x}_j) \right) \frac{Y_{ji}}{Y_{jt}} \quad \text{for j = 1, 2, and 3,} \tag{8}$$

In equation (8), $\bar{x}_j = \frac{Y_{jt}}{E_{jt}}$ is sector j's labor productivity in the nation and $x_{ji} = \frac{Y_{ji}}{E_{ji}}$ is defined in equation (4) above, where Y_{jt} and E_{jt} are sector j's GDP and employment in the nation, respectively.

We can also measure regional inequality in labor productivity using sectoral GDP and employment figures as follows.

$$T = \sum_{j=1}^{3} \sum_{i=1}^{n} \left(\frac{Y_{ji}}{Y} \right) \log\left(\frac{Y_{ji}/Y}{E_{ji}/E} \right) = \sum_{j=1}^{3} \sum_{i=1}^{n} \left(\log(x_{ji}) - \log(\bar{x}) \right) \frac{Y_{ji}}{Y} . \tag{9}$$

As opposed to equation (7), this equation compares each sector's labor productivity in region i with the national labor productivity. The additive decomposability of Theil indices enables us to decompose this Theil T index into two components: the within-sector inequality component (T_W) and the between-sector inequality component (T_B) as follows.[3]

$$T = \sum_{j=1}^{3} \left(\frac{Y_j}{Y} \right) T_j + \sum_{j=1}^{3} \left(\frac{Y_j}{Y} \right) \log\left(\frac{Y_j/Y}{E_j/E} \right) = T_W + T_B \tag{10}$$

where T_j is defined in (8) and T_B is written as

$$T_B = \sum_{j=1}^{3} \left(\frac{Y_j}{Y} \right) \log\left(\frac{Y_j/Y}{E_j/E} \right) = \sum_{j=1}^{3} \left(\log(\bar{x}_j) - \log(\bar{x}) \right) \frac{Y_j}{Y} .$$

T_W is the weighted average of regional inequalities in labor productivity within each sector, while T_B presents inequality in labor productivity between sectors.

Relationship between Regional Inequalities in Per Capita GDP and Labor Productivity by Theil T Index

Now we consider $y_i = x_i e_i$ in (1). If we take the log of both sides of $y_i = x_i e_i$, we have

$$\log(y_i) = \log(x_i) + \log(e_i) \tag{11}$$

We also have

$$\log(\overline{y}) = \log(\overline{x}) + \log(\overline{e}) \tag{12}$$

where $\overline{y} = \frac{Y}{P}$, $\overline{x} = \frac{Y}{E}$, and $\overline{e} = \frac{E}{P}$. Using equations (11) and (12), we obtain

$$\sum_{i=1}^{n}\left(\log(y_i) - \log(\overline{y})\right)\frac{Y_i}{Y} = \sum_{i=1}^{n}\left(\log(x_i) - \log(\overline{x})\right)\frac{Y_i}{Y} + \sum_{i=1}^{n}\left(\log(e_i) - \log(\overline{e})\right)\frac{Y_i}{Y}.$$

We can rewrite this equation as follows.

$$\sum_{i=1}^{n}\left(\frac{Y_i}{Y}\right)\log\left(\frac{Y_i/Y}{P_i/P}\right) = \sum_{i=1}^{n}\left(\frac{Y_i}{Y}\right)\log\left(\frac{Y_i/Y}{E_i/E}\right) + \sum_{i=1}^{n}\left(\frac{Y_i}{Y}\right)\log\left(\frac{E_i/E}{P_i/P}\right) \tag{13}$$

The left hand side of equation (13) presents regional inequality in per capita GDP as measured by the Theil T index (equation (6)), while the first term of the right hand side presents regional inequality in labor productivity as measured by the Theil T index (equation (7)). It should be noted that the second term of the right hand side is not the Theil T index for the labor participation rate, since it uses GDP shares as weights, rather than employment shares.

Weighted Coefficient of Variation for Per Capita GDP and Labor Productivity and Its Sectoral Decomposition

Using population shares as weights, the weighted coefficient of variation for per capita GDP is given by

$$V = \frac{1}{\overline{y}}\sqrt{\sum_{i=1}^{n}(y_i - \overline{y})^2\frac{P_i}{P}} \tag{14}$$

where n is the number of regions. This equation measures regional income inequality in per capita GDP (Williamson, 1965).

If the economy is divided into the primary, secondary, and tertiary sectors, we have $\overline{y} = \overline{y}_1 + \overline{y}_2 + \overline{y}_3$ and $y_i = y_{1i} + y_{2i} + y_{3i}$, where $\overline{y}_j$ is sector j's per capita GDP in the nation (j = 1, 2, and 3). Using these relations, the square of the weighted coefficient of variation V^2 can be written as

$$V^2 = \frac{1}{\overline{y}^2}\left[\sum_{i=1}^{n}\left((y_{1i} - \overline{y}_1) + (y_{2i} - \overline{y}_2) + (y_{3i} - \overline{y}_3)\right)^2\frac{P_i}{P}\right]$$

$$= \frac{1}{\bar{y}^2}\left[\sum_{i=1}^{n}\left((y_{1i} - \bar{y}_1)^2 + (y_{2i} - \bar{y}_2)^2 + (y_{3i} - \bar{y}_3)^2 + 2(y_{1i} - \bar{y}_1)(y_{2i} - \bar{y}_2) + 2(y_{1i} - \bar{y}_1)(y_{3i} - \bar{y}_3) + 2(y_{2i} - \bar{y}_2)(y_{3i} - \bar{y}_3)\right)\frac{P_i}{P}\right]$$

Now, let z_j be the share of sector j in total national GDP. Then, we have $z_j = \frac{\bar{y}_j}{\bar{y}}$, and thus

$$\frac{1}{\bar{y}^2} = \frac{\bar{y}_j^2}{\bar{y}^2}\frac{1}{\bar{y}_j^2} = z_j^2\left(\frac{1}{\bar{y}_j^2}\right) \text{ for each j (j = 1, 2, and 3), and}$$

$$\frac{1}{\bar{y}^2} = \frac{\bar{y}_j}{\bar{y}}\frac{\bar{y}_k}{\bar{y}}\left(\frac{1}{\bar{y}_j\bar{y}_k}\right) = z_j z_k\left(\frac{1}{\bar{y}_j\bar{y}_k}\right) \text{ for each j and k (j, k = 1, 2, and 3; } j \neq k\text{).}$$

Using these relations, the square of the weighted coefficient of variation can be decomposed into[4]

$$V^2 = z_1^2V_1^2 + z_2^2V_2^2 + z_3^2V_3^2 + 2z_1z_2W_{12} + 2z_1z_3W_{13} + 2z_2z_3W_{23}. \tag{15}$$

In equation (15), V_j is the weighted coefficient of variation for sector j (j = 1, 2, and 3), given by

$$V_j = \frac{1}{\bar{y}_j}\sqrt{\sum_{i=1}^{n}(y_{ji} - \bar{y}_j)^2\frac{P_i}{P}}\ , \tag{16}$$

while W_{jk} is the weighted coefficient of covariation between sector j and sector k (j, k = 1, 2, and 3; $j \neq k$), given by

$$W_{jk} = \frac{1}{\bar{y}_j}\frac{1}{\bar{y}_k}\sum_{i=1}^{n}(y_{ji} - \bar{y}_j)(y_{ki} - \bar{y}_k)\frac{P_i}{P} \tag{17}$$

Next, using employment shares as weights, the weighted coefficient of variation for labor productivity is given by

$$V^* = \frac{1}{\bar{x}}\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2\frac{E_i}{E}} \tag{18}$$

If there are three sectors in the economy, the square of the weighted coefficient of variation in labor productivity can be decomposed into six components as in equation (15).

$$V^{*2} = z_1^2V_1^{*2} + z_2^2V_2^{*2} + z_3^2V_3^{*2} + 2z_1z_2W_{12}^* + 2z_1z_3W_{13}^* + 2z_2z_3W_{23}^* \tag{19}$$

In equation (17), V_j^* is the weighted coefficient of variation in GDP per total employment for sector j (j = 1, 2, and 3), given by

$$V_j^* = \frac{1}{\bar{q}_j}\sqrt{\sum_{i=1}^{n}(q_{ji} - \bar{q}_j)^2 \frac{E_i}{E}}\,, \tag{20}$$

while W_{jk}^* is the weighted coefficient of covariation in GDP per total employment between sector j and sector k (j, k = 1, 2, and 3; $j \neq k$), given by

$$W_{jk}^* = \frac{1}{\bar{q}_j}\frac{1}{\bar{q}_k}\sum_{i=1}^{n}(q_{ji} - \bar{q}_j)(q_{ki} - \bar{q}_k)\frac{E_i}{E}\,, \tag{21}$$

where $q_{ji} = \frac{Y_{ji}}{E_i}$ and $q_{ki} = \frac{Y_{ki}}{E_i}$ are defined in equation (4) above, and $\bar{q}_j = \frac{Y_j}{E}$ and $\bar{q}_k = \frac{Y_k}{E}$ are sector j and k's GDP per employment in the nation, respectively (j, k = 1, 2, and 3). We should note that q_{ji} and $\bar{q}_j$ (j = 1, 2, and 3) are not sector j's labor productivity.

It should be noted that equation (20) measures regional inequality in sector j's GDP per total employment, rather than sector j's employment, and is different from

$$V_{xj}^* = \frac{1}{\bar{x}_j}\sqrt{\sum_{i=1}^{n}(x_{ji} - \bar{x}_j)^2 \frac{E_{ji}}{E_{jt}}}\,, \tag{22}$$

which measures regional inequality in sector j's labor productivity, where E_{jt} is total employment in sector j.

3.2. The Data

In order to measure regional inequalities in per capita GDP and labor productivity, we used prefectural data on GDP by industrial origin, employment by industrial origin, and population. Prefectural GDP data for the period of 1955-1974 were obtained from *Retroactive Estimation of Prefectural Accounts, 1955-1974* (ERI, 1991), which was compiled by the Economic Research Institute of the Economic Planning Agency based on the 1968 System of National Accounts (68 SNA). On the other hand, prefectural GDP data for the period of 1975-1999 were obtained from *Annual Report on Prefectural Accounts 2002* (ESRI, 2002), which was compiled by the Economic and Social Research Institute of the Cabinet Office based on the 68 SNA. Finally, prefectural GDP data for the year of 2000 was obtained from *Annual Report on Prefectural Accounts 2003* (ESRI, 2003), which was compiled by the Economic and Social Research Institute of the Cabinet Office based on the 93 SNA.

In this study, nominal GDP figures were converted into those at the 1990 constant prices using national-level sectoral GDP deflators, which were obtained from *Annual Report on National Accounts* (ESRI, various issues).

Annual prefectural population data were obtained either from *Population Census* (Statistics Bureau, various issues) or *Intercensal Population Estimates* (Statistics Bureau, various issues), whereas prefectural data on employment by industrial origin were from *Population Census*. It should be noted that employment data are available only every five years, since *Population Census* has been conducted every five years. Therefore, regional inequality in labor productivity was measured every five years from 1955 to 2000.

4. Results

Regional Inequality in Per Capita GDP by the Weighted Coefficient of Variation

Figure 4.1 presents regional inequality in per capita GDP for 1955-2000, as measured by the weighted coefficient of variation in (14) in the previous section. The regional inequality (V) first increased and reached a peak in 1958 at 0.38. It then declined steadily and hit the bottom at 0.25 in 1979. After 1979, it rose again and reached a peak in 1990 at 0.37. There is a declining trend after 1990. It should be noted that other studies on regional income inequality in Japan observed the first peak in 1962, rather than 1958 (for example, Fujita and Tabuchi, 1997; Mutlu, 1991; Tabuchi, 1988; and Tanioka and Yamada, 2000). There are several reasons for the difference. First, we used prefectural GDP, while some other studies employed prefectural income. Second, we used GDP at constant 1990 prices, while other studies used either GDP at current prices or at the prices of a different year. Third, our study employed prefectural population figures obtained from *Population Census* or *Intercensal Population Estimates* compiled by the Statistics Bureau, whereas some other studies estimated intercensal prefectural population using an interpolation technique.

Sectoral Decomposition Analysis of Regional Inequality in Per Capita GDP by the Weighted Coefficient of Variation

In a three-sector economy consisting of the primary, secondary, and tertiary sectors, we can measure regional inequality in per capita GDP for each of these sectors, as shown in equation (16) in the previous section. Figure 4.2a shows the weighted coefficient of variation of each sector. In 1955, primary sector's regional inequality (V_1) was the smallest at 0.43, but it rose rapidly and reached 0.74 in 1975. V_1 exhibited an increasing trend even after 1975, but the increase was not as large as before and V_1 became stable in the 1990s at around 0.8. On the other hand, second sector's regional inequality (V_2) was the largest in 1955 at 0.51. After it rose slightly, it gradually decreased and hit the bottom in 1977 at 0.27. It exhibited a slight increasing trend after 1977, but became stable in the 1990s at around 0.3. These observations indicate that the primary sector has been distributed increasingly unequally relative to population distribution, as urbanization has proceeded and manufacturing activities has gradually spread over the Japanese archipelago in tandem with the construction of new networks of trunk railway lines, expressways, and communications, and the establishment of large-scale industrial bases around the new networks. But this process seems to have slowed down in the 1970s, in which a hike in oil prices caused by the two oil shocks brought about a structural shift away from heavy and chemical industries to high-tech and service industries and to knowledge-intensive service industries.

In 1955, tertiary sector's regional inequality (V_3) was somewhere in between V_1 and V_2, but gradually decreased until 1965. After it became stable in 1965-1980 at around 0.33-0.34, it started to rise rapidly and reached a peak in 1990 at 0.50, the same level as in 1958, and then gradually decreased to 0.4. It should be noted that V_1 exceeded V_2 and V_3 for the first time in 1959, one year after the regional inequality in per capita GDP (V) hit the first peak, and that V_3 surpassed V_2 in 1972 when it registered 0.36, and since then, V_2 has been the smallest until now.

It is interesting to note that the rising and declining trend of V_3 in the late 1980s and the early 1990s corresponds closely to the rise and collapse of the bubble economy. In the late 1980s, financial institutions increased their loan for investment in stocks and real estate, especially in the Tokyo metropolitan area[5], as it became one of the major international financial and information centers in the world, following the deregulation and liberalization of the financial sector in Japan. As a result, the prices of stocks and real estate increased conspicuously, and their respective capital gain brought huge wealth to the investors. However, this bubble economy collapsed in the early 1990s with a drastic fall in the prices of stocks and real estate, and the Japanese economy entered a period of long recession. Financial institutions have suffered from huge bad loans as a result of excess lending for investment in stocks and real estate. Geographically, the bubble period and the subsequent period of long recession were associated with the rise and fall of the Tokyo metropolitan area. In terms of per capita GDP, the Tokyo metropolitan area grew at 6.2 % in 1985-1990, in which Japan as a whole grew at 5.1%. However, in 1990-2000, the growth rate of the Tokyo metropolitan area dropped substantially to -0.4%, while Japan as a whole registered a growth rate of 0.7%.

In the three-sector economy, we can also calculate the weighted coefficient of covariation between sectors, as shown in equation (17). Figure 4.2b presents the result. The weighted coefficients of covariation between the primary and secondary sectors (W_{12}) and between the primary and tertiary sectors (W_{13}) were both negative over the whole period of 1955-2000. In other words, prefectures having larger per capita GDP in the primary sector tend to have smaller per capita GDP in the other two sectors. On the other hand, the weighted coefficient of covariation between the secondary and tertiary sectors (W_{23}) was positive over the whole period, indicating that these two sectors have been complementary in their development. While W_{12} exhibited an upward trend, W_{23} showed a downward trend over 1955-2000. In 2000, both W_{12} and W_{23} had values that are very close to zero. These observations can be interpreted as follows. As manufacturing activities have dispersed gradually over the Japanese archipelago, there has been a shift in resources from the primary sector to the other two sectors. But, as the GDP share of the primary sector has decreased to almost negligible levels, the relationship in per capita GDP between the secondary sector and the primary and tertiary sectors has been less significant across prefectures.

In order to examine which sector contributes most to the regional inequality in per capita GDP (V), we must consider also the share of each sector in national GDP (see equation (15) in the previous section). Figure 4.3 shows a clear shift in GDP from the primary sector to the secondary sector until the middle of the 1970s. Between 1955 and 1975, the secondary sector gained 13 percentage points, while the primary sector lost 12 percentage points. On the other hand, the share of the tertiary sector exhibited a slight increasing trend from the early 1970s. Between 1975 and 2000, the tertiary sector gained 5 percentage points, but this was achieved by a decrease in the share of the primary and secondary sectors. In the period, the primary and secondary sectors lost 3 and 2 percentage points, respectively.

Figure 4.4 presents the result of a sectoral decomposition analysis, performed as described in equation (15) in the previous section, where shares are the percentage shares of each component in equation (15). The findings are summarized as follows. First, the V_2 and V_3 components seem to have exhibited symmetrical movements over the whole period. In 1955, the V_2 component had 11%, but it increased rapidly and reached 29% in 1964. Since then, it showed a declining trend, and in 2000, it had 13%. On the other hand, the V_3 component started at 70%, but decreased and hit the bottom at 41% in 1964. Since then, the component exhibited a rising trend, and reached 85% in 2000. Second, the V_2 and V_3 components together accounted for 70-90% of the squared weighted coefficient of variation. Third, the V_1 component had 4% in 1955, but decreased to almost negligible levels. Fourth, the W_{23} component began at 51% in 1955. After it increased slightly and hit the peak in 1964, it declined steadily.

These findings signify that the V_3 component played an increasingly important role in the determination of the overall weighted coefficient of variation. On the contrary, the V_2 and W_{23} components have been less significant after they reached the peak in 1964. Their combined share was 87% in 1964, but it declined conspicuously to 19% in 2000. Finally, the V_1 component contributed very little to the overall weighted coefficient of variation.

Regional Inequality in Labor Productivity by the Theil T Index

As discussed in the previous section, regional inequality in per capita GDP can be explained by regional disparities in labor participation rate and labor productivity. Figure 4.5 compares regional inequalities in per capita GDP and labor productivity, as measured by the Theil T index (see equations (6) and (7) in the previous section).[6] Regional inequality in labor participation rate was not significant in the determination of regional inequality in per capita GDP. To a considerable extent, regional inequality in per capita GDP was determined by inequality in labor productivity, though there was a slight difference between these two inequalities in 1955, 1965, and 1985-2000. According to equation (13), the difference is accounted for by the term that reflects, to some extent, inequality in labor participation rate. However, since this term uses GDP shares as weights, rather than employment shares, it is not the Theil T index for labor productivity. Therefore, it can take both positive and negative values. A negative value occurs when prefectures having larger GDP shares tend to have smaller labor participation rates. In 1955, it had a negative value. This is due to the fact that Tokyo and Osaka had much smaller labor participation rates than the national average (0.42 and 0.41 vs. 0.44). These two prefectures together accounted for 24% of total GDP in 1955. On the other hand, the difference was positive between 1985 and 2000, during which Tokyo had a much larger labor participation rate than the national average.

Regional Inequalities in Labor Productivity and Employment Share by Sector

According to equation (5) in the previous section, regional inequality in labor productivity can be explained by inequalities in sectoral labor productivity and sectoral employment share. Figures 4.6 and 4.7 present these regional inequalities, as measured by the Theil T index. Except in 1975, primary sector's inequality in labor productivity was quite stable, while its inequality in employment share exhibited a clear increasing trend. Therefore, primary sector's inequality in per capita GDP (V_1), as shown in Figure 4.2a, was determined in large part by its inequality in employment share (see equation (4)).

Regional inequalities in employment share for the secondary and tertiary sectors were, respectively, 0.08 and 0.04 in 1955, but decreased gradually. After 1980, they became very stable at somewhere below 0.02 and 0.01, respectively. On the other hand, secondary sector's inequality in labor productivity was 0.03 in 1955. After it declined to below 0.02 in 1960, it became stable until 1975. After 1975, it started to rise and reached the peak in 1990. Tertiary sector's inequality in labor productivity started at 0.03 in 1955. After it decreased to below 0.02 in 1965, it started to rise and reach the peak in 1990 at 0.06. Both secondary and tertiary sectors exhibited a declining trend after 1990.

From these observations, we can conclude that a decrease in secondary sector's inequality in per capita GDP (V_2) until the middle of the 1970s, as shown in Figure 4.2a, was due mainly to a fall in its inequality in employment share. On the other hand, a fall in tertiary sector's inequalities in labor productivity and employment share contributed equally to a decrease in its inequality in per capita GDP (V_3) until the middle of 1960s. As described before, there was a rise and a fall in secondary and tertiary sectors' inequalities in per capita GDP (V_2 and V_3) in the 1980s and the 1990s. Since their inequalities in employment share were low and stable in the period, this rise was due solely to a rise and a fall in their inequalities in labor productivity.

Decomposition of Theil T Index into Between-Sector and Within-Sector Components

If overall regional inequality in labor productivity is defined by equation (9) in the previous section, we can decompose it additively into the between-sector and within-sector components, as shown in equation (10). Figure 4.8 and Table 4.1 present the result of this decomposition.

The overall inequality was 0.20 in 1955, but it declined rapidly and went down to 0.07 in 1980. While it increased slightly in the 1980s, it showed a downward trend after 1990. Since the within-sector component is the weighted average of regional inequalities of the primary, secondary, and tertiary sectors with the weights being GDP shares, it had a similar movement to tertiary sector's inequality in labor productivity; it fluctuated between 0.02 and 0.05 in 1955-2000. On the other hand, the between-sector component was very large in 1955 at 0.17, and thus accounted for 86% of the overall regional inequality. However, it declined rapidly, and reached 0.02 in 2000; its contribution also decreased to 36%. Consequently, the contribution of the within-sector component increased from 14% to 64%. This increase was brought mainly by a rise in the contribution of tertiary sector's inequality, especially in the period between 1980 and 1990.

Figure 4.9 shows each sector's labor productivity in the nation, as compared to the national labor productivity (= 1.0). Primary sector's labor productivity was very small, less than 40% of the national productivity, and showed a slight declining trend over the period of 1955-2000. Secondary sector's labor productivity was almost the same as the national productivity in 1955, but increased slightly over the period. In 2000, it was 14% above the national productivity. On the other hand, tertiary sector's productivity was 70% larger than the national productivity in 1955, but it decreased drastically, and became exactly the same as the national productivity in 2000. From these observations, we can conclude that the conspicuous fall in the between-sector inequality is due to the decrease in disparity between the secondary and tertiary sectors.

Figure 4.1
Regional Inequality in Per Capita GDP
Weighted Coefficient of Variation

Figure 4.2a
Regional Inequality in Per Capita GDP
Weighted Coefficient of Variation by Sector

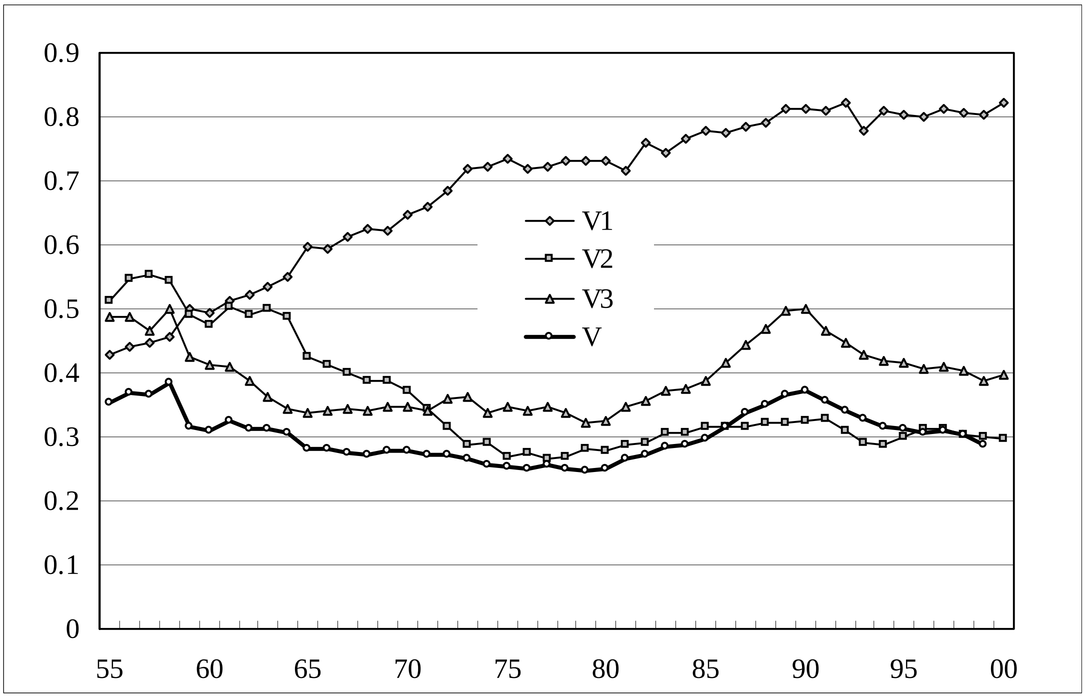


Figure 4.2b
Regional Inequality in Per Capita GDP
Weighted Coefficient of Covariation Between Sectors

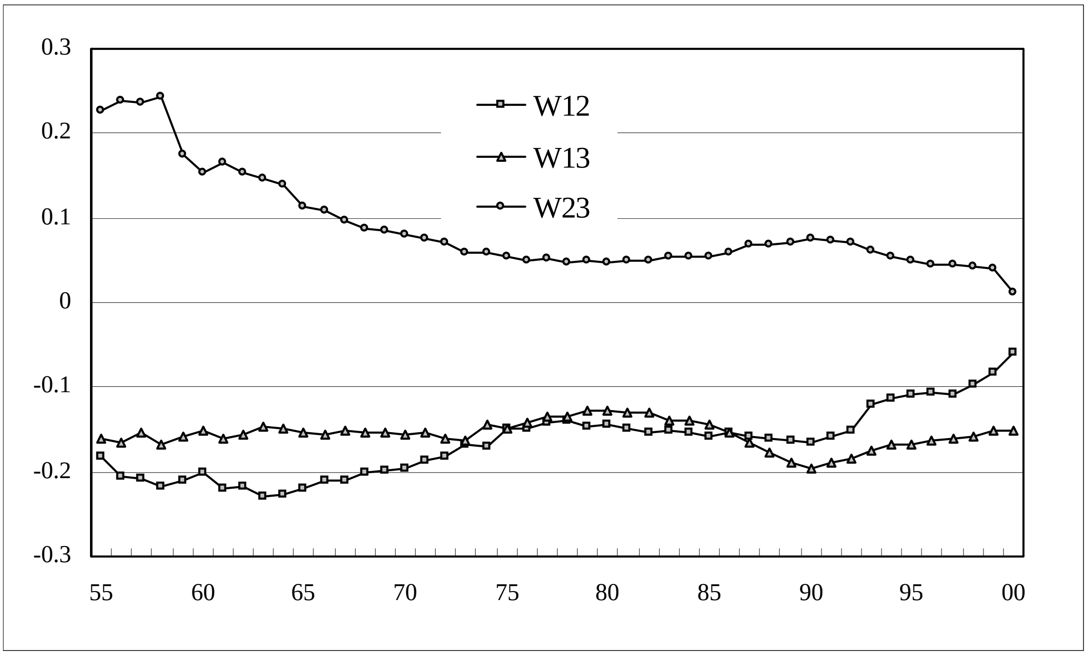


Figure 4.3
GDP Share of Each Sector

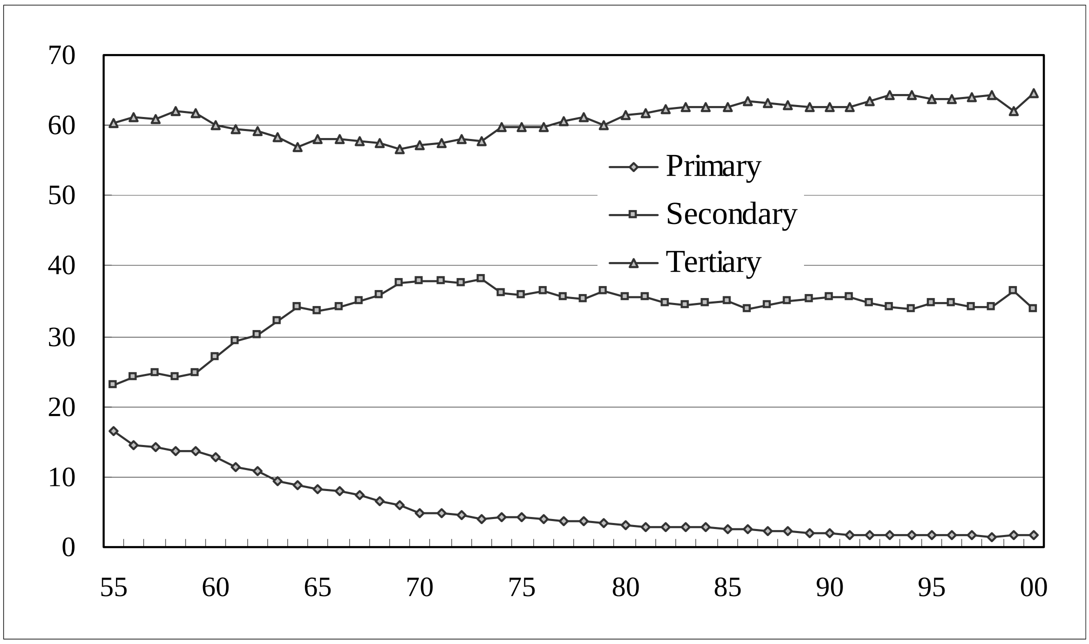


Figure 4.4
Share of Each Component in the Squared Weighted Coefficient of Variation of Per Capita GDP

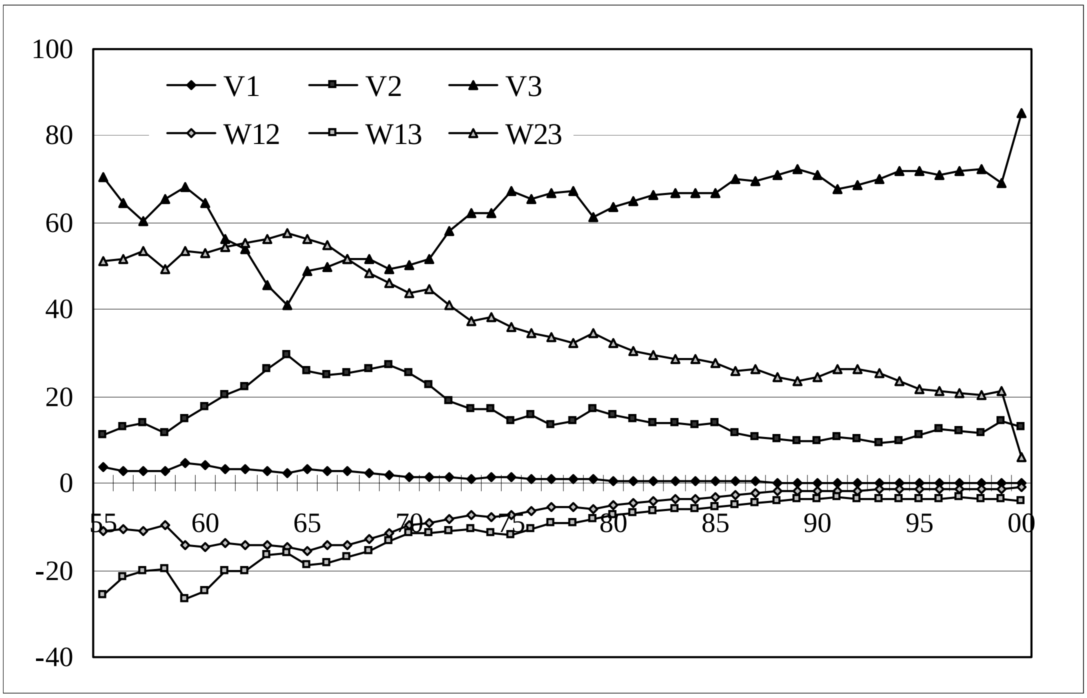


Figure 4.5
Regional Inequality in Per Capita GDP and Labor Productivity Theil T Index

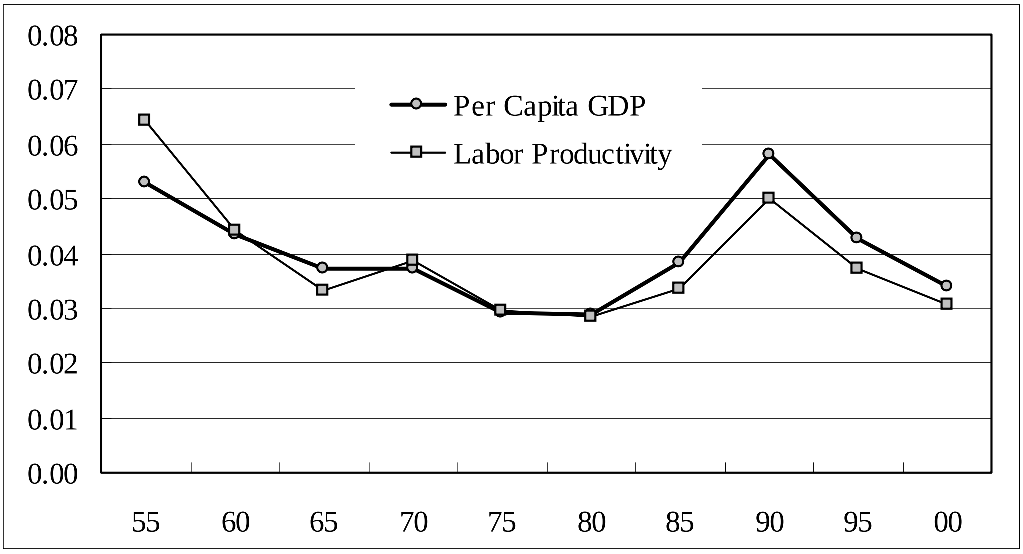


Figure 4.6
Regional Inequality in Labor Productivity by Sector
Theil T Index

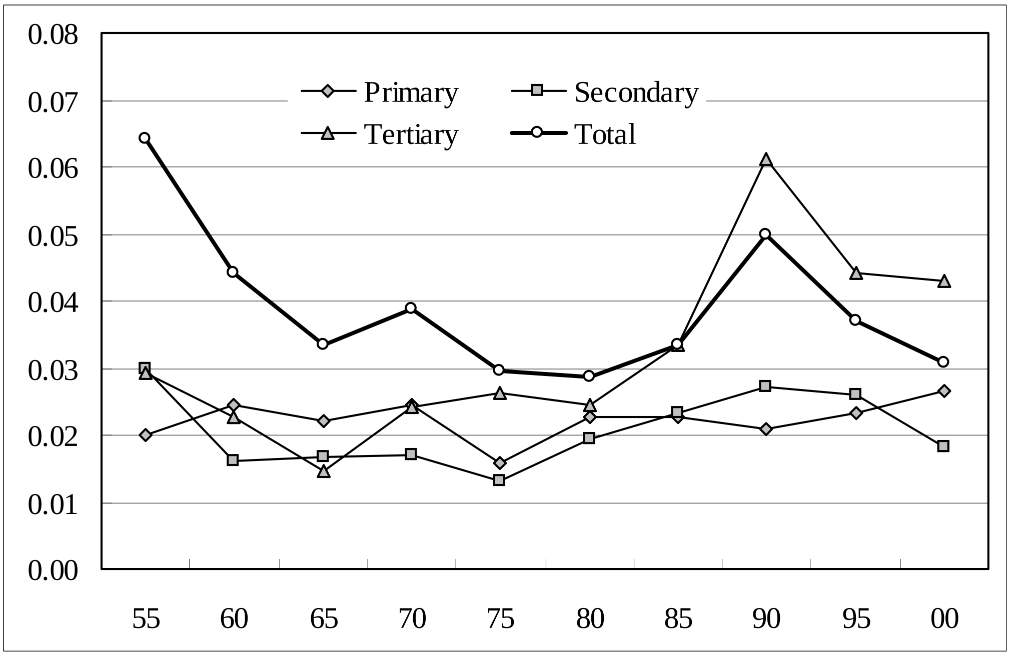


Figure 4.7
Regional Inequality in the Employment Share of Each Sector
Theil T Index

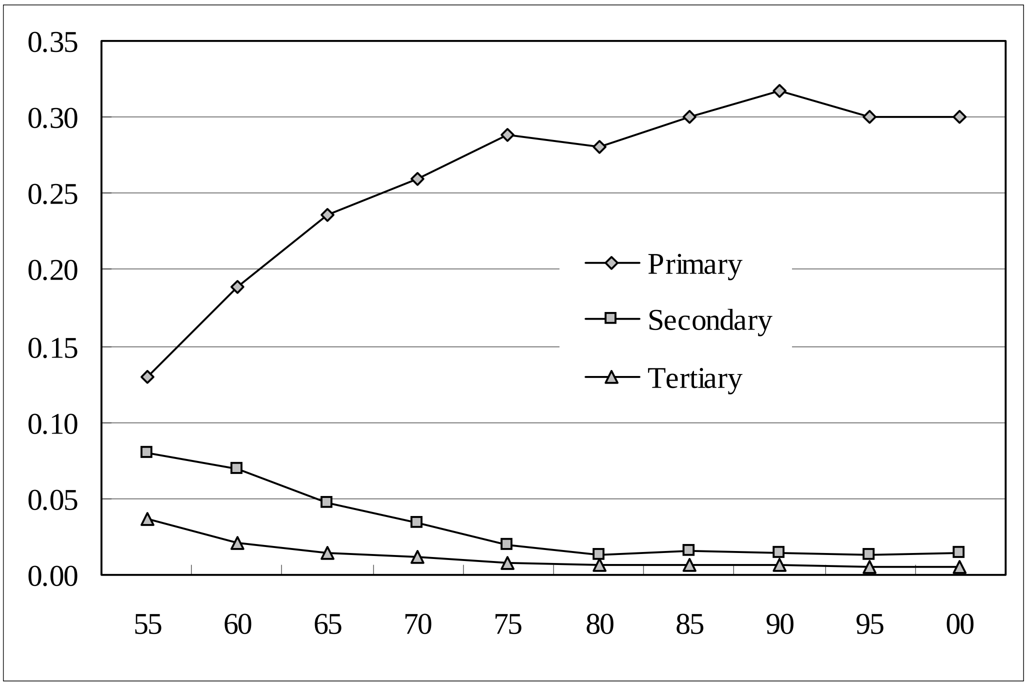


Figure 4.8

Decomposition of Theil T Index for Labor Productivity

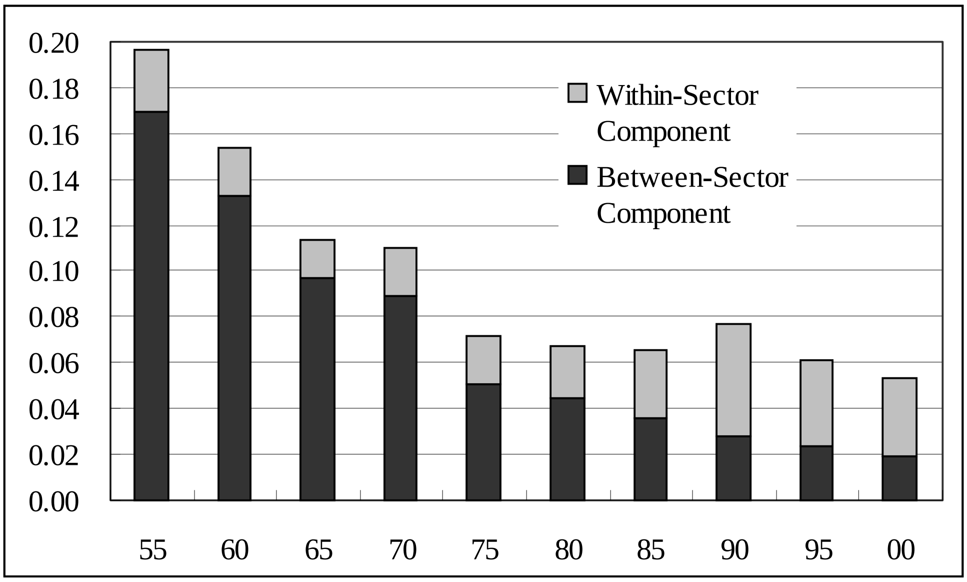


Table 4.1
Decomposition of Theil T Index for Labor Productivity

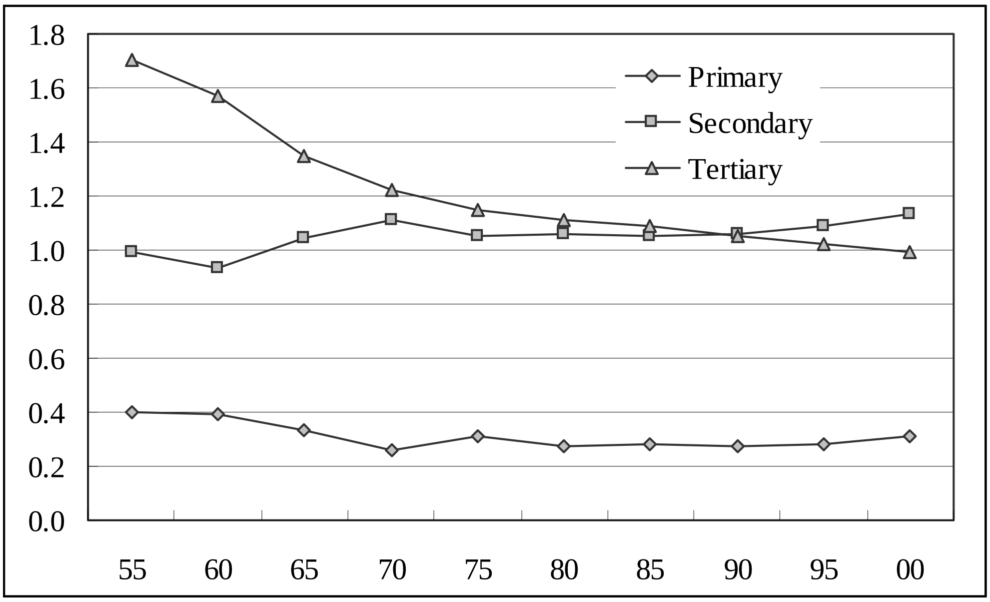
Sector			55	60	65	70	75	80	85	90	95	00
Primary	Inequality	(1)	0.020	0.024	0.022	0.024	0.016	0.023	0.023	0.021	0.023	0.027
	GDP Share (%)	(A)	16.4	12.8	8.3	5.0	4.3	3.0	2.6	1.9	1.7	1.6
Secondary	Inequality	(2)	0.030	0.016	0.017	0.017	0.013	0.020	0.023	0.027	0.026	0.018
	GDP Share (%)	(B)	23.1	27.1	33.7	38.0	35.9	35.5	34.9	35.5	34.7	33.9
Tertiary	Inequality	(3)	0.029	0.023	0.015	0.024	0.026	0.024	0.033	0.061	0.044	0.043
	GDP Share (%)	(C)	60.5	60.1	58.0	57.1	59.8	61.5	62.5	62.5	63.7	64.5
Within-Sector Inequality			0.028	0.021	0.016	0.021	0.021	0.023	0.030	0.048	0.038	0.034
Between-Sector Inequality			0.169	0.133	0.097	0.089	0.051	0.044	0.036	0.028	0.023	0.019
Overall Inequality			0.197	0.154	0.113	0.110	0.072	0.067	0.066	0.076	0.061	0.053

Contribution of Each Component to Overall Inequality (in %)

Primary Sector	(1) x (A)	1.7	2.0	1.6	1.1	1.0	1.0	0.9	0.5	0.6	0.8
Secondary Sector	(2) x (B)	3.5	2.8	5.0	5.8	6.6	10.3	12.4	12.6	14.8	11.5
Tertiary Sector	(3) x (C)	9.0	8.9	7.5	12.5	21.7	22.5	31.8	50.0	46.4	51.8
Within-Sector Component		14.1	13.7	14.1	19.4	29.3	33.8	45.1	63.2	61.8	64.2
Between-Sector Component		85.9	86.3	85.9	80.6	70.7	66.2	54.9	36.8	38.2	35.8

Figure 4.9
Labor Productivity by Sector

National labor productivity = 1.0



[1] These laws include the Resort Law in 1987, the Industry Headquarters Location Law in 1988, the Multi-polar Formation Promotion Law in 1988, and the Law for the Comprehensive Development of Regional Core Cities and the Relocation of Office-work (Office Arcadia) in 1992.

[2] Precisely speaking, e_i denotes (1 – unemployment rate) times labor participation rate. But, for simplicity, the term, labor participation rate, is used to refer to e_i in this study.

[3] For the additive decomposability of Theil indices, please see, for example, Anand (1983).

[4] Akita and Lukman (1995) and Kalirajan and Akita (2002) used this decomposition equation to analyze regional income inequality in Indonesia and India, respectively.

[5] The Tokyo metropolitan area includes the prefectures of Tokyo, Kanagawa, Saitama, and Chiba.

[6] Since employment data are available only every five years, regional inequality in labor productivity was measured every five years from 1955 to 2000. We also measured the regional inequality by employing the weighted coefficient of variation. But, the result was very similar to the Theil T index.

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