The International Journal of Economic Policy Studies

Volume 2 2007 Article 7

ECONOMIC ANALYSIS ON TRADE OF CIRCULAR MATERIALS - AN ANALYSIS ON ENVIRONMENTAL DAMAGE IN IMPORTING COUNTRY

Kazuka NAMBU
Lecturer
Department of Commerce, Meiji University
Nishi-tsutsujigaoka 3-18-3-501, Chofu, Tokyo, 182-0006, Japan
E-mail : knambu@kisc.meiji.ac.jp

ABSTRACT

Recently, the trade of used goods for recycling has increased in Asia. If used goods are recycled as resources with proper treatment in importing countries, such trade will contribute towards the efficient use of scarce resources. However, not using proper treatment in the recycling process may cause environmental damage in the importing country.

Although the Basel Convention restricts the trade of toxic waste, it still allows the trade of used goods for recycling; hence the potential for environmental damage with used goods trade and recycling. Then we need compatibility between the promotion of proper trade and environmental conservation for international recycling. In order to consider this problem, we build an international trade model of used goods with potential for environmental damage on recycling.

In this paper, we model a situation where a certain country imports used goods for recycling, focusing on the behavior of said country. With this basic model, we will analyze the effects of environmental and trade policies on environmental protection and trade of used goods for recycling. In section 2, we show the framework of the model and the first-best policy. In section 3, we consider the second-best policies; import tariff for used goods for recycling and subsidy for abatement. In section 4, we examine the effects of two policies on environmental damage and the quantity of imported used goods for recycling. Finally we observe our conclusions.

Keywords: *environmental damage, waste, tariff, subsidy*
JEL Classification: Q53, Q56

ECONOMIC ANALYSIS ON TRADE OF CIRCULAR MATERIALS - AN ANALYSIS ON ENVIRONMENTAL DAMAGE IN IMPORTING COUNTRY

1. INTRODUCTION

Recently, China's demand for the trade of used goods for recycling in Asia has increased. It is efficient if one country's waste is used as used goods for recycling in other importing countries. Therefore, the importance of the trade of circular materials is increasing. Although such trade has merits, the recycling process of the imported materials may cause environmental pollution and health damage. Electrical waste recycling problems have been reported. For instance, in China, glass parts with lead from cathode-ray tubes and PC monitors are disposed with improper treatment and other unused parts are burned off. They are the source of serious pollution to the liver and water table at adjacent areas[1].

In 1992, the Basel Treaty took effect for an international approach to the problems, prohibiting the trade of hazardous waste from developed countries to developing countries. Furthermore, domestic Acts concerning the trade of hazardous wastes have been initiated at each country. Japan also joined the Basel Treaty in 1993 and enacts the domestic law for the Basel Treaty in 1992. Although these frameworks play an important role to prevent imported materials from polluting developing countries, the Basel Treaty does not forbid the trade of hazardous waste for recycling. The amendment was passed in 1995 and entirely prohibits such trade for recycling does not take effect.

Several Acts for promoting re-usage, reduction, and recycling of resources and materials have taken effect one after another; The Fundamental Plan for Establishing a Sound Material-Cycle Society (2000), Law for the Recycling of Specified Kinds of Home Appliances (2001), etc. Although these Acts provide for domestic waste disposal and domestic recycling, the cost burden of recovering, carrying, storage, disposing and recycling of waste may cause the used goods for recycling to be exported. It is not clear where the responsibilities and correspondences to environmental pollution and health damage in importing countries of used goods lie. Regarding such trade, it is really difficult to identify the causes of pollution and health damage and to recover the original state. Therefore, we need to secure the traceability of used goods for recycling and consider the instruments to encourage promoting trade while protecting the environment.

Several studies have been made on the trade of circular materials. The most controversial topic in the used goods for recycling at present is related to statistical data, law, and the systems of each country in Asia. Kojima (2005) and the Ministry of Economy, Trade and Industry (2005) are of great value in this field. Although these studies have been made on the condition of this trade, there is little investigation on the mechanism of it. And most studies have not focused on the theoretical side of this

[1] See Kojima(2004).

trade. Other studies of trade pattern on used goods, Sen (1962), Strassmann (1968), Smith (1974), Clerides and Hadjiyiannis (2005), have concluded that used goods are traded from high wage or high quality standard countries, to low countries. Most studies, however, have not considered the potential of the pollution and damage and focused on the effect of environmental policy on trade and the environment. In order to consider these problems, it is necessary to construct the international trade model including the potential of pollution by used goods for recycling.

The purpose of this paper is to build a model on importing countries and to analyze the effects of environmental and trade policy on the trade of used goods for recycling and environmental protection. We develop the situation that two sectors in developing countries import used goods for recycling respectively and only one sector voluntarily takes an abatement activity for pollution. The next section explains the structure of the model and shows the first-best policy. Section 3 examines the second-best policies and section 4 considers instruments to raise incentives to promote trade and protect the environment. Finally we observe our conclusions.

2. BASIC MODEL

2.1 Assumptions

In this paper, we suppose that the developing country imports used goods for recycling to produce recycled goods. We also suppose that there are two types of firms in that country: one is type F which takes a voluntary abatement activity for pollution in the recycling process, and the other is type I which does not take a voluntary abatement activity[2]. The number of type F firms and type I firms are n and m respectively. The production functions of each type of firm are given by:

$$x^F = f^F(g^F, a^F) \tag{1}$$

We assume that type F firms produce x^F with imported used goods for recycling g^F, and abatement activity a^F. Also we assume $f_g^F > 0$, $f_{gg}^F < 0$, $f_a^F > 0$. On the other hand, type I firms produce x^I with imported used goods for recycling g^I and abatement activity a^I.

$$x^I = f^I(g^I, a^I) \tag{2}$$

where to make characteristics of type I and F clear, we assume that abatement activity of the informal sector a^I does not affect their production. Then equation (2) is rewritten as

$$x^I = f^I(g^I) \tag{2'}$$

We also assume $f_g^I > 0$, $f_{gg}^I < 0$.

[2] It may be relevant to treat type I firms as the informal sector in this paper. Although a considerable number of studies have been conducted on the informal sector, the main research about the relationship between informal sectors and the environmental problem is Blackman (2000). This research comprehensively summarizes the case studies on environmental policy to the informal sector.

Next, environmental damage from the production process of recycling goods is expressed by

$$D = D(ng^F, mg^I, na^F, ma^I) \tag{3}$$

where $D_g^i > 0$、$D_a^i < 0 (i = F, I)$. The environmental damage, therefore, is enhanced by the increase in the amount of used goods imported for recycling, and decreases by abatement activity.

2.2 Profit maximization problems

First the profit maximization problem of type F firms is expressed by

$$\pi^F = p_F f^F(g^F, a^F) - p_g g^F - V(a^F) \tag{4}$$

where the price of the goods of type F firms, the price of used goods for recycling, and the cost of abatement activity denotes p_F, p_g, and $V(\bullet)$ respectively. We assume that $V' > 0$、$V'' > 0$. The conditions of profit maximization are written as

$$\pi_g^F = p_F f_g^F - p_g = 0 \tag{5}$$

$$\pi_a^F = p_F f_a^F - V' = 0 \tag{6}$$

Next the profit maximization problem of type I firms is expressed by

$$\pi^I = p_I f^I(g^I) - p_g g^I - C(a^I) \tag{7}$$

where the price of the goods of type I firms and abatement costs are denoted as p_I and $C(\cdot)$ respectively. Firm I do not take abatement activity with respect to production. The conditions of profit maximization are written as

$$\pi_g^I = p_I f_g^I - p_g = 0 \tag{8}$$

$$\pi_a^I = -C' = 0 \tag{9}$$

2.3 First Best

We define the social net benefit as follows

$$W = n\pi^F + m\pi^I - D - mC\left(a^I\right) \tag{10}$$

where the property of the cost function is $C' > 0$、$C'' > 0$.

The conditions of social net benefit maximization are written as

$$\begin{aligned} W_g^F &= \pi_g^F - D_g^F = 0 \\ W_a^F &= \pi_a^F - D_a^F = 0 \\ W_g^I &= \pi_g^I - D_g^I = 0 \\ W_a^I &= \pi_a^I - D_a^I = 0 \end{aligned} \tag{11}$$

Here we examine the import tariff on used goods for recycling and the subsidy for an abatement activity as the internalization policy of environmental damage. We assume that authorities implement the import tariff τ^F、 τ^I and the subsidy s^F、 s^I on firms F and I respectively. Then the conditions of profit maximization for used goods for recycling and abatement activity are changed as follows. For type F firms:

$$\pi_g^F - \tau^F = 0 \tag{12}$$

$$\pi_a^F + s^F = 0 \tag{13}$$

and for type I firms:

$$\pi_g^I - \tau^I = 0 \tag{14}$$

$$\pi_a^I + s^I = 0 \tag{15}$$

Although type I firms do not take an abatement activity voluntarily in (7), the subsidy leads firm I to take an abatement activity, that is $a^I > 0$.

Therefore the level of tariffs and subsidys as the first-best are indicated by

$$\tau^F = D_g^F > 0 \tag{16}$$

$$\tau^I = D_g^I > 0 \tag{17}$$

$$s^F = -D_a^F > 0 \tag{18}$$

$$s^I = -D_a^I > 0 \tag{19}$$

3. SECOND BEST

In the previous section, we arrived at the first-best policy by assuming that we are able to capture the imported quantity of used goods for recycling and the level of abatement for each firm. However it is sometimes difficult to levy the individual import tariff on each firm and it may be costly to monitor whether type I firms use their subsidy properly or not[3]. Hence, we examine feasible instruments; common import tariff τ and subsidy only for type F firms.

3.1 Common import tariff

The authorities select the level of import tariff to maximize a country's social net benefit. The level of import tariff is obtained as follows:

[3] Pollution abatement activity is a common problem of all firms. To make characteristic of subsidy clear, we assumed that it is difficult to subsidize to informal sector in this paper. This assumption is based on Blackman (2000), in which it is indicated that firms in informal sector do not use the subsidy to abate pollution.

$$\frac{dW}{d\tau} = n\left(\pi_g^F + \pi_a^F \frac{da^F}{dg^F}\right)\frac{dg^F}{d\tau} + m\pi_g^I \frac{dg^I}{d\tau} - n\left(D_g^F + D_a^F \frac{da^F}{dg^F}\right)\frac{dg^F}{d\tau} - mD_g^I \frac{dg^I}{d\tau} = 0 \tag{20}$$

Here,

$$\frac{da^F}{dg^F} = -\frac{f_{ag}^F}{f_{aa}^F - V''}$$

given that $f_{ag} > 0$, it turns out that $da^F / dg^F > 0$ [4]. Moreover, if firm I decides the input of used goods for recycling and abatement activity independently, it turns out that $da^I / dg^I = 0$. Therefore, the common import tariff τ is represented by

$$\tau = \frac{n\left(D_g^F + D_a^F \frac{da^F}{dg^F}\right)\frac{dg^F}{d\tau} + mD_g^I \frac{dg^I}{d\tau}}{n\frac{dg^F}{d\tau} + m\frac{dg^I}{d\tau}} \tag{21}$$

where $dg^F / d\tau$ and $dg^I / d\tau$ are also negative from comparative statics[5]. Parenthetic terms of numerators show the direct and indirect effect of import tariffs for firm F. The former term represents the direct effect of the change in quantity of imported used goods for firm F on environmental damage and the latter term represents the indirect effect of the change in the level of abatement activity on environmental damage. The import tariff τ will be positive if the former effect is larger than the latter. We assume these conditions are always satisfied through this paper.

Compared with the import tariffs in the first-best τ^F、 τ^I and second-best import tariff τ, we are able to obtain following relationship. First, the relationship of import tariff in the first best for firm F τ^F and in the second best τ is showed by

$$\tau = \tau^F\left(\frac{n\frac{dg^F}{d\tau}}{n\frac{dg^F}{d\tau} + m\frac{dg^I}{d\tau}}\right) + \frac{mD_g^I \frac{dg^I}{d\tau} + nD_a^F \frac{da^F}{dg^F}\frac{dg^F}{d\tau}}{n\frac{dg^F}{d\tau} + m\frac{dg^I}{d\tau}} \tag{22}$$

where the parenthetic terms of the right side are positive, and the second term on the right side is also positive if the direct effect of tariff is larger than the indirect effect. Thus,

$$\tau^F < \tau \tag{23}$$

On the other hand, the relationship of import tariff in the first-best for firm I τ^I and in the second-best τ is showed by

[4] We assume $f_{aa}^F = 0$ for simplicity.

[5] For comparative statics, see Appendix A.

$$\tau = \tau^I \left(\frac{m \dfrac{dg^I}{d\tau}}{n \dfrac{dg^F}{d\tau} + m \dfrac{dg^I}{d\tau}} \right) + \frac{nD_g^F \dfrac{dg^F}{d\tau} + nD_a^F \dfrac{da^F}{dg^F} \dfrac{dg^F}{d\tau}}{n \dfrac{dg^F}{d\tau} + m \dfrac{dg^I}{d\tau}} \tag{24}$$

By the same token, the parenthetic terms of the right side are positive, and the second term on the right side is also positive if the direct effect of the tariff is larger than the indirect effect. Hence,

$$\tau^I < \tau \tag{25}$$

Furthermore, assuming that $D_g^F < D_g^I$, the relationship of each import tariffs is summarized by[6].

$$\tau^F < \tau^I < \tau \tag{26}$$

3.2 Subsidy

Next, the level of subsidy that maximizes the social net benefit is obtained as follows:

$$\frac{dW}{ds^F} = n\left(\pi_g^F \frac{dg^F}{da^F} + \pi_a^F \right) \frac{da^F}{ds^F} - n\left(D_g^F \frac{dg^F}{da^F} + D_a^F \right) \frac{da^F}{ds^F} = 0 \tag{27}$$

Here,

$$\frac{dg^F}{da^F} = -\frac{f_{ga}^F}{f_{gg}^F} > 0$$

and $da^F / ds^F > 0$ from comparative statics. Consequently, the subsidy is represented by

$$s^F = -D_g^F \frac{dg^F}{da^F} - D_a^F \tag{28}$$

The first term and second terms in the right side of equation (28) show the indirect effect and the direct effect of the subsidy respectively. The first term represents the indirect effect of the change in quantity of imported used goods for recycling for firm F on environmental damage, and the second term represents the direct effect of the change in the level of abatement activity on environmental damage. The subsidy s^F will be positive if the former effect is smaller than the latter. We also assume these conditions are always satisfied through this paper.

Now, let the subsidy in the first-best be $\overline{s^F}$ to distinguish from the subsidy in the second-best, and we obtain the following equation

$$s^F = \overline{s^F} - D_g^F \frac{dg^F}{da^F} \tag{29}$$

Since it is clear that the second term is negative, the relationship of the subsidy in the first best and the second best is showed as

$$s^F < \overline{s^F} \tag{30}$$

6 If $D_g^F > D_g^I$, then $\tau^I < \tau^F < \tau$.

3.3 Mixed policies

In this section, we consider the mixed policies that implement the import tariff and subsidy simultaneously. Let the level of import tariff and subsidy in this case be $\tilde{\tau}$ and $\tilde{s}^F$ respectively.

First, as for the import tariff,[7]

$$\frac{dW}{d\tilde{\tau}} = n\left(\tilde{\tau} - \tilde{s}^F \frac{da^F}{dg^F}\right)\frac{dg^F}{d\tilde{\tau}} + m\tilde{\tau}\frac{dg^I}{d\tilde{\tau}} - n\left(D_g^F + D_a^F \frac{da^F}{dg^F}\right)\frac{dg^F}{d\tilde{\tau}} - mD_g^I \frac{dg^I}{d\tilde{\tau}} = 0 \tag{31}$$

Next as for subsidy,

$$\frac{dW}{d\tilde{s}^F} = n\left(\tilde{\tau}\frac{dg^F}{da^F} - \tilde{s}^F\right)\frac{da^F}{d\tilde{s}^F} - n\left(D_g^F \frac{dg^F}{da^F} + D_a^F\right)\frac{da^F}{d\tilde{s}^F} = 0 \tag{32}$$

Thus,

$$\tilde{s}^F = -D_g^F \frac{dg^F}{da^F} - D_a^F + \tilde{\tau}\frac{dg^F}{da^F} \tag{33}$$

From equations (31) and (33), the import tariff is indicated by

$$\tilde{\tau} = \frac{nD_g^F \frac{dg^F}{d\tilde{\tau}} + mD_g^I \frac{dg^I}{d\tilde{\tau}} - nD_g^F \frac{dg^F}{da^F}\frac{da^F}{dg^F}\frac{dg^F}{d\tilde{\tau}}}{n\frac{dg^F}{d\tilde{\tau}} + m\frac{dg^I}{d\tilde{\tau}} - n\frac{dg^F}{da^F}\frac{da^F}{dg^F}\frac{dg^F}{d\tilde{\tau}}} \tag{34}$$

We arrange the above equation as follows

$$\tilde{\tau} = \frac{nD_g^F\left(1 - \frac{dg^F}{da^F}\frac{da^F}{dg^F}\right)\frac{dg^F}{d\tilde{\tau}} + mD_g^I \frac{dg^I}{d\tilde{\tau}}}{n\left(1 - \frac{dg^F}{da^F}\frac{da^F}{dg^F}\right)\frac{dg^F}{d\tilde{\tau}} + m\frac{dg^I}{d\tilde{\tau}}} \tag{35}$$

Here,

$$\frac{dg^F}{da^F} = -\frac{f_{ga}^F}{f_{gg}^F} > 0$$

$$\frac{da^F}{dg^F} = -\frac{f_{ag}^F}{f_{aa}^F - V''} > 0$$

and the parenthetic terms of the numerator and denominator in equation (35) show that

$$\frac{dg^F}{da^F}\frac{da^F}{dg^F} = \frac{\left(f_{ga}^F\right)^2}{f_{gg}^F\left(f_{aa}^F - V''\right)} > 0$$

---

[7] It is supposed that $da^I / dg^I = 0$ in this paper.

Since it is clear that $f_{gg}^{F}\left(f_{aa}^{F}-V''\right)-\left(f_{ga}^{F}\right)^{2}>0$, then

$$0<1-\frac{dg^{F}}{da^{F}}\frac{da^{F}}{dg^{F}}<1 \tag{36}$$

Therefore the sign of the import tariff in mixed policies is determined by

$$\tilde{\tau}>0 \tag{37}$$

Also, using $\tau^{F}=D_{g}^{F}$, the following equation is obtained by

$$\tilde{\tau}=\tau^{F}\left\{\frac{n\left(1-\frac{dg^{F}}{da^{F}}\frac{da^{F}}{dg^{F}}\right)\frac{dg^{F}}{d\tilde{\tau}}}{n\left(1-\frac{dg^{F}}{da^{F}}\frac{da^{F}}{dg^{F}}\right)\frac{dg^{F}}{d\tilde{\tau}}+m\frac{dg^{I}}{d\tilde{\tau}}}\right\}+D_{g}^{I}\left\{\frac{m\frac{dg^{I}}{d\tilde{\tau}}}{n\left(1-\frac{dg^{F}}{da^{F}}\frac{da^{F}}{dg^{F}}\right)\frac{dg^{F}}{d\tilde{\tau}}+m\frac{dg^{I}}{d\tilde{\tau}}}\right\} \tag{38}$$

Since the parenthetic terms in the right side of the equation (38) are also positive, the relationship of the import tariff in the mixed policies and the first-best is represented by

$$\tilde{\tau}>\tau^{F} \tag{39}$$

Substituting $\tau^{I}=D_{g}^{I}$ for the equation (38),

$$\tilde{\tau}>\tau^{I} \tag{40}$$

Therefore,

$$\tau^{F}<\tau^{I}<\tilde{\tau} \tag{41}$$

Next we examine the relationship to the import tariff in the second-best. Comparing with the denominators of equations (21) and (35), we already know by equation (36) that the value of the denominator of equation (35) is smaller than that of equation (21). Also, comparing the numerators of equations (21) and (35),

$$\begin{aligned}A&=nD_{a}^{F}\frac{da^{F}}{dg^{F}}\frac{dg^{F}}{d\tau}-\left(-nD_{g}^{F}\frac{dg^{F}}{da^{F}}\frac{da^{F}}{dg^{F}}\frac{dg^{F}}{d\tilde{\tau}}\right)\\&=n\left(D_{a}^{F}+D_{g}^{F}\frac{dg^{F}}{da^{F}}\right)\frac{da^{F}}{dg^{F}}\frac{dg^{F}}{d\tau}>0\end{aligned} \tag{42}$$

Since equation (28) indicates that the parenthetic terms of equation (42) is negative, it is clear that equation (42) is positive. Using these conditions in equations (29) and (42), the relationship between τ and $\tilde{\tau}$ is showed as follows

$$\tau<\tilde{\tau} \tag{43}$$

Therefore

$$\tau^{F}<\tau^{I}<\tau<\tilde{\tau} \tag{44}$$

Levels of tariff in the second-best and mixed policies are both higher than the first-best levels.

On the other hand, we can arrange for the subsidy such that

$$\tilde{s}^F = -D_g^F \frac{dg^F}{da^F} - D_a^F + \tilde{\tau}\frac{dg^F}{da^F}$$

$$= s^F + \tilde{\tau}\frac{dg^F}{da^F} \tag{45}$$

and the second term is positive, thus,

$$\tilde{s}^F > s^F \tag{46}$$

The relationship to the subsidy in the first-best depends on the levels of the first term and the third term of equation (33). We arrange equation (33) as follows:

$$\tilde{s}^F = \left(\tilde{\tau} - D_g^F\right)\frac{dg^F}{da^F} - D_a^F$$

$$= \left(\tilde{\tau} - \tau^F\right)\frac{dg^F}{da^F} + \overline{s^F} \tag{47}$$

As analyzed before, we know $\tilde{\tau} > \tau^F$, then

$$\tilde{s}^F > \overline{s^F} \tag{48}$$

The relationship is showed by

$$s^F < \overline{s^F} < \tilde{s}^F \tag{49}$$

Consequently, the mixed policies level is higher than the first-best level with regard to the import tariff and subsidy.

4. A CONSIDERATION OF ENVIRONMENTAL DAMAGE

In the previous section, we led the level of import tariff and subsidy in the second-best and examined the mixed policies. The environmental damage is compared with the first-best, the-second best, and the mixed policies in this section. In the beginning, we will examine the responses of environmental damage to import tariffs and subsidies.

$$\frac{dD}{d\tau} = \left(n\frac{dg^F}{d\tau} + m\frac{dg^I}{d\tau}\right)\tau < 0 \tag{50}$$

$$\frac{dD}{ds^F} = -ns^F \frac{da^F}{ds^F} < 0 \tag{51}$$

$$\frac{dD}{ds^I} = nD_a^I \frac{da^I}{ds^I} < 0 \tag{52}$$

Thus the increase of import tariffs and subsidies lead to the decrease of environmental damage.

Let us begin with subsidies. In order to distinguish between the first-best level and the second-best level, we show the damage function in the first-best as follows

$$\overline{D} = \overline{D}(n\overline{g^F}, m\overline{g^I}, n\overline{a^F}, m\overline{a^I}) \tag{53}$$

Damage function in the second-best subsidy is represented by

$$D^{S^F} = D^{S^F}(ng^{FS^F}, mg^{IS^F}, na^{FS^F}, ma^{IS^F}) \tag{54}$$

Let us examine the damage functions in the first-best and the second-best subsidy. From equation (30), we know that the second-best subsidy is lower than the first-best subsidy in type F firms. Abatement activity in the first-best is higher than the second-best due to the direct effect of the change in subsidy from the first-best to the second-best, causing damage levels to increase. Also, the quantity of imports in the second-best is higher than in the first-best because the level of import tariffs will be zero in the case of the second-best subsidy, increasing damage.

Although indirect effects of the second-best subsidy and zero import tariffs will decrease the level of damage, we can neglect such effects simply because we supposed that the direct effect is always larger than the indirect effect. Therefore, compared with the damage levels, damage in first-best may be smaller than the second-best subsidy.

$$\overline{D} < D^{S^F} \tag{55}$$

Next we consider the import tariff. The damage function which levies the second-best import tariff is represented by

$$D^{\tau} = D^{\tau}(ng^{F\tau}, mg^{I\tau}, na^{F\tau}, ma^{I\tau}) \tag{56}$$

We will examine the damage under the first-best and the second-best import tariffs, but it is not clear theoretically which damage is larger. It has been shown that higher import tariffs result in fewer imported used goods for recycling while zero level subsidies reduce abatement activity in type F firms, but the effects of import tariffs and subsidies on damages are opposite. Moreover the indirect effects on damages are also opposite.

It would be reasonable to suppose that the effects of import tariffs are larger than subsidies, because the reduction of imported used goods could contribute to the reduction of damage directly but abatement activity is like an ex post procedure to reduce damage. Thus, we could represent the relationship between D^{τ} and $\overline{D}$ as follows

$$D^{\tau} < \overline{D} \tag{57}$$

As a consequence of the above conditions of equations (55) and (57), the relationship of damage functions is shown by

$$D^{\tau} < \overline{D} < D^{S^F} \tag{58}$$

Lastly with equations (44) and (49), we are able to examine the environmental damage under the mixed policies. Let the damage function under the mixed policies be

$$\tilde{D} = \tilde{D}(n\tilde{g}^F, m\tilde{g}^I, n\tilde{a}^F, m\tilde{a}^I) \tag{59}$$

From equations (44) and (49), under the mixed policies, the social net benefit is maximized with the highest levels of import tariff and subsidy in comparison with other policies. Let us also consider the levels of imported used goods for recycling and abatement activity.

As we know $\tau < \tilde{\tau}$ in equation (43), we find that the imported used goods are decreased in mixed policies and it can cause a decrease in environmental damage. The level of subsidy will change from zero to $\tilde{s}^F (> 0)$, corresponding to the change of policy from the second-best import tariff to the mixed policy. The level of abatement activity is higher in mixed policies and damage will be reduced. Considered with equation (58), we capture the relationship between the levels of damage as follows

$$\tilde{D} < D^{\tau} < \overline{D} < D^{S^F} \tag{60}$$

Therefore we find that the mixed policies lead to the lowest environmental damage[8].

5. CONCLUSION

In this paper, we build a basic model which focuses on the behavior of importing countries and analyze the effects of environmental and trade policies on the trade of used goods for recycling and environmental protection. In our model, we suppose there are two types of firms, F and I, and they produce goods with imported used goods for recycling and labor, where the difference in firms is whether they voluntarily take an abatement activity or not.

First, we showed that the first-best policy achieved the social optimum. Next we examined two policies as the second-best; one being a common import tariff on used goods for recycling, and the other is subsidy for an abatement activity. The import tariff will be positive if the direct effect of the change in quantity of imported used goods for recycling for type F firms on environmental damage is larger than the indirect effect of the change in abatement level on damage. Then, the subsidy will be positive if the direct effect of the abatement on environmental damage is larger than the indirect effect of the change in quantity of imported used goods for recycling on damage. In the case of mixed policies that utilize both policies, the tariff and the subsidy are also positive under the same conditions.

The relationship of each level of tariff and subsidy in the first-best, second-best, and mixed policies, are denoted in section 3. With regard to the level of tariff, the mixed policies, the second-best, the first-best for firm I, and the first-best for firm F are in the order of ascending level. Regarding the level of subsidy, the mixed policies, the first-best and the second-best are also in the order of ascending level.

In turn, we compare the level of environmental damage through the change in quantity of imported used goods for recycling with the level of abatement activity. If the relationship in section 3 is satisfied,

[8] Only 3 cases examined the level of environmental damages here. Even then, considerations about other cases such as the relationship between $\tilde{D}$ and $\overline{D}$ are not in conflict with equation (66) if using comparative statics and the assumptions in this paper.

the environmental damage is lowest under the mixed policies. Tariff in the second-best, the first-best, and subsidy in the second-best followed in the order of descending levels of environmental damage.

As a result of our analysis, if we implement both policies, tariffs and subsidies, at the same time, not only environmental damage but also import quantities of used goods for recycling may decrease. Also, the same result may be obtained if we implement tariffs only. However, implementing subsidies only shows that the trade of used goods for recycling may be promoted and environmental damage may increase in comparison with other cases.

Since we focused on the behavior of the importing country only, our results are restrictive. In order to clear the structure of this trade, we need to consider the conditions of exporting countries and analyze social welfare. Moreover, the types of imported goods may alter the decision to impose tariffs and subsidies.

REFERENCES

Blackman, A. (2000). Informal Sector Pollution Control: What Policy Options Do We Have? , *Resource for the Future.*

Clerides, S. and C. Hadjiyiannis. (2005). International Markets for New and Used Durables, mimeo.

Copeland,B. R. (1991). International Trade in Waste Products in the Presence of Illegal Disposal, *Journal of Environmental Economics and Management* 20(2): 143-162.

Sen, A.K. (1962). On the Usefulness of Used Machines, *The Review of Economics and Statistics* 44: 346-348.

Smith, M.A.M. (1974). International Trade in Second-Hand Machines, *Journal of Development Economics* 1: 261-278.

Strassmann, W.P. (1968). Maintenance, Durability, and Secondhand Equipment, in *Technological Change and Economic Development,* Cornell University Press, New York, 195-220.

Ministry of Economy, Trade and Industry ed. (2005). *Ajiarisaikuru saizensen – ugokihajimeta junkansigen*.

Kojima. (2004). Discussion paper in Society for Environmental Economics and Policy Studies Congress 2004.

Kojima ed. (2005). *Ajianiokeru junkansigen boueki*, IDE-JETRO.

APPENDIX A

The comparative statics for type F firms is given by

$$\begin{bmatrix} p_F f_{gg}^F & p_F f_{gl}^F & p_F f_{ga}^F \\ p_F f_{\lg}^F & p_F f_{ll}^F & p_F f_{la}^F \\ p_F f_{ag}^F & p_F f_{al}^F & p_F f_{aa}^F - V'' \end{bmatrix} \begin{pmatrix} dg^F \\ dl^F \\ da^F \end{pmatrix} = \begin{pmatrix} d\tau \\ 0 \\ -ds^F \end{pmatrix}$$

Assuming that the second order conditions are satisfied, we have a negative sign about determinant on the left side and denote H^F. Also assuming $f_{aa}^F = 0$, $f_{la}^F = 0$, we get the following conditions:

$$\frac{dg^F}{d\tau} = \frac{p_F f_{ll}^F (-V'')}{|H^F|} < 0$$

$$\frac{dl^F}{d\tau} = \frac{-p_F f_{gl}^F (-V'')}{|H^F|} < 0$$

$$\frac{da^F}{d\tau} = \frac{-(p_F)^2 f_{ll}^F f_{ag}^F}{|H^F|} < 0$$

$$\frac{dg^F}{ds^F} = \frac{(p_F)^2 f_{ll}^F f_{ga}^F}{|H^F|} > 0$$

$$\frac{dl^F}{ds^F} = \frac{-(p_F)^2 f_{ga}^F f_{\lg}^F}{|H^F|} > 0$$

$$\frac{da^F}{ds^F} = \frac{-(p_F)^2 f_{gg}^F f_{ll}^F + (p_F)^2 (f_{gl}^F)^2}{|H^F|} > 0$$

Next, the comparative statics for type I firms is given by

$$p^I \begin{bmatrix} f_{gg}^I & f_{gl}^I \\ f_{\lg}^I & f_{ll}^I \end{bmatrix} \begin{pmatrix} dg^I \\ dl^I \end{pmatrix} = \begin{pmatrix} d\tau \\ 0 \end{pmatrix}$$

Assuming that the second order conditions are satisfied, we have a positive sign about determinant on the left side and denote H^I. Accordingly, we get the following conditions:

$$\frac{dg^I}{d\tau} = \frac{p_I f_{ll}^I}{|H^I|} < 0$$

$$\frac{dl^I}{d\tau} = \frac{-p_I f_{\lg}^I}{|H^I|} < 0$$

APPENDIX B

From (23) and (25), assuming $\tau^F < \tau$, $\tau^I < \tau$, and $D_g^F < D_g^I$,

$$\tau^F < \tau^I < \tau \tag{26}$$

Moreover, $dg^F / d\tau$, $da^F / d\tau$, and $dg^I / d\tau$ are all negative, and $a^I = 0$. Thus,

$$\overline{D} = \overline{D}(n\overline{g^F}, m\overline{g^I}, n\overline{a^F}, m\overline{a^I}) \tag{53}$$

$$D^\tau = D^\tau(ng^{F\tau}, mg^{I\tau}, na^{F\tau}, ma^{I\tau}) \tag{56}$$

For each level of input,

$$\overline{g^F} > g^{F\tau} \tag{A-1}$$

$$\overline{g^I} > g^{I\tau} \tag{A-2}$$

$$\overline{a^F} > a^{F\tau} = a^F \tag{A-3}$$

$$\overline{a^I} > a^{I\tau} = 0 \tag{A-4}$$

Considering (A-1) and (A-2), we find that the level of environmental damage in the second-best is less than in the first-best. From (A-3), and (A-4), the level of abatement activity in the second-best is less than the first-best. Therefore it shows that the environmental damage might be enhanced.