Environment for Development

Discussion Paper Series December 2011 ■ EfD DP 11-12

Impacts of Policy Measures on the Development of State-Owned Forests in Northeast China

Theoretical Results and Empirical Evidence

Xuemei Jiang, Peichen Gong, Göran Bostedt, and Jintao Xu

Environment for Development

RESOURCES FOR THE FUTURE

Environment for Development

The **Environment for Development** (EfD) initiative is an environmental economics program focused on international research collaboration, policy advice, and academic training. It supports centers in Central America, China, Ethiopia, Kenya, South Africa, and Tanzania, in partnership with the Environmental Economics Unit at the University of Gothenburg in Sweden and Resources for the Future in Washington, DC. Financial support for the program is provided by the Swedish International Development Cooperation Agency (Sida). Read more about the program at www.efdinitiative.org or contact info@efdinitiative.org.

Central America
Environment for Development Program for Central America
Centro Agronómico Tropical de Investigacíon y Ensenanza (CATIE)
Email: centralamerica@efdinitiative.org

China
Environmental Economics Program in China (EEPC)
Peking University
Email: EEPC@pku.edu.cn

Ethiopia
Environmental Economics Policy Forum for Ethiopia (EEPFE)
Ethiopian Development Research Institute (EDRI/AAU)
Email: ethiopia@efdinitiative.org

Kenya
Environment for Development Kenya
Kenya Institute for Public Policy Research and Analysis (KIPPRA)
Nairobi University
Email: kenya@efdinitiative.org

South Africa
Environmental Policy Research Unit (EPRU)
University of Cape Town
Email: southafrica@efdinitiative.org

Tanzania
Environment for Development Tanzania
University of Dar es Salaam
Email: tanzania@efdinitiative.org

Impacts of Policy Measures on the Development of State-Owned Forests in Northeastern China: Theoretical Results and Empirical Evidence

Xuemei Jiang, Peichen Gong, Göran Bostedt, and Jintao Xu

Abstract

State-owned forest enterprises (SOFEs) in northeast China and Inner Mongolia play important roles both in timber production and in the maintenance of ecological security. However, since the late 1970s, forest resource and economic crises have seriously restricted these functions. Based on a theoretical and an empirical analysis of the harvest and investment behavior of the SOFEs, we examined the effects of forest policies and the socioeconomic conditions on the behavioral choices of the SOFEs. Both the extent to which SOFE supervising authorities emphasized improvement of forest resources in their annual evaluations and the increases in expenses necessary to manage SOFEs had significant impacts on harvest and investment decisions as well as development of forest resources. Promoting the management and utilization of non-timber resources, as well as reforms to increase the efficiency of forest protection and management, have reduced timber harvests as intended, which in turn has increased investment and improved forest resources. The effects have been relatively small, however. In contrast, reforms aimed at timber harvest and afforestation activities actually contributed to increasing the timber harvest, which affected the development of the forest resources negatively.

Key Words: state-owned forest enterprise, “double crises,” sustainable forest management, forest policy

JEL Classification: Q23, Q28

Contents

Impacts of Policy Measures on the Development of State-Owned Forests in Northeastern China: Theoretical Results and Empirical Evidence

Xuemei Jiang, Peichen Gong, Göran Bostedt, and Jintao Xu*

Introduction

Most of the state-owned forest enterprises (SOFEs) in northeast China (Heilongjiang and Jilin Provinces, and Inner Mongolia Autonomous Region) were established in the early 1950s, shortly after the People's Republic of China was founded. Initially, the primary task of the SOFEs was logging (SFA 1987). In the 1950s and 1960s, the forests provided large quantities of much needed timber for the construction and development of the Chinese economy, but few efforts were devoted to forest regeneration and management. As a result, large harvested areas were not replanted. Although investment in afforestation and silviculture increased gradually after the late 1960s (table 1), it did not keep up with the extensive harvesting. In the late 1970s, the so-called "double crises" began to emerge in the SOFEs, characterized by the rapid depletion of forestland suitable for harvesting and the increasing difficulties of the SOFEs to produce sufficient income to cover necessary expenditures (Zhang 1998).

* Xuemei Jiang, School of Economics and Management, Beijing Forestry University, Beijing 100083, and College of Environmental Science and Engineering, Peking University, Beijing 100085, China, (email) joyxuemei@hotmail.com , (tel) +86-10-62337025 ; Peichen Gong, Centre for Environmental and Resource Economics, Department of Forest Economics, Swedish University of Agricultural Sciences, SE-901 87 Umeå, Sweden, (email) peichen.gong@slu.se , (tel) +46 (0) 90-786 8492 ; Göran Bostedt, Centre for Environmental and Resource Economics, Department of Forest Economics, Swedish University of Agricultural Sciences, SE-901 87 Umeå, Sweden, (email) goran.bostedt@slu.se, (tel) +46 (0) 90-786 5027 ; and Jintao Xu, College of Environmental Science and Engineering, Peking University, Beijing 100085, China (email) xujt@pku.edu.cn, (tel) +86-10-62767629 .

Financial support from the National Natural Science Foundation of China (Project no. 70821140353), the World Bank, Rights and Resources Initiative, and the Environment for Development Initiative at the University of Gothenburg, funded by Sida, are gratefully acknowledged.

Table 1. China Forestry Investment (in million yuans)

Year	Total investment	Investment in afforestation and silviculture	Investment in forest industry
1950–1952	81.99	0	81.99
1953–1957	768.97	125.00	643.98
1958–1962	2,516.52	477.09	2,039.43
1963–1965	2,256.8	612.80	1,644.01
1966–1970	3,056.81	835.79	2,221.01
1971–1975	4,578.21	1,329.91	3,248.30
1976–1980	4678.28	2,016.62	2661.65

Source: SFA (State Forestry Administration), 1987. China Compendium of Forestry Statistics 1949–1987 (Beijing: China Forestry Press), 542–43.

Since the late 1970s, a number of policy adjustments have been made to ease the pressure on the SOFEs. In 1978, a reform gave the SOFE managers more leeway to make decisions and increased their share of the profits (Zhang 1998), but the supervising authorities still retained tight control. These authorities approved all production plans and assessed the achievements of the SOFEs.

In 1988 the supervising authorities started to implement a “contract management-responsibility system” to help reduce some of the operating costs of the SOFEs, but it unfortunately also increased exploitation of the forests in the region (Cao 2000). The reforms since 1992 have focused on introducing market mechanisms to the management of state-owned forests (SFA 2010). One of the strategies was to create market-oriented “modern forest enterprises.” To this end, four large-scale forest companies were established in northeast China and Inner Mongolia between 1992 and 1996.

For a long time after the reforms started, the SOFEs were obligated to sell part of their timber to the state at prices pre-determined by the government. In 1986 and 1990, the government adjusted its purchase prices for timber and increased the share of timber that the SOFEs were allowed to sell at market prices. Although the tax burden of the SOFEs had declined since the 1980s, the effects of the taxation relief only partly offset the continuously increasing fees that the SOFEs had to pay (Jiang 2006).

It is worth mentioning that the Natural Forest Protection Program (NFPP), one of the key national forestry programs, has had a considerable impact on the SOFEs in northeast China and Inner Mongolia. The NFPP was started in 1998 and has substantially reduced the amount of forestland managed for timber production. On the other hand, in the course of implementing the NFPP, the government significantly increased its financial support of the SOFEs and passed several reforms to increase the efficiency of forest resource management and protection by the SOFEs (SFA 2010).

The forest coverage of the land area managed by the SOFEs increased from 79 percent in 1980 to 90 percent in 2008. However, the proportion of forests managed for timber production fell from 92 percent in 1980 to 33 percent in 2008 (table 2). The most significant reduction in the share of timber production forests occurred in the late 1990s as part of the NFPP. Furthermore, the growing stock of timber in mature forests decreased from 71 percent in 1980 to 20 percent in 2008 of the total timber stock in the timber production forests (table 3). Significant reduction of the amount of timber in mature forests that could be harvested severely affected the sustainability of forest management. When the SOFE survey (reported below) was conducted, leaders of many of the enterprises admitted that current harvest levels could not be sustained for long.

Table 2. Area of the Different Types of Forests in Heilongjiang and Jilin Provinces and Inner Mongolia Autonomous Region

Year	Timber forest	Shelter belt	Fuelwood forest	Special purpose forests
1980	92.00	4.57	0.13	6.15
1985	93.08	5.12	0.05	2.25
1990	91.81	5.57	0.32	2.59
1995	92.23	5.46	0.42	2.28
1997	92.62	5.27	0.24	2.11
2000	87.65	9.72	0.00	2.63
2004	56.55	34.84	0.00	8.62
2008	33.44	56.07	0.00	0.00

Table 3. Proportion of Mature Timber Stock in Timber Forests (percentage)

Year	Heilongjiang Province	Jilin Province	Inner Mongolia Autonomous Region
1980	65.64	75.27	71.75
1985	47.88	53.63	52.83
1990	16.74	37.43	38.66
1995	10.23	37.39	33.91

1997	8.12	28.21	32.60
2000	3.66	32.40	28.97
2004	3.15	32.60	24.89
2008	3.24	32.60	24.89

Despite this, timber production remained the main source of income for the SOFEs. In 2004, even though the harvest level was too high (relative to the available resource), about one-third of the SOFEs lost money. At the household level, poverty was, and is, sometimes appalling among the SOFE workers. The average household annual income in 2004 was only 3,500 yuans, while the per capita dispensable income of urban residents was 9,422 yuans (Xu et al. 2006).

A fundamental cause of the "double crises" in both forest resource and profitability is the extensive harvesting and inadequate investment in regeneration and forest management that has occurred since the 1950s. To reverse this unsustainable situation with appropriate reforms, we need to analyze the factors that affect the SOFE's timber harvest and investment behavior, starting with their decisionmaking behavior.

When SOFE managers make decisions, they must consider both their own interests and the goals assigned by the supervising authorities. At present, they sign annual contracts with the supervising authorities, which specify both economic and forest resource targets. Obviously, one year is much too short, relative to the production cycle of timber, to allow the SOFEs leaders to make reasonable long-term sustainable management plans. The priority is the economic targets specified in the contracts because achieving these targets dominates the supervising authorities' evaluation of the SOFEs.

The annual assessment of the SOFEs, financial subsidies, and various regulations are the main instruments used by the forestry authorities to control and manage the SOFEs. It seems obvious that the supervising authorities would maximize social welfare and adopt policies and assessment criteria that sufficiently spur SOFE leaders to manage their forests sustainably. However, serious information asymmetry exists between the SOFEs and the supervising authorities, partly due to the large area managed by each SOFE (Xu and Ran 2004).[1] This information asymmetry leads forestry authorities to focus more on the short-term economic performance of the SOFEs, which is easier to evaluate and is more closely related to the forestry

[1] The average area managed by each SOFE is about 200,000 hectares.

authorities' self interests. Consequently, the SOFEs often sacrifice safeguarding forest resources because sale of timber is the main source of income in pursuing profit targets.

The purpose of this study is to examine the factors influencing the timber harvest, forest management investment behavior, and the forest resource change of SOFEs. The remainder of the paper is organized as follows. Section 1 presents a theoretical analysis of the behavior of SOFEs. Sections 2–4 describe the model specification, our survey data, and the results of the empirical analysis, respectively. The fifth section outlines the conclusions.

1. Theoretical Analysis of the Behavior of State-Owned Forest Enterprises

Timber harvest and forest management decisions at the SOFE level are made annually. The decisionmakers at typical SOFEs are concerned with two attributes of the outcome of their decisions: the financial result in the current year and the state of the forest at the end of the year. The financial result of a SOFE is determined by the profits from timber production and forest management, the profits from non-forestry activities (including subsidies from the government), and the SOFE's fixed costs.

The last two components are treated as exogenous variables in the following analysis. Forestry profits refer to the revenue of timber harvest net of the harvest cost and costs of forest management activities. We assume that forest regeneration takes place immediately after an area of forest is harvested. Thus, regeneration cost is modeled as a function of the harvest volume.

The cost of all other forest management activities is represented by a separate decision variable. The state of the forest is described by the growing stock of timber. The preferences of the decisionmaker are described using a Cobb-Douglas utility function. The decision problem is modeled as:

$$\max_{h,I} \quad U(\pi, Q_1) = [\pi_f(h, I) + \pi_n - \bar{c}]^{\alpha_1}[Q_1(h, I)]^{\alpha_2}, \tag{1a}$$

subject to:

$$\pi_f(h, I) = ph - C(r_h, h) - I \tag{1b}$$

$$Q_1(h, I) = g(Q_0 - h)S(r_m, I) \tag{1c}$$

$$0 \le h \le Q_0 \tag{1d}$$

$$I \ge 0 \tag{1e}$$

where h = total volume of timber to be harvested;

p = timber price;

I = total investment in forest management activities (excluding harvest and regeneration costs);

$\pi_f(h, I)$ = forestry profit;

π_n = non-forestry income;

$\bar{c}$ = fixed costs;

α_1, α_2 = utility function coefficients;

$C(r_h, h)$ = the sum of harvest and regeneration costs;

Q_0 = the growing stock of timber at the beginning of the year;

Q_1 = the growing stock of timber at the end of the year;

$g(Q_0 - h)$ = the potential timber growth;

$S(r_m, I)$ = the rate of realized timber growth;

r_h = productivity of timber harvest and regeneration efforts; and

r_m = productivity of forest management efforts.

Large portions of the forests in northeast China are middle-aged or young stands. The SOFEs in this region own very few old-growth forests. Timber harvest commonly starts in the oldest and most easily accessible stands, where trees are larger and the stocking level is higher than in younger stands. As the harvest volume increases, younger and younger stands are harvested, implying that both the marginal harvest cost and the marginal regeneration cost associated with each harvested cubic meter of timber increase with the harvest volume. In profit function (1b), we capture these effects by assuming that $C(r_h, h)$ is an increasing and strictly convex function of the harvest volume h, namely, $C_h(r_h, h) > 0$ and $C_{hh}(r_h, h) > 0$.

The productivity of timber harvest and regeneration efforts r_h is included in the cost function $C(r_h, h)$ to reflect the effect of rationalization of timber harvest and regeneration operations on the cost of the operation. This variable is defined in such a way that, given an arbitrary harvest volume, a larger value of r_h leads to a lower harvest and regeneration cost, in other words, $C_{r_h}(r_h, h) < 0$. Further, we assume that the economic gain (in terms of cost reduction) of rationalization increases as the harvest level increases, which means that $C_{h\,r_h}(r_h, h) < 0$.

When modeling the growing stock of timber at the end of the year, we assume that timber harvest takes place at the beginning of the year. The growth function $g(Q_0 - h)$ tells us how large a growing timber stock of $(Q_0 - h)$ will become in one year, when it is managed ideally and there is no damage or loss due to wildfire or pest outbreak, for example. In other words, $g(Q_0 - h)$ is the maximum stock we will have one year later, if the current timber stock is $(Q_0 - h)$. We assume that $g(Q_0 - h)$ is an increasing and concave function of $(Q_0 - h)$, namely, $g'(Q_0 - h) > 0$ and $g''(Q_0 - h) < 0$.

The function $S(r_m, I)$ refers to the percentage of the potential growth that is actually realized. Presumably, a larger investment leads to more intensive management of the existing stands, which in turn will result in a higher rate of realization of the potential growth. Moreover, the marginal effect of increasing management intensity on timber growth usually becomes smaller when the management intensity grows higher. Based on these arguments, we assume the following properties of the function $S(r_m, I)$: $S_I(r_m, I) > 0$ and $S_{I\,I}(r_m, I) < 0$.

In the same way that we model the effect of rationalization on harvest and regeneration cost, we include a variable r_m in the function $S(r_m, I)$ to describe the growth effect of rationalization of the management of existing stands. We assume that $S_{r_m}(r_m, I) > 0$ and $S_{I\,r_m}(r_m, I) < 0$. That is, rationalization of the management of existing stands will increase the growth of the stands, but the marginal effect is decreasing as the investment increases.

The fixed costs of a SOFE here refer to expenditures for retirement pensions and employee (including their families) benefits, such as medical care, education, etc. We include these costs in the decision model as an exogenous variable because the SOFEs have limited means of controlling these costs.

Substituting equations (1b) and (1c) into objective function (1a), and assuming that an interior optimal solution exists, the decision model (1a) to (1e) can be analyzed as an unconstrained optimization problem. At the optimum, the partial derivatives of the objective function with respect to the decision variables should be equal to zero. That is:

$$\frac{\partial U(\pi, Q_1)}{\partial h} = \frac{\partial U(\pi, Q_1)}{\partial \pi}\frac{\partial \pi(h, I)}{\partial h} + \frac{\partial U(\pi, Q_1)}{\partial Q_1}\frac{\partial Q_1(h, I)}{\partial h} = 0$$

and

$$\frac{\partial U(\pi, Q_1)}{\partial I} = \frac{\partial U(\pi, Q_1)}{\partial \pi}\frac{\partial \pi(h, I)}{\partial I} + \frac{\partial U(\pi, Q_1)}{\partial Q_1}\frac{\partial Q_1(h, I)}{\partial I} = 0$$

Expanding the partial derivatives, and after some simplifications, the first-order conditions for the optimal solution can be expressed as:

$$g(Q_0 - h)S_I(r_m, I)[p - C_h(r_h, h)] - g'(Q_0 - h)S(r_m, I) = 0 \tag{2a}$$

$$\alpha_1 S(r_m, I) - \alpha_2[ph - C(r_c, h) - I + \pi_n - \overline{c}]S_I(r_m, I) = 0 \tag{2b}$$

Equation (2a) implies that if the optimal harvest volume is greater than zero, then the marginal profit of harvesting is greater than zero, in other words, $[p - C_h(r_h, h)] > 0$. Similarly, equation (2b) shows that if the investment in forest management I is greater than zero, then $[\pi_f + \pi_n - \overline{c}] > 0$.

We conducted comparative statics analysis by taking the total derivatives of $\partial U(\pi, Q_1)/\partial h$ and $\partial U(\pi, Q_1)/\partial I$, respectively, and then equating both the total derivatives to zero. It is straightforward to show that $d(\partial U(\pi, Q_1)/\partial h) = 0$ is equivalent to the total derivative of the left-hand side of equation (2a) equaling zero. Similarly, $d(\partial U(\pi, Q_1)/\partial I) = 0$ is equivalent to the total derivative of the left-hand side of equation (2b) equaling zero. Taking the total derivatives of equations (2a) and (2b) yields the following equations:

$$\begin{aligned} Adh + BdI = &\{g''()S() - g'()S_I()[p - C_h()]\}dQ_0 \\ &+ g()S_I()C_{hr_h}()dr_h \\ &+ S_{Ir_m}()\{g'() - g()[p - C_h()]\}dr_m \\ &- g()S_I()dp \end{aligned} \tag{3a}$$

and

$$\begin{aligned} Cdh + DdI = &-S()d\alpha_1 \\ &+ (\pi_f + \pi_n - \overline{c})S_I()d\alpha_2 \\ &+ \alpha_2 S_I()hdp \\ &+ \alpha_2 S_I()d\pi_n \\ &- \alpha_2 S_I()d\overline{c} \\ &- \alpha_2 S_I()C_{r_h}()dr_h \\ &+ \{\alpha_2(\pi_f + \pi_n - \overline{c})S_{Ir_m}() - \alpha_1 S_{r_m}()\}dr_m \end{aligned} \tag{3b}$$

,

where:

$$A = g''()S() - g'()S_I()[p - C_h()] - g()C_{hh}() < 0$$

$$B = g()S_{II}()[p - C_h()] - g'()S_I() < 0$$

$$C = -\alpha_2 S_I()[p - C_h()] < 0$$

$$D = (\alpha_1 + \alpha_2)S_I() - \alpha_2(\pi_f + \pi_n - \bar{c})S_{II}() > 0$$

The signs of A, B, C, and D are determined by the properties of the functions $g(Q_0 - h)$, $S(r_m, I)$, and $C(r_h, h)$, and the facts that $[p - C_h(r_h, h)] > 0$ and $[\pi_f + \pi_n - \bar{c}] > 0$.

Using equations (3a) and (3b), we can examine the effects of changing each parameter $(\alpha_1, \alpha_2, \pi_n, \bar{c}, p, Q_0, r_h, r_m)$ on the optimal harvest volume *h* and forest management investment *I*. Consider, for example, the change of α_1, keeping all the other parameters unchanged. That is, $d\alpha_1 > 0$ and $d\alpha_2 = d\pi_n = d\bar{c} = dp = dQ_0 = dr_h = dr_m = 0$. Equations (3a) and (3b) reduce to:

$$Adh + BdI = 0$$

$$Cdh + DdI = -S()d\alpha_1$$

Solving these two equations yields:

$$\frac{\partial h}{\partial \alpha_1} = \frac{-BS(r_m, I)}{BC - DA} > 0$$

$$\frac{\partial I}{\partial \alpha_1} = \frac{AS(r_m, I)}{CB - AD} < 0$$

In a similar way, we can examine the other parameters' effects on the harvest and investment behavior, as well as the effect on the growing stock of timber at the end of the year. The results of the comparative statics analysis are summarized in table 4.

Table 4. Summary of the Results of Comparative Statics Analysis

Changing parameters	Effects on harvest (*h*)	Effects on investment (*I*)	Effects on timber stock (Q_1)
Q_0	+	+	+
α_1	+	-	-
α_2	-	+	+
r_h	?	+	?

r_m	?	?	?
π_n	-	+	+
$\overline{C}$	+	-	-
P	?	+	?

Based on the results of the theoretical analysis, we can draw the following conclusions.

- An increase in the initial growing stock of timber causes a SOFE to increase both its timber harvest and investment in forest management. The net effect of these changes on the growing stock of timber at the end of the year is positive.
- If the supervising authority increases its emphasis on the financial result of the SOFEs in their annual evaluation, the SOFEs will increase timber harvest and reduce investment in forest management. Accordingly, the growing stock of timber at the end of the year will be smaller.

  If the supervising authority places a greater weight on forest resource development, the SOFEs will decrease timber harvest and increase investment in forest management, which will results in a larger growing stock of timber at the end of the year.
- Reforms that efficiently reduce harvests and regeneration costs will spur the SOFEs to invest more in forest management. The effects of such reforms on timber harvest and on the development of the forest resources are undetermined.
- The impact of reforms—intended to increase the productivity of forest management efforts—on timber harvest, investment, and the development of the forest resources are undetermined.
- An increase in non-forestry income will reduce the timber harvest and increase investment in forest management. This will result in a larger growing stock of timber at the end of the year. In contrast, an increase in fixed costs will increase the timber harvest and reduce investment in forest management, and thus result in a smaller growing stock of timber at the end of the year.
    - Following an increase in timber price, the SOFEs will increase investment in forest management, but impacts on the harvest and on the development of forest resources are ambiguous.

2. Empirical Model Specification

Based on the results of the theoretical analysis, the econometric models are:

$$\ln h_{it} = \beta_0^1 + \beta_1^1 \ln Q_{it}^0 + \beta_2^1 \ln A_{it}^n + \beta_3^1 \ln S_{it} + \beta_4^1 T_{it} + \beta_5^1 \ln p_{it} + \beta_6^1 r_{hit} + \beta_7^1 r_{mit} + \beta_8^1 \alpha_{2it} + \beta_9^1 y + u_{it}$$

$$\ln I_{it} = \beta_0^2 + \beta_1^2 \ln Q_{it}^0 + \beta_2^2 \ln A_{it}^n + \beta_3^2 \ln S_{it} + \beta_4^2 T_{it} + \beta_5^2 \ln p_{it} + \beta_6^2 r_{hit} + \beta_7^2 r_{mit} + \beta_8^2 \alpha_{2it} + \beta_9^2 y + v_{it}$$

$$\ln Q_{it}^1 = \beta_0^3 + \beta_1^3 \ln Q_{it}^0 + \beta_2^3 \ln A_{it}^n + \beta_3^3 \ln S_{it} + \beta_4^3 T_{it} + \beta_5^3 \ln p_{it} + \beta_6^3 r_{hit} + \beta_7^3 r_{mit} + \beta_8^3 \alpha_{2it} + \beta_9^3 y + w_{it}$$

where β_i^j ($i = 0\ldots9$, $j = 1, 2, 3$) are coefficients; u_{it}, v_{it}, and w_{it} are random error terms; and y is time. Definitions of the other variables are presented in table 5.

Table 5. Definitions of Variables in the Econometric Models

Variable	Definition	Explanation
h_{it}	Timber harvest	Total amount of timber harvested by SOFE *i* in year *t*
I_{it}	Fixed assets investment	Fixed assets investment of SOFE
Q_{it}^0	Growing stock of timber	The growing stock of timber of SOFE *i* at the beginning of year *t*
Q_{it}^1	Growing stock of timber	The growing stock of timber of SOFE *i* at the end of year *t*
A_{it}^n	Area of non-forestland	The total area of crop land, pastures, and diversified land area of SOFE *i* in year *t*
S_{it}	Social burden	The total number of retired employees and staff of school and hospital of SOFE *i* in year *t*
T_{it}	Tax and fee burden	Taxes and fees in percentage of the gross revenue for SOFE *i* in year *t*
p_{it}	Timber price	Timber price for SOFE *i* in year *t*
r_{it}^h	Harvest and afforestation reform	Accumulated years since the harvesting and afforestation reform started
r_{it}^m	Forest protection and management reform	Accumulated years since the forest protection and management reform started
α_2	Forest protection incentive	Weight of forest resources improvement in the annual evaluation of the SOFE

In the survey data, investment in forest management activities is included in the fixed assets investment. Therefore, we use the fixed assets investment of the SOFEs as a proxy for total investment in forest management.

In the theoretical analysis, we assumed that the SOFE decisionmakers maximize their utility, which is a function of current profits and the growing stock of timber at the end of each year. In reality, the leadership of each SOFE is responsible to its supervising authority, which evaluates the SOFE's performance, using a number of criteria, including profit and the improvement of forest resources.

The variable "incentive for forest protection" refers to the weight a supervising authority assigns in the annual contract to how well a SOFE improves forest resources. Accordingly, an increase in the "incentive for forest protection" should reduce the timber harvest and increase the investment in forest protection and management, and thus increase the growing stock of timber at the end of the year.

Non-forestland is the combination of agricultural land, pastures, and land used for miscellaneous purposes. This variable is used as a proxy for the non-forestry income of the SOFEs. According to Xu et al. (2006), the management and utilization of non-timber products by the SOFEs promoted the development of this tertiary industry and increased the income of the SOFEs and their workers. Furthermore, the management and utilization of non-timber resources created jobs and reduced the degree of dependence on forest resources.

The most important non-timber resource utilizations are crop growing, livestock farming, and collecting and processing non-timber forest products, such as mushrooms, fungi, herbs, and wild vegetables. Therefore, the area of non-forestland provides a reasonable indication of the scale of the non-timber resource utilization.

In the empirical analysis, we used two variables to describe the fixed costs of the SOFEs. The variable "tax and fees" refers to the sum of the taxes and fees a SOFE pays in one year in proportion to the gross revenue of the SOFE. The second variable, "social burden," refers to the number of retired workers and school and hospital staff hired by each SOFE.

The variable "harvest and afforestation reform" refers to the number of years elapsed since a SOFE reformed the organization and implementation of its harvest and afforestation activities. Similarly, the variable "forest protection and management reform" refers to the number of years elapsed since a SOFE reformed the organization and implementation of forest protection and management activities. These reforms are important means for the SOFEs to increase productivity of timber harvest and afforestation, as well as forest protection efforts. Observations of the changes in efficiency resulting from the reforms are not available, however. Presumably, it takes time to achieve the maximum effects of the reforms. We use the time elapsed since a SOFE started the reforms as proxy for the extent of rationalization of afforestation and forest protection activities.

3. Data

We estimated the empirical models with data for all 75 SOFEs in Heilongjiang and Jilin Provinces and the Inner Mongolia Autonomous Region (see table 6). The data were collected through a survey conducted from June to October in 2005 by Peking University, with the assistance of the State Forestry Agency and the three Provincial Forestry Authorities. The data include information about forest resources, socioeconomic conditions, timber harvest, and investment, as well as the status of forest management reforms from 1980 to 2004. The data collected in the survey are complemented by statistics from the State Forestry Agency. Descriptive statistics of the data are presented in table 7.

Table 6. Distribution of the SOFEs in Heilongjiang and Jilin Provinces and Inner Mongolia Autonomous Region

Province	Supervising authority	Number of SOFEs
Heilongjiang	Songhuajiang Forestry Administrative Bureau	8
	Mudanjiang Forestry Administrative Bureau	8
	Hejiang Forestry Administrative Bureau	7
	Yichun Forestry Administrative Bureau	16
	Dailing Forestry Administrative Bureau	1
Jilin	Jilin Forest Industry Group	8
	Yanbian Forestry Administrative Bureau	10
Inner Mongolia	Daxinganling Forestry Administrative Bureau	17
Total		75

Table 7. Descriptive Statistics of the Variables

Variable	Number of observations	Mean	Std. dev.	Min.	Max.
Total forestland area (1000 hectares)	1,850	198.89	102.86	31.47	588.18
Growing stock of timber (1000 m^3)	1,850	18541	10498	2082	58700
Timber harvest (1000 m^3)	1,850	212.39	119.32	5.14	617.90
Fixed assets investment (million yuans)	1,850	20.24	20.93	0.00	159.79
Area of non-forestland (hectares)	1,850	8479	10228	0	67011

Social burden (number of persons)	1,850	3715	1752	348	9004
Tax and fee burden (%)	1,850	26.51	0.091	0.026	0.586
Timber price (yuan/m^3)	1,850	374.99	96.38	178.55	791.00
Harvest and afforestation reform	1,850	6.88	7.66	0.00	43.00
Forest protection and management reform	1,850	0.52	1.70	0.00	21.00
Forest protection incentive	1,850	0.17	0.04	0.13	0.26

For all 75 SOFEs, total forestland area increased steadily from 1980 to 2004, while the growing stock of timber stayed relatively stable. There are, however, significant differences among the SOFEs in different provinces (see figures 1 and 2). On average, the SOFEs in Inner Mongolia achieved the most significant increase in both area of forestland and the growing stock of timber. Changes in the average forestland area and the growing stock of timber in Jilin Province were small. For the SOFEs in Heilongjiang Province, the area of forested land increased by about 20 percent, with the major part of the increase occurring in the 1990s; the growing stock of timber decreased by more than 20 percent between 1980 and 1989, and has been stable thereafter. The average timber stock per hectare was relatively stable in Jilin Province and Inner Mongolia (about 130 m3/hectare). For the 40 SOFEs in Heilongjiang Province, the average timber stock per hectare decreased significantly from 1980 to 2004.

Figure 1. Average Area of Forestland Managed by the SOFEs in Heilongjiang and Jilin Provinces and Inner Mongolia Autonomous Region

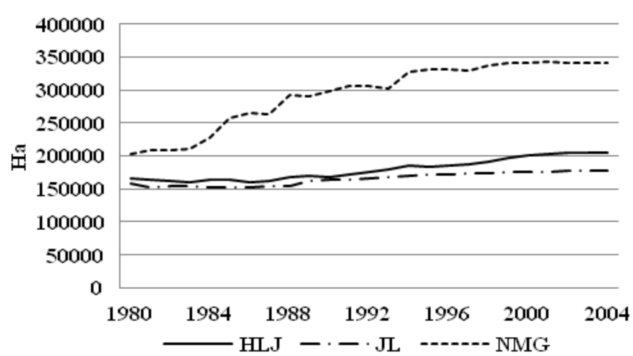
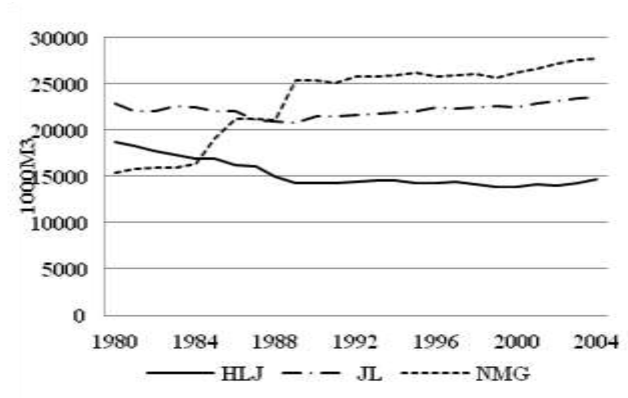


Figure 2. Average Growing Stock of Timber Managed by the SOFEs in Heilongjiang and Jilin Provinces and Inner Mongolia Autonomous Region



The timber harvest of the 75 SOFEs included in this study has decreased dramatically since the mid-1980s (see figure 3). The average annual harvest volume of the SOFEs in Inner Mongolia decreased from 315,000 m^3 in 1986 to 145,000 m^3 in 2004. In Heilongjiang Province, the average harvest volume of the SOFEs dropped from 296,000 m^3 in 1986, to 96,000 m^3 in 2004. The average harvest volume of the SOFEs in Jilin Province decreased from about 297,000 m^3 in 1986, to 116,000 m^3 in 2004. The primary reasons for the reduction in timber harvest during this time were the shift of focus in the national forest policy from timber production to nature conservation and environmental protection, and to the lack of mature forests caused by decades of unsustainable forest management.

Figure 3. Average Timber Harvest of the SOFEs in Heilongjiang and Jilin Provinces and Inner Mongolia Autonomous Region

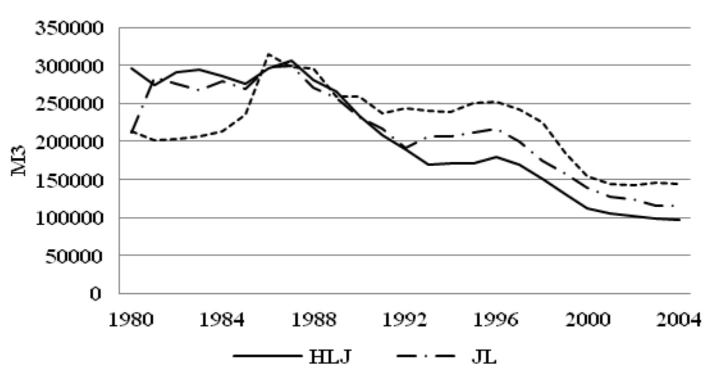


Figure 4. Average Fixed Assets Investment of the SOFEs in Heilongjiang and Jilin Provinces and Inner Mongolia Autonomous Region

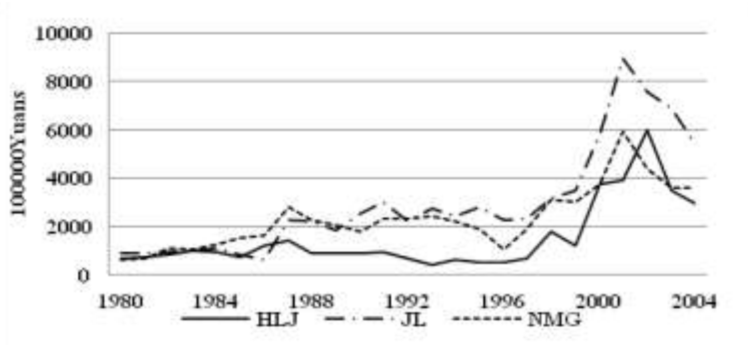


Figure 4 shows that the fixed assets investment in the three provinces increased slightly between 1980 and 1998. After the NFPP was launched in 1998, fixed assets investment increased rapidly for a few years, but quickly fell back to the 1998 level by 2004. On average, the fixed assets investment per hectare of forestland was much higher in Jilin than in Heilongjiang and Inner Mongolia, which may have contributed to the relatively high growing stock of timber per hectare in Jilin Province.

In figure 5, we see that the average area of non-forestland of the SOFEs in Jilin Province decreased steadily in the 1990s before stabilizing in the early 2000s. For the SOFEs in Heilongjiang and Inner Mongolia, the average area of non-forestland started to increase in the late 1990s, following a significant decrease in the late 1980s. The changes in the area of non-forestland of the SOFEs were to a large extent the result of changes in policy concerning the management and utilization of non-timber resources.

Figure 5. Average Number of Retired Workers and Social Service Staff of the SOFEs in Heilongjiang and Jilin Provinces and Inner Mongolia Autonomous Region

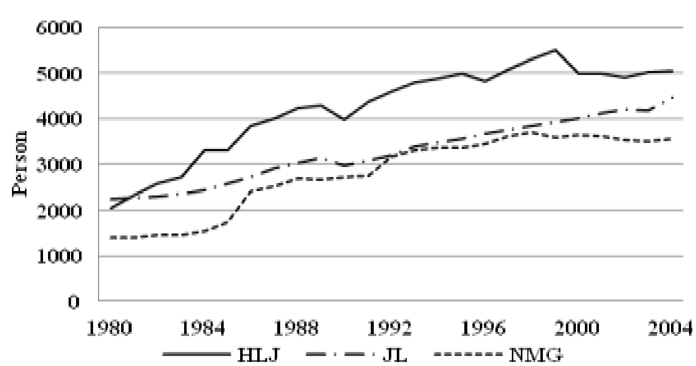
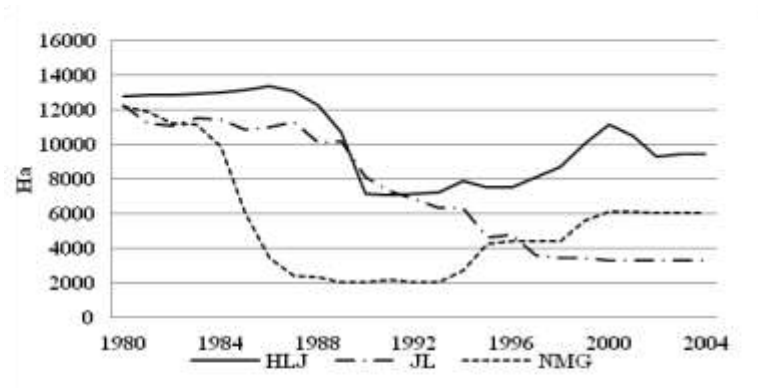


Figure 6. Average Area of Non-Forestland Managed by the SOFEs in Heilongjiang and Jilin Provinces and Inner Mongolia Autonomous Region



Since the late 1990s, these SOFEs significantly reduced the number of employees through a so-called "reallocation" of surplus staff. At the same time, the number of retired workers increased significantly. Figure 6 shows a clear trend where the number of pensioners and school and hospital staff increased in the 75 SOFEs. The timber prices were adjusted, using the producer price index for forest products, to the 2004 price level. The data show that timber prices increased significantly from 1980 to 2004.

4. Estimation Results

The sample is a panel data set. In general, panel data can be analyzed using three types of models: pooled regression models, random effects regression models, and fixed effects regression models. In our analysis, we first compared the pooled regression model and random effects regression model using the F-test. The result showed that the random effects model was superior to the pooled model. Next, we used the Hausman test to compare the random effects model with fixed effect model, and found that the fixed effects model was more effective. Finally, we conducted a Breusch-Pagan Lagrange multiplier test to the fixed effect model and found that we could not reject the correlation assumption among the sample cross-section. Therefore, we estimated the models with the feasible generalized least squares considering the correlation.

Because the generalized least squares estimation controlling the heteroskedasticity and correlation requires balanced data, we removed one of the SOFEs in Jilin Province, which was established in 1990, and estimated the models using 1,850 observations. In order to solve the endogeneity problem, we lagged the independent variables, so the actual number of observations used in the model estimation was 1,776. The estimation results are presented in table 8.

Table 8. Estimation Results

Independent variable	Harvest volume	Fixed assets investment	Growing stock of timber
	lnh	***lnI***	***lnQ***
Initial growing stock of timber	0.689***	0.428***	0.985***
	(79.92)	(15.35)	(320.07)
Areas of non-forestland	-0.011***	0.014**	0.001**
	(5.11)	(2.36)	(2.08)
Social burden	0.436***	0.076***	-0.006**
	(46.68)	(2.76)	(2.07)
Tax and fees	0.854***	-0.218	-0.014
	(17.48)	(1.38)	(0.89)
Timber price	0.146***	0.339***	0.004
	(5.85)	(3.88)	(0.65)
Harvest and afforestation reform	0.004***	0.004	-0.001***
	(4.99)	(1.21)	(2.61)
Forest protection and management reform	-0.019***	0.035***	0.000
	(4.55)	(7.13)	(0.36)
Forest protection incentive	-1.646***	8.977***	0.015
	(6.15)	(8.52)	(0.27)
Time trend	-0.062***	0.023***	0.002***
	(42.11)	(3.62)	(5.83)
Constant	1.902***	-1.596***	-4.131***
	(10.75)	(2.78)	(47.26)
Region dummy variables	Yes	Yes	Yes

Notes: * indicates significant at 10% level, ** indicates significant at 5% level, and *** indicates significant at 1% level. Z value is in parentheses.

The estimation results strongly support the results of the theoretical analysis. The empirical results show that an increase in the weight assigned by the supervising authorities to forest resource improvement will reduce timber harvest and increase the investment in forest protection and management of the SOFE, as the theoretical analysis suggested. The estimation also shows that the effects on both the harvest volume and the investment are large. If the weight of forest resource improvement increases by 1 percent in a contract signed by the supervising authorities and the SOFE, the harvest volume will decrease by 1.65 percent, while the investment will increase by 8.98 percent. Increasing the weight of forest resource improvement has a positive effect on change in the growing stock of timber over time, but the effect is not statistically significant.

The forest protection and management reform had a positive impact on investment, but a negative influence on the harvest volume. Both effects are statistically significant at the 1 percent level. The reform also had a positive effect on change in the growing stock of timber, but the effect is statistically insignificant. The result suggests that the reform focusing on the implementation of forest protection activities started to show effects on the harvest and investment rather quickly, but it will take longer time before we can observe any significant impact of the reform on the development of forest resources over time.

The afforestation reform had a positive impact on the harvest volume and a negative impact on the change in the growing stock of timber. This reform had a positive, but statistically insignificant, effect on the fixed assets investment. The result indicates that the afforestation reform can effectively reduce regeneration costs. All other things the same, the reduction in regeneration costs increases the profits from harvesting and regenerating the forest, and therefore causes the harvest level to increase. Intuitively, the afforestation reform should lead to more forests being successfully established, which would have a positive effect on the development of the growing stock of timber.

In this study, we regressed the growing stock of timber at the end of each year against the growing stock of timber at the beginning of the year, in addition to the other explanatory variables. This means that, in our model, forests established in previous years do not affect the growing stock of timber at the end of the current year. These forests are accounted for in the growing stock of timber at the beginning of the year. Because the growing stock of timber in the newly established forests is very low, the positive effect of the regeneration reform on the growing stock of timber is negligible. Therefore, in our model, the afforestation reform affects the growing stock of timber mainly through its effects on harvest, which explains the negative effect of the reform on the development of the growing stock of timber.

An increase in the social burden of a SOFE will increase its harvest volume and have a negative effect on the development of the forest resources. In relation to the theoretical model, an increase in the social burden corresponds to an increase in the fixed costs of the SOFE. Thus, with respect to the effect on timber harvest and the development of forest resources, the empirical result is consistent with the result of the theoretical analysis. What may appear surprising is the positive effect of social burden on the fixed assets investment. The reason for this positive effect is probably due to the fact that the fixed assets investment included those investments aimed at providing social services, whereas the theoretical model examined the effect on investment in forest protection and management. If the social burden increased by 10 percent, the harvest volume would increase by 4.36 percent; at the same time, the investment would increase by 0.76 percent. The effect on the forest resources stock is small.

As expected, an increase in the tax and fees will significantly increase the harvest volume; at the same time, it will affect the investment and the development of the forest resource negatively, although the later two effects were statistically not significant. The estimated parameters show that a 10 percent increase in the tax and fees will cause a 8.54 percent increase of harvest volume.

An increase in the area of non-forestland would cause the harvest volume to decrease, but had a positive effect on the investment and on the development of the forest resources. Since a larger area of non-forestland implies a higher non-forestry income, this result is consistent with our theoretical result. The effects of the area of non-forestland are small, however. Following a 10 percent increase in the area of non-forestland, the harvest volume would decrease by 0.11 percent, the fixed assets investment would increase by 0.14 percent, and the growing stock of timber at the end of the year would increase by only 0.01 percent.

Increases in timber price had positive effects on the harvest volume and the fixed assets investment. The estimation result showed that if the timber price rose by 10 percent, the harvest volume would increase by 1.46 percent and the fixed assets investment would increase by 3.39 percent. An increase in timber price would affect the development of the forest resources positively, but the effect is statistically not significant.

The growing stock of timber has significant and positive effects on the harvest volume and the fixed assets investment, as well as on the development of the forest resources. If the growing stock of timber at the beginning of a year increases by 10 percent, the harvest volume and the fixed assets investment in the same year to would increase by 6.89 percent and 4.28 percent, respectively, and the growing stock of timber at the end of the year would increase by 9.85 percent.

5. Conclusions

An important conclusion we can draw from the results of this study is that a number of policy measures can effectively change the managerial behavior, as well as the development of forest resources, of the SOFEs. Specifically, the supervising authorities exercise considerable influence on the harvest and investment decisions of SOFEs by how they weight specific elements in the annual SOFE evaluations. By assigning a greater weight to forest resource improvement, the supervising authorities can induce the SOFEs to significantly reduce the harvest level and increase investment. Likewise, reduction of taxes and fees, as well as policy measures that reduce the social burden of the SOFEs, can significantly reduce the harvest level. These measures will have positive effects on the development of forest resources.

A second conclusion is that the reforms within the SOFEs have had relatively few effects on harvest and investment decisions, and on development of the forest resources. The reforms have been aimed at increasing the productivity of timber harvest and forest management (including afforestation and forest protection) efforts. When carrying out these reforms, the SOFEs were not able to make any significant adjustment in the number of employees or the level of social services they provide. The potential of rationalization through such reforms is therefore limited.

A third conclusion is that the strategy of promoting non-timber resource businesses (such as crop growing, livestock farming, etc.) has had a positive effect on the development of the forest resources, although the effect has been small thus far.

The conclusions are the result of an aggregate analysis of all 75 SOFEs in Heilongjiang and Jilin Provinces and Inner Mongolia Autonomous Region, and may not be representative of these areas individually. Another caveat of the analysis is the fact that the data period ends in 2004. China is a fast-changing nation, and our conclusions may appear dated. However, most SOFEs in China are still highly dependent on forestry income and mature forests available for harvesting remain scarce at present. The results of this study can contribute to the continuing reform of SOFEs.

Appendix

$$\frac{\partial h}{\partial \alpha_2} = \frac{B(\pi+\pi_0)S_I(r_m, I)}{BC-DA} < 0$$

$$\frac{\partial I}{\partial \alpha_2} = \frac{-A(\pi+\pi_0)S_I(r_m, I)}{CB-AD} > 0$$

$$\frac{\partial h}{\partial \pi_0} = \frac{B\alpha_2 S_I(r_m, I)}{BC-DA} < 0$$

$$\frac{\partial I}{\partial \pi_0} = \frac{-A\alpha_2 S_I(r_m, I)}{BC-DA} > 0$$

$$\frac{\partial h}{\partial p} = \frac{B\alpha_2 S_I(r_m, I)h + Dg(Q_0-h)S_I(r_m, I)}{BC-DA} <=> 0$$

$$\frac{\partial I}{\partial p} = \frac{-A\alpha_2 S_I(r_m, I)h - Cg(Q_0-h)S_I(r_m, I)}{BC-DA} > 0$$

$$\frac{\partial h}{\partial Q_0} = \frac{-D\{g''(Q_0-h)S(r_m, I) - g'(Q_0-h)S_I(r_m, I)[p-C_h(r_h, h)]\}}{BC-DA} > 0$$

$$\frac{\partial I}{\partial Q_0} = \frac{C\{g''(Q_0-h)S(r_m, I) - g'(Q_0-h)S_I(r_m, I)[p-C_h(r_h, h)]\}}{BC-DA} > 0$$

$$\frac{\partial h}{\partial r_h} = \frac{-S_I(r_m, I)}{BC-DA}\{\alpha_2 BC_{r_h}(r_h, h) - Dg(Q_0-h)C_{hr_h}(r_h, h)\} <=> 0$$

$$\frac{\partial I}{\partial r_h} = \frac{S_I(r_m, I)}{BC-DA}\{\alpha_2 AC_{r_h}(r_h, h) + Cg(Q_0-h)C_{hr_h}(r_h, h)\} > 0$$

$$\frac{\partial h}{\partial r_m} = \frac{\alpha_2 B(\pi+\pi_0)S_{Ir_m}(r_m, I) - \alpha_1 BS_{r_m}(r_m, I) - DS_{Ir_m}(r_m, I)\{g'(Q_0-h) - g(Q_0-h)[p - C_h(r_h, h)]\}}{BC - DA} <=> 0$$

$$\frac{\partial I}{\partial r_m} = \frac{-\alpha_2 A(\pi+\pi_0)S_{Ir_m}(r_m, I) + \alpha_1 AS_{r_m}(r_m, I) + CS_{Ir_m}(r_m, I)\{g'(Q_0-h) - g(Q_0-h)[p - C_h(r_h, h)]\}}{BC - DA} <=> 0$$

Based on the above analysis of the logging and investment, Q can be analyzed as follows:

$$\frac{\partial Q}{\partial Q_0} = g^{'}_{Q_0}(1 - \frac{\partial h}{\partial Q_0}) + g \cdot S^{'}_I \frac{\partial I}{\partial Q_0} > 0$$

$$\frac{\partial Q}{\partial \alpha_1} = g^{'}_h(-\frac{\partial h}{\partial \alpha_1})S + g \cdot S^{'}_I \frac{\partial I}{\partial \alpha_1} < 0$$

$$\frac{\partial Q}{\partial \alpha_2} = g^{'}_h(-\frac{\partial h}{\partial \alpha_2})S + g \cdot S^{'}_I \frac{\partial I}{\partial \alpha_2} > 0$$

$$\frac{\partial Q}{\partial \pi_0} = g^{'}_h(-\frac{\partial h}{\partial \pi_0})S + g \cdot S^{'}_I \frac{\partial I}{\partial \pi_0} > 0$$

$$\frac{\partial Q}{\partial p} = g^{'}_h(-\frac{\partial h}{\partial p})S + g \cdot S^{'}_I \frac{\partial I}{\partial p} <=> 0$$

$$\frac{\partial Q}{\partial r_h} = g^{'}_h(-\frac{\partial h}{\partial r_h})S + g \cdot S^{'}_I \frac{\partial I}{\partial r_h} <=> 0$$

$$\frac{\partial Q}{\partial r_m} = g^{'}_h(-\frac{\partial h}{\partial r_m})S + g \cdot S^{'}_I \frac{\partial I}{\partial r_m} <=> 0$$

References

Cao, Yukun. 2000. National Forest Management Protection and Development of State-Owned Forestry Enterprises. Beijing: China Forestry Press.

Chan, Guoming. 1996. State-Owned Forestry Enterprises Forest Assessment Criteria and Evaluation Methods. Beijing: China Forestry Press.

Jiang, Xuemei. 2006. Research on the Performance of the State-Owned Forestry Industry Enterprise Based on the Principal-Agent Theory. PhD dissertation. College of Economics and Management, Northeast Forestry University, Harbin, China.

SFA (State Forestry Administration). 1987. China Compendium of Forestry Statistics 1949–1987. Beijing, China: China Forestry Press.

———. 2010. China Forest Statistical Yearbook: 1987–2010. Beijing, China: China Forestry Press.

Wan, Zhifang. 2004. Reconstruction of State-Owned Forest Region of the Main Micro. Harbin, China: Northeast Forestry University Press.

Xu, Jintao, Ran Tao, and Wei Jiegen. 2004. Information Asymmetry, Profit-Sharing Contract, and Over-the-Quota Harvesting: Theory and Empirical Analysis of China's State-Owned Forests. Economic Research Journal 3: 37–46.

Xu, Jintao, Xuemei Jiang, and Yongjie Ji. 2006. Key State Forest Reform and Development Trend of the Empirical Analysis. Forestry Economics 1: 10–15.Zhang, Lei. 1998. Strategic Adjustment of State-Owned Forestry Industry Enterprises. Forestry Economics 4: 29–35.