International Trade and Terrestrial Open-access Renewable Resources in a Small Open Economy*

Naoto Jinji†

Hitotsubashi University

This version: July 29, 2003

Abstract

This paper investigates effects of trade liberalization and policies on deforestation. The analysis is conducted by extending a small open economy model with open-access renewable resources developed by Brander and Taylor (1997a). This paper endogenizes the carrying capacity of the renewable resource by linking it to the "base resource," e.g., land. Unlike Brander and Taylor (1997a), trade liberalization may increase the forest stock in the resource abundant country and may decrease the forest stock in the resource scarce country. It is also shown that policies primarily aimed at protecting forest stock, such as import restrictions by importing countries and forest certification for well-managed forest, may have perverse effects on the forest stock.

Keywords: deforestation; forest certification; open-access resources; renewable resources; small open economy; trade sanctions.

JEL classification: F10; Q20.

*I would like to thank seminar participants at Yokohama National University for helpful comments and suggestions on an earlier version of the paper. Any remaining errors are my own.

†Faculty of Economics, Hitotsubashi University, 2-1 Naka, Kunitachi, Tokyo 186-8601, Japan. Phone: +81-42-580-8505. Fax: +81-42-580-8882. E-mail: njinji@econ.hit-u.ac.jp

1 Introduction

Deforestation is currently one of the most important environmental issues in the world. Deforestation substantially increased in the 1980s, with the overall rate doubling from 0.6 per cent in 1980 to 1.2 per cent in 1990 (Barbier *et al.*, 1994). While annual deforestation rates decreased in 1990s, 9.4 million hectare of forest disappeared from the earth during 1990-2000 (FAO, 2003). Estimated annual deforestation rates during 1990-2000 are 0.8 per cent for Africa, 0.4 per cent for Latin America, and 0.1 per cent for Asia (FAO, 2003). There is a suspicion that trade liberalization has contributed to the acceleration of deforestation.

The main purpose of this paper is to examine impacts of international trade and policies on the stock of forest. This investigation is in line with the literature on international trade and renewable resources. Early papers dealing with the issue include McRae (1978) and Tawada (1982). More recently, Brander and Taylor (1997a, b; 1998) have analyzed a Ricardian general equilibrium model with open-access renewable resource. Their analysis is a general equilibrium extension of the Gordon (1954) - Schaefer (1957) model in open economies. Brander and Taylor (1997a) have shown, for example, that trade liberalization causes a decrease in the resource stock in the relatively resource abundant country and an increase in the resource stock in the relatively resource scarce country.

Although Brander and Taylor's findings are very interesting, their findings might not be applied to renewable resources in general. Especially, as long as forest resources are concerned, some of them are not satisfactory, although Brander and Taylor (1997a) write in their introduction that their interests are in deforestation. The main reason is that they describe the basic structure of renewable resource growth by a fishery model

$$\frac{dH}{dt} = G(H) - F,$$

where H is the resource stock, $G(H)$ is the natural rate of growth, and F is the harvest rate. This formula has been developed mainly in the fishery economics literature.[1] In this model, degradation of the resource stock is entirely caused by high demand for the resource good. As long as the forest resource is concerned, however, the extinction of the resource stock, i.e., deforestation, may occur not only because of over-exploitation of the resource, but also because of conversion of forestlands into other land use, e.g., agricultural land. Therefore, a reduction in harvest does not necessarily lead to higher level of the resource stock. In fact, as many case studies have emphasized,[2] large part of deforestation in the last couples of decades has been resulted from the conversion of forestlands to other land use rather than over-cutting of woods. In the Brander-Taylor model, however, there is no possibility of resource degradation due to the conversion of land use.

In this paper, I extend the Brander and Taylor model by endogenizing the maximum possible size of the resource stock, or the "carrying capacity" of the resource. That is, I assume the carrying capacity of the resource depends on the "base resource," which supports the renewable resource stock. For example, for fish, river or ocean water is indispensable. Forest cannot exist without land. Since I am interested in forests, I

[1] See, for example, Munro and Scott (1985) and Clark (1990).

[2] See, for example, Repetto and Gillis (1988), Brown and Pearce (1994), and Barbier *et al.* (1994).

interpret the environment on which the carrying capacity of the resource depends as land. This idea is not new in the literature. Contribution of land to the growth of terrestrial renewable resources has been recognized in the literature on biodiversity (Swanson, 1993, 1994; Schulz, 1996; Schulz and Skonhoft, 1996; Barbier and Schulz, 1997; Schulz and Barbier, 1997). The analysis in this paper is different from the existing papers in the following respects. Unlike Schulz (1996) and Swanson (1993), I analyze general equilibrium effects of trade and trade policies rather than partial equilibrium. Moreover, unlike Schulz (1996), Barbier and Schulz (1997), and Schulz and Barbier (1997), I analyze decentralized market equilibrium with open-access to the resource rather than social planner's case.

Effects of policies on the resource stock are also important issues. There are two important policy issues related to deforestation. The first issue is import restrictions, such as import bans and consumers' boycott. Many environmentalist groups advocate a boycott of tropical timber as a means of combating deforestation in developing countries. However, some people (e.g., Vincent (1990) and Barbier and Rauscher (1995)) argue that import bans are ineffective way of protecting forest stock or might even have increase deforestation. The reasons behind this argument are as follows. First, most (approximately 80 per cent) of the timber extracted is consumed domestically in developing countries rather than exported. Second, demand for timber seldom causes deforestation. Deforestation is likely to result from demand for land as fields, farms, and so on. Although in the short run an import ban may reduce pressure on tropical forests, in the medium and long run a ban would reduce the value derived from timber production by decreasing the gains from trade. As a result, the incentives for tropical forest countries to maintain forest stock decrease. This would lead these countries to decide to convert more forests to alternative uses such as agriculture.

The second issue is forest certification. Forest certification is a relatively new tool for protecting forest. Some third-party organizations set standards for certifying wood products.[3] The certification is awarded only for those products from forests that are managed in a sustainable way. While producers of wood products voluntarily apply for the certification, manufacturing firms and retailers increasingly require products to be certified. Although economic and trade issues related to forest certification have been recognized (e.g., Haener and Luckert, 1998; Tallontire and Blowfield, 2000), there have been only a few attempts on theoretical and empirical investigations on forest certification.[4]

The main results in this paper are as follows: First, unlike Brander and Taylor (1997a), trade liberalization may increase the steady-state level of the forest stock in the relatively resource abundant country and may decrease the steady-state level of the forest stock in the relatively resource scarce country, compared to their stock level

[3]The Forest Stewardship Council (FSC) is the largest international organization for forest certification, launched in 1993. The forest area certified by FSC is 38.25 million hectare as of July 2003, according to FSC's web page (http://www.fscoax.org/). The Pan-European Forest Certification (PEFC) Council is another large European-based forest certification body, launched in 1999. The forest area certified by PEFC is 48.16 million hectare as of June 2003, according to PEFC's web page (http://www.pefc.org/). There are also many other regional and national forest certification schemes.

[4]Swallow and Sedjo (2000) analyze a closed-economy model of forest certification and show that forest certification may cause unsustainable management of forest. Murray and Abt (2001) run simulation to estimate price premium for certified timber.

in autarky steady-state. Second, policies, such as import bans of the forest good by importing countries and forest certification for well-managed forest, may have perverse effects on the forest stock. While these policies are primarily aimed at protecting forest stock, they may actually reduce the forest stock.

The rest of the paper is organized in the following way. Section 2 sets up the model. Section 3 briefly examines the autarky equilibrium. Section 4 analyzes trade and policy effects on the resource stock in a small open economy. Section 5 concludes.

2 The model

2.1 Production and Supply

Consider a country that consists of two sectors: renewable resource extraction (or forestry) sector and agricultural sector. The forestry sector supplies the forest product or timber, F, and the agricultural sector supplies the agricultural product, A. There are two production factors: labour, L, and land, S.

The model that describes the dynamics of renewable resource is the same as the model employed in Brander and Taylor (1997a) except for that I endogenize the maximum possible size for the resource stock, K. I assume that the "carrying capacity" of the forest stock is proportional to the area of forestland, S_F, and given by

$$K = \kappa S_F, \tag{1}$$

where κ is a positive constant. Then, resource dynamics is given by

$$\frac{dH}{dt} = \phi(H, S_F) - F, \tag{2}$$

where H is the stock of forest, F is the harvest rate, or timber production, and $\phi(H, S_F)$ is the natural growth rate, which is assumed to be a logistic function:

$$\phi(H, S_F) = rH\left(1 - \frac{H}{\kappa S_F}\right), \tag{3}$$

where r is called the "intrinsic" growth rate.

Production or harvest of timber is given by the Schaefer production function:

$$F = \eta H L_F, \tag{4}$$

where η is a positive constant and L_F is labour employed in the forestry sector.

All the forest is owned by the government. However, since the enforcement of property rights by the government is incomplete, people treat the forestland just like open-access resources. That is, people have access to the forest without paying the rent of the land. However, people cannot claim the private property right over the forestland. This means that though people can harvest the standing timber without paying any fee, they cannot own the land.

Let p be the price of timber. Then, competitive profit maximizing firms with free entry condition yield

$$p = \frac{w}{\eta H} \tag{5}$$

where w is wage rate.

The agricultural product is produced using labour and land as inputs. The production function in the agricultural sector is given by

$$A = L_A^{\alpha} S_A^{1-\alpha}, \tag{6}$$

where $0 < \alpha < 1$, A is agricultural output, S_A is agricultural land, and L_A is labour in the agricultural sector. Agricultural land must be converted from forestland by using labour:

$$S_A = \gamma L_C, \tag{7}$$

where γ is a positive constant and L_C is labour employed for clearing forestland.[5] If one converts forestland into agricultural land, he can claim the property right over the converted land. This means that the private property right is well defined in the agricultural sector. The land can be employed in agricultural production by paying rental rate per unit of land, c. Zero profit condition for land clearance yields

$$c = w/\gamma. \tag{8}$$

The production in the agricultural sector is carried out by competitive profit maximization under free entry condition. Then, the first-order condition for profit maximization and Eq. (8) yield

$$L_C = \frac{1-\alpha}{\alpha} L_A. \tag{9}$$

I normalize price of agricultural good to 1. Substitute Eqs. (7) and (9) into Eq. (6) to obtain

$$A = \theta L_A, \tag{10}$$

where $\theta \equiv [(1-\alpha)\gamma/\alpha]^{1-\alpha}$. From zero profit condition in the agricultural sector I obtain

$$w = \alpha\theta. \tag{11}$$

[5] For simplicity, I assume that in order to convert each plot of land all the standing trees should be burned and that one cannot sell timber on that land.

Since labour moves freely between the two sectors, both sectors must pay the same wage. Thus, substituting Eq. (11) into Eq. (5) gives

$$p = \frac{\alpha\theta}{\eta H}. \tag{12}$$

2.2 Utility and Demand

I assume identical households. A representative household is endowed with one unit of labour and consumes the forest good and the agricultural good. The utility function of the representative household is given by

$$u(f, a) = f^{\beta} a^{1-\beta} \tag{13}$$

where f is consumption of the forest good, a is consumption of the agricultural good, and $0 < \beta < 1$. Then, the aggregate demands for the forest and agricultural goods are respectively given by

$$F^d = \beta wL/p, \tag{14}$$

$$A^d = (1-\beta)wL. \tag{15}$$

3 Autarky Equilibrium

3.1 Temporary Equilibrium

Here I examine the autarky equilibrium. I first look for the temporary equilibrium. At a given moment the level of forest stock, H, is given. The full employment conditions are given by

$$L = L_F + L_A + L_C, \tag{16}$$

$$S = S_F + S_A. \tag{17}$$

Equating the supply of and the demand for the forest good (Eqs. (4) and (14)) with equilibrium wage (11) and price (12) yields

$$L_F^a = \beta L. \tag{18}$$

Substitute Eqs. (9) and (18) into Eq. (16) to yield

$$L_A^a = \alpha(1-\beta)L, \tag{19}$$

$$L_C^a = (1-\alpha)(1-\beta)L. \tag{20}$$

Then, substituting Eq. (18) into Eq. (4) gives

$$F = \eta H \beta L. \tag{21}$$

Also, substituting Eq. (20) into Eq. (7) gives

$$S_A^a = (1-\alpha)(1-\beta)\gamma L. \tag{22}$$

Substituting Eq. (22) into Eq. (17) yields

$$S_F^a = S - (1-\alpha)(1-\beta)\gamma L. \tag{23}$$

I assume that $S > (1-\alpha)(1-\beta)\gamma L$. Then, substitute Eq. (19) into Eq. (10) to obtain

$$A^a = \theta\alpha(1-\beta)L. \tag{24}$$

3.2 Steady States

Steady state is determined by $dH/dt = 0$. Equating the resource growth rate given by Eq. (3) and the harvest rate given by Eq. (21) yields

$$rH\left(1 - \frac{H}{\kappa S_F}\right) = \eta\beta L H. \tag{25}$$

Solving for H yields $H = 0$ or $H = H^a$, where

$$H^a = \kappa \left\{ S - (1-\alpha)(1-\beta)\gamma L \right\} \left(1 - \frac{\eta\beta L}{r} \right). \tag{26}$$

If the steady state resource stock is given by H^a, then the corresponding steady state autarky price, p^a, is obtained by substituting Eq. (26) into Eq. (12), which yields

$$p^a = \frac{\alpha\theta}{\eta H^a}. \tag{27}$$

Also, substituting Eq. (26) into Eq. (21) gives the steady-state autarky harvest:

$$F^a = \eta\beta L H^a \tag{28}$$

Note that since consumption and production of agricultural good are unaffected by the resource stock adjustment, the steady-state autarky level of agricultural good is given by Eq. (24).

Conditions for the existence of a steady-state autarky solution with a positive resource stock are given by $r/L > \eta\beta$ and $S/L > (1-\alpha)(1-\beta)\gamma$.

4 The Small Open Economy

I now examine a small open economy. The small country takes the world relative price, p^w, as given. I assume that the country is initially at the autarky steady state. There are two cases to consider. One case is that the small country is relatively resource abundant and hence $p^w > p^a$ holds. The other case is that the small country is relatively resource scarce and hence $p^w < p^a$ holds.

4.1 Resource Abundant Country

First, assume that the small country is relatively resource abundant. Then, it holds that $p^w > p^a$. Since the small country is initially at the autarky steady state, the resource stock is at the level of H^a. At this level of resource stock, by facing with a relatively higher world relative price, the value of marginal product of labour in the forestry sector becomes higher than the wage in the agricultural sector, i.e.,

$$p^w \eta H^a > w = \alpha\theta. \tag{29}$$

As a result, labour moves from the agricultural sector to the forestry sector since the wage in the forestry sector is equal to the value of marginal product of labour. Temporarily, it hold that $L_A = L_C = 0$ and that $S_A = 0$ and $S_F = S$. Now, resource dynamics leads towards a new steady state with a new steady state level of forest stock, H^z, given by

$$H^z = \kappa S \left(1 - \frac{\eta L}{r}\right). \tag{30}$$

There are two cases to consider, depending on whether the value of marginal product of labour in the forestry sector at H^z is higher or lower than the wage in the agricultural sector. Then, the following proposition is obtained:

Proposition 1 *(i) When the resource abundant country specializes in forest good in the free trade steady state equilibrium, its forest stock may be higher or lower than that in autarky steady state.*

(ii) When the resource abundant country is diversified in the free trade steady state equilibrium, its forest stock is necessarily lower than that in autarky steady state.

Proof. (i) If $p^w \eta H^z > \alpha\theta$, all the labour stays in the forestry sector along the path to the new steady state and at the new steady state. The forest stock then converges monotonically to H^z. In this case, the small country specializes in timber production. H^z may be higher or lower than H^a.

(ii) If $p^w \eta H^z < \alpha\theta$, it is necessarily the case that $H^z < H^a$, and there exists some H^D between H^z and H^a such that

$$p^w \eta H^D = \alpha\theta. \tag{31}$$

On the way to H^z, the economy hits H^D. Since the value of marginal product of labour in the forestry sector becomes equal to the wage rate in the agricultural sector, at H^D workers are indifferent between these two sectors. However, if we still have $L_F = L$, then the resource stock continues to fall and hence the value of marginal product of labour in the forestry sector becomes less than the wage rate in the agricultural sector, which induces all workers to move into the agricultural sector. Thus, by adjusting L_F and S_F the economy converges to a new steady state where the resource stock is H^D. In this case, the economy produces both timber and agricultural good. □

Unlike Brander and Taylor (1997a), trade does not necessarily cause a reduction of the resource stock in the resource abundant country. In fact, when the country specializes in forest good after opening up to trade, the forest stock may be higher than that in autarky. The intuition is that by facing a higher world price of forest good, the value of the forest stock becomes higher. Then, not only more labour but also more land are devoted to the forestry sector.

4.2 Resource Scarce Country

I now turn to the case of the relatively resource scarce country. In this case, it holds that $p^w < p^a$. The small country is again initially at the autarky steady state and the resource stock is at the level of H^a. At this level of resource stock, by facing with a relatively lower world relative price, the value of marginal product of labour in the forestry sector becomes lower than the wage in the agricultural sector, i.e.,

$$p^w \eta H^a < w = \alpha\theta. \tag{32}$$

Then, labour moves away from the forestry sector to the agricultural sector. Temporarily, it holds that $L_F = 0$, $L_A = \alpha L$, and $L_C = (1-\alpha)L$. Then, if $S/L \leq (1-\alpha)\gamma$, the country specializes in agricultural product and its resource stock is extinct. If $S/L > (1-\alpha)\gamma$, the country may specialize in agricultural product or may be diversified. When the country specializes in agricultural product, its resource stock may be higher or lower than that in autarky. The following proposition summarizes trade effects on the resource scarce country.

Proposition 2 *(i) When the resource scarce country specializes in agricultural good in the free trade steady state equilibrium, its forest stock may be higher or lower than that in autarky steady state. It may even be extinct.*

(ii) When the resource scarce country is diversified in the free trade steady state equilibrium, its forest stock is necessarily higher than that in autarky steady state.

Proof. First, if $S/L \leq (1-\alpha)\gamma$, then after opening up to trade it holds that $S_A = S$ and $S_F = 0$. Thus, there is no possibility of regeneration of resource stock. Since

$L_C = S/\gamma$ and $L_A = L - S/\gamma$, it holds that $A = (L - S/\gamma)^{\alpha} S^{1-\alpha}$. Obviously, $F = 0$ in this case. There is no transition.

Second, if $S/L > (1-\alpha)\gamma$, some part of land remains forestland. Now, the agricultural land is temporarily at the level of $\tilde{S}_A = (1-\alpha)\gamma L$ and some land, $\tilde{S}_F$, remains forestland, which is given by

$$\tilde{S}_F = S - (1-\alpha)\gamma L. \tag{33}$$

Since all the labour is temporarily employed in the agricultural sector, nobody harvests timber. As a result, forest stock grows to its maximum possible level with $\tilde{S}_F$:

$$\tilde{H} = \kappa \tilde{S}_F = \kappa \left\{ S - (1-\alpha)\gamma L \right\}. \tag{34}$$

There are two subcases to consider. In the first subcase, if

$$p^w \eta \tilde{H} < w = \alpha\theta, \tag{35}$$

then with the forest stock being at $\tilde{H}$ the value of marginal product of labour in the forestry sector is still less than the wage in the agricultural sector and hence nobody moves back to the forestry sector. In this case, the country produces agricultural good only. The forest stock is at the level of $\tilde{H}$ in steady state. $\tilde{H}$ may be higher or lower than H^a. In the second subcase, if

$$p^w \eta \tilde{H} > \alpha\theta, \tag{36}$$

then when the resource stock grows to $\tilde{H}$, the value of marginal product of labour in the forestry sector becomes higher than the wage rate in agricultural sector. Thus, before the resource stock grows to $\tilde{H}$, some labour moves back to the forestry sector.

As a result, S_A decreases and S_F increases. The economy adjusts L_F and S_F until it reaches a new steady state where the resource stock is at H^D, which is given by Eq. (31). The country produces both timber and agricultural good. In this subcase, H^D is higher than H^a. □

Unlike Brander and Taylor (1997a), under free trade the resource stock in the resource scarce country is not necessarily higher than that in autarky. In an extreme case, it may be extinct. A lower resource stock under free trade may prevail when the country specializes in agricultural good. This is mainly because a lower world price of forest good reduces the value of the forest stock. The lower value of the forest stock causes conversion of land into agricultural land. Therefore, while less people engage in harvesting timber, the size of the resource stock shrinks due to loss in forestland.

4.3 Trade Sanctions

I now turn to analyze effects of trade sanctions on the resource stock in the exporting country of the resource good. Trade sanctions may be in the form of import ban on the forest goods from ill-managed forests or consumers' voluntary boycott of those goods. In my model, these trade sanctions can be seen as an instantaneous decrease in the world price of the forest good. Thus, I conduct comparative statics analysis of a decrease in p^w in the resource abundant country. Here, I compare the forest stock level in steady state under free trade with that after p^w is decreased due to a trade sanction.

First, if the exporting country of the forest good specializes in the forest good, effects of trade sanctions by importing countries on the resource stock are as follows:

Proposition 3 *When the country specializes in forest good in the free trade steady state equilibrium, a trade sanction (i) has no effect on the resource stock if the country continues to specialize in the forest good, (ii) raises the resource stock if the country becomes diversified, and (iii) has an ambiguous effect on the resource stock if the country becomes specialized in the agricultural good.*

Proof. Suppose that the world price of the forest good drops from p^w to $p^{w\prime}$. That is, $p^w > p^{w\prime}$. First, if it still holds that $p^{w\prime}\eta H^z > \alpha\theta$, all the labour stays in the forestry sector and there is no change in the timber production and hence in H^z. Second, if $p^{w\prime}\eta H^z < \alpha\theta$ holds, then there are three subcases to consider. The first subcase is that $S/L > (1-\alpha)\gamma$ and $p^{w\prime}\eta\tilde{H} > \alpha\theta$, where $\tilde{H}$ is defined by Eq. (34). In this subcase, there must exist some $\hat{H}^D > H^z$ such that

$$p^{w\prime}\eta\hat{H}^D = \alpha\theta \tag{37}$$

and the country is diversified. In the second subcase in which $S/L > (1-\alpha)\gamma$ and $p^{w\prime}\eta\tilde{H} < \alpha\theta$. While the country specializes in agricultural good, some land remains forestland. The resource stock in steady state is at $\tilde{H}$, which may be higher or lower than H^z. In the third subcase in which $S/L \leq (1-\alpha)\gamma$, $S_F = 0$ and hence $H = 0$. In this subcase, the country specializes in agricultural good and the resource stock unambiguously falls. □

Thus, a trade sanction has no effect on the forest stock in the specialized resource abundant country if the country continues to specialize in the forest good and may even have perverse effect if the country becomes specialized in the agricultural good. Note that trade sanctions may cause the exporting country of the forest good to become the importer of the forest good.

Second, if the exporting country of the forest good is diversified, effects of trade sanctions by importing countries on the resource stock are as follows:

Proposition 4 *When the country is diversified in the free trade steady state equilibrium, a trade sanction (i) raises the resource stock if the country continues to be diversified, and (ii) has an ambiguous effect on the resource stock if the country becomes specialized in the agricultural good.*

Proof. Suppose, as in the proof of Proposition 3, that the world price of the forest good drops from p^w to $p^{w\prime}$. That is, $p^w > p^{w\prime}$. In the diversified country, initially it must hold that $p^w \eta H^D = \alpha\theta$. Then, by dropping from p^w to $p^{w\prime}$, it must hold that $p^{w\prime}\eta H^D < \alpha\theta$. In order for the country to be diversified at the world price $p^{w\prime}$, there must exist some $\hat{H}^D > H^D$, which is defined by Eq. (37). If the country specializes in agricultural good at the world price $p^{w\prime}$, the forest stock is either at $\tilde{H}$ (Eq. (34)) or $H = 0$. $\tilde{H}$ may be higher or lower than H^D. $\square$

The results in Propositions 3 and 4 contrast sharply with those in the existing papers. First, in Brander and Taylor's (1997a) model, trade sanctions always increase the resource stock in the resource abundant country. By contrast, Swanson (1993) argues that if a renewable resource competes with other economic activities for the base resource, trade bans on the resource goods cause the base resource to be reallocated to other economic activities and then the resource stock to be depleted. Moreover, in a model with the carrying capacity of the renewable resource being a function of land, Schulz (1996) shows that effects of trade sanctions on the resource stock are ambiguous.

The results in the above propositions imply the followings: Unlike Brander and Taylor (1997a), trade sanctions do not always increase the resource stock in the resource abundant country. However, unlike Swanson (1993), trade sanctions *do* work under some conditions. Moreover, unlike Schulz (1996), it can be shown under what conditions trade sanctions do or do not work. The above propositions imply that if a decrease in price of the resource good due to trade sanctions is small, the resource stock in the resource abundant country is likely to increase. If a decrease in price of the resource good due to trade sanctions is very large, on the other hand, the resource stock in the resource abundant country is likely to decrease.

4.4 Forest Certification

Now I investigate effects of forest certification on the resource stock in the relatively resource abundant country. Since forest certification segments markets for certified and uncertified goods, different prices can be given to these two goods. Normally, a price premium is given to certified goods. Thus, in my model, forest certification causes a higher price for certified forest good and a lower price for uncertified forest good. Let p^c and p^u be world prices for certified and uncertified forest goods, respectively. Then, it holds that $p^c > p^w > p^u$.

In order for a forest good to be certified, it must be produced from a forest that is managed in a sustainable way. A forest good produced from an open-access forest is clearly not eligible for a certification. With regard to the definition of "well-managed forests," I simply follow Brander and Taylor's (1997b) definition of "conservationist country." They define the conservationist country as country that controls the harvest of the resource so as to maximize steady-state utility for the representative consumer.

I add one element to Brander and Taylor's definition. That is, in order for the government to enforce the property right of the forest and control the harvest of timber, it must incur some enforcement costs. For simplicity, I assume that the enforcement cost takes a form of some labour cost. That is, the government must employ some fixed number of labour, $\bar{L}_E$, for the enforcement activity. Then, assuming that the country is diversified, the steady-state stock level of the well-managed forest is obtained from the following maximization problem: $\max_H \; U(F, A)$ subject to $F = rH(1 - H/\kappa S_F)$ and $A = \theta L_A = \theta(L - L_F - \bar{L}_E) = \theta(L - r(1 - H/\kappa S_F)/\eta - \bar{L}_E)$. The first-order condition yields the steady-state stock level of the well-managed forest:

$$H^* = \frac{\kappa S_F}{2} + \frac{\theta}{2p^c\eta}. \tag{38}$$

If the net profit in the forestry sector at H^* is positive, a country applies for a certification. Thus, the condition for applying for a certification is given by $\pi^F(p^c, H^*, \bar{L}_E) = (p^c\eta H^* - w)r(1 - H^*/\kappa S_F)/\eta - w\bar{L}_E \geq 0$. If $\pi^F(p^c, H^*, \bar{L}_E) < 0$, on the other hand, the country does not apply for a certification and the forest in the country remains open-access.

Here, I first examine the case of the diversified resource abundant country. At the end of this subsection, I briefly discuss the case of the specified resource abundant country. Consider first the case in which the diversified resource abundant country obtain a certification. The following results are obtained:

Proposition 5 *When the diversified resource abundant country obtains a certification, an introduction of forest certification (i) necessarily increases the forest stock if the forest stock is over-harvested in the sense that* $H^D \leq \kappa S_F/2$ *before the certification is introduced, and (ii) may reduce the forest stock if the forest stock is not over-harvested before the certification is introduced.*

Proof. Before the forest certification is introduced, the diversified resource abundant country is in its steady state and its forest stock is at H^D, which is defined by Eq. (31). When the country applies for a certification, its forest stock is at H^*, which is given by Eq. (38). From Eq. (38), it is obvious that $H^* > \kappa S_F/2$. Hence, if $H^D \leq \kappa S_F/2$, it clearly holds that $H^* > H^D$. If $H^D > \kappa S_F/2$, on the other hand, it is ambiguous whether $H^* > H^D$ holds. In fact, $H^* < H^D$ if $\theta(\alpha/p^w - 1/2p^c)/\eta - \kappa S_F/2 > 0$. □

The proposition implies that certifying forest does not necessarily guarantee a higher forest stock. If the premium for the certified forest good is very high, the certification encourages harvest of the forest good and may result in a lower forest stock.

Consider next the case in which the diversified resource abundant country does not obtain a certification. In this case, the forest good exported from the diversified resource abundant country is not certified and hence its world price is given by p^u rather than p^c. Consequently, effects of forest certification on the uncertified forest stock are similar to those of trade sanctions in Proposition 4. The following proposition summarizes those effects:

Proposition 6 *When the diversified resource abundant country does not obtain a certification, an introduction of forest certification (i) raises the resource stock if the country continues to be diversified, and (ii) has an ambiguous effect on the resource stock if the country becomes specialized in the agricultural good.*

Proof. Since the country does not apply for a certification, its forest good is not certified and the price of its forest good is given by p^u, which is lower than p^w. Then, the results are directly proved by Proposition 4. □

Thus, an introduction of forest certification may raise or reduce the forest stock in uncertified countries. Forest certification may be more controversial if it causes deforestation in uncertified countries. Note that the proposition implies that if an exporting country of the resource good is uncertified, it may become an importer of the resource good.

So far I have focused on the diversified resource abundant country. Let me briefly discuss the case of the specialized resource abundant country. In the specialized resource abundant country, it is rather difficult to manage forest in a sustainable way if it continues to specialize in the forest good. This is because all the labour is employed for timber harvest and hence there is no room for adjusting the size of the employment unless the government can reallocate some of the labour into another sector or unemployment is allowed. Thus, in order for the (initially) specialized resource abundant country to obtain a certification, it needs to become diversified. This implies that when the (initially) specialized resource abundant country exports a certified forest good, the situation is basically the same as that of the diversified resource abundant country. Similar conditions can be derived for the forest stock to be higher or lower with certification. When the specialized resource abundant country does not obtain a certification, its forest good is uncertified and hence its price is given by p^u, which is lower than p^w. Then, effects of the forest certification on the forest stock are analogous to effects of trade sanctions in Proposition 3. The forest stock may increase, decrease, or remain the same.

5 Conclusions

In this paper, I have examined effects of trade liberalization and some policies on the forest stock in a small open economy. I have extended Brander and Taylor's (1997a) model by endogenizing the maximum possible size of the renewable resource stock. It has been shown that trade liberalization may have some unexpected effects on the forest stock in a small open economy, which are not seen in Brander and Taylor (1997a). That is, liberalizing trade may increase the forest stock in the relatively resource abundant country and may decrease the forest stock in the relatively resource scarce country. This paper has also shown that import bans of the forest good by importing countries and forest certification for well-managed forest may have some unexpected effects on the forest stock. While these policies are primarily aimed at protecting forest stock, they may cause deforestation. Thus, the analysis in this paper suggests that there should be some caution for the use of these policies.

References

[1] Barbier, Edward B., Burgess, Joanne C., Bishop, Joshua, and Aylward, Bruce. 1994. *The Economics of the Tropical Timber Trade*. Earthscan Publications.

[2] Barbier, Edward B. and Rauscher, Michael. 1995. "Policies to control tropical deforestation: trade intervention versus transfers." In Perring, C. et al. (eds.) *Biodiversity Loss: Economic and Ecological Issues*. Cambridge University Press.

[3] Barbier, Edward B. and Schulz, Carl-Erik. 1997. "Wildlife, biodiversity and trade." *Environment and Development Economics* 2: 145-172.

[4] Brander, James A. and Taylor, M. Scott. 1997a. "International trade and open-access renewable resources: the small open economy case." *Canadian Journal of Economics* XXX, No. 3: 526-552.

[5] ——. 1997b. "International trade between consumer and conservationist countries." *Resource and Energy Economics* 30:526-552.

[6] ——. 1998. "Open access renewable resources: trade and trade policy in a two-country model." *Journal of International Economics* 44: 181-209.

[7] Brown, Katarina and Pearce, David W. 1994. *The Causes of Tropical Deforestation*. Vancouver: University of British Columbia Press.

[8] Clark, Colin W. 1990. *Mathematical Bioeconomics: The Optimal Management of Renewable Resources: Second Edition*. New York: John Wiley & Sons.

[9] Food and Agriculture Organization (FAO). 2003. *The State of the World's Forests 2003*. United Nations.

[10] Gordon, H. Scott. 1954. "The economics theory of a common property resource: the fishery." *Journal of Political Economy* 17: 69-77.

[11] Haener, M.K. and Luckert, M.K. 1998. "Forest certification: Economic issues and welfare implications." *Canadian Public Policy* 24(supplement): S83-S94.

[12] McRae, James J. 1978. "Optimal and competitive use of replenishable natural resources by open economies." *Journal of International Economics* 8: 29-54.

[13] Munro, Gordon R. and Scott, Anthony D. 1985. "The economics of fisheries management." in Kneese, Allen V. and Sweeney, James L. eds. *Handbook of Natural Resource and Energy Economics* Vol. II. Amsterdam: North-Holland.

[14] Murray, Brian C. and Abt, Robert C. 2001. "Estimating price compensation requirements for eco-certified forestry." *Ecological Economics* 36(1): 149-163.

[15] Repetto, Robert and Gillis, Malcolm. eds. 1988. *Public Policies and the Misuse of Forest Resources*. Cambridge: Cambridge University Press.

[16] Schaefer, Milner B. 1957 "Some considerations of population dynamics and economics in relation to the management of the commercial marine fisheries." *Journal of the Fisheries Research Board of Canada* 14: 669-81.

[17] Schulz, Carl-Erik. 1996. "Trade policy and ecology." *Environmental and Resource Economics* 8: 15-38.

[18] Schulz, Carl-Erik and Barbier, Edward B. 1997. *Trade for Nature*. Fondazione Eni Enrico Mattei Working Paper Series 80.97.

[19] Schulz, Carl-Erik and Skonhoft, Anders. 1996. "Wildlife management, land-use and conflicts." *Environment and Development Economics* 1: 265-280.

[20] Swallow, Stephen K. and Sedjo, Roger A. 2000. "Eco-labelling consequences in general equilibrium: a graphical assessment." *Land Economics* 76(1): 28-36.

[21] Swanson, Timothy M. 1993. "Regulating endangered species." *Economic Policy* 16: 185-205.

[22] ——. 1994. *The International Regulation of Extinction*. London: MacMillan.

[23] Tallontire, Anne and Blowfield, M.E. 2000. "Will the WTO prevent the growth of ethical trade? Implications of potential changes to WTO rules for environmental and social standards in the forest sector." *Journal of International Development* 12(4): 571-584.

[24] Tawada, Makoto. 1982. "A note on international trade with a renewable resource." *International Economic Review* 23(1): 157-163.

[25] Vincent, Jeffrey R. 1990. "Don't boycott tropical timber." *Journal of Forestry* 88(4); 56.