A Note on Sitting of Geothermal Power Plant and Loss of View for Sightseeing

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Shigeru Watanabe*
Tomohiro Sada**

1. Introduction

The geothermal power plant[1] is important for environment[2]. A purpose of this note is to analyze the geothermal power plant considering the loss of view. The higher the research cost, the higher the possibility of finding the adequate place for the geothermal power plant.

The view for the sightseeing will be lost due to the sitting of the plant. In addition to the loss, the source of the hot spring may run dry. Then the firm must compensate it.

It is assumed that a part of the compensation is paid from an insurance. A fair insurance is assumed, which includes government subsidy.

The following results have been derived; (i) in the first case where the desired scale of the plant is exogenously given, and the insurance covers a part of the compensation when the source of hot spring runs dry due to the sitting of the plant, an increase in the given scale of the plant will not always raise the research expenditure to find the place for geothermal power plant. An increase in the amount of subsidy will raise the research expenditure for finding the place for geothermal power plant, (ii) in the second case where the scale of the geothermal power plant is also endogenous and the insurance covers a part of the compensation when the source of hot spring runs dry due to the sitting of the plant, an increase in the amount of subsidy will raise the research expenditure for finding the place for geothermal power plant, but the increase in the subsidy will have no effect on the endogenous scale of the geothermal power plant.

In the next section a simple model of geothermal power plant will be shown.

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* Professor of Economics at the Osaka Prefecture College of Economics, 1-1, Gakuencho, Nakaku, Sakai-City, Osaka 599-8531, Japan
** Post graduate student of Economics at Osaka Prefecture University

In section 3 concluding remarks will be given.

Key Words; geothermal power plant, loss of view for sightseeing, environment.

2. A Simple Model of Geothermal Power Plant

In the first case the scale of the plant $\overline{V}$ is assumed to be exogenously given and fair insurance for $\hat{M}$ is considered, where $\hat{M}$ is the compensation if the source of hot spring runs dry.

The expected profit $E\pi$ of the electric power company is denoted by the following equation (1).

$$E\pi = q(R)PY(V) - R - q(R)\{C(V) + M(V) + \alpha + h(V)(1-\beta)\hat{M}(V)\}, \quad (1)$$

where $q(R)$ is the probability of finding the adequate place for geothermal power plant, $\frac{dq}{dR} > 0$, R is the research expenditure, P is the price of the electric power, $Y(V)$ is output of electric power, $\frac{dY}{dV} > 0$, $C(V)$ is the cost for producing electric power, $\frac{dC}{dV} > 0$, $M(V)$ is the compensation, which is not covered by the insurance and must be paid always, due to the loss of view, $\frac{dM}{dV} > 0$, α is the insurance premium, $h(V)$ is the probability that the source of hot spring may run dry due to the plant, $\frac{dh}{dV} > 0$, β is portion paid by the insurance for $\hat{M}$.
The fair insurance including government subsidy is denoted by

$$\alpha + S = h(\overline{V})\beta\hat{M}(\overline{V}), \quad (2)$$

where S is subsidy for the fair insurance by the government.

From (2)

$$\alpha = h(V)\beta\hat{M}(V) - S.$$

$E\pi$ is rewritten in the following maner;

$$\begin{aligned} E\pi &= q(R)\{PY(\overline{V}) - C(\overline{V}) - M(\overline{V}) - h(\overline{V})\beta\hat{M}(\overline{V}) + S - h(\overline{V})(1-\beta)\hat{M}(\overline{V})\} - R \\ &= q(R)\{PY(\overline{V}) - C(\overline{V}) - M(\overline{V}) + S - h(\overline{V})\hat{M}(\overline{V})\} - R. \end{aligned} \quad (3)$$

Maximizing (3) with respect to R yields the following first order condition.

$$\frac{dE\pi}{dR}=\frac{dq}{dR}\left\{PY\left(\overline{V}\right)-C\left(\overline{V}\right)-M\left(\overline{V}\right)+S-h\left(\overline{V}\right)\hat{M}\left(\overline{V}\right)\right\}-1$$
$$=0\,. \tag{4}$$

Second order condition is satisfied.

$$\frac{d^2E\pi}{dR^2}=\frac{d^2q}{dR^2}\left\{PY\left(\overline{V}\right)-C\left(\overline{V}\right)-M\left(\overline{V}\right)+S-h\left(\overline{V}\right)\hat{M}\left(\overline{V}\right)\right\}<0\,, \tag{5}$$

where $\left\{PY\left(\overline{V}\right)-C\left(\overline{V}\right)-M\left(\overline{V}\right)+S-h\left(\overline{V}\right)\hat{M}\left(\overline{V}\right)\right\}>0$ from (4) and $q(R)$ is specified such that $q(R)=r_0R^{\frac{1}{2}}$, then $\frac{d^2q}{dR^2}<0$.
From equation (4) we obtain

$$R^*=\frac{{r_0}^2\left\{PY\left(\overline{V}\right)-C\left(\overline{V}\right)-M\left(\overline{V}\right)+S-h\left(\overline{V}\right)\hat{M}\left(\overline{V}\right)\right\}^2}{4}\,. \tag{6}$$

From (6) the following results are obtained straightforwardly.

$$\frac{\partial R^*}{\partial S}>0\,, \tag{7}$$

then

$$\frac{dq}{dR}>0\,. \tag{8}$$

Hence the probability q of siting of geothermal power plant is increased by the increase in the subsidy.
Next, we will examine the effect of the change in $\overline{V}$.

$$\frac{\partial R^*}{\partial\overline{V}}=\frac{r_0}{2}\left\{PY\left(\overline{V}\right)-C\left(\overline{V}\right)-M\left(\overline{V}\right)+S-h\left(\overline{V}\right)\hat{M}\left(\overline{V}\right)\right\}\left\{P\frac{dY}{d\overline{V}}-\frac{dC}{d\overline{V}}-\frac{dM}{d\overline{V}}-\frac{dh\left(\overline{V}\right)}{d\overline{V}}\hat{M}\left(\overline{V}\right)-h\left(\overline{V}\right)\frac{d\hat{M}}{d\overline{V}}\right\}.$$

Hence, we get following result.

$$\frac{\partial R^*}{\partial\overline{V}}\gtreqless 0\,, \tag{9}$$

according as

$$Py_0 \gtreqless c_0 + m_0 + 2h_0 \hat{m}_0 \overline{V} ,$$

where functions are specified such that

$$Y = y_0 \overline{V} , C = c_0 \overline{V} , M = m_0 \overline{V} , \hat{M} = \hat{m}_0 \overline{V} , h = h_0 \overline{V} .$$

Therefore the increase in $\overline{V}$ will not always increase R.

In the second case V is also endogenous and fair insurance for $\hat{M}$ is considered. The expected profit $E\pi$ of the electric power company is denoted by the following equation (10).

$$E\pi = q(R)\left\{PY(V) - C(V) - M(V) + S - h(V)\hat{M}(V)\right\} - R . \qquad (10)$$

Maximizing (10) with respect to R and V yields the following first order conditions.

$$\frac{\partial E\pi}{\partial R} = \frac{\partial q}{\partial R}\left\{PY(V) - C(V) - M(V) + S - h(V)\hat{M}(V)\right\} - 1$$
$$= 0 , \qquad (11)$$

$$\frac{\partial E\pi}{\partial V} = q(R)\left\{P\frac{dY}{dV} - \frac{dC}{dV} - \frac{dM}{dV} - \frac{dh}{dV}\hat{M} - h(V)\frac{d\hat{M}}{dV}\right\}$$
$$= 0 . \qquad (12)$$

The following second order conditions (13) (14) are satisfied.

$$\frac{\partial^2 E\pi}{\partial R^2} < 0 , \text{ where } \frac{d^2 q}{dR^2} < 0 . \qquad (13)$$

$$\begin{vmatrix} \frac{\partial^2 E\pi}{\partial R^2} & \frac{\partial^2 E\pi}{\partial R \partial V} \\ \frac{\partial^2 E\pi}{\partial V \partial R} & \frac{\partial^2 E\pi}{\partial V^2} \end{vmatrix} > 0 , \qquad (14)$$

where

$$\frac{\partial^2 E\pi}{\partial V^2} = q(R)\left\{ p\frac{d^2Y}{dV^2} - \frac{d^2C}{dV^2} - \frac{d^2M}{dV^2} - \frac{d^2h}{dV^2}\hat{M} - 2\frac{dh}{dV}\frac{d\hat{M}}{dV} - h(V)\frac{d^2\hat{M}}{dV^2} \right\}$$
$$< 0 ,$$

where

$$\frac{dY}{dV} > 0, \frac{d^2Y}{dV^2} \leqq 0, \frac{dC}{dV} > 0, \frac{d^2C}{dV^2} \geqq 0, \frac{dM}{dV} > 0, \frac{d^2M}{dV^2} \geqq 0, \frac{d\hat{M}}{dV} > 0, \frac{d^2\hat{M}}{dV^2} \geqq 0, \frac{dh}{dV} > 0, \frac{d^2h}{dV^2} \geqq 0$$

are assumed,
and

$$\frac{\partial^2 E\pi}{\partial R \partial V} = \frac{dq}{dR}\left\{ p\frac{dy}{dV} - \frac{dC}{dV} - \frac{dM}{dV} - \frac{dh}{dV}\hat{M} - h(V)\frac{d\hat{M}}{dV} \right\}$$
$$= 0 .$$

From (11) (12) we get

$$R^{**} = \frac{{r_0}^2}{4}\left\{ \frac{(Py_0 - c_0 - m_0)^2}{4h_0\hat{m}_0} + S \right\}^2 , \tag{15}$$

$$V^{**} = \frac{Py_0 - c_0 - m_0}{2h_0\hat{m}_0} . \tag{16}$$

From (15) (16) we get the following results;

$$\frac{\partial R^{**}}{\partial S} > 0, \frac{\partial V^{**}}{\partial S} = 0, \text{ and}$$

$$\frac{\partial V^*}{\partial P} > 0, \frac{\partial V^*}{\partial y_0} > 0, \frac{\partial V^*}{\partial c_0} < 0, \frac{\partial V^*}{\partial h_0} < 0, \frac{\partial V^*}{\partial m_0} < 0, \frac{\partial V^*}{\partial \hat{m}_0} < 0 . \tag{17}$$

Hence, from (17) we get the following results; an increase in the amount of subsidy for fair insurance will raise the research expenditure for finding the place for geothermal power plant, but the increase in the subsidy will have no effect on the scale of the geothermal power plant.

3. Concluding Remarks

A purpose of this note is to analyze the geothermal power plant considering the loss of view. The higher the research expenditure, the higher the possibility of finding the place for the geothermal power plant.

The view will be lost due to the sitting of the plant. In addition to the loss, the source of hot spring may run dry.

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1. See Ebara (2011).
2. See Maruo (2010), Watanabe (2009, 2010a, 2010b), Wtanabe and Sada (2011).

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