International Trade and Renewable Resource:

Endogenous Property Rights

Abstract: This paper examines trade patterns and welfare outcome under endogenous property rights. The most interesting result is when facing a lower price for resource good, the small economy may export resource good and import manufacturing. That is trade patterns are affected not only by the property regime in place, but also the change of property regime. With switch of property rights, trade will always be benefit to an autarkic enforced economy, whereas the autarkic open-access economy suffers welfare loss in some special case. Trade sanctions may make things worse.
Key words: Endogenous property rights; International trade; Renewable resource; Property rights; Trade sanction

1. Introduction

Economists are interested in whether trade causes depletion of renewable resources and immizerisation. Many facts have shown there is a relationship between world resources and trade. According to Global Forest Resource Assessment 2005, deforestation continues at an alarmingly high rate-about 13 million hectares per year (FAO, 2006). At the same time, world forest products trade has grown rapidly in volume and value fuelled by world economic growth and falling trade barriers (Zhu et. al, 2001). With a regression analysis, Ferreira (2004) also argues openness is a significant predictor of deforestation under open access.

Nevertheless, several researchers hold opposite viewpoint. Burgess (1993) has stated that only 6% of total tropical roundwood production enters the international trade, and in addition, timber trade can lead to greater net returns for forestry investment, making sustainable management of forest more attractive than deforestation. Lopez and Galinato (2005) find that trade has no significant effect on forest cover in Indonesia and Malaysia.

With regards to welfare, the over-exploitation may result in long run welfare losses, which have been described in Brown (1995) and Lopez (1997).

Chichilnisky (1993, 1994) and Brander and Taylor (1997a, b, 1998) have formalized this anecdotal evidences and developed theoretical model to demonstrate that opening of trade can cause over-exploitation and reduce welfare under open access, whereas the enforced economy always gains from trade. Hannesson (2000) and Jinji (2006) have extended their basic model from "diminishing returns to manufacturing" and "endogenize the carrying capacity" respectively. The former concludes that opening up for trade may result in gains from trade even under open-access diversification, while the latter shows free trade may increase forest stock in resource-exporting countries[1].

All above papers assume that property rights are exogenously and remain unchanged before and after the opening of trade.

[1] For valuable overviews on trade and renewable resources, see Barbier and Bulte (2004) and Bulte and Barbier (2005).

More and more economists, however, have emphasized that in any given economy, the property rights regimes should be modeled endogenously. See Hotte et al., 2000; Karp (2005), Margolis and Shogren (2009). Copeland and Taylor (2009) argue policy analysis based on the assumption of a fixed degree of property rights protection may lead to serious error. In addition, they suggest that securing those rights is the result of a cost-benefit analysis on the part of the private owner. If there are costs associated with property enclosure, ownership will be claimed only as long as the benefits from exploitation exceed the costs of enclosure (Hotte, 2005). This is the focus of this paper.

This paper is based on the classical model developed by Brander and Taylor (1997a, b). We consider the effects of endogenous property rights on trade patterns and welfare outcome for a small open economy. An apparently closely related paper is Francis (2005), in which the fixed cost of enforcement is postulated such that the decision of resources owner is binary: either to enforce the property rights perfectly by paying the fixed cost or not to enforce it at all, i.e. open access.

While Francis (2005) mainly focuses on the effect of trade on the change of property rights, we focus on what the trade patterns and welfare will be under the above effect[2]. To analyze trade patterns, we give the precise conditions that determine the property rights under autarky, which is not mentioned in Francis (2005). Also, we show the effects of trade interventions.

The main results are as follows.

The most striking consequence is that although facing a lower world price for the resource good (comparative disadvantage in resource sector), this economy may export resource good and import manufactures under endogenous property rights. The economic logic behind this is a shift of supply function of resources good, triggered by regime switch, which is referred to as "effects of regime switch on trade patterns".

In addition, the choice of regime in autarky is endogenously determined by the cost of enforcing property rights L_R. There exists a critical value L_R^*, which is fully dependent on parameters of national characteristic, such that the autarkic economy adopts enforcement if $0 < L_R < L_R^*$, while open access is preferred if $L_R^* < L_R < L$. Similarly, there also exists a threshold price $\overline{p}$, such that it is indifferent between the two regimes after trade.

Furthermore, the autarkic enforced economy must enjoy higher trade welfare even trade induces regime switching to open access. Conversely, the autarkic open-access economy may suffer welfare loss after trade even though regime switches from open access to enforcement. This well-known "immiserizing effects of resource enforcement" will happen under some special conditions.

Finally, trade sanctions such as import ban or consumers' boycott may result in

[2] Francis (2005) reports trade patterns and welfare in a special case where the autarkic price under open access and enforcement are the same. It will happen when the curve of RS^R and RS^O intersect (See Figure 1 and 2 in this paper). This paper, however, analyzes the cases where the above two curves doesn't intersect, which is more general.

some unexpected consequences, which make things worse. Alternatively, internalization of external effects from resources may be more effective.

The remainder of the paper is organized as follows. Section 2 sets out basic model. Section 3 investigates the endogenous choice of property rights regime in autarky. Section 4 considers the small open case. Section 5 examines effects of trade sanctions. Section 6 contains concluding remarks.

2. Basic model

2.1 Resource dynamic

Within a given country, the stock of the resource at time t is denoted by $S(t)$. The natural growth rate of the resource, G, depends on the existing stock. The net change in the stock at time t is the natural growth rate, $G(S(t))$ minus the harvest rate, $H(t)$.

$$dS/dt = G(S(t)) - H(t) \tag{1}$$

We omit the time argument hereafter.

As is usual in the previous studies, we assume resource growth is given by a specific functional form of the logistic type:

$$G(S) = rS(1 - S/K) \tag{2}$$

The variable K, referred to as the carrying capacity, is the maximum possible size for the resource stock. The variable r is the intrinsic or uncongested growth rate. See Brander and Taylor (1997a) for more discussion about Eq. 2.

2.2 Production and supply

The country produces and consumes two goods. H is the harvest from a renewable resource. M is some other good, which we refer to as manufactures. Good M is treated as the numeraire whose price is normalized to 1. Aside from the stock of the renewable resource S, there is only one additional factor of production, labor, L. Manufactures are produced using labor as the only input. Using L_M to denote the labor used in manufacturing, we can write

$$M = L_M \tag{3}$$

As the price of good M is 1, it follows that labor's value of marginal product in manufacturing is 1. Therefore, the wage in manufactures sector must equal 1 if manufactures are produced.

On the other hand, the harvest of the resource is carried out according to the Schaefer production function, which is written as follows,

$$H^P = \alpha S L_H \tag{4}$$

where L_H is the amount of labor used in resource harvesting and α is a positive constant, measuring the productivity of labor, with superscript P denoting production.

Productions in both sectors are carried out by competitive profit-maximizing firms

under free-entry.

As in Brander and Taylor (1997a), we mainly focus on the analysis of steady state, where the steady state is defined as a situation in which the resource stock, S, is stationary.

By definition, the steady state harvest of resource is

$$H^P = G(S) = rS\left(1 - S/K\right) \tag{5}$$

Combination Eq.4 and 5 yields steady state stock $S = 0$ or

$$S = K\left(1 - \alpha L_H / r\right) \tag{6}$$

As shown in Brander and Taylor (1997a), a positive steady state solution exists if and only if r/ $L > \alpha\beta$. We assume this condition holds throughout the paper.

With the full employment[3] condition, given by $L = L_H + L_M + L_R$, we have

$$M^P = L - L_R - \left(r/\alpha\right)\left(1 - S/K\right) \tag{7}$$

Dividing Eq. 5 by Eq. 7 allows us to obtain the steady state relative supply of the harvest to manufactures as a function of the steady state stock S:

$$H^P / M^P = [rS\left(1 - S/K\right)]/[L - L_R - \left(r/\alpha\right)\left(1 - S/K\right)] \tag{8}$$

In order to keep our analysis from becoming excessively taxonomic, however, we focus our attention on economies that are diversified in steady state, which also implies[4] that $p > 1/\left(\alpha K\right)$. Furthermore, as Brander and Taylor (1997a,b) have shown that the possibility of one country specializing in good H can be ruled out by assuming $r/L < \alpha$, which is postulated in present paper.

2.3. Utility, consumption and demand

Identical households are assumed. A representative household is endowed with one unit of labor and is assumed to have instantaneous utility given by the following Cobb-Douglas utility function: $u = h^{\beta} m^{1-\beta}$, where h and m represent individual consumption of goods H and M, respectively. Taste parameter β is strictly between 0 and 1($0 < \beta < 1$). Let p denote the price of good H. The instantaneous budget constraint is given by $ph + m = I$, where I is the household's total income, which includes wage income and rents from resources, if any. Aggregate demands for goods H and M are given by

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[3] $L_R = 0$ when the economy chooses an open access regime. This condition is also adopted in Eq.7 and 8.

[4] More precisely, if $p \le 1/\left(\alpha K\right)$, then the marginal value product of labor in the resource sector , which cannot exceed $p\alpha K$, must less than 1. In this case, labor is worth more in manufacturing (where its marginal value product is 1) than in harvesting and no resource good would be produced.

$$H^D = \beta IL / p, \quad M^D = (1-\beta) IL \tag{9}$$

where the superscript D indicates variables in the demand side. Thus we can write the relative demand of the harvest good to manufactures as:

$$H^D / M^D = \beta / \left[(1-\beta) p \right] \tag{10}$$

Furthermore, making use of the indirect utility function, welfare is given by

$$U = CIL / p^{\beta} \tag{11}$$

where $C = \beta^{\beta} (1-\beta)^{(1-\beta)}$ and is a constant.

3. Endogenous choice of property rights in autarky

3.1. Two management regimes

The following analysis is concerned with one single owner of resources as a representative of many identical owners of resources. He tries to maximize the steady-state rents from resources.

Following Francis (2005) and Jinji (2007b), we assume that the property rights can be perfectly enforced by hiring a fixed number of workers, L_R, where $0 < L_R < L$. Therefore, the decision of resource owner is binary: either to enforce or not to enforce the property rights. In other words, the management regime of resources is either private property rights or open access. In case of enforced property rights, rents in resource sector, π^R, are given by

$$\pi^R = pH - w^R L_H^R - w^R L_R \tag{12}$$

where w is the wage in resource sector and the superscript R stands for variables under enforced property rights. In case of diversification, the wage in resource sector must be 1 because of freely mobile labour.

Maximizing Eq. 12 subject to Eq. 4 and Eq. 6 yields the optimal solution for a given p as:

$$S^R(p) = K/2 + 1/2\alpha p \tag{13}$$

Using Eq. 5, Eq. 12 and Eq. 13, we arrive at the steady-state supply of resource goods and maximized rents under enforced property rights:

$$H^R(p) = (r/\alpha p)(\alpha Kp + 1)(\alpha Kp - 1)/(4\alpha Kp) \tag{14}$$

$$\pi^{R*}(p) = (r/\alpha)(\alpha Kp - 1)^2 / (4\alpha Kp) - L_R \tag{15}$$

On the other hand, when the owner of resources decides not to enforce the property rights, it means the open access regime is adopted, which requires current-period rents for the representative harvester to be zero. This yields $p = w^O / \alpha S$, where superscript

O refers to variables under open access. Under the conditions of diversification and freely mobile labor, the following equation is obtained:

$$S^O = 1/\alpha p \tag{16}$$

Substituting Eq. 16 into Eq. 5 gets steady-state production of H under open-access:

$$H^O(p) = (r/\alpha p)(1 - 1/\alpha K p) \tag{17}$$

The representative owner acts to maximize the rents from resources. In case of open access, the rents in resource sector are zero. That is, if the regulated resources generate positive rents, then enforcement is preferred. Otherwise, open access is preferred.

3.2. Endogenous choice of property rights in autarky

Differentiating Eq. 15 with respect to p yields $\partial \pi^{R*} / \partial p = \left(1 - 1/(K\alpha p)^2\right) rK/4$. Note that $p > 1/(\alpha K)$ under diversification. Therefore, for any $p > 1/(\alpha K)$, it follows that $\partial \pi^{R*} / \partial p > 0$ implying π^{R*} is strictly increasing in p.

Setting $\pi^{R*}(\overline{p}) = 0$ in Eq. 15 allows us to obtain[5]

$$\overline{p}(L_R) = \left((r + 2\alpha L_R) + 2\sqrt{\alpha L_R (r + 2\alpha L_R)}\right) / (Kr\alpha) \tag{18}$$

Equating the domestic supply of resource good with domestic demand gives

$$\beta\left(L + \pi^{R*}(p)\right) / p = (r/\alpha p)(\alpha K p + 1)(\alpha K p - 1) / (4\alpha K p) \tag{19'}$$

We can then obtain autarkic price under enforcement regime, p_A^R, as the solution to the above equation[6]:

$$p_A^R(L_R) = \frac{\left(r + 2(L_R - L)\alpha\right)\beta - \sqrt{\Delta}}{r\alpha K(\beta - 1)} \tag{19}$$

where $\Delta = r^2 + 4r(L_R - L)\alpha\beta^2 + 4(L_R - L)^2 \alpha^2 \beta^2$. For any $0 < L_R < L$, $\Delta > 0$ follows[7].

In addition, it holds[8] that both $\overline{p}$ and p_A^R exceed $1/(\alpha K)$, which implies that if the autarky price under enforced property rights, p_A^R, exceeds $\overline{p}$, then the owner of resources chooses to adopt a regulatory regime. By contrast, if $p_A^R < \overline{p}$, it follows

[5] Proofs are presented in the Appendix A.
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that $\pi\left(p_A^R\right) < 0$, implying resource regime will be open access.

Combining Eq.18 and Eq.19 derive the critical value[9] of L_R that makes $p_A^R = \overline{p}$.

$$L_R^* = \left(-r + \sqrt{r^2 + 4\alpha^2\beta^2 L^2}\right)/(2\alpha) \tag{20}$$

Thus, we have established the following result:

Proposition 1

Given $L_R^* = \left(-r + \sqrt{r^2 + 4\alpha^2\beta^2 L^2}\right)/(2\alpha)$, the choice of property rights over resources in autarky is endogenously determined by the cost of enforcing property rights, L_R. If L_R is small such that $0 < L_R < L_R^*$, then the economy is under enforcement. Otherwise, if L_R is high such that $L_R^* < L_R < L$, then the economy is under open access.

For the proof see the Appendix B.

Proposition 1 implies the property rights of resources is entirely endogenous in autarky, not given exogenously as in Brander and Taylor (1997a,1998) and Chichilnisky (1993, 1994) and the cost of enforcing property rights plays an determinant role. If L_R is smaller than L_R^*, that means the enforced economy generates positive rents, then enforcement is preferred, and vice-versa. According, we refer to $0 < L_R < L_R^*$ and $L_R^* < L_R < L$ as the "low cost of enforcement" and "high cost of enforcement" case respectively.

Furthermore, Eq. 20 shows the critical value L_R^* is entirely determined by the parameters of an economy, which represent national characteristic. Differences across countries in r, α, β, L may lead to different L_R^*, leading to Corollary 1.

Corollary 1

(i) An increase in α, β and L will increase L_R^*.

(ii) An increase in r will decrease L_R^*.

For the proof see the Appendix B.

With Corollary 1 in hand, it is found that in autarky, an improvement in harvesting technology may be an effective artifice to manage resources.

4. The Small Open Economy

4.1 Endogenous choice of property rights in free trade

We assume the small country is at initial autarkic steady state, then becomes open to trade. For a small open economy the world price p^w is exogenous and independent

[9] Proofs are presented in the Appendix A.

of the choice of regime. As we have proposed in section 3, for any $p > 1/(\alpha K)$, π^{R*} is strictly increasing in p. With the definition of $\overline{p}$, i.e. $\pi^{R*}(\overline{p}) = 0$, the following proposition can be given.

Proposition 2

Given $\overline{p} = \left((r + 2\alpha L_R) + 2\sqrt{\alpha L_R (r + 2\alpha L_R)}\right)/(Kr\alpha)$, the choice of regulation regime for a small open economy is endogenously determined, which depends on the divergence between p^w and $\overline{p}$. In detail, if $p^w > \overline{p}$, then the open economy is under enforcement. Otherwise, if $p^w < \overline{p}$, then the economy is under open access.

Proposition 2 is similar to Proposition 4 in Francis (2005). A little improvement is we point out the critical value of p^w, i.e. $\overline{p}$. Combination Proposition 1 and 2 shows the resources regime is endogenously determined both in autarky and opening to trade.

We analyze the model using relative demand and supply constructs because it is very useful for determining trade patterns by looking at the difference between its relative supply and demand curve. Brander and Taylor (1997b) specify the comparative location of relative supply and demand curves in the case of $L_R = 0$, in which the relative supply in conservationist country is denoted as RS^V given by Eq. 27 of their paper. Denote the relative supply under enforcement as RS^R, given by Eq. 8. By comparison of expressions between RS^V and RS^R, it can be shown that their nominators are the same, while the denominator of RS^R is strictly smaller than that of RS^V as $L_R > 0$. Thus, given L_R fixed, the locus RS^R must lie to the right of RS^V locus and is always upward sloping. Furthermore, the relative supply curve under open access, RS^O, and relative demand curve RD keep the same as what Brander and Taylor (1997b) have shown. Figure 1 and 2 illustrates the typical relative supply and demand curves[10].

From Proposition 1, it is useful to consider the case of $0 < L_R < L_R^*$ (low cost of

[10] Note that RS^R may exceed RS^O for any price $p > 1/(\alpha K)$, implying there is no intersection between them for $p > 1/(\alpha K)$. However, reasonable restrictions on function forms can ensure an intersection as depicted in the diagram. Meanwhile, the case that RS^R exceeds RS^O for $p > 1/(\alpha K)$ is essentially equivalent to those in case of "severe overuse", which will be discussed in the following section. Accordingly we exclude the possibility.

enforcement) and $L_R^* < L_R < L$ (high cost of enforcement) separately. The former corresponds to the case of an autarkic regulated economy. Conversely, the latter implies open access regime. What we are most interesting in is whether and when the resources regime will switch from one to the other, and what the effects of the switch on the small economy.

4.2 Low Cost of Enforcement ($0 < L_R < L_R^*$)

In this case, the autarkic economy is under enforcement at price $p_A^R > \overline{p}$. When trade opens, if $p^w > p_A^R$, then $\overline{p} < p_A^R < p^w$. Conversely, if $p^w < p_A^R$, it is apparent that two different possibilities arise, $\overline{p} < p^w < p_A^R$ and $p^w < \overline{p} < p_A^R$. The above three cases will be discussed one by one.

4.2.1 Case i: $\overline{p} < p_A^R < p^w$ and Case ii: $\overline{p} < p^w < p_A^R$

With Proposition 2, it follows that an enforced regime is preferred for the open economy in case i and ii. Thus, the resources regime remains the same in autarky and free trade.

In Figure 1 and 2, the intersection of the relative demand curve and relative supply curve under enforcement shows the regulated autarky price of the resource good, p_A^R. In case i, the small open economy trades at a fixed world (relative) price for the resource good in excess of the autarky price, p_A^R, then reading off the corresponding quantities on RS^R and RD we find that since its relative supply of the resource good to manufactures exceeds its relative demand, it would export the resource good and import manufactures in free trade. Alternatively, if trade opened at a world price below this country's autarky price it would export manufactures and import the resource good, which corresponds to the case ii.

Conventional wisdom of trade theory suggests that in small open economy case, a higher world price for resource good implies the country has a comparative advantage in the resource good and will export this good under free trade. Conversely, a lower price world price for resource good means a comparative disadvantage in resource good and will import this good. Hence case i and ii can be said to support this conventional wisdom.

4.2.2 Case iii: $p^w < \overline{p} < p_A^R$

Unlike the above two cases, the opening of trade will change the property rights regime from enforcement to open access as described in Proposition 2.

As explained in Brander and Taylor (1997b), there are two sub-cases, i.e. "severe overuse" and "mild overuse". The former refers to $p_A^R < p_A^o$, while the latter

implies $p_A^R > p_A^o$.

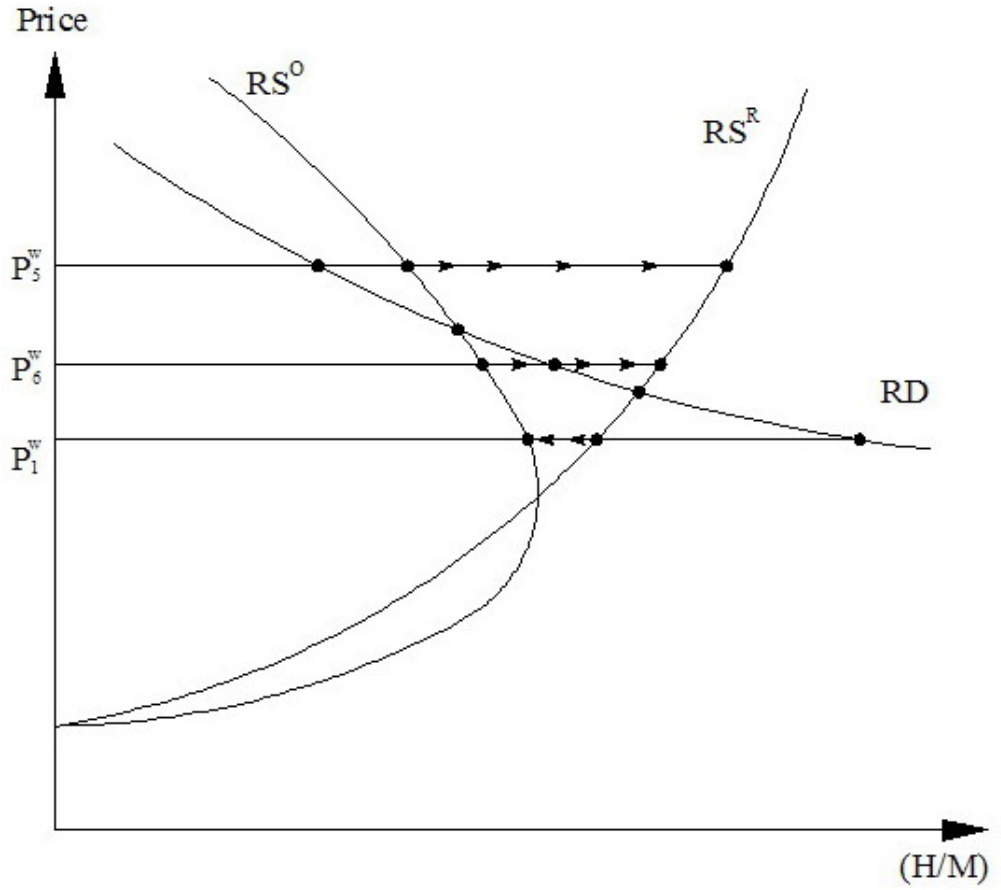

Fig. 1. Trade patterns under endogenous property rights in severe overuse.

In severe overuse, $p^w < \overline{p} < p_A^R < p_A^o$. As shown in Figure 1 (p^w is denoted as p_1^w in this case), the relative demand at world price, $RD(p_1^w)$, exceeds the relative supply, $RS^O(p_1^w)$. Therefore, the economy imports resource good and exports manufactures in free trade.

In mild overuse, if $p^w < p_A^o < p_A^R$, similar to the explanation in case of severe overuse, this country imports resource good and exports manufactures at the steady state trading equilibrium. Figure 2 illustrates this case where p^w is denoted as p_2^w. Alternatively, if $p_A^o < p^w < p_A^R$, a striking consequence is presented as Lemma 1.

Lemma 1

In the case of low enforced cost, resources regime may switch from enforcement to open access after opening trade, which is a race-to-the-bottom-like result. Although facing a lower world price for the resource good (comparative disadvantage in

resource sector), this economy may export resource good and import manufactures, in which the conventional wisdom of trade theory is reversed.

For the proof see the Appendix B.

The striking result owes to a switch of relative supply function induced by the regime switch from enforcement to open access. In Figure 2, the transition of relative supply function is depicted by the arrows. At world price $p_A^o < p_3^w < p_A^R$, the regime switch results in a corresponding change, i.e. shifting the relative supply out from $RS^R(p_3^w)$ to $RS^O(p_3^w)$, where $RS^R(p_3^w) < RD(p_3^w)$ while $RS^O(p_3^w) < RD(p_3^w)$, implying this economy is an exporter of resource good despite appearing to have comparative disadvantage in resource good. We refer to this as "effects of regime switch on trade patterns".

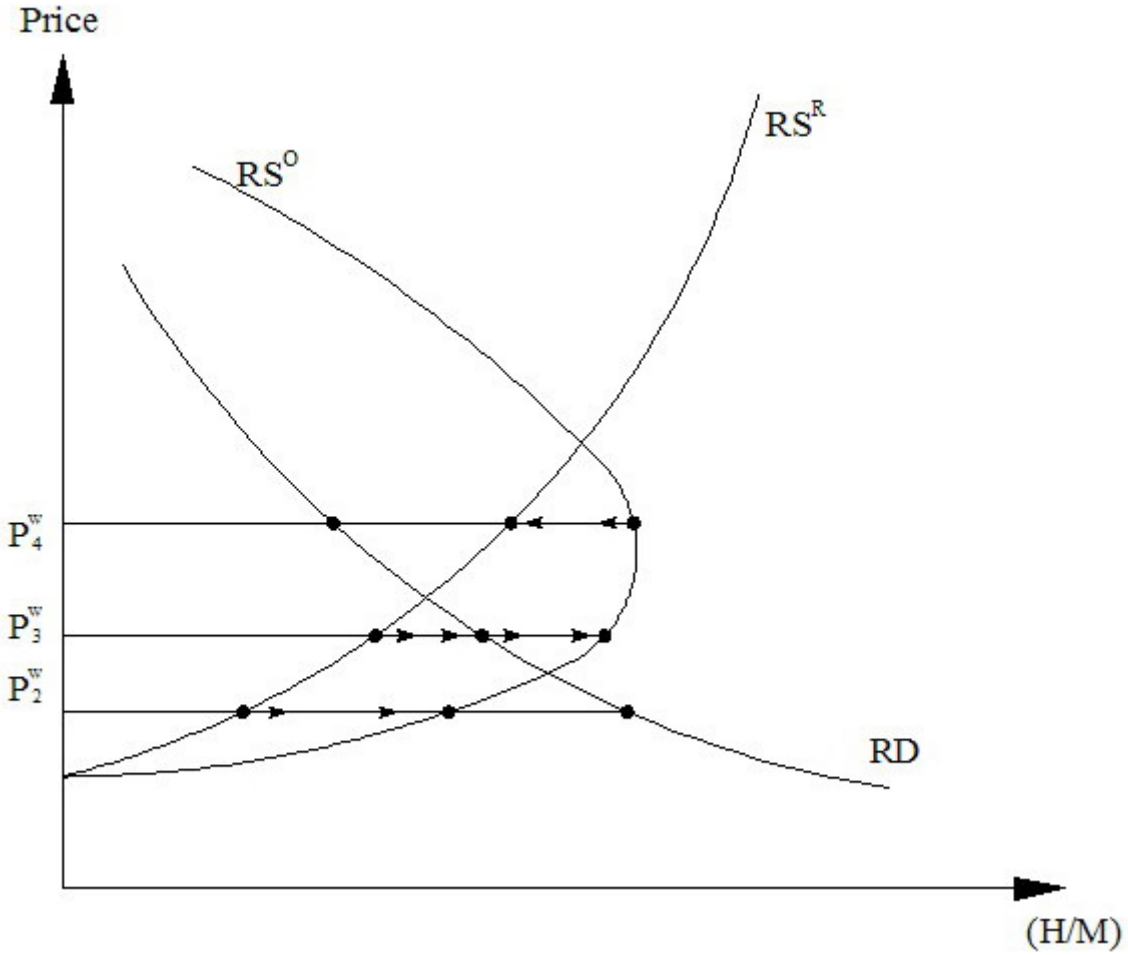

Fig. 2. Trade patterns under dynamic property rights in mild overuse.

4.2.3 Welfare Effects

With regard to the welfare implications for trade, Brander and Taylor (1997b) have shown that, in mild overuse, the regulated country gains from trade whereas the open access country has lower utility from in free trade. In severe overuse, both countries enjoy higher steady-state welfare. However, all the above conclusions are based on

the assumption that property rights over resources are fixed in autarky and free trade. Proposition 3 describes the general properties of welfare for an open economy. "General" means it holds for any cases, no matter what the cost of enforcement.

Proposition 3

(i) If an open economy is under enforcement, welfare, U_T^R, must be decreasing for any feasible price below p_A^R, and increasing for any prices above p_A^R. In other word, U_T^R has a minimum at p_A^R.

(ii) If an open economy is under open access, welfare, U_T^O, must be decreasing for any feasible price above $1/(\alpha K)$.

(iii) The welfare function of an open economy must be continuous at any price $p^w > 1/(\alpha K)$.

For the proof see the Appendix B.

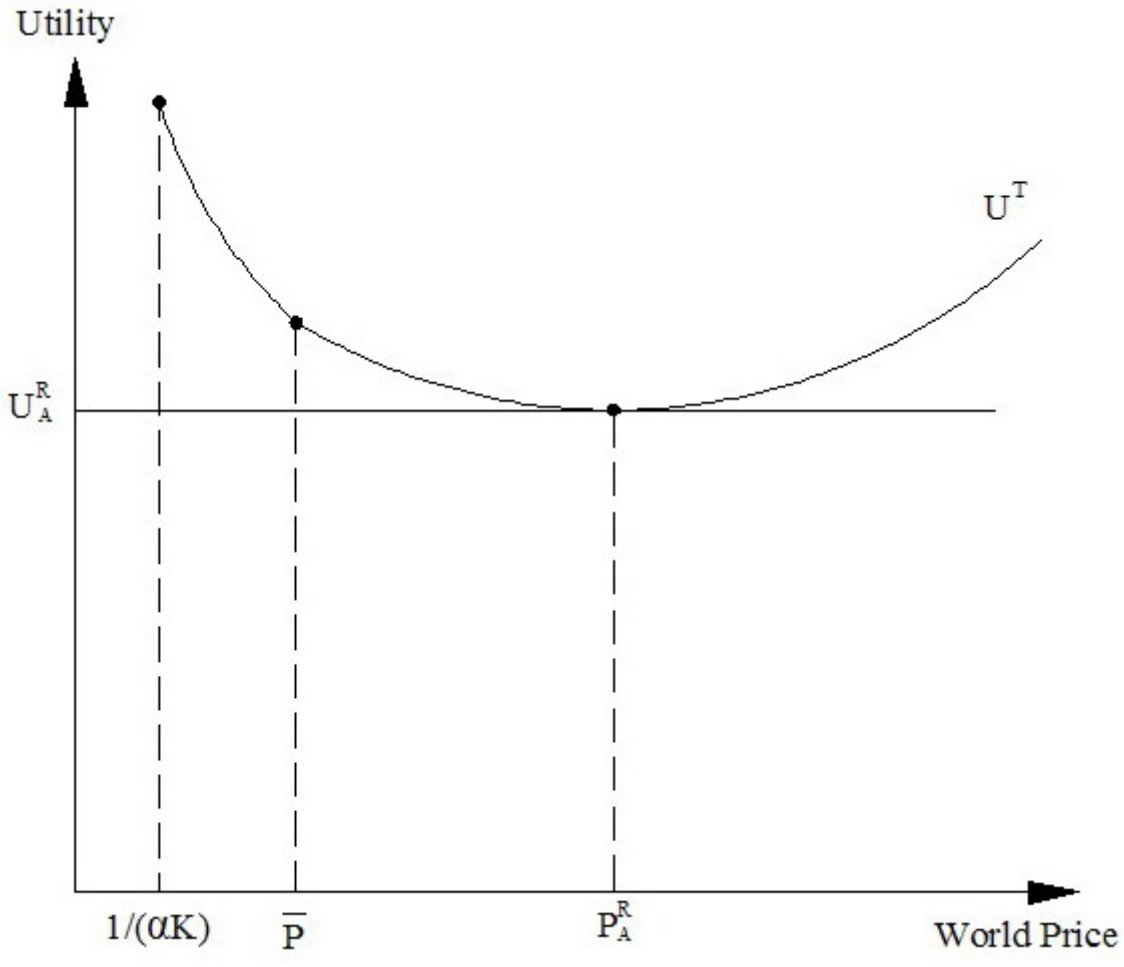

Fig. 3. Steady-state utility for an autarkic enforced economy.

By Proposition 3, we obtain figure 3. The flat line labeled U_A^R represents the steady-state utility of an autarkic enforced economy. The other line represents steady-state level of utility under free trade as a function of the world price of resource good for this economy. The prices $1/(\alpha K)$, $\overline{p}$, p_A^R marked on the horizontal axis are pivotal prices for this case. When opening for trade, world prices less than $\overline{p}$ would lead the small country to switch from enforcement to open access. With case (ii) of Proposition 3 in hand, the steady-state utility must be monotonically falling for any price in the range of $1/(\alpha K)$ and $\overline{p}$. At world price above $\overline{p}$, case (i) of Proposition 3 is valid. In this range, steady-state utility is U-shaped and p_A^R minimizes steady-state utility. case (iii) of Proposition 3 ensures the continuity of welfare function.

Figure 3 shows that the opening of trade must improve its welfare, even though property rights regime switches to open access after trade.

Note that this result can not be regarded as the case of "trade creates standards gains" described in Brander and Taylor (1997b) since property rights regime are different, although the welfare implications for trade in this paper are the same as those in their paper.

Although supporting the viewpoint such as "unrestricted trade imposes lower standards (Daly, 1993)," our model suggests that this regime switch can not be regarded as an excuse to restrict free trade, since trade always improve welfare in above case. To some extent, anti-free-trade environmentalists have paid excessive attention to the negative effects of trade on environment.

We now consider the case in which the small country has a high cost of enforcement.

4.3 High Cost of Enforcement ($L_R^* < L_R < L$)

4.3.1 Trade Patterns

In this case, the autarkic economy is under open access at price p_A^O. We do not examine the case where $p^w < \overline{p}$, implying the economy adopts open-access regime before and after opening of trade, since it has been analyzed by Brander and Taylor (1997a). If $p^w > \overline{p}$, free trade induces regime a shift in regime away from open access to a regulatory regime and we have $p_A^R < \overline{p} < p^w$. Similarly to the discussion in 4.2.2,

in the mild overuse case, it holds that $p_A^O < p_A^R < \overline{p} < p^w$, which is denoted as p_4^w in Figure 2. It shows that the relative supply at world price, $RS^O(p_4^w)$, exceeds the relative demand, $RD(p_4^w)$. Therefore, the economy exports resource good and imports manufactures in free trade. Alternatively, in the severe overuse case, if $p_A^R < p_A^o < p^w$ (corresponding to p_5^w in Figure 1), similar to the analysis in case of mild overuse, this country exports resource good and imports manufactures at the steady state trading equilibrium. On the contrary, if $p_A^R < p^w < p_A^o$, a striking counterintuitive consequence is presented as Lemma2.

Lemma 2

In the case of high enforced cost, resources regime may switch from open access to enforcement after opening trade, which is a race-to-the-top-like result. Although facing a lower world price for the resource good (comparative disadvantage in resource sector), this economy may export resource good and import manufactures, in which the conventional wisdom of trade theory is overturned. Furthermore, as long as trade induces a switch of regime under high cost of enforcement, the economy must be an exporter of resource good.

For the proof see the Appendix B.

As described in 4.2.2, this counterintuitive result due to a shift in relative supply function away from RS^O to RS^R, induced by regime switch, which is called as "effects of regime switch on trade patterns" again.

Lemma 1 and Lemma 2 are summarized by Proposition 4.

Proposition 4

Although facing a lower world price for the resource good (comparative disadvantage in resource sector), this economy may export resource good and import manufactures no matter what the regime is in autarky, thus the conventional wisdom of trade theory is reserved. In other words, trade patterns are affected not only by the property regime in place, but also the change of property regime.

4.3.2 Welfare Effects of Trade Liberalization

It is useful to consider the case of $p_A^O < \overline{p}$ and $p_A^O > \overline{p}$. In the former case, by Proposition 3, when world prices are ranged from $1/(\alpha K)$ to $\overline{p}$, the small open economy is under open access thus the steady-state utility must be monotonically falling. Additionally, for prices above $\overline{p}$, this economy adopts enforced regime and trading welfare is monotonically increasing, which ensures that there exists a threshold price $\overline{p}^w$, such that steady-state utility in free trade exceeds that in autarky

for $p^w > \overline{p}^w$. See Figure 4. Moreover, this economy would suffer welfare loss for world prices located between p_A^O and $\overline{p}^w$, while enjoy higher trade welfare for prices in other ranges.

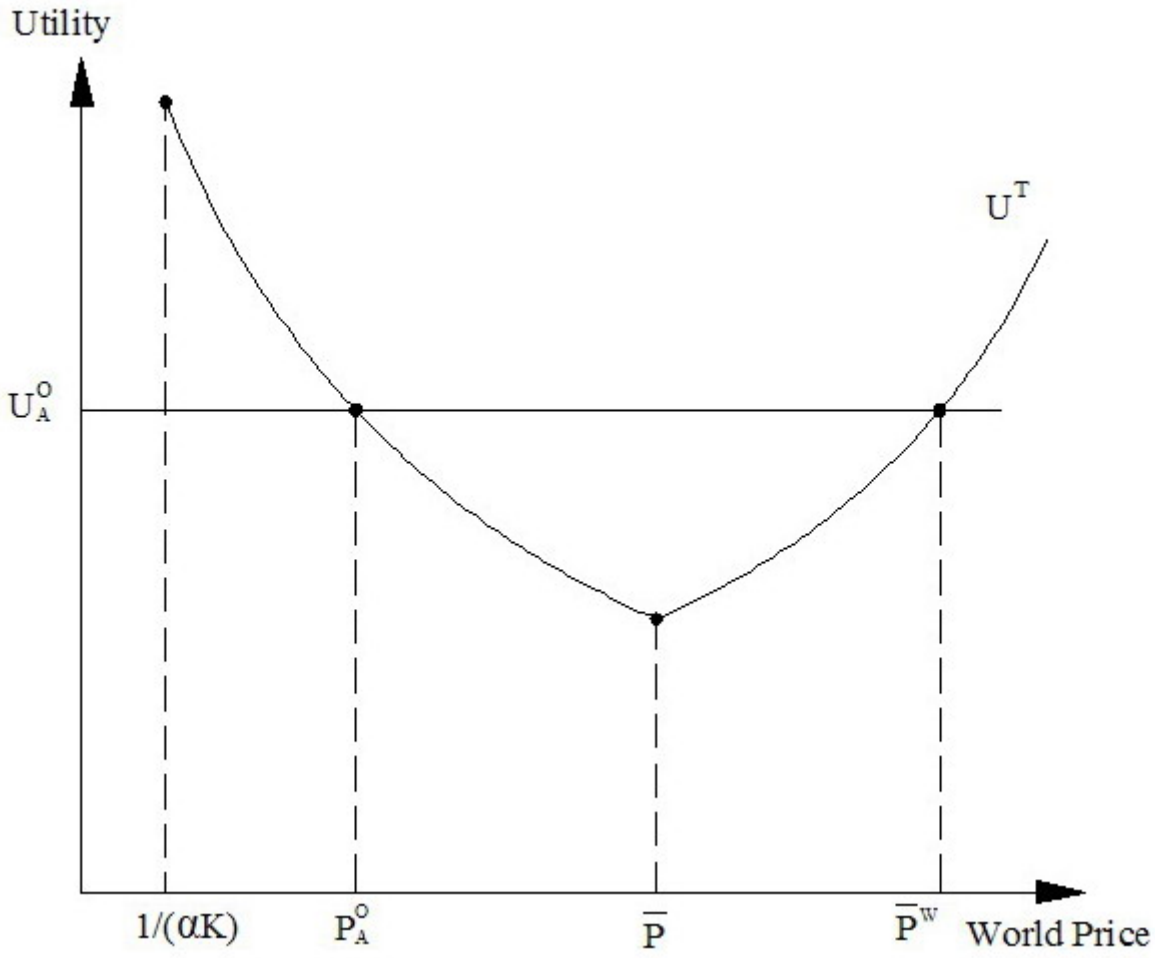

Fig. 4. Steady-state utility for an autarkic open-access economy ($p_A^O < \overline{p}$).

The welfare effects of trade in the case of $p_A^O > \overline{p}$ can be established by similar analysis as illustrated by Figure 5. Like the case of $p_A^O < \overline{p}$, the utility locus has a U shape and reaches the minimum at $\overline{p}$. However, in the case of $p_A^O > \overline{p}$, the autarkic open-access economy must gains from trade for any world prices above $1/(\alpha K)$.

To summarize, welfare effects of trade are ambiguous for an autarkic open-access economy. Even though regime would switch from open access to enforcement, gains from trade can not be guaranteed, either, which is well known as "immiserizing effects of resource enforcement" in Hannesson (2000) , Hotte et al. (2000) and Emami

and Johnston (2000). Furthermore, it is demonstrated that this immiserizing effects would happen only when world price for resource good is in the range of p_A^O and $\overline{p}^w$ in the case of $p_A^O < \overline{p}$.

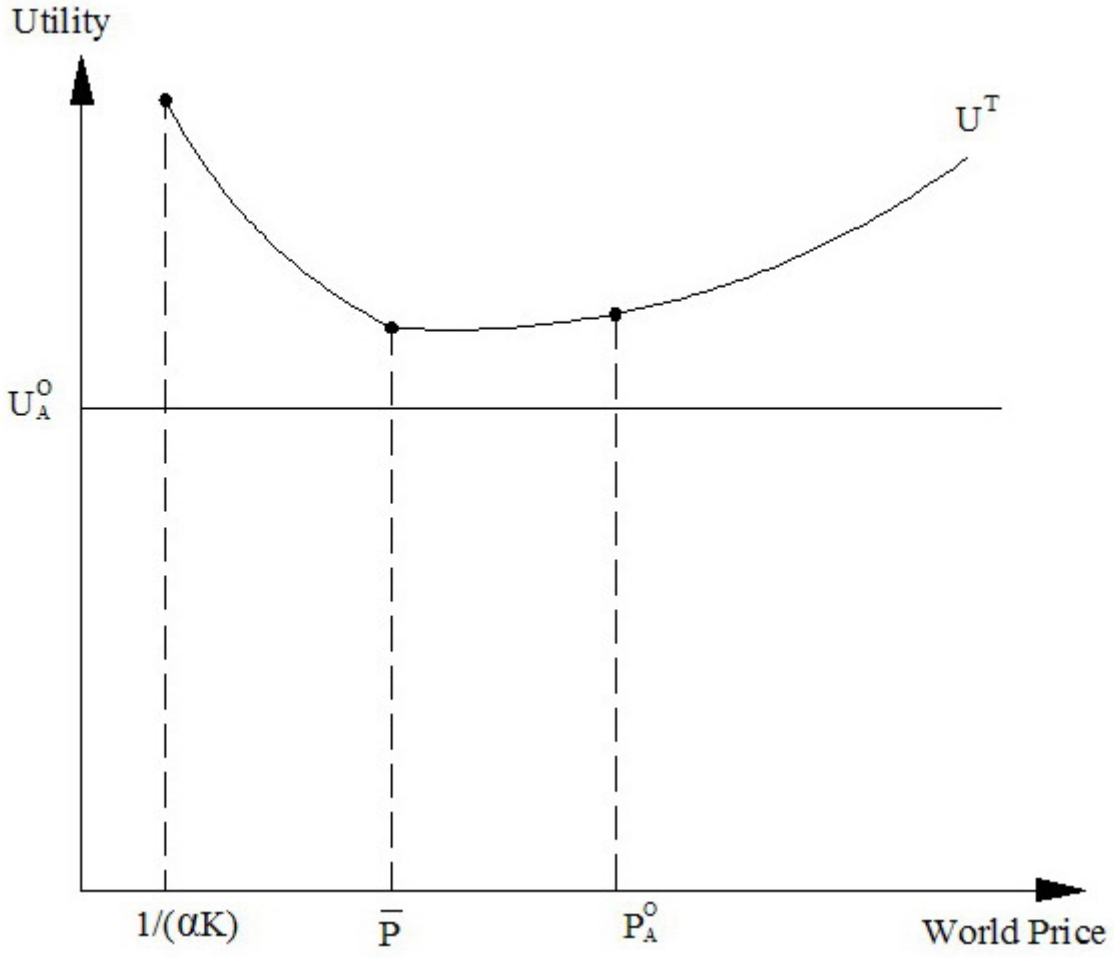

Fig. 5. Steady-state utility for an autarkic open-access economy ($p_A^O > \overline{p}$).

5. Trade sanctions and policy implications

Trade sanctions may be in the form of import ban on resource good exploiting from ill-managed resources or consumers' voluntary boycott of those good. Similar to Jinji (2006), we consider trade sanctions as an instantaneous decrease on the world price of resource good, and assume that the small open economy is in a trading steady state. The following proposition describes the effects of trade sanctions.

Proposition 5

Suppose a small open economy is initially in a trading steady-state equilibrium, a trade sanction may result in (i) a switch of regime over resources from enforcement to open access, (ii) a transition of trade patterns from importer to exporter or

vice-versa, (iii) a lower trade welfare relative to that without sanctions, and (iv) a smaller resource stock and a higher output of resource good.

For the proof see the Appendix B.

Proposition 5 states trade sanctions are not always effective tools of resource management, while they can even make things worse, in the sense that the inefficient exploitation and overuse increase, which is the opposite of what the initial goal of policy instrument itself. Moreover, it can be said to support the view put by some researchers, e.g. Vincent (1990), who declares[11] that "Don't boycott tropical timber."

It is worth noting that an outcome identical to that arises with trade sanctions might occur if external benefits of resources could not be fully internalized, i.e., the price of resource good is underestimated. To see this, according to Proposition 5, the underestimated price may induce the open economy adopts open access regime, whereas it might choose enforced regime if these externalities are fully internalized.

Without loss of generality, we refer to resources as forests. Usually, forests provides various "non-commercial" values, such as carbon sinks, biodiversity and water-retention services, which do not enter into the decision of private due to market failure, thus making a distinction between the private and social returns of forests.

Researchers have long been aware of the lack of property rights and externalities are two main reasons for excessive deforestation. Secure property rights could be established and enforced to eliminate the open access problem. Even when property rights are established, forested lands provide external benefits that do not accrue to the owner, government forester, or other decision maker (von Amsberg, 1998).

What we find, however, is externalities of resources increase the likelihood of open access. That implies externalities have dual effects on resource depletion. The first one is direct effect, i.e. the undervalued price of resource causes excessive conversion from forest land to others use, see Barbier and Burgess (1997). The second is indirect effect, i.e. externalities increase the likelihood of open access and exacerbate the common-property issue.

Furthermore, the above sights explains to some extent why developing countries where externalities of resources are not or not fully internalized, tend to adopt open-access regime, whereas developed countries exhibit opposite tendencies in the real world[12].

With regards to policy interventions, Chichilnisky (1994) points out property-rights policies may be more effective. Given the above discussion, we further suggest that internalization of external effects from resources may be an effective instrument to enforce property rights and mitigate the common-property issue.

6. Concluding remarks

This paper has examined patterns of trade and welfare outcome for a small open economy with endogenous and dynamic property rights. The threshold

[11] Vincent (1990) argues that an import ban would reduce the profitability of forestry and hence encourage the conversion of forestlands to other uses. This paper, however, shows an import ban may cause regime switch to open access such that resources stock decreases. Hence, we have different economic logics.

[12] For data on the states of resource management standards in developing and developed countries, see table 1in Jinji (2007a).

value, L_R^* and $\overline{p}$, are obtained to endogenously determine the property rights in autarky and free trade, respectively. Then, a surprising conclusion that defies common wisdom comes out, i. e. when facing a lower world price for resources, the small country may export resource good and import manufacturing, resulting from a shift in the supply function of resources good induced by regime switch, which is referred to as "effects of regime switch on trade patterns".

The welfare effects of trade are notably different. The autarkic enforced economy always enjoys higher welfare regardless of trader patterns. For the autarkic open-access economy, however, gains from trade can not be ensured, thus the immiserizing effects of resource enforcement would happen under certain conditions.

In addition, trade sanctions which are primarily aimed at protecting resources may cause worse consequences, whereas internalization of the external effects from resources may be more effective.

There are some additional lines of research that could be pursed. The starting point of this paper focuses on the small open economy. A natural extension is to consider a two-country model with endogenous world price. Recalling that L_R plays an important role in determining property rights in autarky and free trade, hence some interesting results may be obtained if we consider a two-country model with different L_R.

Moreover, the set-up of fixed enforcing cost simplifies the problem and avoids unnecessary complications since it makes the choice of regime binary: either enforcement or open access. However, Francis (2005) argues that the cost of regulating the resource would be linked to the level of harvesting efforts. Meanwhile Hotte et al. (2000) models this cost as an increasing function in the enforcement level. Therefore, it will be more general to allow intermediate levels of property rights and a variable enforcing cost such that different levels of property rights can happen simultaneously in one country, which is more realistic. These interesting issues seem to warrant further research.

Appendix A: Proof for section 3.2

Proof for the value of $\overline{p}$ and $\overline{p} > 1/(\alpha K)$

Setting Eq. 15 equal to zero yields two roots

$$p_1 = \left((r + 2\alpha L_R) - 2\sqrt{\alpha L_R (r + 2\alpha L_R)} \right) / (Kr\alpha),$$

$$p_2 = \left((r + 2\alpha L_R) + 2\sqrt{\alpha L_R (r + 2\alpha L_R)} \right) / (Kr\alpha).$$

It can be proved that $p_1 < 1/(\alpha K)$ while $p_2 > 1/(\alpha K)$. To verify this, recalling that $1/(\alpha K) = r/(Kr\alpha)$, therefore the relationship of p_1 and $1/\alpha K$ is identical to

compare $2\alpha L_R - 2\sqrt{\alpha L_R\left(r+2\alpha L_R\right)}$ and zero. Square operation shows that

$$4\alpha^2 L_R^2 - 4\alpha L_R r - 8\alpha^2 L_R^2 = -4\alpha L_R r - 4\alpha^2 L_R^2 < 0,$$

implying $2\alpha L_R - 2\sqrt{\alpha L_R\left(r+2\alpha L_R\right)} < 0$ and $p_1 < 1/(\alpha K)$.

Moreover, $p_2 > 1/(\alpha K)$ follows by parallel reasoning. Note that $p > 1/(\alpha K)$ under diversification. Hence $\overline{p} = p_2$.

Proof of $\Delta > 0$, the value of p_A^R and $p_A^R > 1/(\alpha K)$

Eq. 19' also has two roots

$$p_3 = \frac{\left(r+2\left(L_R - L\right)\alpha\right)\beta - \sqrt{\Delta}}{r\alpha K\left(\beta - 1\right)}, \; p_4 = \frac{\left(r+2\left(L_R - L\right)\alpha\right)\beta + \sqrt{\Delta}}{r\alpha K\left(\beta - 1\right)},$$

where $\Delta = r^2 + 4r\left(L_R - L\right)\alpha\beta^2 + 4\left(L_R - L\right)^2\alpha^2\beta^2$.

We now prove $\Delta > 0$ for any $0 < L_R < L$. Think of the expression of Δ as a function of L_R, and rewrite it after some manipulations as follows $f(L_R) = AL_R^2 + BL_R + Z$, where $A = 4\alpha^2\beta^2 > 0$, $B = 4\alpha r\beta^2 - 8\alpha^2\beta^2 L$, $Z = r^2 - 4\alpha r\beta^2 L + 4\alpha^2\beta^2 L^2$. The quadratic function $f(L_R)$ has a minimum at $\overline{L}_R = -B/2A = L - r/(2\alpha)$, where the minimal value is $f(\overline{L}_R) = r^2\left(1-\beta^2\right)$. Note that $0 < \beta < 1$, thus $\Delta > 0$ for any $0 < L_R < L$.

Then we prove that p_3, not p_4, is the autarkic price under enforcement regime p_A^R, since $p_3 > 0$ while $p_4 < 0$. To see this, define $V = \left(r+2\left(L_R - L\right)\alpha\right)\beta$, thus we have $V^2 = r^2\beta^2 + 4r\left(L_R - L\right)\alpha\beta^2 + 4\left(L_R - L\right)^2\alpha^2\beta^2$. The unique difference between V^2 and Δ is the first term of their expressions. Since $0 < \beta < 1$, it follows that $V^2 < \Delta$. Furthermore, $V < \sqrt{\Delta}$ holds no matter what V is positive or negative. Thus the nominator of p_3 and p_4 is negative and positive, separately, while their same denominators are negative due to $0 < \beta < 1$. Therefore, $p_3 > 0$ whereas $p_4 < 0$,

implying p_A^R must be p_3.

Finally, we prove p_3, i.e. p_A^R exceed $1/(\alpha K)$. Differentiating p_A^R with respect to L_R yields $\frac{\partial p_A^R}{\partial L_R} = \frac{2\beta}{rK(\beta-1)}\left(1-\frac{V}{\sqrt{\Delta}}\right)$. Recalling that $V<\sqrt{\Delta}$ and $0<\beta<1$, thus $\partial p_A^R / \partial L_R < 0$, implying p_A^R is strictly decreasing in L_R. Setting $L_R = L$ obtains $p_A^R(L) = 1/(\alpha K)$. Therefore, $p_A^R(L_R)$ must exceed $1/(\alpha K)$ for any feasible $L_R \in (0, L)$ since p_A^R is monotonically decreasing in L_R.

Proof for the value of L_R^* and $0 < L_R^* < L$

Setting $\overline{p}(L_R)$ in Eq. 18 equal to $p_A^R(L_R)$ in Eq. 19 yields two roots

$$L_R^1 = \left(-r+\sqrt{r^2+4\alpha^2\beta^2L^2}\right)/(2\alpha),\ L_R^2 = \left(-r-\sqrt{r^2+4\alpha^2\beta^2L^2}\right)/(2\alpha)$$

It can be readily seen that $L_R^1 > 0$ while $L_R^2 < 0$. Thus the critical value L_R^* must be L_R^1.

We now prove $L_R^* < L$.

$L_R^* - L = \left(-M+\sqrt{N}\right)/(2\alpha)$, where $M = r+2\alpha L$, $N = r^2+4\alpha^2\beta^2L^2$.

$$M^2 - N = \left(r^2+4\alpha^2L^2+4\alpha rL\right)-\left(r^2+4\alpha^2\beta^2L^2\right) = 4\alpha L\left[\alpha L\left(1-\beta^2\right)+r\right] > 0$$

Recalling that $M>0$ and $N>0$, thus $-M<\sqrt{N}$ and $L_R^* < L$.

Appendix B: Proofs of Propositions

Proof of Proposition 1

It can be directly seen from Eq. 18 that $\overline{p}(L_R)$ is a strictly increasing function of L_R, while $p_A^R(L_R)$ is a strictly decreasing function of L_R. Hence $\overline{p}(L_R) > \overline{p}(L_R^*)$ holds for any L_R above L_R^*, while $p_A^R(L_R) < p_A^R(L_R^*)$ holds for any L_R above L_R^*. Given $p_A^R(L_R^*) = \overline{p}(L_R^*)$, thus for $L_R^* < L_R < L$, it follows that $p_A^R < \overline{p}$, which implies the autarkic economy must adopt open access regime. Similarly, for $0 < L_R < L_R^*$, it follows that $p_A^R > \overline{p}$ implying enforcement regime is preferred.

Proof of Corollary 1

It can be directly obtained that L_R^* is a monotonically increasing function in β and L. The comparative steady-state effects of changes in r, α and r/L are slightly more subtle. Note that $r < \sqrt{r^2 + 4\alpha^2\beta^2L^2}$, thus we have

$$\partial L_R^* / \partial \alpha = r\left(1 - r/\sqrt{r^2 + 4\alpha^2\beta^2L^2}\right)/\left(2\alpha^2\right) > 0$$

$$\partial L_R^* / \partial r = \left(r/\sqrt{r^2 + 4\alpha^2\beta^2L^2} - 1\right)/2\alpha < 0$$

Case (iii) follows by Proposition 1.

Proof of Lemma 1

The proof is simple and illustrated in Figure 2, where p^w is denoted as p_3^w. In the case of $p_A^o < p_3^w < p_A^R$ under mild overuse, the relative supply at world price, $RS^O(p_3^w)$, exceeds the relative demand, $RD(p_3^w)$. Therefore, the economy exports resource good and imports manufactures in free trade.

Proof of Proposition 3

(i) By Eq. 11 and 15, under enforcement, welfare function for an open economy is $U_T^R = C\left(L + \pi^{R*}\left(p^w\right)\right)/\left(p^w\right)^\beta$, where $\pi^{R*}\left(p^w\right) = (r/\alpha)\left(\alpha K p^w - 1\right)^2/\left(4\alpha K p^w\right) - L_R$. In section 3.2, we have calculated $\partial\pi^{R*}/\partial p = \left(1 - 1/\left(K\alpha p\right)^2\right)rK/4$. With this derivative in hand, differentiating U_T^R with respect to p^w, and doing some manipulations yields

$$\partial U_T^R / \partial p^w = \frac{\left[K^2\alpha^2(1-\beta)r\right]\left(p^w\right)^2 + 2K\alpha\beta\left[r + 2\alpha\left(L_R - L\right)\right]p^w - r(1+\beta)}{4K\alpha^2\left(p^w\right)^{\beta+2}} \qquad \text{(B1)}$$

Setting the nominator of Eq. B1 equal to zero yields two roots:

$$p_1^w = \frac{\left(r + 2\left(L_R - L\right)\alpha\right)\beta - \sqrt{\Delta}}{r\alpha K\left(\beta - 1\right)}, \; p_2^w = \frac{\left(r + 2\left(L_R - L\right)\alpha\right)\beta + \sqrt{\Delta}}{r\alpha K\left(\beta - 1\right)},$$

where $\Delta = r^2 + 4r\left(L_R - L\right)\alpha\beta^2 + 4\left(L_R - L\right)^2\alpha^2\beta^2$.

Referring back to Appendix A, it can be found that $p_1^w = p_3 = p_A^R$, $p_2^w = p_4$, and $\Delta > 0$. Hence, Eq. B1 can be rewritten as:

$$\partial U_T^R / \partial p^w = \frac{\left[K^2\alpha^2(1-\beta)r\right]\left(p^w - p_A^R\right)\left(p^w - p_4\right)}{4K\alpha^2\left(p^w\right)^{\beta+2}} \tag{B2}$$

Recalling that $p_4 < 0$ and $0 < \beta < 1$, for any feasible price p^w, if $p^w > p_A^R$, $\partial U_T^R / \partial p^w > 0$ holds. Conversely, if $p^w < p_A^R$, $\partial U_T^R / \partial p^w < 0$ holds. Thus U_T^R must be decreasing for any feasible price below p_A^R, and increasing for any prices above p_A^R, implying p_A^R minimizes U_T^R.

(ii) This case is similar to the case of $r/L < \alpha$ described in Brander and Taylor (1997a). See page 548 and Figure 5 in their paper for more detailed explanation.

(iii) The only possible discontinuous point is at $\overline{p}$ since welfare function changes at this point. Welfare function under two regimes is $U^R(p) = C\left(L + \pi^{R*}(p)\right)/(p)^\beta$ and $U^O(p) = CL/(p)^\beta$ separately. At $\overline{p}$, $\pi^{R*}(\overline{p}) = 0$, thus $U^R(\overline{p}) = U^O(\overline{p})$.

Proof of Lemma 2

The proof is simple and illustrated in Figure 1, where p^w is denoted as p_6^w. In the case of $p_A^R < p_6^w < p_A^o$ under severe overuse, the relative supply at world price, $RS^R(p_6^w)$, exceeds the relative demand, $RD(p_6^w)$. Therefore, the economy exports resource good and imports manufactures in free trade despite appearing to have comparative disadvantage in resource good. To summarize the analysis in the other cases under high cost of enforcement (see paragraph above Lemma 2), it can be found that as long as regime switched after trade under high enforcing cost, this country must be an exporter of resource good and importer of manufacturing.

Proof of Proposition 5

Consider the case of low cost of enforcement and assume the property rights are enforced in the initially trading steady state. Let $p^{w'}$ be the world price for resource good after the price falls caused by trade sanctions. If $p^{w'} < \overline{p}$, then the economy shifts to the open-access regime. Case (ii) and (iii) can be simply proved as described in section 4.2. For the proof of case (iv), Proposition 1 in Jinji (2007b) is valid.

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