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EFFECT OF PUBLIC INVESTMENT ON THE REGIONAL ECONOMIES IN POSTWAR JAPAN

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This paper examines the effect of public investment on the regional economies of postwar Japan. It evaluates the effects of efficiency-verses-equity-oriented allocation policies by estimating the aggregate regional production function and calculating the marginal productivity of public capital for each region, using panel data covering the 47 prefectures over the period from 1955 to 2000. The empirical results show that public capital investment has alternated between an allocation policy based on efficiency and one that is based on equity, and, in fact, such investment was used as a policy tool for adjusting income distribution and accelerating economic growth. Numerical simulations are used to analyze the trade-offs between economic efficiency and inter-prefectural equity. The results indicate that in the case of income-elastic labor mobility, an efficiency-oriented allocation policy leads to larger aggregate gross domestic product by promoting both growth and equity simultaneously.

1. Introduction

Public capital is one of the critical factors for regional economic development. As a result, government decisions on the regional allocation of public investment are of great political concern among policymakers. In the regional science context, the literature examining the effect of public capital on output growth and productivity using the production function framework is extensive.[1] In the US economy, Aschauer (1989) empirically demonstrated the effects of national public capital on output and productivity growth by means of the Cobb–Douglas production function and total factor productivity (TFP) regressions, and found that the decline in productivity since the 1970s is due to the decline in public investment. Using state-specific time series data from 1970 to 1986, Munnell (1990) estimated elasticities showing that while public capital had a positive effect on output productivity, it is only half the size of the effect of private capital. Garcia-Milà *et al.* (1996) estimated a Cobb–Douglas production function with three types of public capital as inputs. The study specifies a model of the first differences with fixed-state effects; the public capital variables were not significant, whereas the fixed-state effects and private input variables are significant. In addition, Nijkamp and Poot (2004) review most of the relevant studies.

[1] The cost function approach is also used to study the productivity outcomes of public capital. See Lynde and Richmond (1992) and Nardi and Mamunes (1994).

In Japan, Mera (1973) estimated prefectural production functions using data from Fukuchi *et al.* (1967) (regarding employment, private capital and public capital), and derived the marginal productivity of public capital. Mera (1986) also studied the regional allocation of public investment using data from nine regions in Japan in the period 1958–1978. He indicated that the government-allocated public investment was roughly in proportion to private investment, but with a slight bias towards redistribution for the observed period, as industries were concentrated in highly developed regions in the period before 1976. Using 1975–1988 data, Asako *et al.* (1994) found that actual regional allocation of public capital resulted in a national gross domestic product (GDP) that was 3% lower than an optimized regional allocation policy. Yoshino and Nakano (1994) estimated different production functions for nine regions and concluded that public capital had a more significant effect on the highly developed regional economies compared with the less developed regional economies. Doi (1998) estimated a translog production function with seminal estimates of public capital data, which factored in the effects of the privatization of public corporations, namely Nippon Telegraph and Telephone Corporation and Japan Railway Company. He found that right before the onset of the oil shocks, the relationship between private and public capital shifted dramatically from being one of substitution to one of complementarity. Yamano and Ohkawara (2000) studied the effect of public investment on the regional economies of Japan using 47 prefectural time-series data sets in the period 1975–1994. Their study shows that public investment had not been allocated in accordance with marginal productivity and that public capital investment was used as a policy tool for adjusting income inequalities in this period.

These studies confirmed that public capital had a positive effect on the regional economy, but in other studies, such as Iwamoto *et al.* (1996) and Nakazato (1999), public capital actually had negative coefficients when its effects on the regional economy were evaluated. Iwamoto *et al.* (1996) explained that a negative coefficient is due to a simultaneity bias, which is a reverse causation from output to public capital.[2] Nakazato (1999) estimated a reduced form that represents the effects of public investment on output growth and implies that public investment is allocated on the basis of regional income redistribution rather than on marginal productivity.

In Japan, because regional development was a key issue in the postwar economic development process, despite the lack of regional public capital data, many economists have studied this relationship between regional allocation of public capital and regional output. Japan's postwar economy progressed from reform and reconstruction to full economic recovery within a short period. By 1956, Japan's national manufacturing output attained and surpassed prewar peak levels. From then until the mid-1970s, the postwar Japanese economy enjoyed favorable economic growth concomitant with the allocation of public capital in accordance with comprehensive national development plans. The first two plans' aims were to pursue economic efficiency through "Growth Pole Strategy and Large-Scale Project Development", which signified that the propulsive industries must produce basic or intermediate goods to maximize linkage effects, and that they must be in a large rather than a small town. At the same time, there were increasing concerns that regional income inequalities between the developed and less-developed regions had increased. Thus, the government pursued an equity policy called "harmonized regional development", which made provisions for public capital in the less-developed regions. In the

[2] In Japan, the negative coefficients for public capital reported in several studies may reflect regional income redistribution allocation, whereas in other countries, the positive coefficient may reflect efficient allocation (Hayashi, 2002).

mid-1970s, the oil-crises and the appreciation of the Japanese yen decreased the growth rate of the Japanese economy to half the rate of the previous era of rapid growth. Moreover, the exogenous factors in the 1970s forced an industrial shift into energy-saving and higher value-added industries, such as high-tech and information technology.

In the early 1980s, the appreciation of the US dollar because of tight monetary policy eroded the export competitiveness of US firms. The Plaza Accord was announced in 1985, which led to the devaluation of the US dollar in relation to the Japanese yen and German mark through intervention in currency markets. By the end of 1987, the yen had almost doubled in value. The consequent increase in the price of Japanese exports reduced their competitiveness in overseas markets, but the Japanese government implemented credit expansion measures to boost domestic demand. The measures resulted in an increase in corporate investment, higher stock prices, and real estate appreciation. This boom in the financial and real estate sectors concentrated economic activities in the Tokyo metropolitan region and again resulted in an increase in interregional income inequalities. In 1989, the government tightened its monetary policies, which sent stock and land prices into a downward spiral from their speculative peak; subsequently, interregional income inequalities decreased. This boom and bust economy is called the "bubble economy".

Thus, the Japanese government alternated between pursuing a growth-oriented and an equity-focused policy in the postwar period. The developed regions are usually characterized as having higher productivity and per capita income, while the less-developed regions are characterized as having lower productivity and per capita income. However, it is obvious that had the government allocated more public capital to the more developed and more productive regions, the national economy would have grown faster, while regional income inequalities would also have increased. More specifically, the allocation of regional public capital involves a trade-off between efficiency and equity. Thus, this gives rise to the question of what is the best policy for the government to use in deciding the allocation of public capital.

The purpose of this paper is to investigate the relationship between the regional allocation of public capital and regional and national output in the postwar Japanese economy. This study uses the Cobb–Douglas production function for simplicity and comparability, and analyzes several public investment allocation policies. Moreover, this study expands the observation period by using newly estimated data and introduces a new measurement indicator, the "equally effective allocation ratio", and simulation techniques derived from previous studies. This study also adds to the existing body of data and analysis by constructing seminal estimates of the time-series public stock data for Okinawa.

This article is structured as follows. Section 2 presents the model, the prefectural data sets, and the estimate results of the prefectural production functions. Section 3 investigates the question of whether or not regional allocation of public capital led to increases in efficiency or in equity during the period between 1955 and 2000. Section 4 presents the numerical simulations of different regional allocations of public investment, and the final section summarizes this paper's findings and further tasks, and then provides direction for future studies in these issues.

2. Model, data and estimates of production functions

This section presents the theoretical aggregate production functions used to evaluate the effects of public capital on regional economies, the data set, and estimates of the production functions.

2.1 Model: prefectural production function

In this panel-data estimate, a simple Cobb–Douglas production function is used as the regional aggregate production function because the main scope of this paper is to analyze several allocation policies of public investment. Therefore, this study uses the following simple equation, Equation (1), for ease of comparison with other estimates in the literature.

$$\ln Y_{it} = \mu_i + \ln K_{it} + \beta \ln E_{it} + \gamma \ln G_{it} + \varepsilon_{it} \tag{1}$$

where i stands for prefecture i and t for period t. Y, K, E and G represent production, private capital, employment, and public capital, respectively. The various specifications of this basic equation involve different assumptions about the constant term, μ, and the error term, ε. Although the constant term has a time component and a regional component as fixed effects,[3] this study ignores the time component because its focus is on long-term effects rather than business-cycle effects on production; thus, this study alternatively employs regional specific-effects as fixed effects.[4] Another assumption used in the study is that the parameters are different among prefectures with respect to public capital because public capital is not allocated based on the profit-maximization behavior of firms.[5] Therefore, the study captures this assumption by constructing a tripartite model that includes no individual effects, fixed effects, and a model with a dummy variable for public capital.

2.2 Data

The data set consists of 46 annual observations for the 47 prefectures; however, not all regional economic data are officially estimated in Japan. Consequently, the data set for the 47 prefectures' levels of production, private capital, employment, and public capital are estimated variously from past seminal studies.[6] All data, namely production, private capital and public capital, are expressed in 1990 constant prices and are shown in Tables A1 and A2 in the Appendix.

Production

As a measure of production, gross prefectural product (prefectural GDP) is used in this analysis. Prefectural GDP data for the period 1955–1974 were obtained from *Retroactive Estimation of Prefectural Accounts, 1955–1974* (Economic Research Institute, 1991). Prefectural GDP data for the period 1975–2000 were obtained from the *2002 Annual Report of Prefectural Accounts* (ARPA; Economic and Social Research Institute, 2002b) and the *2003 Annual Report of Prefectural Accounts* (Economic and Social Research Institute, 2003). In the present study,

[3] In the panel data analysis, these individual effects can be modeled as either random or fixed. The approaches can be contrasted by comparing the data transformations: the fixed-effects model is appropriate for using data in its entirety from the original data, whereas the random-effects model is appropriate for using data from only a portion of the original data (Hsiao, 1986).

[4] See Garcia-Milà and McGuire (1992).

[5] See Yamano and Ohkawara (2000).

[6] See Asako *et al.* (1994), Yoshino and Nakano (1994), Doi (1998), and Yamano and Ohkawara (2000).

all GDP figures were converted into 1990 constant prices; the prefectural GDP data for the earlier period (1955–1974) had been published in 1980 constant prices, whereas those for the later period (1975–2000) had been published in 1990 prices[7].

Private capital

Data for private capital at the national level are officially reported in the *Gross Capital Stock of Private Enterprises* (GSPE; Economic and Social Research Institute, 2002a) from 1955 to 2000 at 1990 constant prices, whereas those at the prefectural level are not reported. Therefore, this study uses the national-level private capital data in 1970 as a starting point. This is then allocated to each prefecture based on its share of cumulative prefectural investment from 1955 to 1970, as recorded by ARPA. The levels of prefectural private capital after 1970 were then obtained by adding estimated prefectural private investment in the current year to the previous year's prefectural capital, while subtracting the current year's capital disposal. Prefectural private capital figures before 1970 were obtained by subtracting the estimated prefectural private investment in the current year from the previous year's prefectural capital, while subtracting capital disposal in the current year.

The present study assumes that the private capital of Okinawa and privatized public corporations are the discrepancies between reported national private capital figures and the consequent calculation results, which add the national private capital in the previous year to the private investment in the current year after subtracting the current year's private capital disposal.[8] The present study considers the privatization of these state enterprises as public capital. I calculate the ratio of each prefectural privatized stock to national private capital in the year of their privatization and assume that this ratio can be a ratio of prefectural investment series data of privatized companies to national investment after the year of their privatization.

Employment

The employment variables are the number of workers in the employment base, rather than at the residential base, because employment is a determinant of GDP and not gross national product. The workers in the employment base include those working in but not necessarily living in the prefecture, whereas those in the residential base include workers living in but not necessarily working in the prefecture. The total employment data in the employment base for each prefecture between 1975 and 2000 are available in the ARPA, but data between 1955 and 1974 are not. The method used to estimate the employment variables is based on the methodology used by Doi (1998).

[7] The prefectural GDP data for the year 2000 is based on 93SNA, whereas the others are based on 68SNA. Despite this discrepancy, this study treats prefectural GDP data for the year 2000 as 68SNA bases.

[8] Under this calculation process, the subsequent calculations revealed a discrepancy of 1.15 trillion yen for Okinawa's private capital in 1971, 22.19 trillion yen for the capital of Nippon Telephone and Telegraph Corporation (NTT) in 1985, 1.63 trillion yen for Electric Power Development in 1986, 12.35 trillion yen for Japan Railway Company (JR) in 1987, and 12.31 trillion yen for Bullet Train Lines in 1992. These privatized capital investments are regionally allocated based on the following rules: the capital from the privatization of NTT was allocated in proportion to the number of telephone lines in each prefecture (Ministry of Posts and Telecommunications, 1991). The capital from the privatization of JR and Bullet Train Lines was allocated in proportion to each prefecture's railroad mileage (Japan Transport Economics Research Center, 1990). The capital from the privatization of Electric Power Development was allocated in proportion to each prefecture's level of private capital.

Public capital

Neither the national nor regional public capital data have been officially reported since the 1970 *National Wealth Survey* of Japan (NWS) (Economic Planning Agency, 1975). For this reason, several regional scientists, including Asako *et al.* (1994), Yoshino and Nakano (1994), Doi (1998), and Yamano and Ohkawara (2000), estimated their own national and regional public capital data.[9] In the present study, the estimates of the public capital data are based on the modified perpetual inventory method used by Doi (1998) and Yamano and Ohkawara (2000). In this method, public capital levels are constructed by accumulating each year's public capital formation and subtracting the capital disposal of previous investment flows. Using the data of each prefecture's public capital from the *Reference Data for the Report of the Economic Deliberation Council Subcommittee on Regional Studies* (Economic Planning Agency 1968), this study utilized the 1955 levels as the benchmark and recalculated them according to 1990 constant prices. The 1970 NWS reported that 65% of the national public capital in 1955 comprised capital that had been invested for less than 10 years. Thus, it is assumed that 65% of each prefecture's public capital in 1955 had been equally accumulated during the period between 1945 and 1954 and that the remaining 35% had been equally accumulated during the period between 1905 and 1944. Based on these assumptions, this study also assumes that the schedule of capital disposal obeys a gamma distribution, with a mean of 30 years and with 90% of investments fully depreciated after 40 years. In addition, the prefectural public investment figures from ARPA were used as the annual public investment and added to the prefectural capital stock of each prefecture in 1955. The disposal rate was assumed to be the same across all the prefectures. In addition, this study provides seminal estimates of the value of public capital in Okinawa prefecture.[10]

Figure 1 presents GDP per employment by prefecture in 2000. The Japanese prefectures are divided into five groups according to the level of GDP per employment. In 2000, the two groups with the lowest level of GDP per employment included 25 prefectures, and the two groups with the highest level included only four prefectures: Tokyo, Kanagawa, Shiga, and Osaka. The GDP per capita in only nine prefectures were greater than the national average in 2000: Tochigi, Chiba, Tokyo, Kanagawa, Aichi, Shiga, Osaka, Hyogo, and Ooita.

2.3 Estimation results

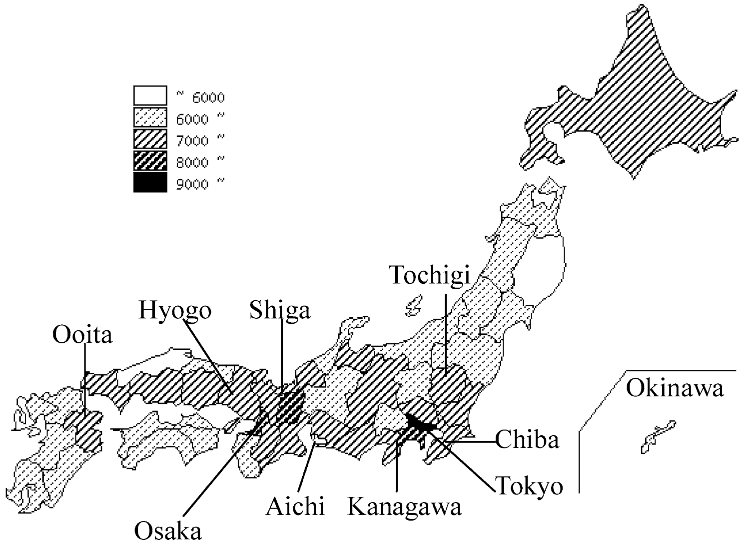
This study divides the data set into two observation periods: the pre-oil shock and the post-oil shock periods. This is in recognition of the major industrial and regional structural

[9] Cabinet Office (2002) estimated the contiguous data for national and prefectural public capital from 1953 to 1998, but these were not publicly reported as official statistics.

[10] Before World War II, the public capital data of Okinawa were periodically reported in the National Wealth Survey of Japan in 1921, 1923, 1930, and 1935. During the period of US administration in Okinawa from 1945 to 1972, the US administrative government did not officially estimate public capital data of Okinawa. After reversion of Okinawa, the *Report of Okinawa Public Capital Formation* (Okinawa Development Agency, 1981) officially reported the data of public capital stock from 1965 to 1977 at 1970 constant prices using the acceleration principle method.

Okinawa's share of national public capital in 1930 was 0.13% as recorded by the 1930 NWS (Statistical Bureau, 1933); the comparable figure in 1965 was 0.82% as recorded by the *Report of Okinawa Public Capital Formation*. As a result, this study estimates that Okinawa's share of national public capital in 1955 was 0.61% (108.4 billion yen at 1990 constant prices); it is further assumed that Okinawa's share of public capital increased proportionally on an annual basis.

Figure 1. GDP per employment by prefectures (2000)



changes experienced by the postwar Japanese economy due to the oil shocks, as demonstrated by Fujita and Tabuchi (1997).

Table 1 shows estimates of the prefectural production function under the three assumptions about individual effects in both periods. In the "no individual effects" model of Cobb–Douglas functions, Model 1, the parameters of the production factors are significant and the coefficients of determination, R^2, are sufficiently high; however, the F-statistic under the hypothesis of the different constant term (A) and parameters (B) suggests that the individual effects on the constant terms or the parameters of production factors should be considered in both periods. In the "fixed effects" model, Model 2, the parameters of the production factors are also significant, and the coefficient of determination, R^2, is also sufficiently high; however, the null hypotheses in both periods, that the parameters of production factors take the same values across prefectures, are rejected at a high level of confidence. In addition, all of the constants of the fixed effects, μ_i, are statistically insignificant. Therefore, this study uses the production functions with dummy parameters to signify public capital, which is Model 3.

The estimates of Model 3 reveal three findings in Tables 1 and 2. The first is that all the parameters are statistically significant and positive, and that the coefficients of determination are sufficiently high for both the pre-oil shock and post-oil shock periods. The positive sign of each parameter indicates that each production factor produced output gains rather than allocation effects on the regional economy. Thus, this confirms that the level of production factors determines regional production levels and regional inequalities. The second finding is that the parameter values, namely the elasticities of private capital and employment, were stable in both the pre-oil shock and post-oil shock periods. Nevertheless, the elasticity of public capital decreased by one-quarter to one-fifth. The elasticity of public capital ranges from 0.294 to 0.340 during the pre-oil shock period, as compared with a range with much smaller magnitude from 0.0574 to 0.0883 during the post-oil shock period. Because of the different parameter values for public capital, the degree of scale economy ranges from 1.222 to 1.267 in the pre-oil shock

Table 1. Estimates of the production functions

Period 1:1955–1975						
Model No.	Constant	Ln *K*	Ln *E*	Ln *G*	Adj-R^2	F-statistic
1: No Individual Effects	−1.299*	0.431*	0.446*	0.250*	0.977	$F^c = 8.25^*$
	(−12.6)	(32.1)	(40.8)	(20.1)		
2: Fixed Effects	a	0.354*	0.507*	0.313*	0.999	$F^d = 52.01^*$
		(15.1)	(16.4)	(14.5)		
3: Dummy on Public Capital	−2.830*	0.350*	0.578*	b	0.993	
	−(6.1)	(16.4)	(16.3)			
Period 2: 1976–2000						
Model No.	Constant	Ln *K*	*Ln E*	Ln *G*	Adj-R^2	F-statistic
1: No Individual Effects	−0.251*	0.469*	0.674*	−0.065*	0.990	$F^g = 86.11^*$
	(−4.07)	(49.3)	(87.0)	(−5.81)		
2: Fixed Effects	e	0.380*	0.603*	0.056*	0.999	$F^h = 34.12^*$
		(33.5)	(20.3)	(4.13)		
3: Dummy on Public Capital	0.436	0.374*	0.581*	f	0.998	
	(1.11)	(33.3)	(17.6)			

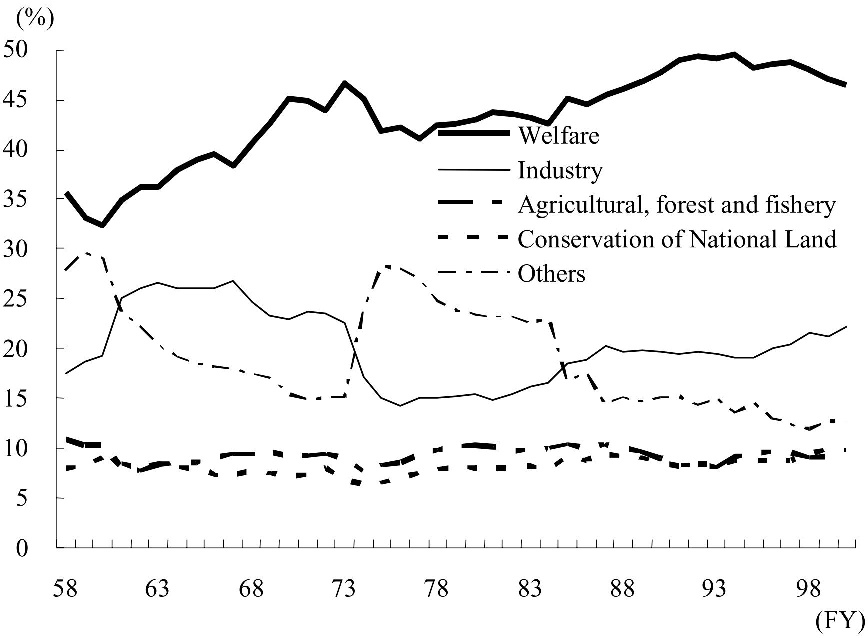
Note: t-ratios are shown in parentheses. The asterisks denote significance at the 0.01 level.
a: differ by prefecture. Range from −2.17 to −1.63.
b: differ by prefecture and see Table 2.
c: null hypotheses (A, B = Ai, Bi)
d: null hypotheses (Ai, B = Ai, Bi)
e: differ by prefecture. Range from 0.02 to 0.459.
f: differ by prefecture and see Table 2.
g: null hypotheses (A, B = Ai, Bi)
h: null hypotheses (Ai, B = Ai, Bi)

Table 2. Estimates γ_i of the production functions

Prefecure	Period 1	Period 2	Prefecure	Period 1	Period 2	Prefecure	Period 1	Period 2
Hokkaido	0.295	0.0654	Nagano	0.300	0.0619	Okayama	0.306	0.0619
Aomori	0.311	0.0636	Shizuoka	0.318	0.0701	Hiroshima	0.307	0.0701
Iwate	0.299	0.0574	Toyama	0.312	0.0649	Yamaguchi	0.309	0.0649
Miyagi	0.320	0.0694	Ishikawa	0.319	0.0683	Tokushima	0.320	0.0683
Akita	0.312	0.0602	Gifu	0.313	0.0667	Kagawa	0.328	0.0667
Yamagata	0.312	0.0612	Aichi	0.307	0.0722	Ehime	0.316	0.0722
Fukushima	0.294	0.0625	Mie	0.326	0.0699	Kochi	0.316	0.0699
Niigata	0.301	0.0653	Fukui	0.306	0.0604	Fukuoka	0.306	0.0604
Ibaraki	0.304	0.0719	Shiga	0.322	0.0796	Saga	0.322	0.0796
Tochigi	0.317	0.0691	Kyoto	0.328	0.0748	Nagasaki	0.315	0.0748
Gunma	0.305	0.0695	Osaka	0.309	0.0743	Kumamoto	0.308	0.0743
Saitama	0.325	0.0756	Hyogo	0.313	0.0736	Oita	0.318	0.0736
Chiba	0.316	0.0725	Nara	0.340	0.0750	Miyazaki	0.305	0.0750
Tokyo	0.307	0.0833	Wakayama	0.328	0.0615	Kagoshima	0.301	0.0615
Kanagawa	0.322	0.0779	Tottori	0.336	0.0667	Okinawa	0.316	0.0667
Yamanashi	0.318	0.0678	Shimane	0.306	0.0576			

period and from 1.013 to 1.039 in the post-oil shock period among prefectures. The third finding is obtained by a comparison of some of the parameter values. The parameter ratio of private capital to employment is approximately 1:1.6. This implies that the distribution share of employment is approximately 60%, which corresponds with findings often observed in other empirical studies on the Japanese economy.

Figure 2. Administrative investment by purpose (share %). Notes: Investment for others refers to unemployment measures, disaster restoration, government office repairs, railways, subways, electricity, gas, and residential land formation. Source: Local Administration Bureau, Ministry of Public Management, Home Affairs, Posts and Telecommunications (various years).



The sharp and consistent decline in the parameters of public capital stock in the post-oil shock period is partially caused by a change in the objectives of public investment during the pre- and post-oil shock periods. Figure 2 shows the actual administrative investment and indicates that welfare-oriented public investment,[11] which contributes less to regional output, increased on a consistent basis, whereas industry-oriented public investment, which contributes more to regional output, declined after the first oil shock and remained at a lower level in comparison to the pre-oil shock period. This qualitative change in public investment may have caused the decline in the parameters of the public capital variable.

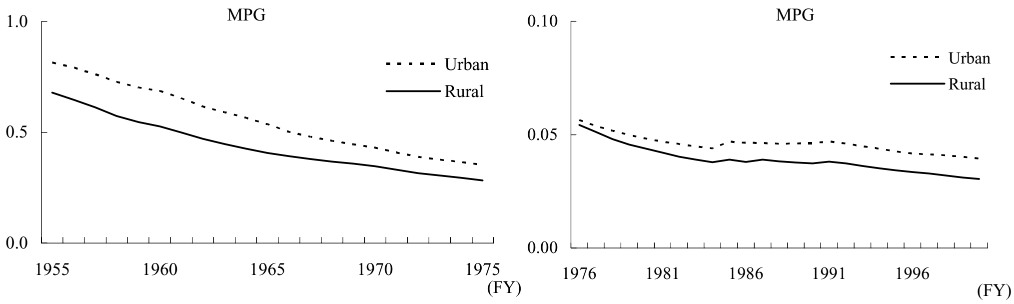
3. Regional allocation of public capital: efficiency or equity?

This section examines whether the government pursued efficiency or equity in its regional allocation policy for public capital. Initially, the marginal productivity rates of public capital (MPG) in the urban and rural regions were estimated and observed for different periods.[12] A new measurement indicator, the "equally effective allocation ratio", which is the ratio of

[11] "Welfare-oriented public investment" includes works of hospitals, nursing care services, national health insurance, insurance for the elderly care and hospitals attached to public universities.

[12] Urban regions are defined as the following nine prefectures: Saitama, Chiba, Tokyo, Kanagawa, Aichi, Mie, Kyoto, Osaka, and Hyogo; rural regions are defined as all other prefectures.

Figure 3. Marginal productivity of public capital: urban and rural regions



capital stock allocation that would have an equal effect on the output in each of the developed and the less-developed regions, is then introduced and examined to determine whether the government had pursued an allocation policy of efficiency or equity. Using the estimated parameters of the regional prefectural production functions obtained in the previous section, the marginal productivity rates of public capital in the urban and rural regions are estimated. In the Cobb–Douglas function, marginal productivity is defined as the product of the coefficient for the production factor and the ratio of regional production to that factor. For the purposes of this calculation, the predicted value of regional production is used instead of the actual value. Thus, the MPG is affected by the estimate of the prefectural individual effects, and the difference in marginal productivity rates among prefectures depends on each prefecture's endowment of production factors and the prefecture-specific parameters for public capital (see Table 2).

The marginal productivity rates for public capital in urban and rural regions are shown in Figure 3.[13] The MPG in the urban region exceeds the rural region during the entire period between 1955 and 2000, thus indicating that the urban region is more developed and productive on the margin than the rural region.

The MPG in both the urban and rural regions decrease at a constant rate in the first period but become more stable during the mid-1980s, and in fact decrease only slightly during the remainder of the period. Due to the law of diminishing returns, a relatively large accumulation of regional public capital in the regional economies induces a decreasing trend in the MPG in those economies. Conversely, a relatively smaller accumulation of regional public capital induces an increasing trend in the MPG.

Next, using these estimate results, a new measurement indicator, the "equally effective allocation ratio", is introduced and compared with actual regional allocations. The equally effective allocation ratio is also used in the study of Usuki and Yamada (2000) and Endo (2002). However, in the present study this ratio is instead originally derived from the growth accounting equation.

For this purpose, let Equation (2) be defined as a growth accounting equation derived from a Cobb–Douglas production function, where Y, K, E, and G stand for national production, private

[13] The elasticities in the urban and rural regions are calculated in proportion to the amount of compounding prefectural output.

capital, employment, and public capital, respectively.

$$
\begin{aligned}
\frac{\dot{Y}}{Y} &= \frac{\dot{A}}{A} + \alpha\frac{\dot{K}}{K} + \beta\frac{\dot{E}}{E} + \gamma\frac{\dot{G}}{G} \\
&= \frac{\dot{A}}{A} + \left(\frac{\alpha+\beta+\gamma-1}{\alpha+\beta+\gamma}\right)\left(\alpha\frac{\dot{K}}{K} + \beta\frac{\dot{E}}{E} + \gamma\frac{\dot{G}}{G}\right) + \left(\frac{\alpha}{\alpha+\beta+\gamma}\right)\frac{\dot{K}}{K} \\
&\quad + \left(\frac{\beta}{\alpha+\beta+\gamma}\right)\frac{\dot{E}}{E} + \left(\frac{\gamma}{\alpha+\beta+\gamma}\right)\frac{\dot{G}}{G}
\end{aligned} \tag{2}
$$

In Equation (2), $\dot{A}/A$ is the growth rate of total factor productivity or residual, $\left(\frac{\alpha+\beta+\gamma-1}{\alpha+\beta+\gamma}\right)$, which expresses the scale economy, and the parameters, α, β, and γ are each variable's elasticity. Let $(\dot{Y}/Y)_g$ be defined as the output increase ratio from public capital in Equation (3). By multiplying (Y/Y) to the right-hand side, Equation (3) can be expressed as follows

$$
\left(\frac{\dot{Y}}{Y}\right)_g = \left(\frac{\gamma}{\alpha+\beta+\gamma}\right)\frac{\dot{G}}{G} = \gamma'\frac{IG}{G}\cdot\frac{Y}{Y} = \frac{\gamma'\frac{Y}{G}\cdot IG}{Y} \tag{3}
$$

where IG is defined as national public investment; since $\dot{G}$ can be equal to IG, the disposal rate of public investment is assumed to be zero. From Equation (3), output increase from public investment $\dot{Y}_g$ can then be decomposed into the marginal productivity of public capital $\gamma(Y/G)$ and public investment IG.

Next, if the whole economy is divided into two regions, urban and rural, then let $(\dot{Y}_U/Y_U)_g$ and $(\dot{Y}_R/Y_R)_g$ be defined as the output increase from public capital in the urban and rural regions, respectively. By using Equation (3), $(\dot{Y}_U/Y_U)_g$ and $(\dot{Y}_R/Y_R)_g$ can then be written as follows

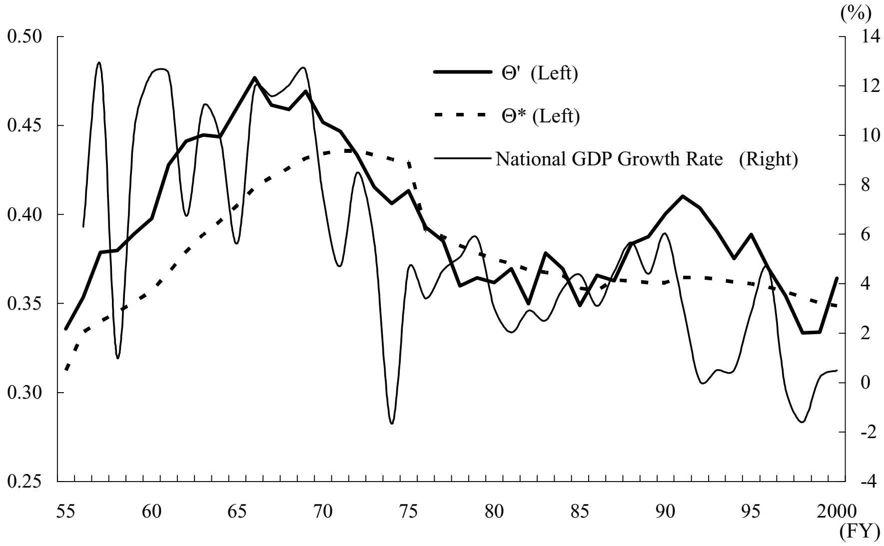
$$
\left(\frac{\dot{Y}_U}{Y_U}\right)_g = \frac{\gamma'_U\frac{Y_U}{G_U}\cdot IG_U}{Y_U} = \frac{\gamma'_U\frac{Y_U}{G_U}\cdot IG\cdot\theta}{Y_U} \tag{4}
$$

$$
\left(\frac{\dot{Y}_R}{Y_R}\right)_g = \frac{\gamma'_R\frac{Y_R}{G_R}\cdot IG_R}{Y_R} = \frac{\gamma'_R\frac{Y_R}{G_R}\cdot IG\cdot(1-\theta)}{Y_R} \tag{5}
$$

where θ is the regional allocation ratio of public national investment IG to the urban region and the subscripts U and R stand for the urban and rural values of that particular variable. By equating Equations (4) and (5) and rearranging the terms, the equally effective allocation ratio (θ^*) can then be expressed as

$$
\theta^* = \frac{\gamma'_R\frac{Y_R}{G_R}\cdot Y_U}{\left(\gamma'_R\frac{Y_R}{G_R}\cdot Y_U + \gamma'_U\frac{Y_U}{G_U}\cdot Y_R\right)}. \tag{6}
$$

Figure 4. Regional allocation of public investment to the urban region and national economic growth. Note: National GDP Growth Rate is obtained from the Economic and Social Research Institute (2002a).



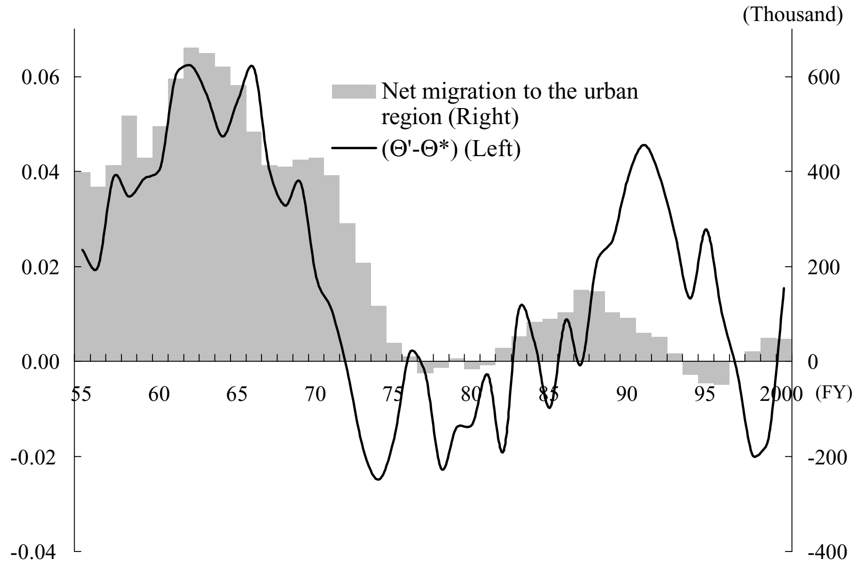
The actual allocation ratio of public investment to the urban region (θ') is calculated as follows

$$\theta' = (IG_U/(IG_U + IG_R)). \tag{7}$$

Comparing ratios θ^* and θ', the larger θ' indicates that public investment was allocated relatively more to the region with a higher marginal productivity and thus contributed to higher national economic growth. This indicates that the government pursued an allocation policy of efficiency rather than equity. On the other hand, a smaller ratio θ' indicates that public investment was allocated relatively more to the region with a lower marginal productivity and thus contributed to reducing regional income inequalities, which implies that the government pursued equity rather than efficiency in its allocation policy.

Figure 4 shows the ratios θ^* and θ' for the period between 1955 and 2000. In this figure, the ratio θ' exceeded θ^* during the period from 1955 to 1971, after which the ratio θ' was lower than θ^* during most of the period from 1972 to 1986. Then, θ' again exceeded θ^* during the period from 1987 to 1996 and, finally, this was reversed from 1997 to 2000. This indicates that the government pursued a public investment allocation policy of efficiency by allocating more public investment to the more productive region prior to the oil shock. As a result, the Japanese economy recorded rapid economic growth during the late 1950s and 1960s. However, after the era of rapid economic growth, the government shifted to an equity policy by investing more in the less productive region, which resulted in a lower economic growth rate. The government again pursued a policy of efficiency during the era of the bubble economy and afterwards implemented policy measures aimed at stimulating the less developed regional economies in the late 1990s. In conclusion, the above analysis indicates that the government made alternating shifts in its allocation policies that aimed at either efficiency or equity in different periods.

Figure 5. Net migration to urban region and excess ratio of actual public investment allocation to the urban region. Note: Net migration to urban region is obtained from *Population and Interprefectural Migration Statistics*. Source: Statistical Bureau, Ministry of Internal Affairs and Communications (various years).



Moreover, the study also focuses on the relationship between the relative regional allocation of public investment and interregional migration to the urban region. Here, the ratio $(\theta' - \theta^*)$ is defined as the excess ratio of actual public investment allocation to the urban region. Figure 5 is a plot of this ratio $(\theta' - \theta^*)$ and net migration to the urban region from 1955 to 2000. It indicates that during the period before the oil shock from 1955 to the early 1970s, the trend in this ratio $(\theta' - \theta^*)$ follows that of net migration to the urban region. However, the two trends diverge in subsequent periods. The coefficient of correlation of $(\theta' - \theta^*)$ and net migration is 0.914 for the period from 1955 to 1972, but drops sharply to 0.0047 for the period from 1973 to 2000. These facts indicate that regional allocation of public capital and interregional migration have a positive correlation with each other. It is theoretically followed by the previous study of Mera (1986) and Tabuchi (1988) that accumulation of net migration to the developed regions with high income contributes to the convergence of interregional income differentials in the long run.

4. Simulations

This section examines the effects of changes in the prefectural allocation of public capital on the regional and national economies by using the numerical simulation approach of Yamano and Ohkawara (2000). The estimates of the prefectural production functions in Section 2 reveal the positive effects of public capital on prefectural economies, and more public investment allocation brings about greater output in a prefecture. Based on this finding, the study examines below the alternating allocations of public investment. In all simulation cases, the sum of the prefectural public investment (abbreviated as AIG) is made equal to the actual amount of national public investment.

$$AIG_t = \sum_{i=1}^{47} IG_{it}^k \qquad (k = 1, 2, 3) \tag{8}$$

where IG_{it}^k is the prefectural public investment and superscript k is a notation that corresponds to the following scenarios: (i) the base scenario; (ii) the redistributive allocation scenario; and (iii) the efficient allocation scenario. Building on the previous study of Yamano and Ohkawara (2000), this study considers two additional scenarios that assume income-elastic interregional labor mobility is included in the efficient allocation scenario. Adding new public investment to the previous capital stock, the simulated public capital in prefecture i is then calculated. The study calculates prefectural production under the new allocation by substituting the new public capital stock into the equation with dummy parameters to signify public capital modified from Equation (1). An equation example of scenario k is written as follows:

$$\ln Y_{it+1}^k = \mu + \alpha \ln K_{it+1} + \beta \ln E_{it+1} + \gamma_i \ln G_{it+1}^k \qquad (1995 \le t \le 2000). \tag{9}$$

The allocation process is made from 1956 to 2000 for each simulation scenario. In these simulations, the levels of national production and the prefectural income inequalities are compared over the sample period. It is assumed that private capital investment is not affected by the change in public capital investment.

4.1 Simulation scenarios

Scenario 1: base scenario

The base scenario is a benchmark scenario with which other scenarios are compared. In this scenario, the prefectural allocation of public investment is the same amount as actual prefectural investment in each year. Thus, prefectural production in each year is calculated by using actual private capital, labor, and public capital.

Scenario 2: redistributive allocation scenario

In this scenario, it is assumed that the less developed prefectures receive more resources than the more developed ones when resource allocation changes are made. It is in fact assumed that the redistribution of public investment is based on the following inequality rule:

$$\begin{aligned} IG_{1t}^2 > IG_{2t}^2 > \cdot\cdot IG_{nt}^2 \cdot\cdot > IG_{47t}^2 \qquad & (l \le n \le 47, 1956 \le t \le 2000) \\ (Y/E)_{1t} < (Y/E)_{2t} < \cdot\cdot (Y/E)_{nt} \cdot\cdot < (Y/E)_{47t} \qquad & (l \le n \le 47) \end{aligned}$$

IG_{it}^2: public investment of scenario 2 in prefecture i in year t
$(Y/E)_{it}$: prefecture GDP per employment in prefecture i in year t

where n is the number of prefectures in the reverse order of per capita employment.

Based on the assumption of Yamano and Ohkawara (2000), the income deviation index is defined as

$$\lambda_{it} = \left[\frac{(Y/E)_{it} - (Y/E)_{\max,t}}{(Y/E)_{\max,t}}\right] \tag{10}$$

where $(Y/E)_{\max,t}$ is the maximum prefectural income among all prefectures.

λ_{it} is zero in the highest income prefecture and is negative for other prefectures. It is assumed that the allocation for a given prefecture with income deviation index λ_{it} is determined by the relation

$$\lambda_{it} = \frac{IG^2_{\max,t} - IG^2_{it}}{IG^2_{\max,t}} \tag{11}$$

which can be rewritten as

$$IG^2_{it} = (1 - \lambda_{it}) \times IG^2_{\max,t} \tag{12}$$

where $IG^2_{\max,t}$ is an unknown variable at this stage. From condition (8), AIG is given by

$$AIG_t = \sum_{i=1}^{47} (1 - \lambda_{it}) \times IG^2_{\max,t}. \tag{13}$$

Solving for $IG^2_{\max,t}$ in Equation (13) and substituting $IG^2_{\max,t}$ into Equation (11), gives

$$IG^2_{it} = \frac{(1 - \lambda_{it})}{\sum_{i=1}^{47}(1 - \lambda_{it})} \times AIG_t. \tag{14}$$

Scenario 3: efficient allocation scenario

An efficient allocation scenario requires that the more developed prefectures receive more resources than the less developed prefectures when resource allocation changes are made. If public investment has been efficiently allocated, then the maximum level of national production is obtained. Here, it is assumed that the efficient allocation scenario for public investment satisfies the following conditions,

$$\begin{aligned} MPG_{1t-1} > MPG_{2t-1} > MPG_{nt-1} \cdots > MPG_{47t-1} &\qquad (1 \le n \le 47) \\ IG^k_{1t} > IG^k_{2t} > \cdots > IG^k_{mt} &\qquad (1 \le m \le 47) \\ MPG_{1t} = MPG_{2t} = \cdots = MPG_{mt-1} &\qquad (m \le n) \end{aligned}$$

S.T.

$$\sum_{m=1}^{m} IG^2_{it} = AIG_t, \quad 0 \le IG^k_{it}$$

where k signifies scenarios 3, 3a, and 3b, respectively.

According to this condition, prefectural allocation of public capital from the year 1956, IG^k_{mt}, is determined by the marginal productivity of public capital in the previous year, MPG_{mt-1}, as the benchmark year is the year 1955.

It follows, according to this allocation procedure, that the prefecture with the highest *MPG* initially gains the largest amount of investment. As *MPG* naturally decreases with additional public capital due to the law of diminishing returns, the prefecture with the second highest *MPG* begins to receive public capital allocations only when the *MPG* of the prefecture with the highest *MPG* drops to the level of the prefecture with the second highest *MPG*. The prefectures with the highest and second highest *MPG* are the only two prefectures that receive public capital allocations until their *MPG* decrease to the level of the prefecture with the third highest *MPG*. The other prefectures are also allocated capital according to this rule until the sum of the investment to all prefectures becomes equal to the total actual national investment. According to this rule, all prefectures are eventual beneficiaries of national public investment allocations, although it may happen that prefectures with the lower *MPG* do not obtain any public investment at the early simulation periods because initially there is an *MPG* gap across prefectures in 1955.

Scenarios 3a and 3b: efficient allocation with interregional labor mobility

In this scenario, it is assumed that there is interregional labor mobility that is determined by relative prefectural per capita income in the previous year. This scenario is constructed by adding the conditions below to the conditions in scenario 3. Like scenario 3, the prefectural labor supply beginning from 1956 is determined by the gap between the national and prefectural GDP per employment in the previous year, which is also the benchmark year 1955.

$$\begin{aligned} &\frac{E_{it+1}}{E_{t+1}} = \left(1.0 + \delta \cdot \frac{w_{it} - w_t}{w_t}\right) \cdot \frac{E_{it}}{E_t} \\ &w_{it} = \frac{Y_{it}}{E_{it}}, \qquad w_t = \frac{\sum_{i=1}^{47} Y_{it}}{\sum_{i=1}^{47} E_{it}} \end{aligned} \tag{15}$$

Y_{it}: production in prefecrure i in year t
E_t: employment in prefecrure i in year t
E_t: national employment in year t
δ: elasticity of interregional labor mobility to wage

In the above simulation, it is assumed that $\delta = 0.01$ indicates income-inelastic interregional labor mobility, whereas $\delta = 0.05$ indicates income-elastic interregional labor mobility. For example, $\delta = 0.01$ presents that if the prefecture i has wages that are twice as high as the national average in the previous year, then prefecture i can obtain a 1% increase in labor share to national in this year.

Assuming that the ratio of each prefecture's employment to population is the same as the actual ratio in each year, prefectural population in scenarios 3a and 3b can be estimated by using the following formula:

$$
\begin{aligned}
P_{it+1} &= \nu_{t+1} \cdot \varphi_{it+1} \cdot E_{it+1} \\
\varphi_{it+1} &= \frac{P^{\bullet}_{it+1}}{E^{\bullet}_{it+1}} \\
\nu_{t+1} &= \frac{P_{t+1}}{\sum_{i=1}^{47} \varepsilon_{it+1} \cdot E_{it+1}} \\
P_t &= \sum_{i-1}^{47} P^{\bullet}_{it}
\end{aligned}
\qquad (16)
$$

E_{it}: estimated employment in prefecture i in year t
$E^{\bullet}_{it}$: actual employment in prefecture i in year t
P_{it+1}: estimated population in prefecture i in year t
$P^{\bullet}_{it}$: actual popoulation in prefecture i in year t

4.2 Simulation results

Table 3 presents the simulation results by comparing three different aspects: the urban concentration of resources, efficiency, and equity in the years 1975 and 2000. The urban concentration of resources is defined by the simulated prefectural public capital and employment that are allocated to the urban region. As for the other criterion, efficiency is represented by the national GDP and per capita GDP, whereas equity is expressed by a weighted coefficient of variation (WCV) and Theil index of per capita income. The simulation results are shown by the national GDP and per capita GDP in the years of 1975 and 2000.

In terms of the urban concentration of resources, 38.3% of total public capital was allocated to the urban region in the base scenario in the year 2000; the efficient allocation scenario with income-elastic interregional labor mobility (scenario 3b) resulted in the highest level of urban concentration of resources at 64.0%, whereas the redistributive allocation scenario (scenario 2) resulted in the lowest level of urban concentration at 18.0%. Within the efficiency scenarios (3, 3a, and 3b), scenario 3b resulted in the highest urban concentration, with scenario 3 second at 58.6%, and scenario 3a third at 55.0%. In terms of the urban concentration of employment, the order of the scenarios is the same as that of public capital.

In terms of efficiency, the base scenario resulted in a national GDP of 511.5 trillion yen and an average per capita GDP of 4.03 million yen in 2000. Among all the scenarios, scenario 3b resulted in the highest national GDP at 524.2 trillion yen and per capita GDP at 4.13 million yen; scenario 2 resulted in the lowest national GDP at 493.7 trillion yen and per capita GDP at 3.90 million yen. Compared with the base scenario, scenario 3b resulted in an additional 12.7 trillion yen worth of production and 0.1 million yen of additional per capita GDP. The national economy could have grown 2.5 percentage points more than the actual level of growth if the government had pursued an efficiency-oriented allocation policy together with high interregional mobility of labor. Within the efficiency scenarios, scenario 3b resulted in the highest level of national output, with scenario 3 second, and scenario 3a third. This indicates that income-elastic interregional

Table 3. Simulation results

		Base		Retributive		Efficient					
Scenario	Benchmark Year	Interregional Labor Immobility						Interregional Labor Mobility			
								$\mu = 0.01$		$\mu = 0.05$	
		Scenario 1		Scenario 2		Scenario 3		Scenario 3a		Scenario 3b	
Year	1955	1975	2000	1975	2000	1975	2000	1975	2000	1975	2000
Urban Concentration (%): Public Capital	33.3	43.2	38.3	19.1	18.0	59.2	58.6	52.8	55.0	61.8	64.0
Urban Concentration (%): Employment	33.3	44.0	47.3	44.0	47.3	44.0	47.3	36.6	39.4	48.4	55.9
National GDP (Trillion Yen)	49.2	270.3	511.5	243.6	493.7	275.5	516.7	265.8	505.7	281.0	524.2
Per capita GDP (1000 Yen)	546.6	2,414.9	4,029.9	2,175.8	3,889.3	2,461.1	4,071.3	2,374.6	3,984.3	2,510.5	4,130.3
– WCV	0.296	0.296	0.314	0.139	0.261	0.383	0.356	0.416	0.385	0.355	0.273
– Theil	0.069	0.040	0.043	0.010	0.030	0.070	0.054	0.081	0.065	0.062	0.034

Note: National GDP and per capita GDP are at 1990 constant prices.

labor mobility brings about the highest economic growth. Comparing the simulation results of the base and the efficient allocation scenarios, it is apparent that the efficient allocation scenario in 2000 was markedly less effective than in 1975. This indicates that the actual public investment in the pre-oil shock period was more efficiently allocated than in the post-oil shock period.

The simulations also have different effects on inter-prefectural equity, as can be seen in the weighted coefficient of variation and the Theil index. Regional income inequalities across prefectures are greater in the efficient allocation scenario (scenario 3) than in the redistributive allocation scenario (scenario 2) in 2000, whereas the base scenario results in equity levels between scenario 2 and scenario 3. Efficient allocation with income-elastic interregional labor mobility (scenario 3b) produced the lowest levels of income inequality, as can be seen in both indices.

Through these quantitative simulations, this study found strong evidence of a trade-off between economic efficiency and inter-prefectural equity. However, economic efficiency contributes to both economic efficiency and inter-prefectural equity under the assumption of income-elastic interregional labor mobility.

5. Conclusion

By using the regional production function approach, this study has demonstrated three interesting findings, which are summarized in this section.

The first finding is that during Japan's postwar period, the government's regional allocation policy alternated between promoting economic efficiency and promoting regional equity. The empirical analysis indicates that the government allocated more public investment to the higher productivity region prior to the oil shock; after the onset of the oil shock, more public investment was allocated to the lower productivity region. This switched once again during the era of the bubble economy. These shifts in allocation policy correspond with the relatively high economic growth rates during the late 1950s, the 1960s, and the late 1980s, as well as the relatively low economic growth rates from the early 1970s to the mid-1980s.

The second finding, according to the plot of the ratio $(\theta' - \theta^*)$ and net migration to the urban region from 1955 to 2000, is that the regional allocation of public capital and interregional migration have a positive correlation to each other during the pre-oil shock period. This is in line with the study of Mera (1986), which demonstrated that public policy measures that influence the distribution of employment in high productivity sectors are potentially useful to governments in stabilizing interregional migration to the urban region between 1955 and 1978.

Finally, the third finding is demonstrated by numerical simulations that indicate a trade-off between economic efficiency and inter-prefectural equity. Redistributive allocation reduces income inequalities but concomitantly decreases national GDP growth, whereas efficiency allocation increases income inequalities but concomitantly increases national GDP growth. However, with an assumption of income-elastic interregional labor mobility, this trade-off can be mitigated and both national economic growth and prefectural inequalities can be achieved simultaneously.

Although this study examines the relationship between changes in public investment allocation and national and regional growth, there are several major future improvements to be made. The first improvement to be made is in the estimated parameters of the production functions from the pre- to the post-oil shock period. It was explained that the decrease in the parameters of the public capital variable was caused by an increase in the share of public investment for welfare purposes; however, the parameters for the private capital and employment variables remained constant over the entire period of the study despite the structural changes wrought by the oil shocks. Therefore, these should be qualitatively tested for further tasks. The second improvement is based on the simulation methodology. The income-elastic interregional labor mobility scenarios were assumed to be applicable to the entire population of a prefecture in the simulations; however, the majority of population migration in Japan occurs in the population cohort that is in their 20s. Thus, not only economic but also social factors should be included in future studies because the age composition and labor participation of each prefecture differ considerably from each other. The third possible improvement for this study is that it did not include the behavior of private investment in the analysis because private investment was treated as independent from prefectural public investment allocation. Doi (1998) pointed out that the relationship between private and public capital shifted dramatically from being one of substitution during the 1950s and 1960s to one of complementarity after the 1970s. A logical extension of this study is to focus on interregional trade of goods and services. Active interregional trade of goods and services contributes to reducing regional income inequalities. Undertaking simulations within the framework of an interregional computable general equilibrium (CGE) model can be a useful analytical tool to examine this hypothesis. As more techniques for analyzing regional data are developed, this will contribute to further discussions and studies on the issues surrounding regional allocation policy.

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Appendix

Table A1. Production and employment

		Production (billion yen)			Employment (×1000)		
Region	Prefecture	1955	1975	2000	1955	1975	2000
Hokkaido	Hokkaido	2729	10 073	19 671	2174	2542	2803
Tohoku	Aomori	481	2624	4497	674	701	747
	Iwate	508	2471	4804	735	730	805
	Miyagi	748	4076	8242	790	943	1181
	Akita	577	2336	3678	662	630	600
	Yamagata	503	2336	4063	686	636	656
	Fukushima	792	3302	7627	1029	1034	1102
Kannto	Niigata	1098	4720	8983	1266	1275	1297
	Ibaraki	777	4696	10 578	1007	1105	1403
	Tochigi	721	2978	7848	741	835	1035
	Gunma	622	3364	7271	809	901	1069
	Saitama	808	7462	19 154	654	1655	2610
	Chiba	802	7388	17 629	741	1476	2303
	Tokyo	9009	41 349	81 082	4696	7065	8519
	Kanagawa	1739	13 499	29 159	891	2500	3577
	Yamanashi	258	1403	3113	394	382	463
Chubu	Nagano	741	3522	8551	1081	1073	1202
	Shizuoka	1505	7144	15 283	1326	1754	2117
	Toyama	500	2445	4247	515	558	595
	Ishikawa	464	2208	4255	521	570	642
	Gifu	784	3482	7057	774	915	1049
	Aichi	2564	13 884	32 610	1948	3007	4138
	Mie	833	3235	6594	725	773	920
Kinki	Fukui	369	1553	3168	400	408	441
	Shiga	427	1998	5495	421	465	642
	Kyoto	1064	4956	9283	890	1163	1254
	Osaka	3514	21 114	38 897	2296	4076	4625
	Hyogo	2537	10 277	18 700	1475	2060	2350
	Nara	362	1579	3611	265	358	510
	Wakayama	592	2347	3120	470	488	490
Chugoku	Tottori	290	1085	2079	318	316	323
	Shimane	339	1323	2381	485	412	399
	Okayama	772	3757	6702	842	900	951
	Hiroshima	1038	5788	10 676	1056	1325	1472
	Yamaguchi	902	3270	5392	762	773	756
Shikoku	Tokushima	323	1406	2476	418	391	389
	Kagawa	430	1951	3517	481	490	525
	Ehime	689	2539	4705	762	754	759
	Kochi	354	1416	2426	458	408	402
Kyushu	Fukuoka	2172	9216	16 527	1660	1987	2390
	Saga	378	1476	2765	439	396	438
	Nagasaki	695	2403	4203	759	685	716
	Kumamoto	663	2741	5861	898	818	914
	Oita	513	2148	4416	614	560	583
	Miyazaki	397	1726	3344	558	526	555
	Kagoshima	630	2550	5109	1061	824	847
	Okinawa	219	1491	3355	319	368	547
Total		49 235	240 110	484 207	42 945	54 012	64 112

Yen values are in 1990 constant prices.

Table A2. Private and public capital

		Private capital (billion yen)			Public capital (billion yen)		
Region	Prefecture	1955	1975	2000	1955	1975	2000
Hokkaido	Hokkaido	1319	10 821	37 000	1560	16 887	58 837
Tohoku	Aomori	267	2064	10 670	297	3049	11 575
	Iwate	297	2403	10 483	309	3589	12 101
	Miyagi	322	3537	19 438	339	3919	15 583
	Akita	336	2408	8705	277	2654	11 622
	Yamagata	214	2023	9968	273	2817	10 370
	Fukushima	490	4106	19 648	379	3947	14 093
Kannto	Niigata	585	4828	22 355	475	6477	21 356
	Ibaraki	501	5408	25 026	321	4621	19 126
	Tochigi	464	4248	18 389	278	2577	9848
	Gunma	473	4011	17 893	255	2956	10 379
	Saitama	627	7110	38 930	326	6567	24 239
	Chiba	760	8654	41 531	443	6551	31 648
	Tokyo	4584	35 800	179 074	1432	33 932	75 168
	Kanagawa	1875	15 715	64 098	567	10 002	36 676
	Yamanashi	143	1367	7397	140	1959	7581
Chubu	Nagano	469	4266	19 381	388	4576	20 174
	Shizuoka	729	6943	33 221	427	5793	17 238
	Toyama	404	3459	12 701	215	2456	8879
	Ishikawa	266	2274	9771	199	2625	9472
	Gifu	494	3930	16 276	337	3602	13 324
	Aichi	1887	16 413	86 433	804	11 277	33 807
	Mie	444	3813	12 874	290	3269	11 886
Kinki	Fukui	229	2476	8837	168	2745	8130
	Shiga	311	2675	11 845	163	1995	7622
	Kyoto	539	4692	19 957	382	3517	12 890
	Osaka	2913	24 065	87 332	966	17 447	45 498
	Hyogo	1466	12 707	48 266	757	9934	38 042
	Nara	184	1533	6978	132	1915	7600
	Wakayama	299	2511	8597	292	2616	8340
Chugoku	Tottori	89	784	4468	150	1389	5704
	Shimane	189	1476	5564	186	2104	8573
	Okayama	547	5973	17 868	384	4004	14 926
	Hiroshima	815	7110	25 648	467	6453	19 720
	Yamaguchi	631	4897	15 638	435	3770	10 160
Shikoku	Tokushima	137	1327	5616	179	2297	6729
	Kagawa	225	2314	8810	195	1688	6766
	Ehime	370	3282	11 261	257	2689	10 706
	Kochi	200	1686	5077	206	1715	8101
Kyushu	Fukuoka	1414	11 114	40 778	684	7864	26 847
	Saga	174	1561	6365	175	1932	7236
	Nagasaki	376	2702	10 622	248	2455	11 657
	Kumamoto	333	3062	13 572	270	3023	13 078
	Oita	227	2554	11 092	271	2577	9636
	Miyazaki	258	2134	8419	210	2408	10 266
	Kagoshima	294	2480	11 421	285	3569	14 981
	Okinawa	622	1561	6832	108	1280	10 650
Total		30 792	262 278	1 122 124	17 903	237 492	808 842

Yen values are in 1990 constant prices.

Table A3. Simulation results: GDP

	GDP (billion yen)									
	1975					2000				
Prefecture	S1	S2	S3a	S3b	S3c	S1	S2	S3a	S3b	S3c
Hokkaido	11 660	8809	9178	9610	8239	18 848	17 516	17 814	18 538	15 492
Aomori	2365	2812	1970	2200	1654	4798	4943	4616	5021	3659
Iwate	2235	2553	1686	1922	1427	4511	4634	4297	4614	3159
Miyagi	4231	4587	4107	4237	3564	8790	8846	8668	8372	7258
Akita	2278	2788	1996	2431	1918	3708	3810	3503	4295	3167
Yamagata	2214	2700	1852	2258	1650	4144	4291	3968	4664	3340
Fukushima	3172	3535	2664	3024	2210	7514	7636	7340	8165	6107
Niigata	4879	4682	3999	4612	3591	9331	9231	9021	10 450	8146
Ibaraki	4434	4636	4020	4351	3432	11 295	11 189	11 243	11 266	9746
Tochigi	3521	4280	3838	4217	3763	7681	7961	7775	7917	7116
Gunma	3141	3740	3008	3212	2542	7832	8104	7890	8068	6767
Saitama	9429	8448	10 445	6195	6794	20 709	20 113	21 231	13 166	15 215
Chiba	8208	7437	8426	6017	6136	19 060	18 145	18 956	13 248	14 680
Tokyo	48 057	28 345	52 335	50 733	67 373	91 342	80 266	98 011	99 975	133 644
Kanagawa	17 446	13 484	21 421	13 011	20 586	32 157	30 032	33 161	22 831	33 427
Yamanashi	1397	1870	1124	1321	960	3298	3483	3183	3375	2568
Nagano	3774	4010	3221	3721	2801	7964	7920	7638	8343	6249
Shizuoka	8448	8124	9486	9356	9176	15 349	15 354	15 703	15 146	14 381
Toyama	2366	2898	2190	2438	2059	4508	4687	4403	4916	4250
Ishikawa	2343	2842	2101	2302	1873	4526	4709	4407	4671	3832
Gifu	3765	4186	3611	3766	3259	7265	7398	7184	7309	6158
Aichi	15 926	12 777	17 235	15 363	16 581	35 237	33 471	36 543	31 611	34 913
Mie	3953	4392	4130	4879	4750	6443	6592	6330	6876	6308
Fukui	1652	1981	1227	1380	1013	3056	3194	2913	3217	2490
Shiga	2106	2705	2045	2282	2013	5728	6014	5827	5797	5745
Kyoto	5696	6260	6864	6980	7341	9906	10 076	10 077	10 657	10 752
Osaka	25 928	18 106	28 975	24 246	31 280	40 042	37 156	41 175	38 342	46 639
Hyogo	12 416	10 113	12 866	12 576	14 126	21 076	19 767	20 883	21 297	23 550
Nara	1900	2394	1829	1766	1696	3822	4028	3745	3257	3135
Wakayama	2533	2986	2387	2842	2649	3281	3425	3223	3841	3211
Tottori	1195	1778	1064	1254	954	2136	2300	2042	2349	1740
Shimane	1279	1690	962	1258	872	2327	2434	2176	2750	1831
Okayama	3995	4308	3699	4140	3433	7030	7080	6852	7742	6644
Hiroshima	6301	5894	5822	5856	5299	11 369	11 245	11 430	11 746	10 639
Yamaguchi	3518	3817	3184	3797	3364	5577	5755	5486	6707	5796
Tokushima	1524	1944	1183	1440	1055	2555	2720	2477	2972	2131
Kagawa	2126	2919	2263	2679	2292	3695	3921	3629	4160	3495
Ehime	3011	3651	2987	3576	2966	4634	4784	4461	5260	4051
Kochi	1461	2028	1290	1648	1252	2354	2471	2225	2753	2064
Fukuoka	9670	8602	9823	10 551	10 437	17 454	16 950	17 356	17 746	16 869
Saga	1575	2099	1351	1720	1323	2783	2942	2667	3103	2310
Nagasaki	2560	3194	2463	3180	2618	4564	4689	4370	5301	4048
Kumamoto	2842	3387	2568	3197	2399	5774	5896	5571	6369	4682
Oita	2350	2891	2108	2659	2066	4300	4459	4164	5061	4014
Miyazaki	1731	2192	1392	1670	1213	3157	3263	2982	3399	2348
Kagoshima	2500	2874	1985	2754	1915	5035	5109	4769	6090	4056
Okinawa	1214	1817	1111	1181	1103	3531	3648	3363	2957	2424
Total	270 327	243 564	275 490	265 808	281 019	511 497	493 654	516 747	505 709	524 244

Yen values are in 1990 constant prices.

Table A4. Simulation results: per capita GDP

	Per capita GDP (billion yen)									
	1975					2000				
Prefecture	S1	S2	S3a	S3b	S3c	S1	S2	S3a	S3b	S3c
Hokkaido	2184	1650	1719	1711	1726	3317	3082	3135	2995	3276
Aomori	1610	1915	1341	1321	1364	3251	3349	3128	2894	3439
Iwate	1613	1843	1217	1190	1306	3186	3272	3034	2834	3530
Miyagi	2164	2346	2100	2109	2112	3716	3740	3665	3694	3896
Akita	1848	2262	1619	1565	1599	3118	3204	2945	2500	3003
Yamagata	1814	2212	1517	1466	1521	3331	3449	3189	2790	3401
Fukushima	1610	1794	1352	1321	1386	3533	3590	3451	3142	3701
Niigata	2040	1958	1672	1628	1676	3769	3728	3644	3222	3703
Ibaraki	1893	1979	1716	1702	1742	3783	3747	3766	3697	3889
Tochigi	2074	2521	2260	2238	2219	3831	3971	3878	3764	3895
Gunma	1788	2130	1712	1697	1736	3868	4002	3897	3770	4086
Saitama	1956	1752	2166	2415	2291	2985	2899	3060	4247	3550
Chiba	1978	1792	2031	2203	2121	3216	3062	3199	4072	3548
Tokyo	4117	2428	4483	4519	4118	7571	6653	8124	7875	6445
Kanagawa	2727	2108	3348	3692	3265	3788	3537	3906	5027	3706
Yamanashi	1784	2389	1435	1400	1449	3713	3922	3584	3378	3908
Nagano	1871	1987	1596	1552	1611	3595	3575	3448	3181	3725
Shizuoka	2553	2455	2867	2893	2811	4074	4075	4168	4207	4189
Toyama	2210	2706	2045	2010	2021	4022	4182	3928	3567	3837
Ishikawa	2190	2656	1963	1942	1962	3833	3987	3731	3518	3880
Gifu	2016	2241	1933	1926	1926	3447	3510	3408	3310	3539
Aichi	2689	2157	2910	2994	2855	5003	4752	5188	5664	5081
Mie	2431	2701	2540	2479	2411	3469	3549	3408	3157	3273
Fukui	2135	2561	1586	1555	1617	3686	3853	3514	3216	3717
Shiga	2136	2744	2075	2049	2034	4265	4479	4339	4282	4187
Kyoto	2349	2581	2831	2839	2721	3746	3810	3811	3599	3499
Osaka	3132	2187	3500	3635	3335	4548	4220	4676	4840	4137
Hyogo	2487	2026	2577	2594	2453	3797	3561	3762	3647	3333
Nara	1764	2222	1697	1725	1679	2649	2792	2596	2822	2764
Wakayama	2363	2785	2227	2167	2125	3067	3201	3012	2610	2780
Tottori	2056	3059	1831	1799	1826	3483	3751	3330	2960	3510
Shimane	1663	2198	1252	1194	1254	3056	3196	2857	2373	3055
Okayama	2202	2374	2039	1999	2021	3603	3629	3512	3163	3408
Hiroshima	2381	2227	2200	2211	2193	3949	3906	3970	3828	3858
Yamaguchi	2262	2454	2047	1987	1980	3650	3766	3591	3054	3311
Tokushima	1893	2415	1469	1426	1470	3100	3300	3005	2590	3083
Kagawa	2211	3036	2354	2301	2291	3612	3834	3548	3161	3474
Ehime	2055	2492	2038	1979	1994	3104	3204	2988	2609	3042
Kochi	1807	2508	1596	1530	1570	2892	3036	2734	2306	2930
Fukuoka	2252	2004	2288	2271	2210	3480	3379	3460	3348	3369
Saga	1880	2505	1613	1552	1584	3174	3356	3042	2682	3172
Nagasaki	1629	2032	1567	1500	1516	3010	3092	2882	2465	2893
Kumamoto	1657	1975	1497	1441	1489	3105	3171	2996	2675	3194
Oita	1975	2429	1771	1705	1739	3521	3651	3410	2912	3327
Miyazaki	1596	2020	1283	1244	1298	2698	2789	2549	2281	2832
Kagoshima	1450	1667	1152	1078	1140	2819	2860	2670	2201	2831
Okinawa	1164	1743	1066	1067	1165	2678	2767	2551	2752	2949
National	2415	2176	2461	2375	2510	4030	3889	4071	3984	4130