The effect of government capital on labor productivity in Japan’s prefectures

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Abstract

This paper uses Japanese prefecture level data to investigate the role of government capital in explaining the cross-sectional pattern in output per worker. We document some facts that suggest the overall role of government capital on output per worker might be negative. We then develop a model with private and public production that relates variations in the share of prefecture government capital in total capital to prefecture labor productivity. An empirical assessment of the model shows that the model predicts seven out of ten of the prefectures with the highest labor productivity and seven out of ten of the prefectures with the lowest labor productivity.

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Introduction

Since 1990 Japan has experienced its worst recession in over 40 years. One cornerstone of the government's policy to revive the economy in the 1990's has been to increase government investment. Between 1990 and 1997 the share of public investment in total investment has risen from 21% to 29%. Japan has borrowed heavily to finance these investments accumulating a massive amount of government debt[1]. Two reasons are given for government investment. The first reason is that government investment provides jobs in sectors that have seen the largest job losses e.g. the construction industry. A second rationale given for this policy is that government investment is good for the private sector. It boosts private sector output and can reduce inequality.

This second rationale appears to be supported by standard economic theory (see e.g. Barro (1990)). Consider an aggregate production technology whose arguments are labor input, private capital and government capital. Under standard assumptions an increase in government capital will raise output and the marginal products of both private capital and labor. Moreover, if government investment is focused in areas with low incomes, it will also reduce inequality.

The point of this paper is to argue that this reasoning misses some important negative effects of government investment and that these effects may be particularly important in Japan.

Our analysis proceeds in two stages. In the first stage we conduct a statistical analysis that is designed to uncover the effects of government capital on the private sector using historical prefecture-level Japanese data. Following Prescott and Parente (1983), Quah (1996a) and Kawagoe (1999) we treat individual realizations of prefecture performance as outcomes from a Markov chain. Markov chains provide an attractive way to document facts about the dynamics of a distribution such as speed of convergence and the properties of the long-run or *ergodic* distribution. Markov chains are estimated for the marginal distributions of relative prefecture private capital per worker, total capital per worker, per capita income and output per worker. Tokyo Prefecture, the leading prefecture throughout our sample, is chosen to be the numeraire.

The results from this analysis provide some interesting insights into the dynamics of the private sector and how these dynamics have been influenced by government capital. We find strong evidence of convergence of private capital per worker. Prefectures that had relatively high private capital per worker ratios in 1955 have seen this ratio steadily decline. Prefectures that had relatively low private capital per worker have seen this ratio steadily rise. The rate of convergence of private capital is estimated to lie between 4 and 6 percent per year.

A merit of the Markov chain approach is that it offers a characterization of the long-run ergodic distribution. The mean of the ergodic distribution of capital per worker is centered at about the level of Tokyo.

To get at the role of government capital we then investigate the distribution of total capital per worker, which consists of private capital plus government capital. The distribution of total capital per worker also shows strong evidence of both σ- and β-convergence. The mean of the distribution of total capital per worker is centered at the level of Tokyo and the ergodic variance of total capital per worker is smaller than the ergodic variance of private capital per worker. These findings suggest that the

[1] It is estimated that by the end of fiscal 1999 Japan will overtake Italy in terms of its debt to GDP ratio.

government has played an active role in equalizing capital per worker among Japan's Prefectures.

How have these government actions been reflected in measures of prefecture income and labor productivity? Our findings for per capita Income and GDP per worker suggest that the overall impact of these actions may be negative. Neither the distribution of per capita Income nor the distribution of GDP per worker shows much evidence of convergence since 1978. The most noteworthy features of these two distributions are summarized in our fifth fact. There is no evidence of either a widening or narrowing of the distributions of per capita Income and GDP per worker since 1978 and the means of the ergodic distributions of both per capita income and GDP per worker are well below the level of Tokyo.

In the second stage of our analysis we focus on the levels facts: relative private and total capital converge to about 1 while relative per capita income and output per worker converge to levels that are well less than 1. The Solow model predicts the equalization of capital per worker that we find coming through so strongly in Japanese data. However, it predicts that income and labor productivity should converge to 1 as well.

Augmenting the production technology of the Solow model with government capital along the lines described above only makes the puzzle worse. Government investment in Japan has been large and directed towards low income prefectures as evidenced by our results on relative total capital per worker and a strong negative correlation between per capita income and the public share of capital in our data[2]. However, our data shows no evidence of a reduction of inequality as measured by a narrowing in the dispersion of per capita income. Another counter-factual feature of this model is that it continues to predict that relative output per worker should converge to one.

These facts lead us to question the conventional reasoning relating to the effects of government capital on the private sector. Barro (1990) has previously pointed out that neglecting public production is an innocuous assumption as long as the private and public sectors have access to the same technology. In the second stage of our analysis, we relax this later assumption and assume instead that the total factor productivity in the public sector is lower than in the private sector.

We posit a model in which output is produced by private and public production. The only difference between these two technologies is that public production has lower total factor productivity, reflecting a difference in management capability. We then derive the equilibrium implications of this model and demonstrate that the model is qualitatively consistent with the levels facts outlined above.

After documenting the qualitative properties of the model, we investigate its quantitative implications. In this part of the analysis the model is asked to explain the prefecture data on GDP per worker using shares of government capital in total prefecture capital as the only input. The model does surprisingly well. It predicts 7 out of 10 of the winners as measured by output per worker and 7 out of ten of the losers. To address issues of simultaneity, we also ask the model to predict future relative performance using current shares of government capital. The model also does quite well according to this metric, predicting once again a majority of the winners and the losers. Finally, we measure the fraction of the cross-sectional variation in prefecture output per worker that

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[2] For instance, in 1993 the correlation between per capita income and the share of public capital was -.76.

can be attributed to variation in government capital. The model explains between 7% and 40% of the variance in measured GDP per worker as the relative total factor productivity of the government sector to the private sector is varied from 0.9 to 0.5.

Our work integrates research from several different areas. Barro and Sala-i-Martin (1992) and Shioji (1996) have used prefecture level data to document convergence of incomes and investigate the extent to which migration patterns have reacted to differences in prefecture income. Their research has found that convergence of prefecture incomes has been slow relative to the predictions of neoclassical theory. And their efforts to explain the slow speed of convergence have met with only limited success.

A distinct line of research has focused on the role of government capital in improving private productivity in U.S. State level or Japanese Prefecture level production functions. For the U.S., the general conclusion of this literature is that the effect of government capital on productivity is negligible (see e.g. Balmaseda (1996) or Garcia-Mila et. al (1995)).

In Japan the government capital share is typically estimated to be smaller than the private capital share and is often close to zero or even negative. Asako et. al. (1994) estimate a Cobb-Douglas production function using pooled panel data for Japan's prefectures from 1975 through 1988 and find that the magnitude of the estimated coefficient for government capital per worker is half the size of the coefficient for private capital. Asako et. al. (1994) and Ohkawara (1996) report results also using a Cobb-Douglas production technology in which the share parameter for public capital is smaller and even negative in some cases. Doi (1998) estimates a trans-log quadratic production function on pooled Japanese data from 1966 through 1993, and finds that the estimated coefficients for both the linear and quadratic term on government capital are significantly negative.

These results have led Shioji (1999) to pose a weaker question: Is government capital productive? He finds that the answer to this question is yes provided that prefecture fixed effects are modeled. Shioji's results do not allow one to infer the relative productivity of private versus public capital.

Our work is most closely related to research by Schmitz (1998). Schmitz (1998) develops a two-sector model and in which government enterprises may operate in either the consumption or investment goods sector. He shows that if government enterprises are highly concentrated in the investment goods sector his model can explain as much as 30% of the difference in national labor productivity between Egypt and the United States.

The remainder of the paper is divided into 3 sections. Section 2 reports the main empirical results. Section 3 describes the model and analyzes its performance and Section 4 concludes. The paper also contains two appendices. The data is described in Appendix A and a brief review of Markov chains is provided in Appendix B.

Growth Facts

In this section we summarize the principal growth facts that emerge from considering changes in the distribution of relative prefecture ranks. We will focus our attention on the marginal distributions of relative private capital per worker, relative total capital per worker, relative GDP per worker and relative per capita income. The reader is referred to Appendix A for a description of the data used in this analysis. Appendix B contains a brief review of the tools of Markov Chains that we use to summarize the data.

Prefecture relative private capital per worker

Our first fact is that private capital per worker has converged rapidly in Japan since 1955. Figure 1 reports the performance of the top 5 and bottom 5 prefectures' capital per worker ratios relative to Tokyo. From this figure we see that capital per worker of the five lowest prefectures was about one-third of the level of Tokyo in 1955. By 1987 private capital per worker for the five poorest prefectures had risen to about two-thirds of the level of Tokyo. An examination of the top five prefectures shows relative capital per worker levels declining from three-halves the value of Tokyo in 1955 to about the level of Tokyo in 1993. It is clear from this figure that the range has narrowed considerably over this period. Using the terminology of Barro and Sala-i-Martin (1992), this is referred to as σ -convergence or a narrowing of the variance of the distribution over time. It should be noted that Canova and Marcet (1998), Quah (1996), and Den Haan (1995), have pointed out that this is not compelling evidence of convergence. Instead this narrowing of the range may reflect different realizations of the long-run stationary distribution or even realizations from a divergent distribution.

In Figure 1 we also see some visual evidence of what Sala-i-Martin and Barro (1992) refer to as β-convergence. That is, the prefectures with low private capital per worker are growing more quickly. Quah (1996) argues at length that β-convergence may at times be misleading.

More formal evidence on convergence of relative private capital per worker ratios is given in Table 1 which reports the results from fitting an eight state first order Markov chain to data for 46 of Japan's Prefectures (Okinawa is left out for reasons of data availability). The eight states are based on an equally spaced grid. The midpoints of each cell in the grid are reported in Table 1.

Consider first the transition probabilities. Observe that the two lowest states, states 1 and 2, and the highest state, state 8, are transient. This offers formal confirmation of the narrowing of the distribution that we documented in Figure 1. The remaining states, states 3-7, are ergodic. Most of the mass of the ergodic distribution is centered between .69 and 1.15 relative to Tokyo. The mean of the ergodic distribution is 0.90 with a standard deviation of 0.17. This last piece of evidence suggests that private capital per worker ratios may be converging to a level slightly below that of Tokyo. Still, a formal test of the hypothesis that the ergodic mean is one cannot be rejected at conventional significance levels.

Given estimates of the transition probabilities it is straightforward to calculate the mean transition time from each of the transient states to the ergodic set. For state 1 the mean transition time to the ergodic set is 10.8 years. For state 2 the mean transition time is 5.9 years and for state 8 the transition time is 7 years.

This information can be used to assess speed of convergence. For instance, the rate of convergence from state 1 to state 3 is about 6% per year. The rate of convergence from state 2 to state 3 is about 5% per year and the rate of convergence from state 8 to state 7 is about 4% per year. Taken together, these results indicate that the rate of convergence of prefectures that are further from the stationary distribution is in fact more rapid.

Another feature of the distribution of relative private capital to worker is that there is lots of mobility. The prefectures that have experienced the most upward mobility include; Oita, which has increased its relative rank by 26 positions; Fukui, which increased its relative rank by 19 positions and; Miyagi, which increased its relative rank by 16 positions. The prefectures that have experienced the most downward mobility include; Saitama; which is fallen by 32 positions; Hokkaido, which has fallen by 24 positions and Nara; which has fallen by 23 positions.

To summarize this discussion the most interesting features of the distribution of private capital per worker are:

Fact 1 *There is strong evidence of convergence of private capital per worker.*

Fact 2 *The ergodic distribution of private capital per worker is centered at about the level of Tokyo.*

Relative total capital per worker

A question that has received considerable attention in both Japan and the United States is the role of government capital in improving labor productivity. As we noted in the introduction, most production function analyses have found that the productivity of government capital is small or even negative. An alternative strategy for investigating the role of government capital is to compare the distribution of private capital per worker with that of total capital per worker. Table 2 reports estimates of fitting a first order Markov chain to relative total capital per worker for the 1965-1993 sub-period. This is the period for which data on both private and public capital is available.

A comparison of the estimates reported here with those in Table 1 reveals some interesting differences. On the one hand, relative total capital per worker is nearly in its ergodic distribution. State one is the only transient state and the persistence of state one is only 0.5. Relative private capital per worker, on the other hand, is further from its ergodic distribution. The distribution has a larger initial variance and the transient states are more persistent. Another useful comparison is the ergodic means and standard devations of the two distributions. The ergodic mean of relative private capital per worker at 0.90 is slightly lower than the ergodic mean of relative total capital per worker, which is 1.03. The standard deviation of total capital per worker is also quite a bit smaller- 0.12 versus 0.17 for private capital per worker.

To examine the robustness of these findings to the choice of grid and the sample period we re-estimated both datasets using the same grid and sample period. The results which are reported in Table 3 are about the same. The ergodic mean of private capital per worker rises to 1.08 with a standard deviation of 0.20 and the ergodic mean of total capital per worker remains at 1.03 with a standard deviation of 0.15.

Taken together, these results suggest that government capital has increased the pace of convergence and produced a tighter long-run distribution of relative capital per worker that is centered at the level of Tokyo. We summarize these points in the following two facts:

Fact 3 *The mean of the ergodic distribution of relative total capital per worker is centered at the level of Tokyo.*

Fact 4 *The variance of the ergodic distribution of relative total capital per worker is more tightly distributed around the level of Tokyo than the distribution of relative private capital per worker.*

Relative per capita income

Our next step is to try and relate these facts regarding the distribution of inputs to measures of prefecture output and labor productivity. The most suitable measure of prefecture output for our purposes is GDP. However, most previous research has instead focused on various aspects of the distribution of personal income. Part of the reason for this is that there is better and longer time-series data available for prefecture Income. We will start, by first reporting results for the distribution of per capita Income and then turn to report results on the distribution of labor productivity using properly aligned inputs and outputs.

Figure 2 reports the performance of the top 5 and bottom 5 prefectures expressed in terms of per capita income relative to Tokyo. Comparing this figure with Figure 1 suggests that the rate of convergence of per capita income is considerably slower than that of private capital per worker. The top 5 prefectures are steady at a level of about 80% of Tokyo while the bottom five prefectures gradually rise from a level of about 40% of Tokyo in 1955 to a level of about 58% of Tokyo in 1994. Most of this rise though occurs in the period before1978. Finally, Figure 2 also shows only limited evidence of either β-convergence or σ-convergence. These results are similar to those reported in Kawagoe (1999) who fits 4, 5 and 6 state Markov chains to the distribution of Japanese Prefecture relative incomes.

Table 4 reports results from fitting an 8 state Markov chain to relative per capita income for the 1955-1994 period. Notice first that there are no transient states. According to these estimates, there is no statistical evidence that relative prefecture incomes are converging toward Tokyo. The weak visual evidence of β-convergence and σ-convergence in Figure 2 instead reflects different realizations of the long-run distribution of per capita Income. The mean of the ergodic distribution is 0.62. and the variance is 0.014. It is clear from these two statistics that the distribution of prefecture per capita Income is centered well below the level of Tokyo.

Perhaps the most striking of these results is the finding that there appears to be something special about Tokyo. Tokyo has maintained its lead throughout the whole sample and there is no evidence that the distribution of other prefectures is catching up with Tokyo. Quah (1996a) and Canova and Marcet (1998) report evidence of convergence clubs using European country and regional data. According our estimates Japan has two convergence clubs: Tokyo and the rest of the Japan.

Although the overall distribution is stable there is considerable mobility in the distribution of per capita Income. The most successful prefectures include; Yamanashi, which improved its rank by 25 positions and; Chiba and Tochigi, which both experienced gains of 19 positions in relative rank. At the other end of the spectrum Wakayama was the biggest net loser falling 29 positions. It was followed by; Nara, with a loss of 25 positions and; Hyogo, with a loss of 20 positions.

Relative GDP per worker

Before presenting the results on relative GDP per worker we want to point that reporting conventions for GDP were changed during our sample period. Starting in the early seventies Japan began estimating Prefecture GDP using the UN's reporting conventions. The exact date of the change varies by prefecture but appears to have been completed by 1975. In Figure 3 reports plots of the top 5 and bottom 5 prefectures for the entire 1965-1994 period.

The most notable feature of Figure 3 is that the gap between the top 5 prefectures and Tokyo is considerably smaller than in Figure 2. While the top 5 prefectures have on net lost ground relative to Tokyo since 1977, the gap has diminished in recent years. Notice also that there does appear to be a steady narrowing of the range of the distribution prior to 1978. From 1978 on the range of the distribution appears to be reasonably stable.

Table 5 reports results from estimating a Markov chain on GDP per worker for the 1965-1994 sample. As in the case of income per worker, we find no transient states. The mean of the distribution of relative capital per worker is 0.74 which is 0.12 higher than the mean of relative per capita income. The standard deviation of the distribution is 0.15. It is also interesting to see how the Markov chain reproduces what appears to be visual evidence of convergence. This is accomplished by an asymmetry in the probabilities of transiting in and out of the lowest states. Notice that the probability of migrating out of the lowest states in Table 4 is an order of magnitude higher than the probability of migrating into them.

There have also been large changes in relative position between 1965 and 1994. Ibaragi experienced the largest change in relative position improving its rank by 22 positions. Gunma came in second with an increase in rank of 20 positions and Oita and Yamanashi came in third with increases of 18 positions. The two biggest declines in relative position were Wakayama, which fell by 24 positions and Hokkaido, which fell by 17 positions.

The most important facts of our analysis of per capita Income and GDP per worker can be summarized in the following two facts.

Fact 5 *There is no evidence of a statistically significant widening or narrowing of the distribution of either Prefecture per capita Income or GDP per worker.*

Fact 6 *The ergodic distributions of per capita Income and GDP per worker are both centered at a level well below that of Tokyo.*

Discussion and analysis

The results presented in this section suggest that government capital has had a big impact on the relative distribution of total capital per worker. It has increased the speed of convergence, and tightened the distribution more narrowly around the level of Tokyo. The patterns of prefecture Per capita income and GDP per capita reveal a different picture. Although there is some evidence of convergence in the first part of our sample, the distributions of both of these variables seem to have gotten stuck around 1978. Moreover, these distributions are both centered at a level well below that of Tokyo.

It is useful to relate these findings to some current theories of growth. Consider first the Solow growth model with capital and labor are free to flow to the location where their marginal products are highest. For the moment, assume further that there is no distinction between private and public capital. Under these assumptions the Solow model predicts that total capital per worker in each prefecture should converge to one and that the variance of prefecture capital per worker should be zero. The data on capital per worker is indeed settling into a stationary distribution that is centered at one. However, the variance of this distribution is not zero. This dispersion does not strike us as being to too troubling. The measured dispersion and mobility in relative positions could conceivably be explained by a combination of prefecture specific technology shocks plus some of the rigidities that Boldrin, Christiano and Fischer(1998) find are needed to produce a plausible risk premium. If it is costly to quickly reallocate labor across prefectures, investment is irreversible, and capital takes time to build, then we would expect to see at least short-term variations in capital per worker across the prefectures.

A more troubling feature of the Solow model is that it also predicts convergence of relative incomes and relative output per worker to one. This is not occurring in the data.

Consider next a generalization of the Solow model in which government capital appears as a separate argument. This generalization of the Solow model continues to predict that relative total capital per worker will be one for each prefecture. Government capital can produce a long run dispersion in output. However, output will vary across prefectures in a way that is positively related to the share of government capital in total capital. This implication is at odds with our data. In our data the correlation between per capita income and the share of public capital in total capital is negative. In 1983, for instance, this correlation was –0.66 and the average share of public capital was 0.41. The negative correlation might be due to issues of simultaneity. Still, given the size of public capital, one would expect to see some reduction in dispersion of prefecture incomes over the subsequent ten years. This does not occur in our data.

The implications of this model for output per worker are also at odds with the data. This model predicts that relative output per worker will be one in each prefecture.

However, as we have seen, output per worker in the data is converging to a value that is well less than one.

Including government capital as an input in the aggregate production function is a shorthand. More generally, we can think of the government as producing services using its own production technology. If there are differences in the productivity of public and private production, this shorthand is not innocuous. There is considerable evidence that public production is less productive than private production (see e.g. Schmitz (1996) and the references cited therein). At an intuitive level it is not surprising that differences in the share of public production across prefectures could produce long-run differences in average productivity. This is because average labor productivity in a model with public and private production is a weighted average of public and private sector labor productivity. Moreover, this type of specification can also reproduce the negative cross-sectional correlation between output and the share of public capital found in the data. The next section of the paper presents a model that formalizes these arguments and assesses the extent to which such a model can quantitatively account for the level facts.

The model

Consider a collection of identical households who solve the following optimization problem:

$$\begin{aligned} &\max_{\{c_t, k_{t+1}, n_t\}} \sum_{t=0}^{\infty} \beta^t u(c_t) \\ &s.t. \\ &c_t + k_{t+1} - (1-\delta)k_t = w_t n_t + r_t k_t \end{aligned} \qquad (1)$$

where c_t is consumption in period t, k_t is capital that the household enters the period with and n_t is labor supplied by the household. In making its plans each household takes as given the sequence of wage rates and rental rates $\{w_t, r_t\}$. Since households don't value leisure, they will inelastically supply the one unit of labor that they are endowed with each period. The other first order condition for the problem described above is given by:

$$u'(c_t) = \beta u'(c_{t+1})(r_{t+1} + 1 - \delta) \qquad (2)$$

In order to explain the facts documented above, it is necessary to elaborate on the details of how production occurs at the prefecture level. The structure that we posit here is very similar to the structure developed in Schmitz (1998). Assume that each prefecture produces an identical good that can be either consumed or invested. Within each prefecture the private sector produces this good using the following Cobb-Douglas production technology:

$$y_{i,t}^{p} = Z_t k_{i,t}^{p\,\theta} N_{i,t}^{p\,1-\theta} \qquad (3)$$

where $i = \{1,\ldots,I\}$ indexes the prefecture. Notice that the private production technologies in all prefectures have the same capital share parameter, θ, and the same total factor productivity, Z_t. We will assume that the government also operates in each prefecture producing the same good as private firms using inputs of government capital and labor:

$$y_{i,t}^{g} = \mu_g Z_t k_{i,t}^{g\,\theta} N_{i,t}^{g\,1-\theta} \qquad (4)$$

and assume that μ_g is less than one. This assumption is meant to proxy for differences in management and organization between government and private production. Empirical evidence that government production is less efficient than private production can be found in Schmitz (1998,1996) and the references the cited there.

Both private firms and the government are assumed to act competitively that is they take prices as fixed when making their production plans. Given this assumption, it is necessary to impose a set of taxes on private firms and subsides on government production to ensure that both types of enterprises operate. The specific details of the tax and subsidy system we consider are described below. At this point though it is convenient to introduce the notation for the tax and subsidy into the problems of respectively a private firm and the government.

A private firm's problem in prefecture *i* is:

$$\begin{aligned} &\max_{N_{i,t}^p, k_{i,t}^p} (1-\tau_{i,t}) y_{i,t}^p - w_t N_{i,t}^p - r_t k_{i,t}^p \\ &s.t.\ \text{equation (3)} \end{aligned} \tag{5}$$

taking as given w_t,r_t and τ_t .The first order conditions for this problem are

$$\begin{aligned} r_t &= (1-\tau_{i,t})\theta y_{i,t}^p / k_{i,t}^p \\ w_t &= (1-\tau_{i,t})(1-\theta) y_{i,t}^p / N_{i,t}^p \end{aligned} \tag{6}$$

The government's production problem in prefecture *i* is:

$$\begin{aligned} &\max_{N_{i,t}^g, k_{i,t}^g} (1+s_{i,t}) y_{i,t}^g - w_t N_{i,t}^g - r_t k_{i,t}^g \\ &s.t.\ \text{equation (4).} \end{aligned} \tag{7}$$

The government takes as given wages, the rental rate on capital and the level of the subsidy, $s_{i,t}$, when making its production decision. The first order conditions for this problem are:

$$r_t = (1 - s_{i,t}) q\, y^g_{i,t} \,/\, k^g_{i,t}$$
$$w_t = (1 - s_{i,t})(1 - q)\, y^g_{i,t} \,/\, N^g_{i,t} \qquad (8)$$

Given these assumptions, prefecture output is $y_{i,t} = y^p_{i,t} + y^g_{i,t}$, prefecture employment is $N_{i,t} = N^p_{i,t} + N^g_{i,t}$, and prefecture total capital is $k_{i,t} = k^p_{i,t} + k^g_{i,t}$.

To complete the description of the model we need to describe how the tax and subsidy scheme is implemented and how prefecture production is divided between government and private production. In Japan both national and local taxes are set by the central government. National taxes are the same across all prefectures and though local taxes do vary somewhat, the amount of variation is very small. To capture this pattern of taxation in the model we will assume that private firms in all prefectures pay the same tax rate. However, the level of the subsidy will vary by prefecture depending on the scale of activity of the government in that prefecture. It will also be assumed that the government budget constraint is balanced: total revenue from taxes equals total outlays for subsidies. The government also chooses the scale of its activity in each prefecture by setting the ratio of government capital to total prefecture capital and the ratio of government employment to total prefecture employment to the same constant. These restrictions can be summarized using the following equations:

$$t_{i,t} = t_{j,t} = t_t, \forall i, j \in \{1, \ldots, I\} \qquad (9)$$

$$(1 - t_t) = (1 + s_{i,t}) m_g \qquad (10)$$

$$t_t \sum_{i=1}^{I} y^p_{i,t} = \sum_{i=1}^{I} s_{i,t} y^g_{i,t} \qquad (11)$$

$$l_i = k^g_{i,t} / k_{i,t} = N^g_{i,t} / N_{i,t} \qquad (12)$$

Competitive Equilibrium

The next step is to define a competitive equilibrium for the economy we have described above. At first blush it might appear that it is more tractable to limit attention to steady-state equilibria. However, it turns out that the equilibrium implications we will use to investigate the quantitative implications of the model apply off the steady-state as well.

Definition 1: Competitive Equilibrium

A competitive equilibrium is a vector of prices $\{w_t^*, r_t^*\}$, a vector of household plans $\{c_t^*, k_{t+1}^*, N_t^*,\}$ and a vector of prefecture production plans $\{k_{i,t}^p*, N_{i,t}^p*, k_{i,t}^g*, N_{i,t}^g*\}, i=1,2\ldots,I$, a vector of taxes and subsidies $\{\tau_{i,t}, s_{i,t}\}, i=1,2\ldots,I$ and a set of government production shares $\{\lambda_{i,t}\}, i=1,2\ldots.,I$ that satisfy the household's budget constraint and first order condition (equations (1) and (2)), firms' first order conditions (6) and (8), market clearing, the restrictions of government policy (9)-(12), market clearing (zero profits) and feasibility.

The most important equilibrium restrictions relate to the evolution of the distribution of capital per worker and output per worker. These restrictions are relatively straightforward to derive. If firms maximize profits then they will choose their capital and labor inputs according to equations (6) and (8). It follows from (8) that private firms will choose their inputs in a way that equalizes the capital per worker ratio across all private firms. Moreover, taking the ratio of the wage to the interest rate in (8) and setting it equal to the same ratio in (8) implies that the government capital-worker ratio will equal the private capital-worker ratio in the same prefecture. With a little more work it can be shown further that each firm's capital per worker ratio will equal the aggregate capital to worker ratio. These facts imply the following chain of equalities:

$$k_i^p*/N_i^p* = k_{i,t}^g*/N_{i,t}^g* = k_{i,t}*/N_{i,t}* = k_t*/1 = k_t*. \quad (13)$$

It follows immediately from (13) that prefecture employment can be expressed as $N_{i,t}^{*} = k_{i,t}{*} / k_t{*}$. These two facts provide a convenient way to express private and public prefecture output:

$$\begin{aligned} y_{i,t}^{p}{*} &= Z k_{i,t}{*}^{\theta} (1-\lambda_i) N_{i,t}{*} \\ y_{i,t}^{g}{*} &= \mu_g {*} Z k_{i,t}{*}^{\theta} \lambda_i N_{i,t}{*} \end{aligned} \tag{14}$$

Given (14) it is straightforward to derive average productivity in each prefecture

$$y_{i,t} / N_{i,t} = Z_t k_t{*}^{\theta} (\lambda_{i,t}\mu_g + (1-\lambda_{i,t})). \tag{15}$$

In equilibrium prefecture average labor productivity will depend on the fraction of government production in that prefecture. Prefectures with high shares of government production will have lower average productivity than prefectures with low shares of government production.

How do these predictions of the model line up with the empirical facts outlined in the previous section of this paper? The model predicts that both relative private capital per worker and relative total capital per worker should converge to 1 in all prefectures. In the data we see this convergence towards 1. However, there is still some cross-sectional dispersion in the data that the model, cannot account for. It is conceivable that a more elaborate version of the model that imposes irreversibility conditions on investment and limits labor mobility might explain these differences, but evaluating this conjecture is beyond the scope of the current paper.

The model is also consistent with convergence of relative incomes and average labor productivity to values that are less than one and long-run dispersion in these variables. The relative mean of the cross-sectional distribution of these variables will depend on the exact pattern of government production. However, the model predicts that the correlation between income and the share of government production will be negative.

This discussion, though suggestive, does not provide direct support for our assertion that government capital is in fact an important determinant of cross-sectional differences in output per worker. To do this we need to investigate the quantitative properties of the model. We will do that in the next sub-section.

Model Parameterization and Evaluation

In order to assess the quantitative properties of the model we need to first parameterize the model. We set the capital share parameter θ to be 0.25. This lies in the middle of the range of values that have been estimated in previous analyses. The depreciation parameter δ is set to 0.025. There is less a priori information on the value of μ_g. We started by setting μ_g to 0.9 and experimented with alternative values. After experimenting with different values we found that our basic results are the same for values of μ_g that range from about 0.5 to 0.9.

The most important parameter is the share of government production in each prefecture. Our model assumes that the government behaves competitively and produces the same consumption good produced by private firms. Ideally what we would like is prefecture data on either the government capital share or the employment share of just those activities that are close substitutes for private goods. Unfortunately, such data is very difficult to collect. Instead we assume that *all* government capital is used in producing goods that these goods are perfect substitutes for private goods. Aside from the issue of data availability, we think that it is difficult to produce examples of goods or services produced by the government that do not have close substitutes in the private sector. Based on this reasoning, we measured $\lambda_{i,t}$ using data on the share of total government capital in total prefecture capital.

Three criteria are used to assess the quantitative properties of the model. The first criterion is the ability of the model to reproduce the winners and losers, as measured by output per worker, in a particular period using current data on government shares in production. The second criterion is the ability of the model to predict future losers and winners using historical data on the government shares in production. And the third criterion is the ability of the model to reproduce the cross-sectional variation in the data. Table 5a and b report the model's performance according to the first two criteria. The first column reports the top ten and bottom ten prefectures in 1993 using GDP per worker. The second column reports the model's predictions using the shares of government production for 1993. Notice that the model predicts 7 out of 10 of the winners and 7 out of 10 of the losers. The third column reports the models predicted winners and losers using data on the government share of production from 1983. Notice that the model predicts 7 out of 10 of the winners using data from 1983 and 7 out 10 losers. We find this performance surprisingly good given that government capital is the only source of variation in prefecture productivity in our model.

One noteworthy feature of the results is that the model predicts that Hokkaido should be among the worst performing prefectures. In this regard it is interesting to note that government investment in Hokkaido is administered by a separate organization from the rest of Japan. This adds support to our claim that the source of the difference in total factor productivity may be differences in managerial capabilities between the private and public sectors. Our results suggest that Hokkaido does a surprisingly good job of administering investment and the production of government services.

Table 5a

Performance of the top 10 Japanese Prefectures: model and data

Top 10 Prefectures GDP/worker, 1993	**Model predicted Top 10 Prefectures using 1993 data**	**Model predicted Top 10 Prefectures using 1983 data**
Tokyo	Aichi*	Aichi*
Shiga	Tokyo*	Osaka*
Hyogo	Osaka*	Kanagawa*
Kanagawa	Shizuoka	Tochigi
Chiba	Shiga*	Fukuoka*
Kyoto	Tochigi	Tokyo*
Aichi	Kanagawa*	Kyoto*
Osaka	Fukuoka*	Shiga*
Okayama	Gunma	Toyama
Fukuoka	Kyoto*	Shizuoka

Table 5 b

Performance of the bottom 10 Japanese prefectures: model and data.

Bottom 10 Prefectures GDP/Worker 1993	**Model predicted Bottom 10 Prefectures using 1993 data**	**Model predicted Bottom 10 Prefectures using 1983 data**
Tottori	Kagoshima*	Kochi*
Kumamoto	Saga	Kagoshima*
Yamagata	Tokushima	Yamanashi
Kagoshima	Kochi*	Akita*
Aomori	Aomori*	Shimane*
Akita	Shimane*	Niigata
Kochi	Akita*	Aomori*
Shimane	Iwate*	Iwate*
Miyazaki	Tottori*	Hokkaido
Iwate	Hokkaido	Tottori*

Evidence on the model's ability to predict the overall variation in the data is reported in Table 6. In this table we report the model's predicted variability in 1993 using alternative configurations of the model's parameters.

Table 6
Predicted relative dispersion: model and data.

μ_g	0.9	0.7	0.5	0.4
σ_m/σ_d	.07	.22	.39	0.49

This table shows that the model requires large differences in the relative total factor productivity of private and public production technologies to explain even a third of the variation in the data. Schmitz (1998) finds that more variation can be produced in predicted average productivity if government activity is concentrated in the investment goods sector.

Conclusion

In this paper we have documented a number of new growth facts about Japan's Prefectures and offered an explanation for these facts. We formalized our explanation using a variant of the neoclassical growth model that allows for government production but assumes that the total factor productivity of the government production technology is less than that of the private sector's production technology. We argued informally that this specification might be due to a difference in managerial capabilities between the private and public sector. We found that the qualitative properties of the model line up reasonably well with the facts and that the model replicates some of the main features of the Japanese distribution of output per worker. Results from our calibration exercise also provide new evidence supporting our claim that managerial capability differs between the private and public sector. The performance of Hokkaido, which was surprisingly good from the perspective of our model, has a distinct administrative structure for allocating public capital from the rest of the country.

We conclude with the following caveat. It is not our attention to assert that all forms of government capital could be more efficiently provided by the private sector. Instead we interpret our findings as presenting evidence that the negative effects of poor project selection and management have overwhelmed any potential benefits from public production in Japan. And the way we have demonstrated this point is to show that a model that focuses explicitly on the negative aspects of government production does a better job of explaining the facts than models that assume that government capital enhances private productivity.

Appendix A: Data description

We use the following data for in our study: prefecture population, employment, GDP, Income and prefecture private and public capital stock.

The source for prefecture GDP and prefecture Income data is the Annual Report of Prefecture Accounts issued by the Economic Planning Agency. This accounting system of the Japanese regional economy is based on the 1968 UN System of National Accounts. All transformations to this system were completed in 1978. We use two different measures of prefecture output Gross Domestic Product for the period from 1975 to 1994 and Net Domestic Product data in the period before that. This choice is driven by data-limitations for the pre 1975 period. Prefecture GDP is equivalent to prefecture Gross Domestic Expenditure and is composed of prefecture production valued at market prices. It is meant to capture domestic production that occurs in each particular prefecture. Market price refers to producers' costs in case of the production processes and the purchasers' price at other stages.

Prefecture income is income of all residents residing in a prefecture. It can be related to prefecture GDP in the following way. First, subtract off depletion of capital from GDP to get Net GDP. Second, Subtract indirect taxes from Net GDP to get Net GDP at factor cost. Third, subtract element income from other prefectures from Net GDP at factor cost to get prefecture income.

Our data on private and public capital is from Doi T. (1998) . This data consists of private capital from 1955-1993 and public capital from 1965-1993. Before discovering Doi's data we constructed our own measure of prefecture capital for the period 1975-1994 using data on investment flows from the Prefectural Accounts. The investment flows were then converted to stocks using geometric depreciation and initial and terminal conditions on aggregate capital stocks as reported in Historical Statistics of Japan. The terminal condition was used to identify the depreciation rate and the initial capital stock for each prefecture was backed out from the aggregate initial capital stock by using the weights based in the initial share of investment in total investment. After encountering Doi's data we compared of our measure of capital stocks with Doi's and found them to be virtually the same. Since Doi has a longer time-series of data, we chose to use his data. This measure of public capital is comprehensive and includes items that fall into the following four general categories:

1. Agricultural, fishery and forestry infrastructure.
2. Industrial infrastructure (roads and highways, seaports and airports)
3. Transportation and communication infrastructure
4. Living infrastructure (city and town roads, parks, concert halls, community centers, schools and hospitals)

Appendix B: Markov chains

Markov chains defined

One of the principal methods we will use to summarize our data is as a markov chain. A Markov chain is a sequence of random variables $\{X_t, t=1,2,\ldots\}$ each of which can take on *m* distinct realizations. We will restrict attention to stationary or time-homogenous Markov chains. In this case, the transition probabilities between t and t+j depend only on the number of periods between t and t+j. Suppose that the (*mxm*) transition matrix of one period ahead conditional probabilities is given by:

$$\mathbf{P} = \begin{bmatrix} P_{11} & P_{12} & P_{13} & \cdots \\ P_{21} & P_{22} & P_{23} & \cdots \\ . & . & . & . \\ . & . & . & . \end{bmatrix} \qquad (1)$$

$$where,$$

$$P_{ij} = P(X_{t+1} = j \mid X_t = i)$$

Notice that **P** has two defining properties: each element of **P** is non-negative and the sum of each row of **P** is one.

The j step ahead transition matrix can be recursively calculated using the formula:

$$\mathbf{P}^{\mathbf{j}+1} = \mathbf{P}^{\mathbf{j}} \cdot \mathbf{P}. \qquad (2)$$

Estimating the transition matrix.

Given an initial state and a time-series of transitions the maximum likelihood estimates of the transition matrix **P** can be estimated from the transition counts. Let n_{i1} equal the number of times you count a transition from state *i* to state 1 and n_i denote the total number of times that you observe state i. Then it can be shown that the maximum likelihood estimates are given by the following formula

$$\hat{p}_{ij} = \frac{n_{ij}}{n_i} \quad i, j = 1,2,3,\ldots,m \qquad (3)$$

Limiting Behavior of Markov chains

In our empirical work we will want to infer some of the long-run or steady-state properties of the distribution of Japanese prefectures from estimates of the transition matrix **P**. It is not difficult to see that some states are not relevant for describing the long-run properties of the distribution. Some states when once left my never be visited again. In characterizing the limiting behavior of a Markov chain we will be interested in the ergodic states. Ergodic states satisfy certain properties that we describe below. Moreover, defining the ergodic states is important in describing the conditions under which Markov chains are ergodic stochastic processes. This in turn is needed for the application of many laws of large numbers[3]. To describe the ergodic states we need to classify Markov chains into several categories. The states of a Markov can be classified into two broad categories: *transient* and *recurrent.* A recurrent state has the property that

[3] In econometrics applications you often want to appeal to laws of large numbers that apply to a situation where you have only one realization of the stochastic process. If the stochastic process is ergodic you can learn everything about the stochastic process from one long realization regardless of the initial condition.

if it is started from it will almost surely revisited. Transient states are states that are not recurrent. Recurrent states can be broken further into two categories depending on whether the mean recurrence time is finite or infinite. If the mean recurrence time is finite we refer to the state as *positive recurrent* and if it is infinite we refer to it as *null recurrent*. For the reasons described above ergodic states are *positive recurrent.* A second classification relates to the periodicity of the states. Ergodic states are also *aperiodic*. That is, the greatest common integer divisor for which $P_{ii}^{n} > 0$ is 1. These properties are summarized in the following definition:

Definition 2: ergodic states

Ergodic states are states that are positive recurrent and aperiodic.

Give this definition of the ergodic states of a Markov chain we now turn to a description of how to calculate their probability. Before doing this we need to make one more definition.

Definition 3: irreducible ergodic markov chain

A Markov chain is irreducible if all of its states are ergodic.

The probability of the ergodic states of irreducible ergodic markov chains can be calculated recursively from the following formula:

$$\mathbf{X_{t+1}} = \mathbf{P'} \mathbf{X_t} \qquad (4)$$

The ergodic or long-run probabilities X_∞ satisfy:

$$\mathbf{X}_\infty = \mathbf{P'} \mathbf{X}_\infty \qquad (5)$$

One simple way to calculate the ergodic probabilities is to operate recursively on equation (4) from any initial $\mathbf{X_0}$ that sums to one. Alternatively, the ergodic probabilities can also be found by solving a particular set of linear equations (see e.g. Bhat(1984)).

References

Asako, Kazumi et. all, (1994) “Shakai Shihon no Seisanryoku Kouka to Koukyou Toushi Seisaku no Keizai Kousei Hyouka (Effects on Productivity of Social Capital and Welfare Economic Evaluation of Public Investment Policy)), ” (in Japanese), *Keizai Bunseki* No. 135, pp.1-90.

Baht, U. Narayan. 1984. Elements of Applied Stochastic Processes. *Wiley* , New York, NY. 2nd ed.

Balmaseda, Manuel 1996. Production Function Estimates of the Rate of Return on Public Infrastruture. Centro Estudios Monetarios Financieros, unpublished manuscript.

Barro, Robert J. Government Spending in a Simple Model of Endogenous Growth. *Journal of Political Economy* 98 (September, pt. 2):S103-S125.

Barro, Robert J., and Sala-i-Martin, Xavier. 1992. Convergence. *Jounal of Political Economy* 100 (April):223-51.

Barro, Robert J., and Sala-i-Martin, Xavier. 1992. Regional Growth and Migration: A Japan-U.S. Comparison. *Jounal of Japanese and International economies,* 6, 4:312-346.

Canova, Fabio, and Marcet, Albert. 1998. The Poor Stay Poor: Non-Convergence across Countries and Regions. Unpublished Manuscript March.

Den Haan, Wouter J. 1995. Convergence in Stochastic Growth Models: The Importance of Understanding Why Income Levels differ. *Journal of Monetary Economics,* 32(3):395-415.

Doi, Takero, “Nihon no shakai shihon ni kannsuru paneru bunnseki (Panel Analysis on Social Capital of Japan),” (in Japanese), Kokumin Keizai No. 161 (1998), pp. 27-52.

Durlauf, Steven N., and Quah, Danny T. 1998. The New Empirics of Economic Growth. Unpublished Manuscript.

Economic Planning Agency. 1970-1997. Annual Report on Prefectural Accounts.

Garcia-Mila, Teresa, Therese J. McGuire and Robert H. Porter, 1995. “The Effects of Public Capital in State-Level Production Functions Reconsidered”, *Review of Economics and Statistics.*

Ito, Takatoshi. 1992. The Japanese Economy. MIT Press, Cambridge MA.

Kawagoe, Masaaki. 1999. Regional Dynamics in Japan: A Reexamination of Barro Regressions. *The Journal of Japanese and International Economies* 13 (March): 61-72.

Lucas, Robert E. Jr. 1993. Making a Miracle. *Econometica* 61 (March):251-72.

Ohkawara, Toru, "Koukyou Toushi, Shakai Shihon to Chiiki Keizai (Public Investment, Social Capital, and Regional Economy)," (in Japanese) *ESP*, (May 1996), 32-35.

Parente, Stephen L., and Prescott, Edward C. 1993. Changes in the Wealth of Nations. *Federal Reserve Bank of Minneapolis Quarterly Review,* (Spring): 3-16.

Quah, Danny T. 1996. Aggregate and Regional Disaggregate Fluctuations. *Empirical Economics,* 21:137-159.

Quah, Danny T. 1996a. Convergence Empirics Across Economies with (Some) Capital Mobility. *Journal of Economic Growth* 1:95-124.

Shioji, Etsuro. 1999. Public Capital and Regional Income Dynamics: A US_Japan Comparison. Unpublished Manuscript.

Shioji, Etsuro. 1996. Regional Growth in Japan. CEPR Discussion paper No. 1425.

Schmitz, James A. Jr. 1993. Early Progress on the "Problem of Economic Development." *Federal Reserve Bank of Minneapolis Quarterly Review,* (Spring): 17-35.

Schmitz, James A. Jr. 1996. The Role Played by Public Enterprises:
How Much Does It Differ Across Countries? *Federal Reserve Bank of Minneapolis Quarterly Review,* (Spring): 2-15.

Schmitz, James A. Jr. 1998. Government Production of investment Goods and Aggregate Labor Productivity. Federal Reserve Bank of Minneapolis Staff Report 240.

Stokey, Nancy L., and Lucas, Robert E. Jr. 1989. Recursive Methods in Economics. *Harvard University Press,* Cambridge MA.

Table 1

Private capital per worker relative to Tokyo 1955-1993
8 state markov chain

Midpoints							
0.3231	0.4166	0.5371	0.6924	0.8926	1.151	1.484	1.913
Transition Probabilities							
0.8	0.2	0	0	0	0	0	0
0.01205	0.8072	0.1807	0	0	0	0	0
0	0	0.8544	0.1456	0	0	0	0
0	0	0.01053	0.92	0.06947	0	0	0
0	0	0	0.0364	0.9393	0.02426	0	0
0	0	0	0	0.05	0.9444	0.005556	0
0	0	0	0	0	0.2667	0.7333	0
0	0	0	0	0	0	0.1429	0.8571
Ergodic Probabilities							
0.00	0.00	0.01863	0.2562	0.4861	0.2343	0.004875	0.00

Table 2

Total capital per worker relative to Tokyo 1965-1993
8 state markov chain

Midpoints							
0.5564	0.6341	0.7227	0.8237	0.9388	1.07	1.219	1.39
Transition Probabilities							
0.5	0.5	0	0	0	0	0	0
0	0.72	0.28	0	0	0	0	0
0	0.03093	0.7113	0.2577	0	0	0	0
0	0	0.0131	0.8384	0.1485	0	0	0
0	0	0	0.0199	0.9154	0.06468	0	0
0	0	0	0	0.06269	0.8925	0.04478	0
0	0	0	0	0	0.09934	0.894	0.006623
0	0	0	0	0	0	0.1429	0.8571
Ergodic Probabilities							
0	0.000287	0.00259	0.05076	0.3773	0.3873	0.1738	0.008013

Table 3

Relative private capital per worker and relative total capital per worker 1965-1993, 8 state markov chain

Relative Private capital per woker

Midpoints							
0.3255	0.4276	0.5618	0.7381	0.9696	1.274	1.674	2.199
Transition Probabilities							
0.7857	0.2143	0	0	0	0	0	0
0.009615	0.8173	0.1731	0	0	0	0	0
0	0.0125	0.8583	0.1292	0	0	0	0
0	0	0.007177	0.9258	0.06699	0	0	0
0	0	0	0.01899	0.9335	0.04747	0	0
0	0	0	0	0.04118	0.9588	0	0
0	0	0	0	0	0.1429	0.8571	0
0	0	0	0	0	0	0.2	0.8
Ergodic Probabilities							
2.16E-05	0.0004772	0.006544	0.1167	0.4081	0.4682	0	0

Relative total capital per worker

Midpoints							
0.3255	0.4276	0.5618	0.7381	0.9696	1.274	1.674	2.199
Transition Probabilities							
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0.7105	0.2895	0	0	0	0
0	0	0.003891	0.8638	0.1323	0	0	0
0	0	0	0.009056	0.9677	0.02329	0	0
0	0	0	0	0.06849	0.9315	0	0
0	0	0	0	0	1	0	0
0	0	0	0	0	0	0	0
Ergodic Probabilities							
0	0	0.0006681	0.04918	0.7093	0.2408	0	0

Table 4

Per capita income relative to Tokyo 1955-1994

8 state markov chain

Midpoints							
0.3045	0.3568	0.4181	0.49	0.5741	0.6728	0.7884	0.9238
Transition Probabilities							
0.7333	0.2667	0	0	0	0	0	0
0.08889	0.6667	0.2444	0	0	0	0	0
0	0.05521	0.7423	0.2025	0	0	0	0
0	0	0.08092	0.7659	0.1532	0	0	0
0	0	0	0.06586	0.8163	0.1179	0	0
0	0	0	0	0.1004	0.8514	0.04819	0
0	0	0	0	0	0.1641	0.8047	0.03125
0	0	0	0	0	0	0.06557	0.9344
Ergodic Probabilities							
0.00402	0.01195	0.05236	0.1299	0.2999	0.3506	0.1026	0.04863

Table 5

GDP per worker relative to Tokyo 1955-1994
8 state markov chain

Midpoints							
0.3435	0.4118	0.4936	0.5917	0.7093	0.8503	1.019	1.222
Transition Probabilities							
0.6364	0.3636	0	0	0	0	0	0
0.07292	0.6458	0.2813	0	0	0	0	0
0	0.05333	0.77	0.1767	0	0	0	0
0	0	0.05374	0.856	0.09021	0	0	0
0	0	0	0.04356	0.9072	0.04924	0	0
0	0	0	0	0.08333	0.8728	0.04386	0
0	0	0	0	0	0.131	0.8571	0.0119
0	0	0	0	0	0	0.06667	0.9333
Ergodic Probabilities							
0.002276	0.01131	0.05942	0.1944	0.4007	0.2368	0.07988	0.01521

Figure 1
Private capital per worker relative to Tokyo: top and bottom five prefectures

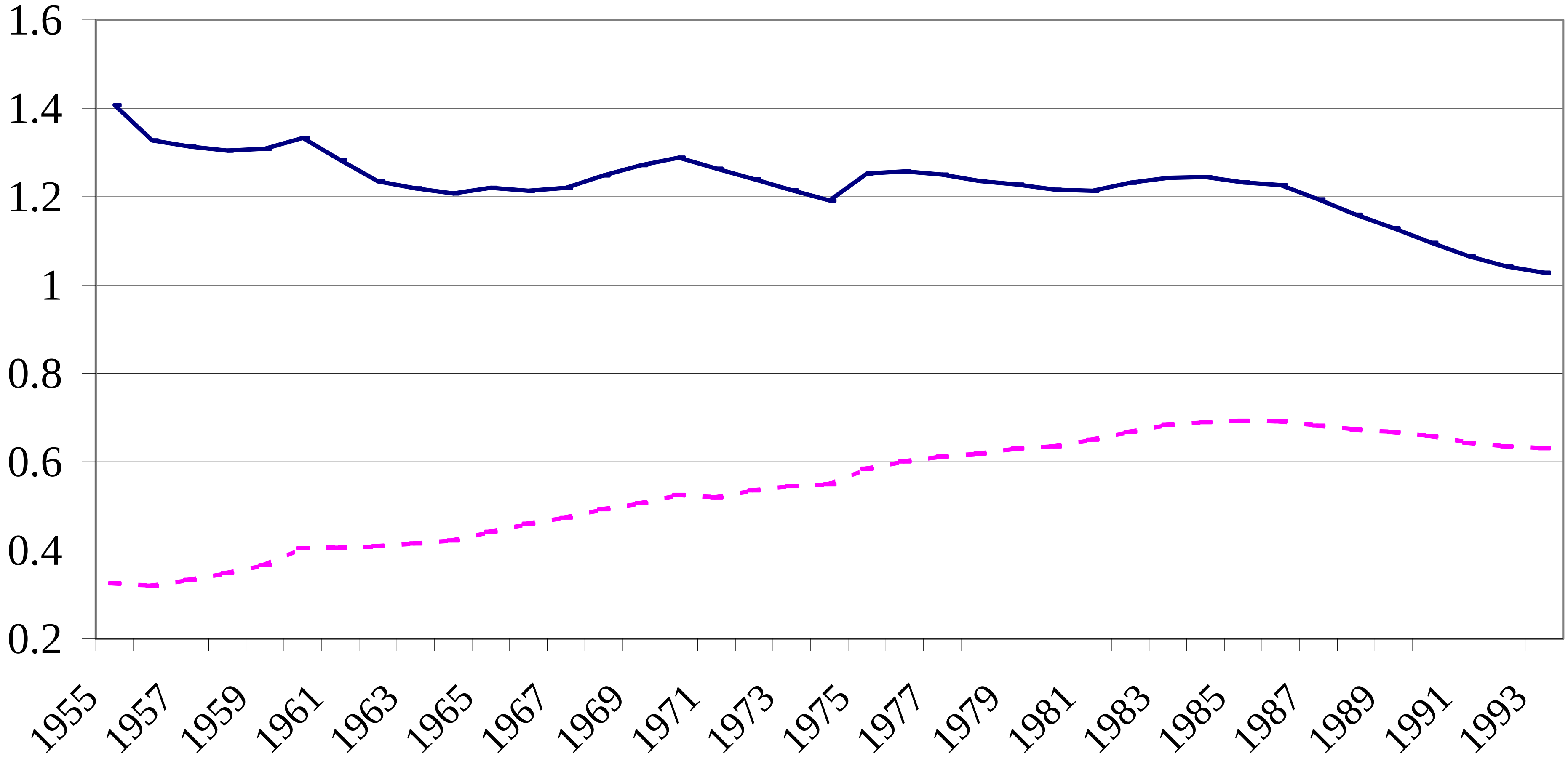

Figure 2

Per capita income relative to Tokyo: top and bottom 5 prefectures.

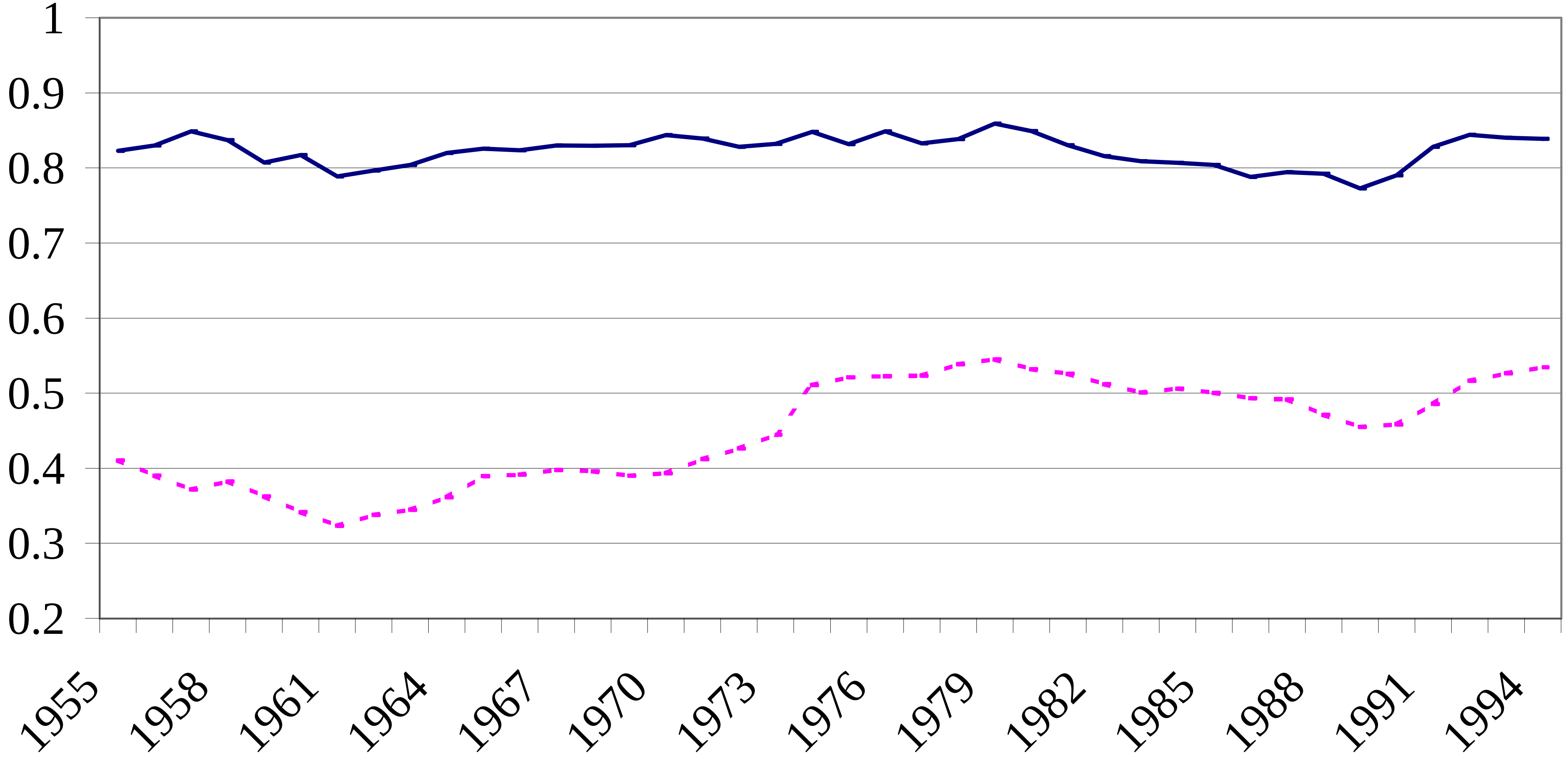

Figure 3

GDP per worker relative to Tokyo: top and bottom five prefectures