EVALUATION AND POLICY ANALYSIS OF JAPANESE FORESTRY

Shunsuke Managi

Associate Professor
Faculty of Business Administration
Yokohama National University
79-4, Tokiwadai, Hodogaya-ku
Yokohama 240-8501 Japan
managi@ynu.ac.jp

Abstract: This study evaluates efficiency of forest management in Japan. Our results show that efficiency of forest management decreases over 25 years period from 1975-2000 on average. The study indicates a substantial variation in efficiency across prefectures with a potential for output saving in the range of forty percent on average. Our econometric results seem to support the hypothesis that government subsidies had an adverse effect on economic performance of forestry sector. More subsidized prefectures were found to exhibit statistically significantly lower levels of efficiency.

Key words: forest managements, renewable energy policies, efficiency, and subsidy

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1 Introduction

Historically, forests have been often treated as a nonrenewable resource since few provisions were made for regeneration (Sedjo, 1997)[1]. In theory, however, the appropriate economic management of forests is one of the classical problems in renewable resource economics. In many countries as well as Japan, conservation movement was emerging, characterized by concerns that forests could not provide an infinite source of wood supply if past practices continued. The forests need to be managed as a perpetually renewable resource for the welfare of the nations for many countries. Today, many of the forest areas are being managed for the production of industrial wood resources and other outputs including recreation and environmental outputs. Furthermore, the emphasis on forest growth, management, and regeneration is increasing.

In the last decade, the concept of sustainable forest management, which supports a balance among social, economic, and ecological benefits, has become the guiding principle for advanced countries including Japan. There is a growing interest in the sustainability of forests and in the ability of forest owners and/or policy makers to sustain themselves through uncertain environmental and political conditions. Especially, increasing concerns about environmental values have also driven forest policies in new directions. In Japan, as a public side, 2001 law by the forestry agency in Japan consider more fully the sustainability of both biophysical systems and a range of human uses of forests. Over the past decade in private sector, a significant trend has emerged in the governance of forest management in Japan. Forest certification began as an effort by international and local environmental groups to use the market place to raise the level of social and environmental performance of forest companies[2].

Interested parties of all stripes are attempting to understand how changes in forest management policies enhance or harm the future of these communities. Subsidies by government drive the management of forests in Japan. In other words, subsidies are a main financial source for forests managers. However, recent budget limitation requires the evaluation of forest management and the reallocation of the subsidies in Japan. It is expected that, as a goal of the forest management, production of forests need to be maintained to its maximum level of output given efforts, *i.e.*, efficient management.

The principal focus of this paper is to measure efficiency for market production and environmental side in the forestry industry in Japan using prefectures data from 1975 to 2001. A mathematical programming technique called data envelopment analysis (DEA) is applied for computation (see Charnes *et al*., 1978). DEA estimates the relative efficiency of production units, identifies best practice frontiers. A key advantage of this approach is that it provides a convenient way to describe a multi-input, multi-output production technology without the need to specify functional forms or behavioral objectives, such as cost-minimization or profit-maximization. Several studies employ DEA in forestry sector in the literature (Kao, 1998, 2000; Kao and Yang, 1992, Ohta and Shiba, 1998; Viitala and Hanninen, 1998; Yin, 1998; Bogetoft *et al.*, 2003). In general, obtaining the data is difficult in forestry and none of the studies utilize the observations over three years.

Subsidies are commonly utilized to support the wood production in Japan. Ideally, policies are expected to improve the efficiency. In this study, we provide the determinants of forest efficiency and production focusing on the effects of subsidies. From the economic viewpoint, subsidies generally lead to inefficient allocation of resources whenever they interfere with the functioning of the market price mechanism. This argument holds for producer subsidies given that their purpose is to enable high cost (i.e. inefficient) wood producers to continue in the market. In this study, we test two hypotheses that 1) government subsidies had an adverse effect on economic performance of forestry sector, 2) forest producer benefits from the subsidy.

This paper proceeds as follows. Background of forestry issue in Japan is provided in section two. Section three provides the structure of efficiency measurements and following econometric modeling. Then, data description and DEA and econometric models are examined. The conclusion of the paper is provided.

2 Background

Sedjo (1997) examines an innovations and technologies that are impacting the forest extraction (logging) and tree growing industry in North America and Nordic countries. He focuses on the new innovations on the raw resource itself and on important innovations in harvesting and growing industrial wood fiber, and finds that three sets of innovations in forestry have been discussed. These are 1) new logging technologies; 2) tree growing innovations and organizational changes as reflected in forest plantations, with a focus also on technical change in the form of genetic improvements; and 3) the expanding array of environmentally motivated restrictions on logging and forest practices, including the large areas being designated as forest set asides.

Applicability of new technologies, however, does not become good story easily for Japan. Forest product companies in United States and Canada vigorously pursue the elimination of trade barriers for all forest products, to increase their access to European, Japanese, and other developing countries' market. Countries like Japan have comparative disadvantage in forestry and loose the market in free trade market. Figure 1 provides the forest production from 1961 to 2002 (Food and Agriculture Organization (FAO), 2004). Although the world production increases 56% in these periods, Japan loses 70% of initial production. Note several developed countries also increase the wood production over time including countries such as France and United Kingdom.

The role of forest carbon sequestration has received increasing attention as concern of climate change has grown and the discussion of mitigation options progressed. Augmenting carbon sequestration by protecting and expanding biomass sinks can have the potential to remove a significant amount of CO_2 from the atmosphere within the relevant ranges of carbon abatement targets (IPCC, 1996; Richards and Stokes, 1999). If the trees are harvested, accompanied by regeneration of the area, and sequestered carbon is locked through non-CO_2 emitting use of such wood (Noble and Scholes, 2001). Carbon sequestration by growing trees is a relatively cost-effective option for reducing the net emissions of CO_2 that has additional ecological, economic and social benefits. Efforts on carbon sequestration can also save time to develop appropriate technologies without hampering the progress during these periods. Duration of the retention of a carbon sink is an important consideration for the design of strategies to manage carbon storage (Fung, 2000). The transformation of low productivity croplands, for example, to sequential agroforestry is estimated to triple system carbon stocks in 20 years (Sanchez, 2000). However in practice, deforestation, with an average of over 13 million *ha per year* over 1980–1995, was responsible for 20–25% of global anthropogenic greenhouse gas (GHG) emissions during the 1990s (FAO, 1997; Killmann, 2001).

In Japan, forestry has been proposed as a mean to reduce net greenhouse gas emissions, by either reducing sources or enhancing sinks. Biomass strategies can contribute significantly to global GHG emission reduction. Technological and efficiency change for competing supply options will determine the optimal strategy selection. Under the Kyoto Protocol, Japan plans to use forest absorption, or sinks to achieve 3.9 percentage points of the 6% cut in greenhouse gases from the 1990 level. However, recent prediction by Forestry Agency in Japan shows that actual percentage will be 2.9 since managements of forestry have not been organized well enough to support 3.9 percent sink (Forestry

Agency, 2002). Furthermore, the Japan's forestry productions have reduced significantly as explained in Figure 1. In light of this, the Forestry Agency propose the additional 1 trillion and 174 billion Japanese yen subsidy, which is around 1.6 billion U.S. dollar, over 10 years, which is additional 40 % of the agency's budget though we need to note that their budget to the agency kept decreasing over year, is necessary to support sustainable forestry management[3]. This is the motivation of this study to test whether government's budget is appropriately used in forestry in Japan.

3 Models

Data Envelopment Analysis (DEA), occasionally called frontier analysis, is a linear programming-based technique for evaluating the performance of administrative units (Charnes *et al.*, 1978). Examples of such decision making units (DMUs) to which DEA has been applied include banks, energy firms, agriculture farms, hospitals, tax offices, defense bases, insurance companies, schools, libraries and university departments. The method can successfully be applied to profit and non-profit making organizations, as well. DEA can handle multiple inputs and multiple outputs as opposed to other techniques such as ratio analysis or regression. The performance of a unit is evaluated by comparing its performance with the best performing units of the sample. Best performing units form the efficiency frontier. If the unit is not on the efficiency frontier, it is considered to be inefficient. Hence, DEA is called frontier analysis.

The aim of DEA is to quantify the distance to the efficient frontier for every DMU. The measure of performance is expressed in the form of efficiency score. After the evaluation of the relative efficiency of the present set of units, the analysis shows how inputs and outputs have to be changed in order to maximize the efficiency of the target DMU. DEA suggest the benchmark for each inefficient DMU at the level of its individual mix of inputs and outputs. The basic mathematical formulation of DEA under constant returns to scale has the following form:

$$[d_o^t(x_{j'}^t, y_{j'}^t)]^{-1} = \max_{\phi^{j'},\lambda} \phi^{j'}$$

subject to

$$-\phi^{j'} y_{j'n}^t + \sum_{j=0}^{J} \lambda_j y_{j'n}^t \geq 0, \quad n = 1,\ldots,N, \tag{1}$$

$$x_{j'm}^t - \sum_{j=0}^{J} \lambda_j x_{j'm}^t \geq 0, \quad m = 1,\ldots,M,$$

$$\lambda_j \geq 0, \quad j = 1,\ldots,J.$$

where $\phi=[d(x,y)]^{-1}$ is the estimated efficiency of prefecture j and maximal proportional amount that the output vector, y, can be expanded while remaining technologically feasible given the input vector, x, and λ is a weight. The model is applied to data from a comprehensive 46-prefecture database over the year 1975-2000 in Japan. In this base model, called Model A, our input variables include forestry machinery, labor, forest road, and forestry area, and output variable is production.

We also employ two additional models to provide different interpretations. First model, called Model B, add one environmental or amenity output variable to the equation (1). Model B considers the benefit associated with non-economic environmental benefits. Thus, larger the benefit, larger the efficiency given same input levels. Taking ratio between the efficiency of Model B and that of Model A, we are able to find the contribution of environmental benefits. Second model, called Model C, incorporate the dynamic effect from forest roads, which take time to construct and they contribute to the next year's production. Figure 2 shows the technology of dynamic DEA[4]. Variables inputs x_t and quasi-fixed inputs (which has several subsequent effects on outputs production) k_{t-1} at the beginning of the period t are transformed by the technology process of F_t into regular output y_t and quasi-fixed input k_t. In this study, forest road is the quasi-fixed input. Stock of the road of time periods (t-1) work as input in the model of time periods (t), where that of time (t) was in input in Model A. In addition, flow of the road in time (t) is in output since more construction of the road, or new infrastructure, will make next year's production easy. Since one of the main targets of the government policies by the use of subsidies is to construct the road intensively, we expect the efficiency score is higher in Model C. Thus, our Model C is formulated as follows;

$$[\mathbf{D}_o^t(\mathbf{x}_{j'}^t, \mathbf{y}_{j'}^t)]^{-1} = \max_{\phi^{j'}, \lambda} \delta^{j'}$$

subject to

$$\begin{aligned}
&-\delta^{j'} \mathbf{y}_{j'n}^t + \sum_{j=0}^{J} \nu_j \mathbf{y}_{jn}^t \geq 0, \quad \mathbf{n} = 1, \ldots, \mathbf{N}, \\
&-\delta^{j'} \mathbf{k}_{j'}^t + \sum_{j=0}^{J} \nu_j \mathbf{k}_j^t \geq 0, \\
&\mathbf{x}_{j'm}^t - \sum_{j=0}^{J} \nu_j \mathbf{x}_{jm}^t \geq 0, \qquad \mathbf{m} = 1, \ldots, \mathbf{M}, \\
&\mathbf{K}_{j'}^t - \sum_{j=0}^{J} \nu_j \mathbf{K}_j^{t-1} \geq 0, \\
&\nu_j \geq 0, \qquad\qquad \mathbf{j} = 1, \ldots, \mathbf{J}.
\end{aligned} \tag{2}$$

where k is the flow of forest road and K is the stock of the forest road.

Measurements of DEA show the trend of efficiency score over time. However, the score itself does not provide a policy implication. Our second objective is to evaluate the determinants of efficiency measure of equation (1). Main interest is the impact of subsidy on efficiency. The relation between efficiency and subsidy is a controversial issue. From the economic viewpoint, it is usually argued that subsidies lead to inefficient allocation of resources (*i.e.*, waste of resources) whenever they interfere with the functioning of the market price mechanism. This argument holds for producer subsidies given that their purpose is to enable high cost (*i.e.* inefficient) wood producers to continue in the market. Notwithstanding, the argument for producer subsidies might be accepted within the context of an infant industry, given that the government is decisive in limiting the subsidy to certain period only. In this study, we test the hypothesis that government subsidies had an adverse effect on economic performance of forestry sector. Furthermore, we examine the impact of subsidy to production. Our interest is the size of the elasticity of subsidy.

In particular, we estimate the following equation:

$$\phi^{i,t} = f(s^{i,t}, g^{i,t}) \tag{3}$$

where $\phi^{i,t}$ is the annual efficiency score, which is the function of subsidy, $s^{i,t}$, and average growth rate of tree, $g^{i,t}$. We estimate the determinants of the efficiency measurements over 1975 to 2000. Equation (3) is estimated as a two-way fixed effects model using our cross-section and time-series data. The linear fixed effects model is given by $y^{i,t} = \alpha^i + \gamma^t + X^{i,t}\beta + \varepsilon^{i,t}$, where $y^{i,t}$ is the log of the dependent variable, $X^{i,t}$ is the vector of the log of explanatory variables, α^i is the prefecture-specific terms, γ^t is the time effects, and $\varepsilon^{i,t}$ is a random disturbance term. We also provide the two-way random effects model and OLS for comparison. In our study, we prefer to interpret the fixed effects model since the data exhaust the population[5].

4 Application of the Models

4.1 Data

This study uses panel data, which consists of annual data for 1975-2000; forty-seven prefectures of Japan. The data used in this paper is derived from the national statistics in Japan. Data for wood production, forestry area, man-made forest, forest road and subsidies are taken from Forestry Agency. Forestry labor data is from Statistic Bureau. Forestry machinery data is from Ringyokikaikakyokai, *i.e.*, Organization of Forest Machinery Japan. Forestry machinery is constructed in monetary value from the machine for wood production including chain-saw, bush cutter, grapple saw, loader, yarder, skidder, tower yarder, swing yarder, tractor, crane, harvester, feller buncher, forwarder, and processor. Labor is the number of workers in the forestry. Forest road is the length of forest road in each prefecture. All monetary variables are adjusted to the value of year 2000 using producer price index. Environmental variable is the area of silviculture, which has a roll of forest conservation, recreation, windbreak forest, and flood control in addition to help wood production.

Our data of both inputs and output is depicted in Figure 3 where the values in 1975 of all inputs and output variables are normalized to one. Over 25 years, production decreased 47.4%. Production continued to decrease gradually in the early nineties and decreased heavily after 1990. The inputs data has changed 30.5, -62.6, 44.7, -0.7, and -8.9% for forestry machinery, labor, forest road, forest area, and rate of man-made forest, respectively.

4.2 Results

The result for efficiency in Model A, by taking the average over prefectures, is presented in Figure 4. The efficiency declines by about 17.8 percent from 1975 through 2000, or a mean rate of about 0.7 percent per year. The declines over 1975 and 1990 is about 7% with a mean rate of about 0.45% per year while it declines 11% from 1990 to 2000 with a mean of 1.17%. The score is relatively stable when there is a bobble economy in late 1980s. The decrease of efficiency is mainly caused by the simple decreasing of output since other inputs do not have significant change in the tread except that machinery input are relatively constant after 1993.

A significant decline in the efficiency comes with the corruption of bobble economy in early 1990s[6]. This coincidence of the corruption of bobble economy might be partially because there is a significant decline in subsidy on average where subsidies keep increasing until 1993 and start decreasing after 1993. The budget limitation might cause the decline in subsidies and make the forest management less efficient. Figure 5 shows the average efficiency score over first and last five years of our study periods (see Figure 6 for the annual per hectare production of first and last year of the study periods). In general, the study indicates a substantial variation in efficiency across prefectures with a potential for output saving in the range of forty percent on average (see Figure 4). This inefficiency number is significantly high as a number of general DEA applications. Fukuda *et al.* (2003) estimate the carbon stock for all sugi (*Cryptomeria japonica* D. Don) and hinoki (*Chamaecyparis obtusa* Endl.) plantations in Japan on the basis of age-class-based forestry statistics. Their results suggest that sugi and hinoki plantations in Japan, respectively, store 346.4 million and 139.2 million Mg of carbon, with an area-weighted mean of 76.81 and 58.01 Mg C/ha. High amounts of carbon stock in both sugi and hinoki are located in the southwestern part of Japan. However, our results show efficiency is not relatively higher in southwestern part of Japan, thus we are not able to have a promising conclusion for the regions for sugi and hinoki.

Next, the result of Model B which is the efficiency including environmental output divided by efficiency of Model A shows almost stable trend (see Figure 7)[7]. Over the study periods, the ratio only decreases 0.24%. After the new law that emphasizes the role of sustainable forestry management, the ratio decreases 0.95% instead of increasing. The environmental factor does not appear to have significant influence on the efficiency scores. We are not able to conclude that movements toward sustainable forestry, which new law is enacted finally in 2001 after several revisions, had significant impact on the managements from this result. This might reflect the arguments that producer behavior does not change even after new policy.

Figure 8 shows the result for Model C which forest road flow is included in output. In contrast to Model A, the efficiency steadily increases until 1982, and then start to decreases, and kept relatively constant for last five years. Overall, it decreases 0.57% from 1975 through 2000. Forest roads have kept increasing over the study periods though the rate of increase has been low in the last five years. Production has been relatively constant until 1980s and therefore the efficiency tends to increase. After middle of 1980s, production start to decrease heavily though forest road kept increase, the efficiency of production from the stock of forest road decrease which decrease the score of Model C.

We now turn our attention to analyzing the variation of efficiency score of equation (1). Table 1 shows the determinants of efficiency. In all of the specifications, subsidies have negative and significant impacts to efficiency. We employ two fixed effects model for interpretation as explained above. Elasticity is 0.69 and, therefore, one percent increase in subsidies cause 0.69 percent decreases in efficiency. Thus, government subsidies policy is not successful to encourage the efficiency improvements. Justification of current level of subsidies is weak if the sole objective of the public policy was to enhance efficiency. In actual public policy making, fairness or equality might be more important than efficiency in agricultural policy including forestry in Japan. We also provide the econometric results of production. Our result in Table 2 shows that elasticity is 0.1. Thus, we support our additional hypothesis that subsidies encourage production.

5 Discussion and Conclusions

We are facing rapid changes in new technologies, new dynamics in the political, economic, and social interactions of forestry. These emerging issues previously did not exist in forestry. The 1997 Kyoko Climate Protocol and the subsequent Intergovernmental Panel on Climate Change meeting recognized forest carbon sequestration as an acceptable way of meeting carbon emission targets (IPCC, 1996). Under the Kyoto Protocol, Japan plans to use forest absorption, or sinks to achieve 3.9 percentage points of the 6% cut in greenhouse gases from the 1990 level. However, recent prediction by Forestry Agency in Japan shows that actual percentage will be 2.9 since managements of forestry have not been organized well enough to support 3.9 percent sink (Forestry Agency, 2002). In light of the fact that Japan’s forestry productions have reduced significantly, forest management activities need to be altered to sequester more carbon, and new tree plantations could be raised to sequester additional carbon by providing incentives to landowners. In addition, emergence of forest certification has attracted forest companies to mange the forests more sustainable.

In Japan, production continues to decrease over time. Especially, rate of decrease is high after 1990. Since forestry industry is highly subsidized, it is important to evaluate how the subsidy policy is effective to increase production and efficiency. This study evaluates efficiency of forest management in Japan. In our knowledge, there are no studies that estimate efficiency of forest management system in Japan over long time periods. Our results show that efficiency of forest management decreases over 25 years period from

1975-2000 on average. The study indicates a substantial variation in efficiency across prefectures with a potential for output saving in the range of forty percent on average. This inefficiency number is significantly high as a number of general DEA applications. We also test estimate the effects of environmental factor considering the recent importance of forest certification system. The environmental factor, using the area of silviculture as a proxy, does not appear to have significant influence on the efficiency scores. Thus, the fact, that environmental efficiency does not have significant changes after the new policy, might support the arguments that producer behavior does not change even with new policy.

Our econometric results seem to support the hypothesis that government subsidies had an adverse effect on economic performance of forestry sector in Japan. More subsidized prefectures were found to exhibit statistically significantly lower levels of efficiency. Also we support our additional hypothesis that subsidies can encourage production. The numerical results, however, have to be interpreted with care, since scientists, policy makers, and forest managers are increasingly recognizing the dynamic nature of forests. We now understand forests as complex systems that constantly change, even in the absence of human disturbance. Nevertheless, deriving quantitative estimates of the likely impacts from subsidies of forestry sector might help to focus and advance the policy debate.

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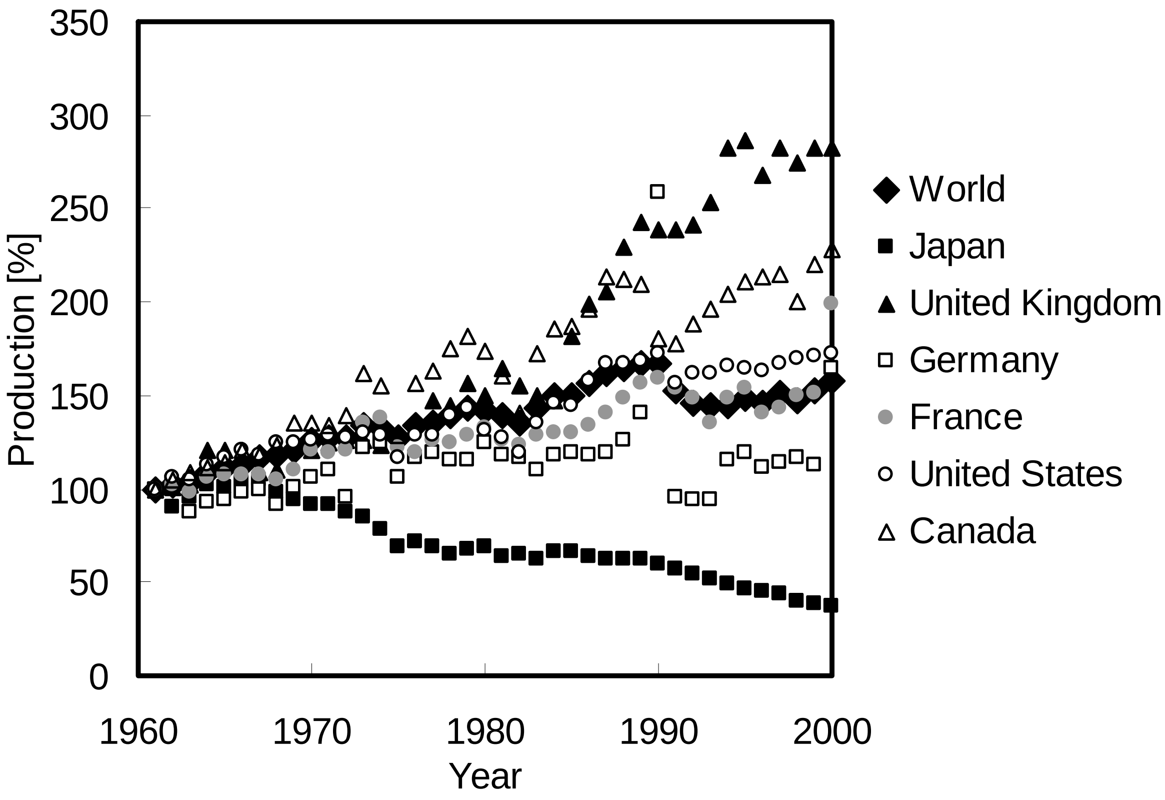

Figure 1. Material production from food and agriculture organization (FAO, 2004)

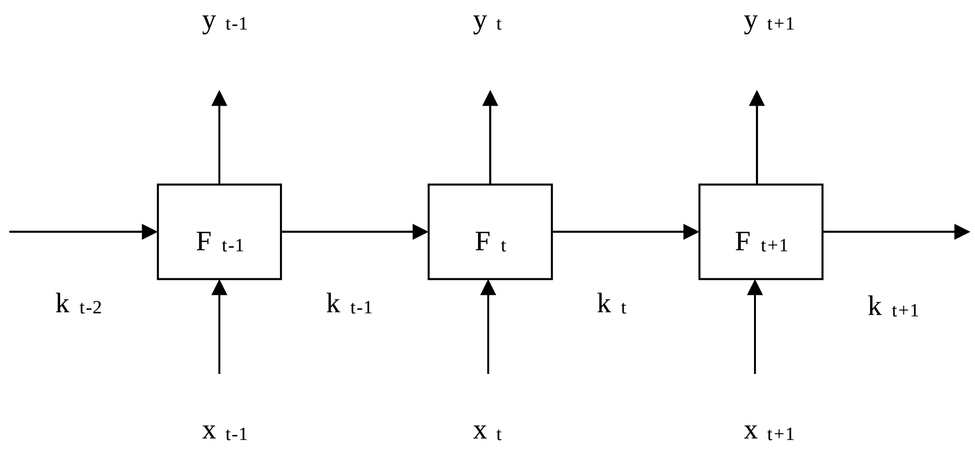

Figure 2. Conceptual model of dynamic data envelopment analysis

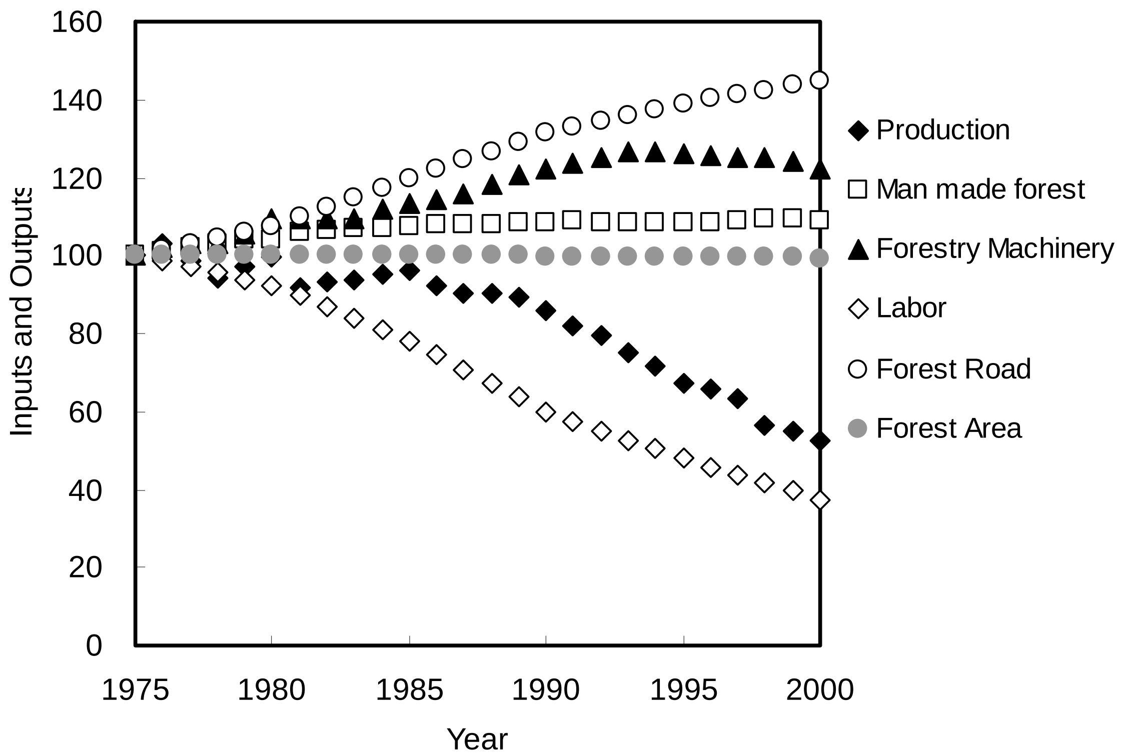

Figure 3. All inputs and output variables normalized in 1975

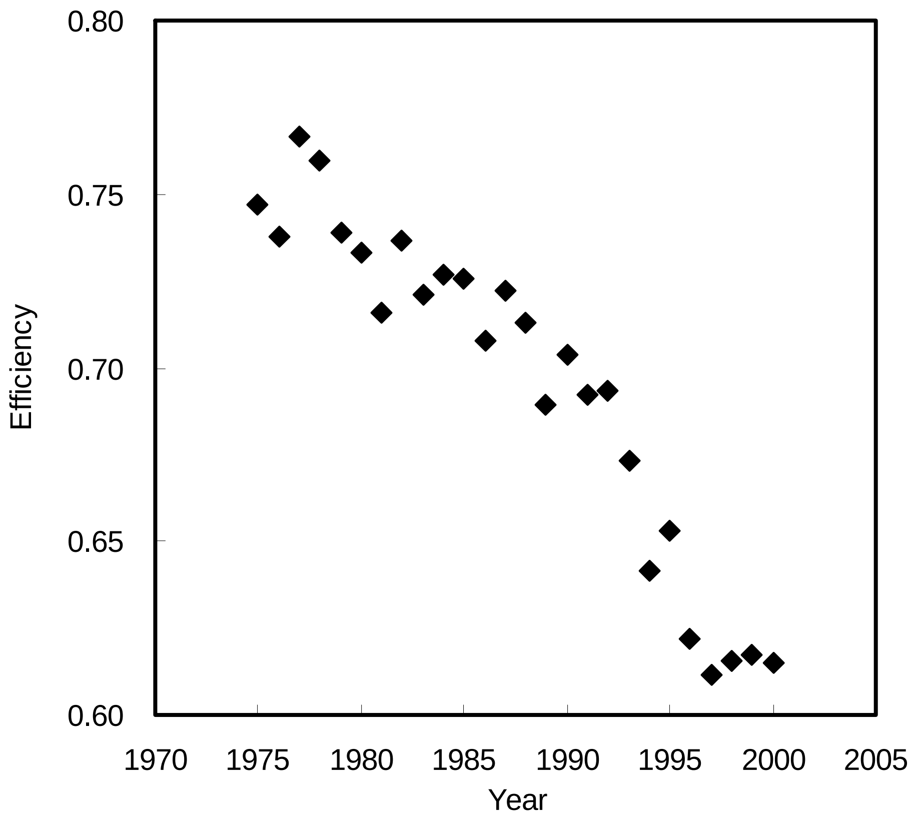

Figure 4. Average efficiency score over prefectures

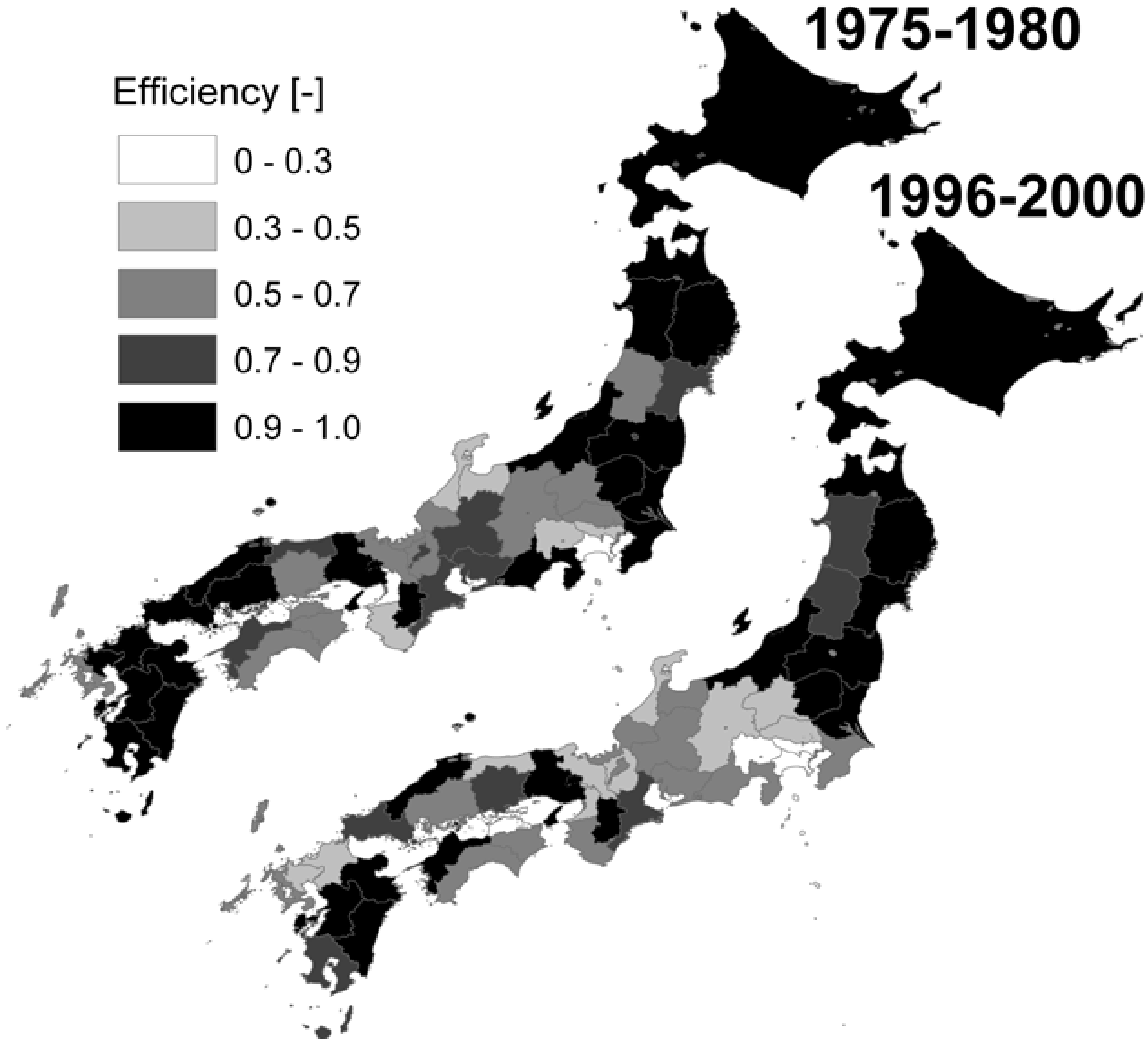

Figure 5. Average efficiency score over first and last five year of study periods

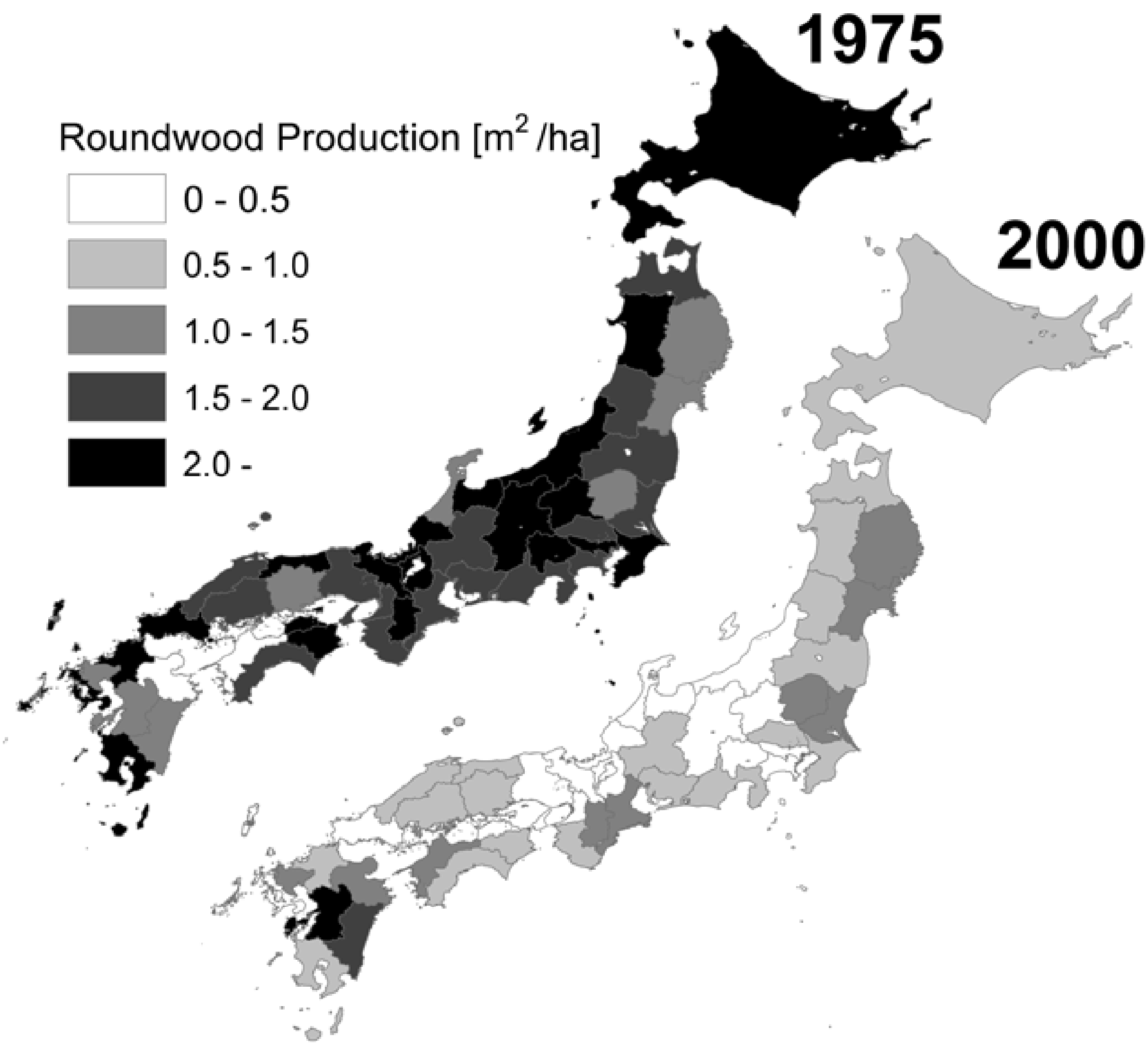

Figure 6. Per hectare production of first and last year of study periods

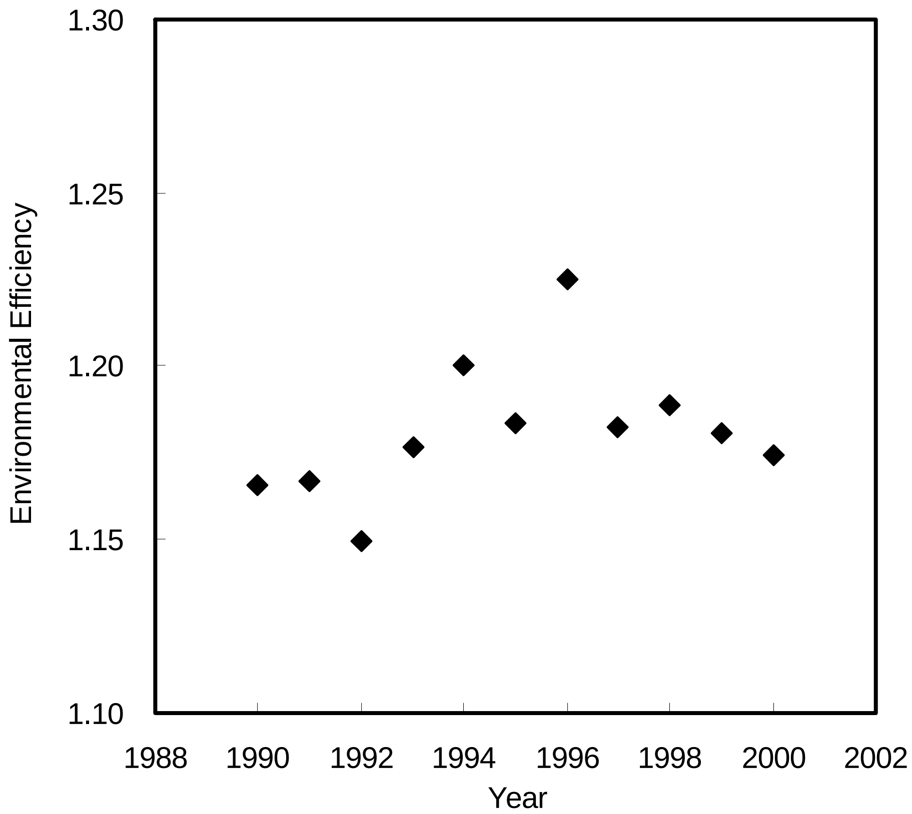

Figure 7. Average efficiency score including environmental output over prefecture

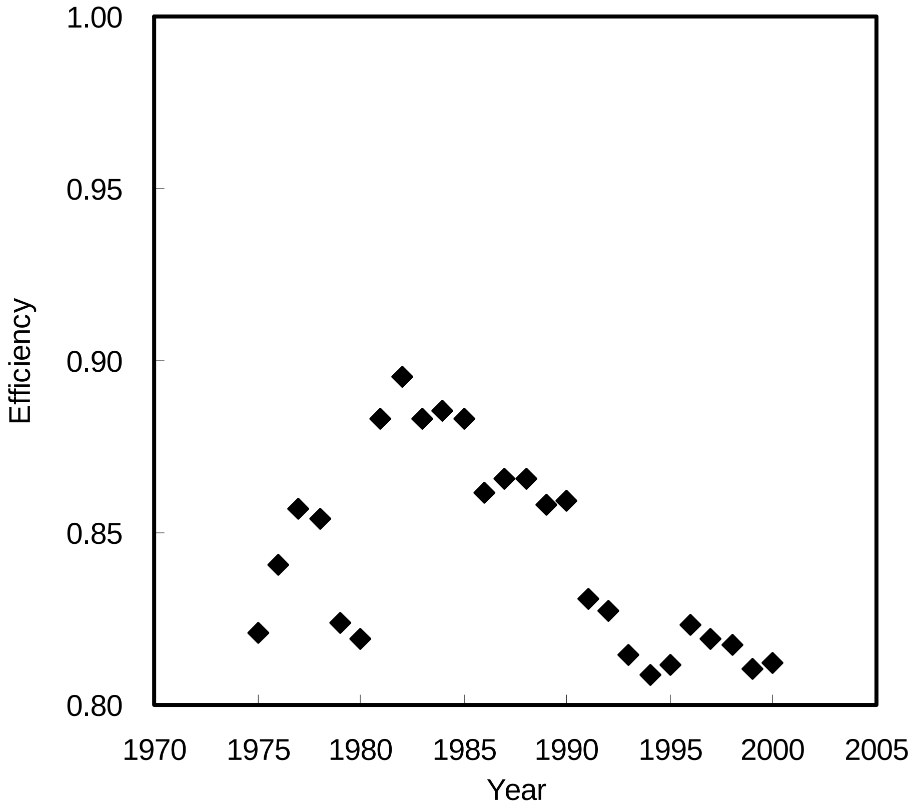

Figure 8. Average dynamic efficiency score over prefecture

Table 1. Determinants of Efficiency Score

Specification	Variable	Estimated Coefficient	Standard Error
OLS	Intercept	1.883***	0.226
	ln(subsidy)	-0.700***	0.013
	ln(growth rate)	0.097	0.079
	R^2	0.697	-
	Adj R^2	0.695	-
Fix-Two	Intercept	2.642***	0.080
	ln(subsidy)	-0.689***	0.018
	R^2	0.930	-
	F-Test	75.580***	-
Random-Two	Intercept	1.844**	0.972
	ln(subsidy)	-0.680***	0.017
	ln(growth rate)	-3.162	0.840
	R^2	0.560	-
	Hausman Test	2.460*	-

Note: * indicates $p < 0.1$, ** indicates $p < 0.05$, *** indicates $p < 0.01$.

Table 2. Determinants of Production

Specification	Variable	Estimated Coefficient	Standard Error
OLS	Intercept	-4.546***	0.585
	ln(subsidy)	1.132**	0.017
	ln(growth rate)	-0.075	0.175
	R^2	0.811	-
	Adj R^2	0.810	-
Fix-Two	Intercept	5.349***	0.489
	ln(subsidy)	0.095**	0.046
	R^2	0.980	-
	F-Test	210.7***	-
Random-Two	Intercept	12.072***	2.481
	ln(subsidy)	0.308***	0.041
	ln(growth rate)	0.085	0.342
	R^2	0.236	-
	Hausman Test	98.79***	-

Note: * indicates $p < 0.1$, ** indicates $p < 0.05$, *** indicates $p < 0.01$.

Note

[1] Traditionally, forest stocks were depleted and the loggers moved on to exploit other deposits (Sedjo, 1997). The lands were often put to other uses including agriculture.

[2] Forest certification is a system of verifying that forest practices meet environment, social and economic objectives.

[3] Fiscal budget is 348 billion yen for 2001 and 294 billion yen for 2003.

[4] See Nemoto and Goto (2003) for comprehensive analysis related to dynamic DEA.

[5] If the data are a drawing of observations from a large population and we wish to draw inferences regarding other members of that population, the fixed effects model is no longer reasonable and random effects model is preferred (Kennedy, 1998). In addition, the random effects model has a drawback that it assumes the random error associated with each cross-section unit is uncorrelated with the other repressors. Given that there are missing other variables, for example climate or environment, which is the factors outside the control of forest owners. This makes forest owners to face difficult task in converting inputs and outputs and is thought to affect the intercept since subsidies and this missing variable are likely correlated. Modeling this as a random effects model might create correlation between the error and subsidies. The result is bias in the coefficient estimates from the random effects model.

[6] A bubble economy occurred when speculation in a good caused the price to increase, thus producing more speculation (late 1990s). The price of the good then reached absurd levels and the bubble was followed by a sudden drop in prices, known as a crash (1990-1993).

[7] Note the ration of being larger than one is because of well-known curse of dimensionality and therefore we do not discuss the value itself. What matter in this graph is the trend over time.