AMSE JOURNALS-AMSE IIETA publication-2017-Series: Advances A; Vol. 54; N°1; pp 1-20
Submitted Jan. 2017; Revised March 15, 2017, Accepted April 15, 2016
https://doi.org/10.18280/ama_a.540101

International Trade, Property Maintenance Intensity and Renewable Resources Sustainability

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Abstract

Based on the model of Brander - Taylor (1997a, b) and Francis (2005), this paper introduced a notion of property right protection sector on the basis of collection proportion of resource exploitation income. By using the supply and demand theory of resource products, the utility maximization theory for both individuals and the society, and the company profit maximization theory, this article studied the selection law of exploitation, stock and property maintenance intensity of renewable resources in closed economy and trade liberalization.

Key words

Renewable resources, Brander and Taylor models, resource stock

1. Introduction

The year of 2015 witnessed around 31% forest cover rate and about 3.999 billion hectares of forest land. Over the five years since 2010, forest land area decreases by 0.13% every year, and the annual net loss of forests is 3.30 million hectares [1]. The 2016 living Planet Report shows

that from 1970 to 2012, the number of vertebrate populations declined by 58%, with an annual average declining amplitude of 2% and no slowdown in deceleration [2]. The reality shows that the problems confronting sustainability of renewable resources are enormous.

In theory, what are the important contributing factors to the sustainability of renewable resources? I reviewed some influential documents and found out that those factors can be summarized into property right regime and international trade. For instance, according to the fundamental mathematical model of property right maintenance intensity difference which is established by Brander and Taylor (1997a), free trade may lead to the over-exploitation of countries with weak resource protection [3]; Brander and Taylor (1997b) found that under certain circumstances, trade liberalization may lead to resource depletion and trade interest loss [4]; Hotte et al. (2000) set up a mathematical model by setting the parameters of illegal exploitation of resources, and the analysis shows that profit motive controls the transformation of property rights system and further affects the level of resource stock [5]; Francis (2005) introduced the use of a fixed number of labor force to inspect and restrict the illegal exploiters' entrance to fishery places, and accordingly established an endogenous property right model. The results show that trade liberalization will boost the over-exploitation of resources [6]. For other studies on property rights and international trade, please refer to Chen Huimin (2016) [7]. Despite massive pioneering studies overseas, there are few research focuses on the interaction between privatized property right system, international trade and resource sustainability.

I extended Brander and Taylor models (1997a, b) with a continuous mode of the property right system, which be viewed as full maintenance and zero maintenance before. We also introduced the thought of continuous labor input based property right maintenance proposed by Hotte et al. (2000) and Francis (2005). With an income proportion, which is similar to resource tax, and the property right maintenance parameter N_{PR}, we designed property right protection variables to research into the selection of property right maintenance intensity and the comparative statics of resource exploitation amount and resource stock when resource products are subject to exogenous conditions with global prices.

The following sections are arranged as follows: Section II analyzes the equilibrium model in closed economy; Section III analyzes the dynamic of renewable resources and the choice of the intensity of property right maintenance under trade liberalization; finally, we draw the conclusion.

2. Models in closed economy

2.1 Labor market

Supposing that the labor market is perfectly competitive, and that full employment is achieved in that labor forces are free to work in the resource sector (resource production and resource property rights protection) and the industrial sector. As input factors are restricted to labor, it is inevitable that labor forces are engaged in legitimate exploitation, illegal exploitation, property rights protection and industrial production, which can be expressed as $N=N_N+N_M$, $N_H=N_L+N_{IL}+N_{PR}$, where N represents the total labor input, N_H is the labor input of resource production sector, N_M denotes the labor input of industrial sector, N_L is the labor input for legitimate exploitation of renewable resources, N_{IL} is the labor input for illegal exploitation of renewable resources, N_{PR} represents the labor input of property right protection of renewable resources. We also assume that the labor input of illegal exploitation is inversely proportional to N_{PR}, with the coefficient of 1, and that those who exist from illegal exploitation activities will be fully employed in resource department and industrial department.

2.2 resource growth model

To simplify our analysis, we adopt the simplified form of the renewal growth function of renewable resources by Gordon (1954) [8] and Schaefer (1957) [9], i.e.

$$G(S(t)) = rS(t)(1 - S(t)/K) \tag{1}$$

$$\dot{S} = G(S(t)) - X(S(t)) \tag{2}$$

In formula (1) and formula (2), $G(S(t))$ is the increment in renewable resources at the moment t, $S(t)$ is the stock of renewable resources at the moment t; r denotes the endogenous growth rate of renewable resources, K is the saturation level of renewable resources, $\dot{S}$ (i.e. ds/dt)is the change of renewable resources at the moment t; X(S(t)) represents the exploitation amount of renewable resources at the moment t (also denoting the manufacturing amount of resource products), which is the difference between the increment in renewable resources and the exploitation amount at the moment t. (Note: in the later part of the paper, "t" is omitted in formula (1) and (2).

2.3 Production and supply function

Countries that have their resource property rights privatized only produce and consume two kinds of goods: resource products X_1 produced from resource production sector and industrial products X_2 produced from industrial sector, where X_2 is regarded as a base product at the price of 1. The superscripts S and D represent supply and demand, respectively.

2.3.1 Production function of the industrial sector

Supposing that labor is the mere input in manufacturing of industrial goods, and that the linear function of Brander and Taylor (1997a) is used as the specific production function:

$$X_2^S = N_M \tag{3}$$

Where X_2^S denotes the supply amount or production amount of industrial products.

2.3.2 Production function of the resource production sector

The production function of Schaefer (1957) is used for the resource production sector, i.e.

$$X_1^S = q \cdot S \cdot N_H \tag{4}$$

In which q is the effort degree to which the renewable resources are being exploited, and S denotes the stock of renewable resources.

2.4.3 Property rights protection sector

By hiring labor forces, property right protection sector fights against illegal exploitation, in order to maximize resource management benefits. If the capture is returned to the resource production sector, the income of the property right protection sector comes from the money handed in by the resource production sector according to the income proportion ϕ, and the expenditure is wages paid to employees. The profit function is

$$\mathrm{R_F} = \phi \cdot \mathrm{P} \cdot X_1^S - w_{PR} \cdot N_{PR} \tag{5}$$

Where P indicates the market price of resource products. On the premise that the labor market is a perfectly competitive market, there is $w_{H=}w_{PR=}w_{ID=1}$, in which w_H is the salary of labor forces in the resource protection department, w_{PR} is the salary of labor forces in the property rights protection sector, w_{ID} is the salary of labor forces in the industrial manufacturing sector. According to the marginal cost pricing rules, there is w_{ID}=1. P_1 represents the price of resource products. Therefore, the formula (5) can be simplified as:

$$R_F = \phi \cdot \mathrm{P} \cdot X_1^S - N_{PR} \tag{6}$$

All in all, in general cases of property right protection execution, the formulas of resource exploitation amount, industrial product output, and the employment amount in these sectors are:

$S_e=0$, or $S_e=K(1-N_H^e \cdot q/r)$ (7)

Where S^e denotes the level of resource stock in balanced conditions, N_H^e is the number of employed people in the resource exploitation sector in balanced conditions.

$$N_{PR} = N_H - \frac{r}{2q}(1+\frac{1}{\phi qKP}),\ N_H > r/2q \tag{8}$$

$$N_H \geq r/2q,\ N_M = N - N_H = N - \frac{r}{2q}(1+\frac{1}{\phi qKP}) - N_{PR} \tag{9}$$

$$S_e^{PR} = K(1-\frac{q}{r}\cdot\frac{r}{2q}(1+\frac{1}{\phi qKP})) = \frac{K}{2}(1-\frac{1}{\phi qKP}) \tag{10}$$

$$X_{1PR}^S = qS_e(N_H - N_{PR}) = q\frac{K}{2}(1-\frac{1}{\phi qKP})\frac{r}{2q}(1+\frac{1}{\phi qKP}) = \frac{r}{\phi qP}(\phi qKP+1)(\phi qKP-1)\frac{1}{4\phi qKP} \tag{11}$$

$$R_F^* = \frac{r}{q}(\phi qKP+1)^2\frac{1}{4\phi qKP} - N_H \tag{12}$$

2.4 Utility and demand function

We assume that all consumers are homogeneous and use the C-D utility function:

$$U = X_1^{\beta} X_2^{1-\beta} \tag{13}$$

β indicates the consumer's preference for X_1, and 1-β is the consumer's preference for industrial product X_2, $\beta \in (0, 1)$.

We let P be the sales price of resource product, and I represents the total revenue of consumers. Therefore, the immediate budget equation of representative consumer is

$$PX_1 + X_2 = I \tag{14}$$

Consumers are pursuing utility maximization under the constraints of (14). Thus, the issue is converted into

$$Max(U(X_1, X_2) = X_1^{\beta} X_2^{1-\beta}) \text{ s.t. } PX_1 + X_2 = I \tag{15}$$

The demand function for industrial products and resource products is obtained as

$$X_1^D = \beta I / P \text{ , } X_2^D = (1-\beta) I \tag{16}$$

An individual utility function can be derived by substituting (16) into the representative utility function (13)

$$U^i = X_1^{\beta} X_2^{1-\beta} = (\beta I / P)^{\beta} ((1-\beta) I)^{1-\beta} = \beta^{\beta} (1-\beta)^{1-\beta} \cdot I \cdot P^{-\beta} \tag{17}$$

We let $\beta^{\beta}(1-\beta)^{1-\beta}$ be exogenous constant, represented by c. Thus, formula (18) can be simplified as

$$U^i = c \cdot I \cdot P^{-\beta} \tag{18}$$

The social welfare function can be determined by collecting the forms of the utility function of individualistic utilitarianism. Accordingly, the total social utility of the economic system of N laborers in the case of property right maintenance is $U^{PR} = \sum U^i = N \cdot c \cdot I \cdot P^{-\beta}$. In light of the total income $NI = w(N_H + N_M) + R_F^*, w = 1, R_F^* = \frac{r}{q}(\phi q K\mathrm{P} + 1)^2 \frac{1}{4\phi q K\mathrm{P}} - N_H$, the social utility function is

$$U^{PR} = c \cdot (N_M + \frac{r}{q}(\phi q K\mathrm{P} + 1)^2 \frac{1}{4\phi q K\mathrm{P}}) \cdot P^{-\beta} \tag{19}$$

2.5 Selection of property maintenance intensity

By hiring work forces, property rights maintenance department fights against illegal exploitation. The intensity of the fight is realized by ϕ, which means that the maintenance intensity is based on profit. High profit corresponds to intense protection of property rights, whilst low profit leads to the execution of loose protection.

2.5.1 zero-maintenance and full maintenance

2.5.1.1 zero-maintenance

If ϕ=0, N_{PR}=*0*, we obtain the same result as the output of the standard model of Brander and Taylor(1997a,b). Thus, the level of renewable resource stock and the exploitation amount are respective

$$S^{O} = 1/qP \tag{20}$$

$$X_1^{O}(P) = (r/qP)(1-1/qKP) \tag{21}$$

Where S^{O} is the level of renewable resource stock under zero maintenance, and $X_1^{O}(P)$ is the exploitation amount of renewable resources under zero maintenance when the price of resource products is P.

2.5.1.2 Full maintenance

Under the full maintenance, there are some important relations such as (10), (11), (12), (16), (19).

2.5.2 Selection of property right maintenance intensity

For $\mathrm{R}_F^* = \frac{r}{q}(\phi qK\mathrm{P}+1)^2 \frac{1}{4\phi qK\mathrm{P}} - N_H$, the first-order derivative of the price of the resource product is given by $\partial R_F^* / \partial P = \frac{\phi rK}{4}(1-(\frac{1}{\phi qKP})^2)$. According to equation (10), the resource stock $S_e^{PR} \geq 0$, and

thus $1/\phi qKP<1$. It can be seen that the profit of the property rights maintenance department is a strictly increasing function of the price of the resource product. Therefore, the intensity of property right maintenance can be explained by profit function and the number of property right protection workers.

2.5.2.1 definition and solution of $\bar{P}(N_{PR})$

We define $\bar{P}(N_{PR})$ as the market price of renewable resource products when the profit of the property right protection sector is zero. In this case, the effect of zero economic protection intensity is the same as that of high economic protection intensity, i.e. $R_F^*(\bar{P})=0$. Thus, the solution to this function becomes:

$$\bar{P}(N_H)=\frac{(2qN_H-r)+2\sqrt{qN_H(qN_H-r)}}{\phi rqK} \tag{22}$$

2.5.2.2 Definition and solution of $P_A^{PR}(N_H)$

$P_A^{PR}(N_H)$ is defined as the balanced price of renewable resource products when the total domestic need is equal to the total domestic supply in closed economy. The balanced price is

$$P_A^{PR}=\frac{-(r+2q(N-N_H))\phi\beta-\sqrt{(2\phi\beta q)^2(N-N_H)^2+4rq\phi^2\beta^2(N-N_H)+r^2}}{\phi qkr(\phi\beta-1)} \tag{23}$$

2.5.2.3 Definition and processing of N_H^*

N_H^* is defined as the amount of employment in resource production department when $P_A^{PR}(N_H)=\bar{P}(N_H)_1$. By simplification, we have

The balanced resource department employment amount:

$$N_H^* = \left[r + 2\phi q\beta N + \sqrt{(2\phi q\beta N)^2 + r}\right]^2 / 4q(2\phi q\beta N + \sqrt{(2\phi q\beta N)^2 + r}) \tag{24}$$

The property right protection employment amount:

$$N_{PR}^* = \left[r + 2\phi q\beta N + \sqrt{(2\phi q\beta N)^2 + r}\right]^2 / 4q(2\phi q\beta N + \sqrt{(2\phi q\beta N)^2 + r}) - \frac{r}{2q}(1 + \frac{1}{\phi qKP}) \tag{25}$$

Through analysis of(22)-(24),we acquire the following propositions.

Proposition 1

As N_H^* is predetermined, $N_{PR}^* = N_H^* - \frac{r}{2q}(1 + \frac{1}{\phi qKP})$ remains as a fixed value. The endogenesis of property right maintenance intensity is decided by the total amount of employment N_H in the resource sector. When $r/2q < N_H < N_H^*$ ($0 < N_{PR} < N_H^* - (r/2q)(1+1/\phi qKP)$),full maintenance is adopted; and when $N_H^* < N_H < N$ ($N_H^* - (r/2q)(1+1/\phi qKP) < N_{PR} < N_H$), zero maintenance is executed.

We plot the relationship curves between the two different prices and N_H in Figure 1.

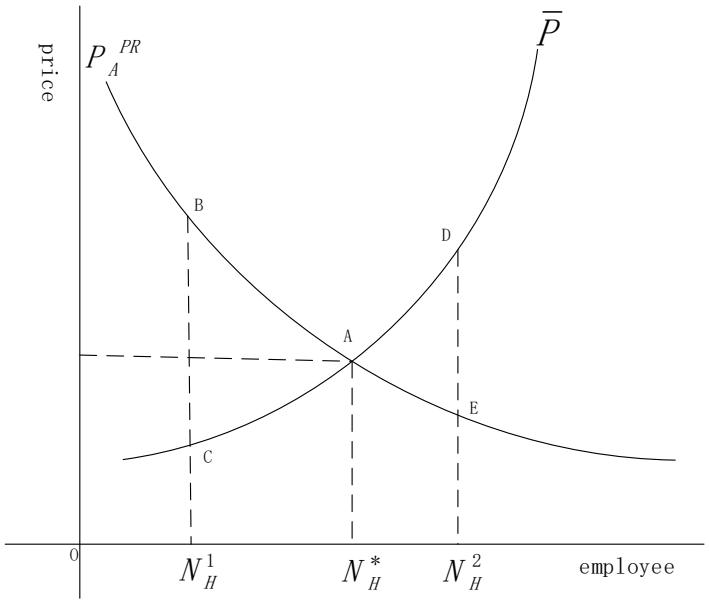

Fig. 1. Relationship Curve between Price and N_H

$P_A^{PR}(N_H) = \bar{P}(N_H)$, N_H^* is the cross point A of the two price curves. $P_A^{PR}(N_H)$ is strictly decreasing, while $\bar{P}(N_H)$ is strictly increasing. On the left of A, $r/2q < N_H < N_H^*$, $0 < N_{PR} < N_H^* - (r/2q)(1+1/\phi qKP)$, $\bar{P}(N_H) < \bar{P}(N_H^*)$, $P_A^{PR}(N_H) > P_A^{PR}(N_H^*)$, and $\bar{P}(N_H) < P_A^{PR}(N_H)$. According to point B and point C, full maintenance is preferred to be executed in the closed economy. On the right side of point A, $N_H^* < N_H < N$, $N_H^* - (r/2q)(1+1/\phi qKP) < N_{PR} < N_H$, $\bar{P}(N_H) > \bar{P}(N_H^*)$, $P_A^{PR}(N_H) < P_A^{PR}(N_H^*)$, and $\bar{P}(N_H) > P_A^{PR}(N_H)$. According to point D and point E, property right maintenance is preferred not to be executed in the closed economy.

Proposition 2

(1) higher resource prices lead to strong property rights maintenance intensity; (2) higher resource prices lead to strong property rights maintenance intensity; (3) higher economic growth, (4) The greater the proportion of income provided by the producers of resource products to the property rights maintenance department, the greater the intensity of property rights maintenance.

When there is internal solution in the closed economy, several laws can be obtained according to equation (12): (1) the higher the growth rate of renewable resources is, the higher the property right maintenance intensity is; (2) higher price of resource products results in more intense property right protection; (3) the rise in the effective labor employment rate ($N_H - N_{PR}$) in the resource sector will weaken the intensity of property right maintenance; (4) the larger the income proportion ϕ provided to the property right maintenance sector by the resource product manufacturer is, the stronger the property right maintenance is.

2.6 graphical analysis of resource exploitation, resource price and selection of property maintenance intensity

We convert the equation (11) into $X_{1PR}^S(P) = rK/4 - r/4\phi^2 q^2 KP^2$, and the maximum amount of resource exploitation will not exceed $rK/4$. The first-order derivative of resource product price versus equation(11) is $\partial X_{1PR}^S / \partial P = (r/2\phi^2 q^2 K) \cdot P^{-3} > 0$, which means that when the property right

intensity is fixed, the amount of resource exploitation is the strictly increasing function of resource product price.

The first-order derivative of property right maintenance variable ϕ versus equation(11) is $\partial X_{1PR}^{S} / \partial P = (r / 2\phi^2 P^2 K) \cdot \phi^{-3} > 0$, which means that when the resource product price is fixed, the amount of resource exploitation with high property right maintenance intensity is larger than that with week property right maintenance.

The first-order derivative of resource product price versus equation(21) is $\partial X_1^O / \partial P = (2 - qKP) / q^2 kP^3$. We let $\partial X_1^O / \partial P = 0$, and then $P^* = 1/qK$. In zero maintenance intensity, the amount of resource exploitation is maximized as $rK/4$.As equation (21) shows the hidden relationship $P > 1/qK$, we have $1/qK < P < 2/qK$, $\partial X_1^O / \partial P > 0$,and the amount of resource exploitation is increasing; when $P > 2/qK$, $\partial X_1^O / \partial P < 0$, the amount of resource exploitation is decreasing. The follow-up graphical representation of the amount of resource exploitation and the price of resource product price is plotted under the guidance of these principles.

We let P^I be the price determined when the exploitation amount of renewable resources in zero maintenance is equal to that in full maintenance. Thus, in the balanced state of closed economy, we have $P^I = (2\phi + 1) / \phi qK$.

$\overline{P}(N_{PR})$ is the balance condition between zero maintenance and full maintenance, and thus there are three possibilities: $P^I < \overline{P}(N_{PR})$、 $P^I = \overline{P}(N_{PR})$、 $P^I > \overline{P}(N_{PR})$. Preposition 2 implies that if the market price of resource products exceeds $\overline{P}(N_{PR})$, the full maintenance Intensity is executed; or otherwise the zero maintenance Intensity is executed. If $P^I = \overline{P}(N_{PR})$, the resource owner is on the critical point of execution of property right maintenance Intensity; If $P^I < \overline{P}(N_{PR})$, strong property right maintenance Intensity is executed. The amount of resource exploitation in non-zero intensity of property rights maintenance is indicated by the solid line jumping upward at point D. The amount of resource exploitation in zero intensity of property rights maintenance is indicated by the solid line cutoff at point C. The broken line represents the in-feasible exploitation amount, as shown in Figure 3. If $P^I > \overline{P}(N_{PR})$, week property right maintenance is executed. The amount of

resource exploitation in non-zero intensity of property rights maintenance is indicated by the solid line jumping upward at point A. The amount of resource exploitation in zero intensity of property rights maintenance is indicated by the solid line cutoff at point B. The broken line represents the in-feasible exploitation amount, as shown in Figure 2.

2.6.1 Selection of low-cost property rights maintenance intensity

If the price of resource products (P_A^{PR}) satisfies $1/qK < P_A^{PR} < \bar{P}(N_{PR})$,zero maintenance intensity of property rights is selected for closed economy; If $\bar{P}(N_{PR}) < P_A^{PR} < P^I$ or $\bar{P}(N_{PR}) < P^I < P_A^{PR}$, week property right maintenance Intensity is selected for closed economy. Figure 2 shows the corresponding law.

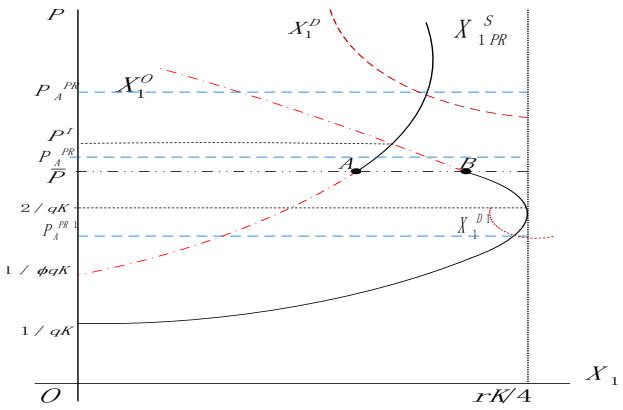

Fig. 2. Diagram of Selection of Low-cost Property Right Maintenance Intensity

2.6.2 Selection of high-cost property right maintenance (as shown in Figure 3)

If the price of resource products (Pc) satisfies $1/qK < P_A^{PR} < \bar{P}(N_{PR})$,zero maintenance intensity of property rights is selected for closed economy; If $P^I < \bar{P}(N_{PR}) < P_A^{PR}$, high property right maintenance intensity is selected for closed economy. Figure 3 shows the corresponding law.

The choice of the intensity of property rights maintenance in a closed economy is determined by the market price of endogenous resource products. As long as the market price of resource products falls within the interval $(1/qK, 1/\phi qK)$, the property right regime with zero maintenance intensity is a must-to-be choice. In addition, privatized property right regime is

adopted in the closed economy, whose property right maintenance intensity (low, high, zero) is determined according to the relationship between the market price P_A^{PR} of resource products, P^I and $\overline{P}(N_{PR})$.

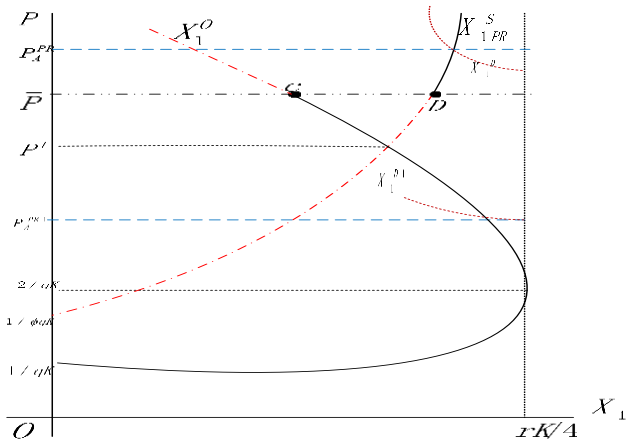

Fig. 3. Diagram of Selection of High-cost Property Right Maintenance Intensity

3. The relationship between trade liberalization and the selection of resource exploitation and property rights maintenance intensity in small country

In this section, in the condition of intense property right maintenance, we study the effect of global price of resource products on the selection of resource exploitation, resource stock and property rights maintenance intensity in small country.

3.1 Low-cost property rights maintenance intensity

Resource products enter the international market to compete, and thus their prices are determined exogenously. Meanwhile, the maintenance intensity of resource property rights, resource stock, and the level of steady state are subject to exogenous factors. We assume that the initial international price of resource products is P^W, and that the adjusted price is P^{W1}. When $P^W > \overline{P}$, we analyze the condition that the global price of resource products is gradually decreasing, and accordingly deduct preposition 3.

Preposition 3

The closed economy is in a steady balance, and the maintenance intensity of the property right system is low. When the international price of resource products drops from P^W to P^{W1}:

(1) When $\overline{P} < P_A^{PR} < P^W$ and the international price of resource products drops from P^W to P_A^{PR}, the amount of resource exploitation will fall down, and the resource stock increases; resource products are exported, albeit in less amount; when the price continues to drop to $\overline{P}$ ($\overline{P} < P^{W1} < P_A^{PR}$),the amount of resource exploitation constantly inclines, and the resource stock continues rising; and the resource products are imported to the small country in a larger amount.

(2) When $P^F < P^{W1} < \overline{P}$ and the property right system of zero maintenance intensity is adopted in the economic body, as the global price of resource products decreases, the amount of resource exploitation increases first, peaking at $rk/4$, and then gradually decreases until hitting the bottom at $X_1^{PR}(P^W) = X_1^O(P^F)$. Meanwhile, the resource stock decreases first and then increases. Compared to the amount of resource exploitation at point E, namely $X_1^{PR}(P^W) = X_1^O(P^F)$, as long as the global price of the resource products $P^{W1} \in (P^F, \overline{P})$,the resource is overly exploited and the resource stock plummets; when $P^{W1} < P^F$, the amount of resource exploitation decreases, and the resource stock increases.

(3) The cross-point at $P^{W1} = \overline{P}$ marks the shift from low-intensity property right maintenance to zero maintenance for the economic body. Preposition 3 is clearly embodied in Figure 4.

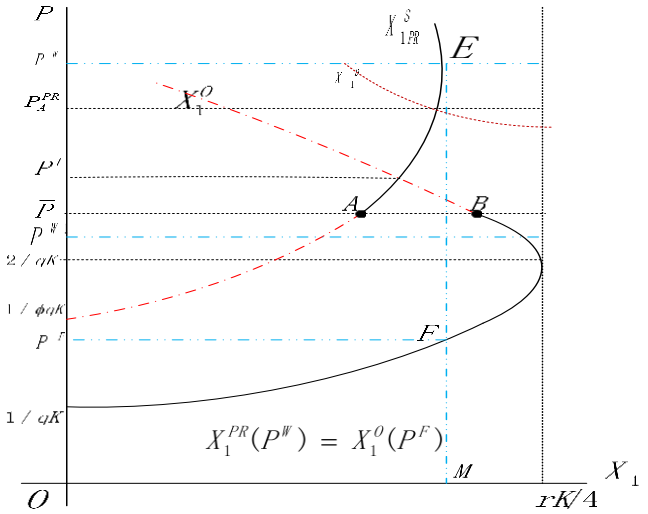

Fig. 4. Diagram of Selection of Low-cost Property Maintenance Intensity in Free Trade

3.2 High-cost property right maintenance intensity

We now focus on strong property right maintenance. On the premise that $P^W > \overline{P} > P^{W1}$, we study the effect of the decrements in the global price of exogenous resource products on selection of property right maintenance intensity, resource production manufacture and resource stock. As shown in Figure 5, the resource exploitation function in zero maintenance is cut off at point C, the resource exploitation function in high-intensity maintenance is cut off at point D. This figure is different from Figure 4 in terms of P^W. The amount of resource exploitation in high-intensity property right is $X_{1PR}^S(P^W)$. There are two prices in zero maintenance, i.e. $P^H = 2\phi P^W/(\phi qKP^W - 1)$ and $P^J = 2\phi P^W/(\phi qKP^W + 1)$. They share the same amount of exploitation $X_1^O(P^H) = X_1^O(P^J)$.

There are three different intervals for the change of global prices of resource products: (1) $P^{W1} \in (P^H, P^W)$;(2) $P^{W1} \in (P^J, P^F)$;(3) $P^{W1} \in (1/qk, P^J)$.The amount of resource exploitation in the interval (2) is larger than $X_{1PR}^S(P^W)$, and the resource stock is smaller than $S_e^{PR}(P^W)$; the amount of resource exploitation in the interval (1) and (3) is smaller than $X_{1PR}^S(P^W)$, and the resource stock is larger than $S_e^{PR}(P^W)$. Such being the case, we continue to proposition 4.

Proposition 4

A balanced small country, whose property right maintenance is high and who has a closed economy, is participating in global competition. When the international price of the exogenous resource product drops from P^W to P^{W1},and $P^{W1} < \overline{P} < P^W$,then

(1)when $\overline{P} < P_A^{PR} < P^W$ and the international price decreases from P^W to P_A^{PR}, the amount of resource exploitation will fall down, and the resource stock increases; resource products are exported, albeit in less amount; when the price continues to drop to $\overline{P}$ ($\overline{P} < P^{W1} < P_A^{PR}$),the amount of resource exploitation constantly inclines, and the resource stock continues rising; but the resource products are imported to the small country in a larger amount. These trends tie in with (1) in proposition 3. $P^H < P^{W1} < \overline{P}$, the amount of resource exploitation is low and the resource stock increases in the new balanced state.

(2)The global price of resource products drop down to P^{W1}, $P^{W1} \in (P^J, P^F)$. As the value of P^{W1} decreases, the amount of resource exploitation first increases and then decreases, with the top of $rK/4$ ($P^{W1} = 2/qK$). Meanwhile, the resource stock declines first and then inclines. Compared to the initial P^W state, the exploitation amount of resource products is larger than $X_{1PR}^S(P^W)$, and resource stock is lower than $S_e^{PR}(P^W)$.

(3) $P^{W1} \in (1/qk, P^J)$, the exploitation amount of resources become less, and resource stock is enlarged.

(4)The cross-point $P^{W1} = \overline{P}$ at marks the shift from high-intensity property right maintenance to zero maintenance for the economic body. Preposition 4 is clearly embodied in Figure 5.

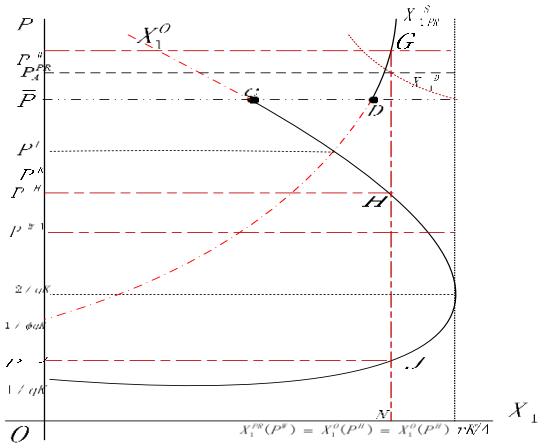

Fig. 5. Diagram of Selection of High-cost Property Maintenance Intensity in Free Trade

4. Conclusion

Based on the model of Brander and Taylor (1997a, b) and Francis (2005), this paper introduced a notion of property right protection sector whose function is to guard against theft with the collection proportion of resource exploitation income. By using the supply and demand theory of resource products, the utility maximization theory for both individuals and the society, and the company profit maximization theory, we studied the selection law of exploitation, stock and property right maintenance intensity of renewable resources in closed economy and trade liberalization.

In closed economy, economic decides the intensity of property rights maintenance endogenously. If $P_A^{PR} < \overline{P}$, zero intensity of property right maintenance is adopted; if $P_A^{PR} > \overline{P}$, full intensity of property right maintenance is used. The cost of property right maintenance intensity is controlled by the value of P^I and $\overline{P}$. When $P^I < \overline{P}$, low-cost property right maintenance intensity is used; when $P^I > \overline{P}$, high-cost property right maintenance intensity is our choice of preference; the condition of $P^I = \overline{P}$ is neglected in this paper due to the difficulty to realize. From the perspective of the number of resource protection employees, we find that for the same issue, the selection of property right maintenance intensity is endogenously decided by N_H^*. When $r/2q < N_H < N_H^*$ ($0 < N_{PR} < N_H^* - (r/2q)(1+1/\phi qKP)$), we adopt the full-intensity property right maintenance; when $N_H^* < N_H < N$ ($N_H^* - (r/2q)(1+1/\phi qKP) < N_{PR} < N_H$),we use zero-intensity property right maintenance. When $\overline{P} < P_A^{PR} < P^I$, the amount of resource exploitation and resource stock in low-cost property right maintenance intensity are respective smaller and larger than those in zero-intensity property right maintenance; when $\overline{P} < P^I < P_A^{PR}$,the amount of resource exploitation and resource stock in low-cost property right maintenance intensity are respective larger and smaller than those in zero-intensity property right maintenance.

Under trade liberalization and privatized property right system, if the global price of resource products drops to $\overline{P}$, the property right maintenance regime with zero maintenance should be selected for the endogenous economy. When the global price of resource product is P^W, the economy is balanced and steady. Compared to this, in low-cost property right maintenance intensity, if $P^{W1} \in (P^F, \overline{P})$, the resources will be overly exploited, and the resource stock may decrease and even return to zero; if $P^{W1} \in (1/qK, P^F)$,the resource exploitation amount and resource stock will decrease and increase, respectively. Compared to the initial state, if $P^{W1} \in (P^J, P^H)$, the resources will be overly exploited, and the resource stock may decrease and even return to zero; if $P^{W1} \in (P^H, \overline{P}) \cup (1/qK, P^J)$, the resource exploitation amount and resource stock will decrease and increase, respectively.

5. Discussion

Despite some similarities, our research is different from the two discussion papers of Jinji (2007) [10] and Zhanghan (2010) [11] in that: (1) in terms of system variables, Jinji (2007) and Zhanghan (2010) used a fixed number of employees to fight against pilferage, while our employees are a dynamic parameter that is linked to the degree of pilferage seriousness; (2) in terms of analysis perspective, we only studied the selection of property right maintenance intensity and the comparative statics of resource exploitation amount and resource stock under the closed economy and trade liberalization, while Jinji (2007) and Zhanghan (2010) analyzed the relationship between endogenization, trade and welfare in the property right system.

Based on the critical point conditions of property right system by Jinji (2007) and Zhanghan (2010), we set up a continuous system variable N_{PR} which is different from that of Hottel et al.(2000). We study the selection of resource exploitation amount, resource stock level, and property right maintenance intensity in balanced economy and trade liberation, and the research results are somewhat similar to the result of Jinji (2007) and Zhanghan (2010). Nevertheless, our starting points and configuration of system variables are different from theirs, in that we emphasize on the shift of property right maintenance intensity and its conditions as well as the comparative statics of resource stock and resource yields, which is done when the economic body is in the general status of privatized property right system. The conclusion drawn from this highly-simplified analysis is inevitably partial. However, our research findings are greatly helpful for those who attempt to have a clear understanding of resource dynamics and the change law of property right maintenance intensity.

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