論 説

Trade Liberalization of Environmental and Final Goods

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Abstract

We examine the effectiveness of trade liberalization of an environmental good and a final good in a small open economy. The environmental good is the one which contribute to reducing an emission of pollution. We will show that a reduction in the tariff on the environmental good may decrease the welfare of the country when the initial tariff on the final good is sufficiently high. The optimal tariff on the environmental good becomes smaller when the government reduces the tariff on the final good and chooses the optimal emission tax.

Keywords : Trade and environmental policies, Eco-industry, Environmental goods, Trade liberalization

1. Introduction

The relationship between trade liberalization and the environment has been an important issue in trade negotiations for many years. Since international trade may degrade the quality of the environment, countries can take trade measures to protect it even under the World Trade Organization (WTO) rule. The main issue so far has been to protect the environment by reducing the volume of trade in final goods which degrade the quality of environment.

Recently, however, the current trade negotiation of the WTO is focusing on trade liberalization in environmental goods that may contribute to improving the quality of environment. The EU, the United States and 15 other members of the WTO have been negotiating an Environmental Goods Agreement (EGA) to remove barriers to trade in

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regard to environmental goods since July 2014. The main objective of the agreement is to increase the trade volume of environmental goods that contribute to the environmental protection, and in particular fight against climate change.

The quality of environment in an open economy is obviously affected by international trade of both final and environmental goods. Therefore, we cannot discuss effects of trade liberalization of these goods independently. The effects of trade liberalization of environmental goods should be examined in the context of the liberalization of final goods.

There are many papers on international trade and environmental policies which incorporate environmental goods or eco-industries but do not include trade policies in final goods, e.g., Baumol (1995), Feess and Muehlheusser (2002), Brock and Boadu (2004), Carpentier et al. (2005), Copeland (2005), Canton (2007), Greaker and Rosendahl (2008), Dijkstra and Mathew (2010), and Nimubona (2012). Among these studies, Canton (2007) extends the model of David & Sinclair-Desgagné (2005) in an international context, and considers environmental taxation when abatement activities are supplied by international eco-industries. Greaker and Rosendahl (2008) use a two-country model with an eco-firm in each country, supplying perfectly competitive polluting goods in both countries. Dijkstra and Mathew (2010) consider the case that an upstream eco-industry is engaged in R & D for a cleaner technology, selling to a downstream firm for a license fee. Nimubona (2012) examines the effectiveness of reduction in trade barriers on environmental goods in a developing country that imports them from a foreign monopolistic eco-industry.

The purpose of this paper is to examine the effects or effectiveness of trade liberalization of environmental goods with trade barriers to final goods. We assume a small open economy that imports both final and environmental goods. An environmental good (EG) is used to reduce emissions of pollution from production of the final good. The government of the country can impose tariffs on the final and environmental goods and an emission tax on pollution.

The main results in this paper are as follows. First, whether a reduction in the tariff on EG increases the welfare of the country or not depends on the level of initial tariff on the final good. In particular, it may decrease the welfare of the country if there is a high tariff on the final good initially. An optimal tariff on EG, however, becomes smaller when the tariff on the final good is reduced and the government chooses the optimal emission tax. In this case, the total amount of emission does not change even if the government chooses the optimal tariff on the EG and the optimal emission tax.

The rest of paper is organized as follows. In section 2, we describe our model and the market equilibrium conditions. In section 3, we analyze the welfare effects of the tariff on EG and derive its optimal tariff. In section 4, we examine the effects of the tariff on the final good when the government chooses the optimal tariff on EG and the optimal emission tax. Finally, in section 5, we make the concluding remarks.

2. The Model and the Market Equilibrium

2.1 The Model

We consider a small open economy with a final good and an environmental good (EG). Both final good and EG are imported by the country, but there is no producer of EG in the country. EG is supplied only by foreign firms. The home country imposes specific tariffs, τ^{EG} and τ^{F}, on the import of EG and the final good from a foreign country, respectively. We denote p as the domestic price of the EG in the home country; $p=p^{*}+\tau^{EG}$, where p^{*} represents the international price of the EG. We denote P as the domestic price of the final good, that is $P=P^{*}+\tau^{F}$ where P^{*} is its international price.

Following the literature (David and Sinclair-Desgange (2005), Canton (2007), Nimubona (2012)), we assume that the final good producers employ an end-of-pipe pollution abatement. The emission level from them is assumed to be given by the additively separable function: $e(x^{H},\ a)=w(x^{H})-\epsilon(a)$ where a represents the total demand for EG and x^{H} is the output of the home firms. This emission function is increasing in the total output and decreasing in the demand for EG. We also assume that the emission function is continuously differentiable, production generates pollution ($w'(x^{H})>0$) with increasing marginal pollution ($w''(x^{H})\geq 0$), and the marginal pollution increases at a constant rate ($w'''(x^{H})=0$).[1] The abatement effort reduces pollution ($\epsilon'(a)>0$) with decreasing returns to abatement ($\epsilon''(a)<0$), and the marginal efficiency of the EG decreases at a constant rate ($\epsilon'''(a)=0$).

The home government imposes an emission tax (t) on the final good producers since they emit pollution from their production process. Therefore, the home firms have an incentive to import the EG in order to abate pollution and reduce the cost related to emission tax.

The total demand for the final good in the home market is given by $D(P)$, and we assume that this demand curve is downward sloping ($D'(P)<0$). The import of final good is given by $x^{F}=D(P)-x^{H}$.

2.2 The Market Equilibrium

Firstly, we consider the behavior of the final good producers. The production cost function of them is represented by $c(x^{H})$. We assume that this cost function is increasing, convex, and marginal cost increases at constant rate; $c'(x^{H})>0$, $c''(x^{H})>0$ and $c'''(x^{H})=0$. This firm determines the output quantity and the demand for the EG to maximize its profit:

$$\pi^H(x^H,a)=Px^H-c(x^H)-pa-t[w(x^H)-\epsilon(a)]. \tag{1}$$

Then, the profit maximization conditions are given by

$$p=t\epsilon'(a), \tag{2}$$
$$P=c'(x^H)+tw'(x^H). \tag{3}$$

Because the market of the final good is completely competitive, the marginal cost of pollution abatement is equal to marginal benefit of pollution abatement, and the marginal cost of production is equal to the domestic final goods price.

From Eq. (2), we obtain the demand for the EG is depend on its domestic price and the emission tax;

$$a=\tilde{a}(t,p). \tag{4}$$

By differentiating Eq. (2) with respect to t and p, we have

$$\frac{\partial\tilde{a}}{\partial t}=-\epsilon'(a)\frac{\partial\tilde{a}}{\partial p}=-\frac{\epsilon'(a)}{t\epsilon''(a)}>0,$$
$$\frac{\partial\tilde{a}}{\partial p}=\frac{1}{t\epsilon''(a)}<0.$$

Analogously, the solution from Eq. (3) yields the output of the home firms:

$$x^H=\tilde{x}^H(t,P^*+\tau^F)\equiv x^H(t,\tau^F). \tag{5}$$

This means that the equilibrium output of the home firms depends on the import tariff on the final good and the emission tax rate. By differentiating Eq. (3) with respect to t and τ^F, we have

$$\frac{\partial x^H}{\partial t}=\frac{-w'(x^H)}{c''(x^H)+tw''(x^H)}<0, \tag{6}$$
$$\frac{\partial x^H}{\partial \tau^F}=\frac{1}{c''(x^H)+tw''(x^H)}>0 \tag{7}$$

Undoubtedly, more stringent emission tax leads to less output of home firms.

On the other hand, the higher emission tax increases the import of final goods from foreign polluters $\left(\frac{\partial x^F}{\partial t}=-\frac{\partial x^H}{\partial t}>0\right)$. Furthermore, the liberalization of the final good increases the import from aboard $\left(\frac{\partial x^F}{\partial \tau^F}=D'(P)-\frac{\partial x^H}{\partial \tau^F}<0\right)$.

Next, we turn to consider the eco-industry which produces EG in a foreign country. The EG producer has a constant marginal cost (g), and maximizes the following profit function:

$$\pi^{EG}=(p-\tau^{EG}-g)a. \tag{8}$$

Therefore, we obtain the domestic equilibrium price of EG when its output is positive:

$$p=\tau^{EG}+g. \tag{9}$$

That is, the EG producer sets its price equal to its marginal cost.

Substituting Eq. (9) into Eq. (2), we obtain the solution for the equilibrium demand for the EG;

$$a=\tilde{a}(t,\tau^{EG}+g)\equiv a(t,\tau^{EG}). \tag{10}$$

That is, the equilibrium demand for EG in the home country depends on the emission tax and the tariff on EG. By differentiating Eqs. (2) and (9) with respect to *t*, we obtain

$$\frac{\partial a}{\partial t}=\frac{-\epsilon'(a)}{t\epsilon''(a)}>0. \tag{11}$$

Clearly, when the government raises the emission tax rate, the polluting firm is willing to import more of EG to reduce the cost related to the unabated pollution. Analogously, totally differentiating Eqs. (2) and (9) with respect to τ^{EG}, we get

$$\frac{\partial a}{\partial \tau^{EG}}=\frac{1}{t\epsilon''(a)}<0. \tag{12}$$

A raise in the tariff on the EG will decrease the consumption of the EG of the final good producers, regardless of the level of emission tax rate.

3. The Effects of Tariff Reduction in the Environmental Good

The social welfare of the home country consists of the sum of consumer surplus for the final good, the home polluting firms' profits, and the tax and tariff revenues, minus the social damage due to pollution. We assume an environmental damage function as $ve(\tilde{x}^H,\tilde{a})=v[w(\tilde{x}^H)-\epsilon(\tilde{a})]$ where v is the constant marginal social damage of pollution. Therefore, the total welfare is described by the following equation.

$$\begin{aligned} W(t,\tau^{EG},\tau^F)=&\left\{\int_0^X P(z)dz-PX\right\}+\{Px^H-c(x^H)-pa-t[w(x^H)-\epsilon(a)]\}\\ &+\{t[w(x^H)-\epsilon(a)]+\tau^F x^F+\tau^{EG}a\}-v[w(x^H)-\epsilon(a)] \\ =&\int_0^X P(z)dz-P^*x^F-c(x^H)-[t\epsilon'(a)-\tau^{EG}]a-v[w(x^H)-\epsilon(a)], \end{aligned} \tag{13}$$

where $X = x^H + x^F = D(P)$.

From Eq. (13), a welfare effect of the tariff on EG is given by

$$\frac{\partial W}{\partial \tau^{EG}} = \{\tau^{EG} - (t-v)\epsilon'(a)\}\frac{\partial a}{\partial \tau^{EG}} \tag{14}$$

From Eqs. (12) and (14) when the initial τ^{EG} is larger than $(t-v)\epsilon'(a)$, the liberalization of EG increases the welfare of the country. This implies that a reduction in the tariff on EG will always increase the welfare if the emission tax is smaller than the marginal social damage of pollution.

Next we will consider the case when the government chooses the optimal emission tax to maximize the welfare by taking τ^{EG} and τ^F as given. To solve this problem, by differentiating this equation with respect to t, we have

$$\frac{\partial W}{\partial t} = (t-v)\left[w'(x^H)\frac{\partial x^H}{\partial t} - \epsilon'(a)\frac{\partial a}{\partial t}\right] + \tau^F\frac{\partial x^F}{\partial t} + \tau^{EG}\frac{\partial a}{\partial t}. \tag{15}$$

The first component of the first term of the right hand side, $t-v$, corresponds to the gap between the initial emission tax and the marginal social damage of pollution or the Pigouvian rate. The square bracket part in the first term on the right hand side of Eq. (15) is negative and represents the marginal effect of the emission tax on total emission. The second and the third terms represent the positive effect of tariff revenue. If $t=v$, the negative effect from the pollution disappears, hence only the positive effect from tariff revenue remains. The home country will gain from stringent emission tax because the government collects more tax revenue from the imports of both final good and EG.

If the initial emission tax is lower than marginal social damage of pollution, $t-v<0$, the regulator has an incentive to raise the emission tax to diminish the negative effect from pollution. In this case, the social welfare increases with emission tax rate. Conversely, when the initial emission tax is higher than the Pigouvian rate, $t-v>0$, more stringent emission tax will not always improve the social welfare.

When we set Eq. (15) equal to zero and solve for optimal emission tax, we obtain

$$t = v - \frac{\tau^F\frac{\partial x^F}{\partial t} + \tau^{EG}\frac{\partial a}{\partial t}}{w'(x^H)\frac{\partial x^H}{\partial t} - \epsilon'(a)\frac{\partial a}{dt}}. \tag{16}$$

The numerator of the second term on the right hand side corresponds to the positive tariff revenue effect, and the denominator corresponds to the negative marginal effect of emission tax on total emission. Therefore, the optimal emission tax is always higher than the Pigouvian rate regardless of the levels of import tariffs as long as they are positive. Thus, we can summarize this result as follows.

Proposition 1 *Suppose that the tariffs on the final good and the EG are positive initially. The optimal pollution tax is higher than the Pigouvian rate.*

Substituting Eqs. (16) into (14), we have

$$\frac{\partial W}{\partial \tau^{EG}}=\frac{\frac{\partial x^H}{\partial t}\frac{\partial a}{\partial \tau^{EG}}}{w'(x^H)\frac{\partial x^H}{\partial t}-\epsilon'(a)\frac{\partial a}{\partial t}}(w'(x^H)\tau^{EG}-\epsilon'(a)\tau^F). \tag{17}$$

Since we know that the sign of the components which are not included in the bracket is negative, we have the following proposition.

Proposition 2 *Suppose that the government sets the optimal emission tax initially. Then we have*

$$\frac{\partial W}{\partial \tau^{EG}}\gtreqless 0 \text{ if and only if } \tau^{EG}\lesseqgtr\frac{\epsilon'(a)}{w'(x^H)}\tau^F.$$

If the initial tariff on the final goods is zero, a reduction of any positive tariff on EG increases welfare. Conversely, if the initial tariff on EG is small enough so that $\tau^{EG}<\frac{\epsilon'(a)}{w'(x^H)}\tau^F$, a reduction in the tariff on EG decreases welfare.

Next we consider the case when the optimal tariff of EG is endogenously determined by the emission tax and final goods tariff. In this case, we must have $\partial W/\partial \tau^{EG}=0$. From Eq. (14), given the emission tax and the tariff on the final good, the optimal import tariff on the EG is shown by

$$\tau^{EG}=(t-v)\epsilon'(a). \tag{18}$$

The tariff of the EG must be positive when the emission tax exceeds the marginal social damage. In the case where the emission tax equals the marginal social damage of pollution (the Pigouvian tax rate), the free trade in EG is the optimal policy. Because the externality of pollution is fully corrected by the Pigouvian tax, the distortion from the tariff of EG should be eliminated. When the emission tax is smaller than the marginal social damage of pollution, the home government should pay a subsidy for the import of EG to relief the negative externality from pollution.

To see the effects of the emission tax and the tariff on the final good, by totally differentiating Eq. (18) we have

$$\left\{1-(t-v)\epsilon''(a)\frac{\partial a}{\partial \tau^{EG}}\right\}d\tau^{EG}=\epsilon'(a)\left\{1-(t-v)\epsilon''(a)\frac{\partial a}{\partial \tau^{EG}}\right\}dt. \tag{19}$$

Hence, how a change in the emission tax will change the optimal tariff on EG is described as

$$\frac{d\tau^{EG}}{dt}=\epsilon'(a)>0. \tag{20}$$

The optimal EG tariff decreases with the emission tax, and this will be followed by the following effects.

$$\begin{aligned}
&\frac{da}{dt}=\frac{\partial a}{\partial \tau^{EG}}\frac{d\tau^{EG}}{dt}+\frac{\partial a}{\partial t}=\frac{\partial a}{\partial \tau^{EG}}\epsilon'(a)-\epsilon'(a)\frac{\partial a}{\partial \tau^{EG}}=0,\\
&\frac{dx^H}{dt}=\frac{\partial x^H}{\partial t}<0,\\
&\frac{de}{dt}=w'(x^H)\frac{\partial x^H}{\partial t}<0.
\end{aligned} \tag{21}$$

Surprisingly, a change in emission tax will not affect the import of EG. This is because the direct effect of emission tax is canceled out by the indirect effect through the change in the tariff of EG. Nevertheless, more stringent emission tax will decrease the output of the home firm, and then the emission also reduces.

Next, we consider the impacts of a change in final goods tariff. We find that the tariff on the final good does not affect the optimal tariff on EG: $d\tau^{EG}/d\tau^F=0$ Then, from Eq. (20), the effects of changing the final good tariff are summarized as follows.

$$\begin{aligned}
&\frac{da}{d\tau^F}=0,\\
&\frac{dx^H}{d\tau^F}=\frac{\partial x^H}{\partial \tau^F}>0,\\
&\frac{de}{d\tau^F}=w'(x^H)\frac{\partial x^H}{\partial \tau^F}>0.
\end{aligned} \tag{22}$$

As already mentioned, changing the final good tariff will not affect the EG tariff. Therefore, when the emission tax is constant, the import of EG will not react to any change of the final good tariff. Nonetheless, the liberalization of the final good decreases home firm output and emissions. The reason for this is because the lower the final good tariff, the cheaper the domestic price and thus more final good is imported from aboard.

Proposition 3 *When the government chooses the import tariff on EG to the maximize welfare by taking the emission tax and the final good tariff as given. More stringent emission tax leads to less output of the final good and reduces emissions. The liberalization of the final good does not affect the import of EG, and reduces the output of the final good and emissions.*

4. The Impacts of Final Good Tariff on the Optimal EG Tariff and Emission Tax

In this section, first, we consider how the tariff on the final good affects the optimal emission tax and the optimal tariff on EG. We assume that the government maximizes welfare by choosing the emission tax and the tariff on EG, while the tariff on the final good is given. Substituting Eqs. (18) into (15), we have

$$\frac{\partial W}{\partial t}=\{(t-v)w'(x^H)-\tau^F\}\frac{\partial x^H}{\partial t}. \tag{23}$$

The optimal emission tax must satisfy the following relation

$$(t-v)w'(x^H)=\tau^F. \tag{24}$$

Therefore, if the initial tariff on the final good is positive, the optimal emission tax must larger than the marginal damage of pollution, that is,

$$t>v \iff \tau^F>0 \tag{25}$$

In addition, if the tariff on the final good is not imposed initially, the optimal emission tax is equal to the Pigouvian rate.

Furthermore, by combining Eqs. (18) with (24), we obtain the relationship between the initial tariff on the final good and that on EG

$$\tau^{EG}>0 \iff \tau^F>0 \tag{26}$$

When the final goods tariff is positive, the optimal EG tariff must be positive. If the tariff on the final good is not imposed initially, the optimal tariff on EG must be zero.

A change in the tariff on the final good affects the optimal emission tax and the tariff on EG. First, totally differentiating Eq. (24), we have

$$\frac{dt}{d\tau^F}=\frac{1}{w'(x^H)}>0. \tag{27}$$

Clearly, the liberalization of the final good will lower the emission tax rate in home country. Next, totally differentiating Eq. (18), we get

$$\frac{d\tau^{EG}}{d\tau^F}=\frac{\epsilon'(a)}{w'(x^H)}>0. \tag{28}$$

The liberalization of the final good must be followed by the liberalization of EG. Summarizing the results, we obtain the following proposition

Proposition 4 *Suppose that government chooses the optimal EG tariff and emission tax. A reduction in the tariff on the final good must be followed by a reduction in the emission tax and the tariff on EG.*

We will turn to focus on the impact of a reduction in the final good tariff on the total emission when the government chooses the optimal emission tax and the EG tariff. We find that

$$\frac{da}{d\tau^F}=\frac{\partial a}{\partial \tau^{EG}}\frac{d\tau^{EG}}{d\tau^F}+\frac{\partial a}{\partial t}\frac{dt}{d\tau^F}=0. \tag{29}$$

A change in tariff on the final good will not affect the import of EG because the effect through the emission tax is canceled out by the effect via the EG tariff. The impact of the final good tariff on the home firms' output is described as

$$\frac{dx^H}{d\tau^F}=\frac{\partial x^H}{\partial \tau^F}+\frac{\partial x^H}{\partial t}\frac{dt}{d\tau^F}=0. \tag{30}$$

Remarkably, the liberalization of the final good does not affect the output of home firms. The reason is that the direct effect is canceled out by the indirect effect via the emission tax. This is followed by

$$\frac{de}{d\tau^F}=w'(x^H)\frac{dx^H}{d\tau^F}-\epsilon'(a)\frac{da}{d\tau^F}=0. \tag{31}$$

This result is obvious since the liberalization of the final good does not affect the output of the final good and the import of EG. So we have the following proposition.

Proposition 5 *A reduction in the tariff on the final good does not change the level of pollution if the government chooses the optimal emission tax and the tariff on EG.*

Finally, we derive the optimal policy combination among the tariffs on the final good and EG and the emission tax. Partially differentiating the welfare function with respect to τ^F, we have

$$\frac{\partial W}{\partial \tau^F}=\{(t-v)w'(x^H)-\tau^F\}\frac{\partial x^H}{\partial \tau^F}+\tau^F D'(P). \tag{32}$$

From Eq. (24), we get

$$\frac{dW}{d\tau^F}=\tau^F D'(P). \tag{33}$$

To maximize the social welfare, the tariff on the final good should be totally removed. That is,

$$\tau^F = 0. \tag{34}$$

Therefore, from Eqs. (25) and (26), we can conclude that the optimal tariff on EG and the emission tax are

$$\tau^{EG} = 0, \tag{35}$$

$$t = v. \tag{36}$$

The optimal policy combination is given by the following proposition.

Proposition 6 *The optimal tariffs on the final good and the EG are zero and the optimal emission tax is equal to the marginal damage of pollution or the Pigouvian rate.*

This result is rather obvious. In this small open economy, the removal of all trade barriers is the optimal trade policy. By doing so, the distortion in trade will disappear. Then, the government should set the emission tax equal to the marginal social damage of pollution just to correct the externality from the emission.

5. Concluding remarks

In this paper, we considered the effects of a tariff reduction of the environmental good in the presence of the tariff on the final good which emits pollution. As we have seen in the analysis, the effect of a reduction in the tariff on the environmental good or the optimal tariff of it is closely related to the initial level of the tariff on the final good. In our partial equilibrium model, the tariff on the final good affects the optimal level of emission tax. In addition, the emission tax affects the effects of the tariff on the environmental good. Thus, the tariff on the final good is connected to the effects of the tariff on the environmental good. The relationship between these tariffs has not been pointed out by any previous paper on this topic.

There are several interesting issues which have not been discussed in this paper. First, we assume that there is no domestic firm that produces environmental goods. Some developing countries, however, have eco-industries and produce environmental goods by themselves. Some firms which produce environmental goods are purely domestic ones while the others are joint-ventures between the home and foreign parent firms. In these situations, the effects of trade liberalization of environmental goods may be different from the ones we have derived in this paper. In addition, the market structure of environmental goods may not be perfectly competitive. It is worthwhile to analyze the effects of trade liberalization of environmental goods in these situations.

Next, in this paper we have not dealt with transboundary pollution. Nevertheless, many kinds of pollution can reaches other countries, e.g., the air pollution from China reaches Japan and Korea. Therefore, if we include the transboundary pollution in the model, we should consider the strategies of polluting and polluted countries. A considenable amount of previous paper deals with transboundary pollution, but it does not incorporate environmental goods. The analysis induding these goods will be interesting.

Notes

1) In this paper, the first, the second, and the third derivative of function f are denoted as f', f'' and f''', respectively.

References

Baumol, W. J. (1995), Environmental Industries with Substantial Start-Up Costs as Contributors to Trade Competitiveness, *Annual Review of Energy and Environment* 20, 71-81.

Brock, A. and F.O. Boadu (2004), Global demand for U.S. environmental goods and services, *Journal of Agricultural and Applied Economics* 36, 49-64.

Canton, J. (2007), Environmental Taxation and International Eco-Industries, *Nota di lavoro 26*, FEEM.

Carpentier, CL. Gallagher, K.P. and S.Vaughan (2005), Environmental Goods and Services in the World Trade Organization, *Journal of Environment Development* 14(2), 225-251.

Copeland, B. (2005), Pollution Policy and the Market for Abatement Services, Paper presented at the EAERE 14th annual conference, Bremen, Germany, 23-25 June 2005.

David, M. and B. Sinclair-Desgagné (2005), Environmental Regulation and the Eco-industry, *Journal of Regulatory Economics* 28(2), 141-155.

Dijkstra, B.R. and A.J. Mathew (2010), Liberalizing Trade in Environmental Goods, *GEP working paper* 10/05, University of Nottingham.

Feess, E. and G. Muehlheusser (2002), Strategic Environmental Policy, Clean Technologies and the Learning Curve, *Environmental Resource Economics* 23, 66-149.

Greaker, M. and K.E. Rosendahl (2008), Environmental Policy with Upstream Pollution Abatement Technology Firms, *Journal of Environmental Economics Management 56*, 246-259.

Nimubona, A-D (2012), Pollution Policy and Trade Liberalization of Environmental Goods, *Environmental Resource Economics* 53, 323-346.

Organization for Economic Cooperation and Development and Eurostat (1999), *The Global Environmental Goods and Services Industry: Manual for Data Collection and Analysis,* OECD Editions, Paris.