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Achieving Environmental Goals in a World of Trade and Hidden Action:

The Role of Trade Policies and Eco-Labeling

by

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Abstract

Consumers, mainly in Europe and North America, frequently express concerns about the environmental, social or health impacts of the products they purchase. When these products are produced abroad, consuming countries often resort to using trade policies and consumer actions targeting imported products in order to reduce negative environmental or social impacts. Traditionally, these policies were *non-discriminatory*, i.e., they treated all imports equally, without considering the actual damages caused by the product. More recently, there is a trend towards *process-discriminatory* policies which attempt to discriminate against imports from environmentally or socially unsound production processes while encouraging environmentally or socially sound alternatives. Such policies often rely on eco-labeling and costly monitoring of the producers' claims. This paper develops a theoretical model of the consuming country's optimal trade policy, allowing for asymmetric information and costly monitoring. I analyze what type of policy is preferable under what conditions, and how the optimal policy depends on the target country's alternative markets and the type of consumer concern. It is shown that imperfect information reduces the optimal level of sound and total imports while raising the level of unsound imports. It is generally optimal to monitor imperfectly, and non-discriminatory policies can be interpreted as corner solutions to the optimal process-discriminatory policy. The observed shift from non-discriminatory policies to process-discriminatory policies over time might be explained by a reduction in monitoring costs. The target country always at least weakly prefers process-discriminatory policies over non-discriminatory policies, possibly explaining why producing countries establish their own labeling systems when faced with the threat of non-discriminatory policies. The optimal tariff on unsound imports is shown to be generally less than the Pigouvian tariff and is less for consumption pollution, health and safety effects, and moral concerns than for production pollution. Implementation of the optimal policy through consumer action rather than trade policy is also discussed.

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1. Motivation

Consumers, particularly in Europe and North America, increasingly value environmentally friendly products. Several surveys have indicated that consumer interest in the environmental effects of products are rising and that a substantial segment is willing to pay a premium for environmentally friendly products [United States Congress, 1992].

At the same time the world economy has become increasingly integrated with a growing share of domestic consumption goods being produced abroad. Production practices in other countries frequently affect environmental quality. For example, tropical timber production affects global forest stands which provide both use and nonuse values to consumers in other countries. This nexus between production and the environment has led consumer groups to translate their environmental concerns into concerns about the environmental impacts of production abroad. Producing countries may not share these environmental concerns, and thus may have little incentive to internalize another country's nonmarket environmental valuations. Some environmental groups have responded by proposing to achieve their environmental goals through trade interventions [Esty, 1994].

National sovereignty limits the policies that a country can use to achieve its environmental objectives abroad. In practice, there are two basic ways to proceed: international cooperation or unilateral action. While cooperation is generally preferable, negotiating global environmental agreements has proven to be both lengthy and difficult [Wilson, 1994]. Therefore, concerned countries have resorted to using unilateral trade policies. (Here, I interpret both government policies and consumer action targeting imported products as trade policies.)

Traditionally, these policies were *non-discriminatory*: They treated all imports equally, without considering the actual damages caused by the product. For example, local governments in Europe and the United States banned all tropical-timber use in public projects [Jackson, 1996]. Similarly, concern about harvesting tuna by setting on dolphins led to calls for canned-tuna boycotts in the United States [United States International Trade Commission, 1992]. Economists have shown that non-discriminatory trade policies can be second-best in the absence of global cooperation, but such policies can also have minimal or even adverse environmental effects [Snape, 1992; Barbier, 1994]. Moreover, non-discriminatory trade policies often conflict with World Trade Organization (WTO) rules.

Consequently, *process-discriminatory trade policies* have grown more popular. These are policies which attempt to discriminate against imports from environmentally damaging production processes while encouraging environmentally friendly alternatives. Process-discriminatory trade policies are defined here to include both government policies which discriminate between products on the basis of environmental impacts, as well as consumers' decisions to incorporate environmental considerations into their purchasing choices.[1] Examples are policies which give preferential market access to timber from sustainable forestry and the formation of groups of retailers which agree to buy some percentage of total timber purchases from sustainable sources, possibly at a price premium. Extreme cases of process-discriminatory trade policies are the International Dolphin Conservation Act of 1992, which mandates that only 'dolphin-safe' tuna can be sold in the U.S. market [Buck, 1996], and laws and initiatives in many European countries and North America prohibiting all timber imports from unsustainable

[1]While consumer-based actions (often referred to as 'voluntary eco-certification') are less likely to be in conflict with the WTO than government policies, consumer-based actions are subject to the potential for free-riding on the part of consumers due to the effect that an individual's purchase of environmentally friendly products leads to an increased provision of a public good that all consumers benefit from. These aspects are ignored for now. Except for these differences, both consumer- and government-led decisions that discriminate between imported goods on the basis of their environmental impacts, are formally unilateral, process-discriminatory trade policies.

forestry on the national, regional, or local level [Ghazali and Simula, 1994].

Because the environmental impacts of production are hard to observe or verify, process-discriminatory trade policies are often combined with *eco-certification*. Eco-certification takes two basic forms: labeling legislation and third-party labeling. The U.S. Dolphin Protection Consumer Information Act of 1990 is an example of the first. It defines "dolphin-safe" and provides for monitoring of firms' claims. The other, more common, form of eco-certification is third-party labeling. Here firms apply to an independent agency for the right to use a label that distinguishes their products from environmentally unfriendly products. The firm either provides evidence of the truthfulness of its claims or the labeling agency tests to verify the firm's claims. Currently, about 20 countries have government-sponsored third-party labeling programs, and the European Union is launching a regional eco-labeling program. Canada, Indonesia, Brazil, Costa Rica, and groups of Nordic and African countries are designing timber certification systems [Ghazali and Simula, 1996].

Process-discriminatory policies are frequently discussed in international fora. Chapter 4 of Agenda 21, at the June 1992 United Nations Conference on Environment and Development in Rio de Janeiro, specifically identifies eco-certification as a potential instrument for making trade and environmental goals mutually supportive. Process-discriminatory trade policies and certification have been criticized by target countries as trade barriers [Wasik, 1996]. Particularly developing countries argue that developed countries have depleted their own resources and common-property, thus enhancing their well-being and standard of living, but degrading environmental quality. Presumably, developing countries should have the same rights. The essential issue is who possesses the property rights to globally significant resources such as forests, and consequently who should pay for the costs of environmental protection. Developing countries believe they will lose from certification as consumers substitute away from their products (e.g., tropical timber) toward developed-country products (e.g., temperate timber) or close substitutes (e.g., metal or plastic) [Ghazali, 1996]. Still, under the pressure of importing nations, several exporting countries, including many developing countries, are designing their own certification systems.

Despite the growing interest by policymakers, consumers, and producers in eco-certification and process-discriminatory trade policies, little economic analysis of this topic exists. This paper develops a model capturing the following stylized facts: (i) the presence of what is formally a transnational externality[2] between one country's technology choice and consumer environmental concerns in another country; and (ii) hidden action caused by the costliness and difficulty of observing the choice of production technologies. The model is used to analyze the conditions under which an environmentally concerned country would prefer process-discriminatory to non-discriminatory trade policies in achieving environmental objectives abroad. Moreover, the target country's alternatives and the type of the consuming country's concerns are explicitly specified and their effect on the concerned country's optimal policy is analyzed.

While most of the paper focuses on production effects, consumption pollution is analyzed as a special case. Also, while the paper is phrased mainly in terms of environmental objectives, the topic is much broader. The basic approach applies to many other social and health objectives, including concerns about human-rights violations, fair

[2] The term 'externality' is potentially value-laden in this context because it could be taken to imply that developing countries are imposing a cost on developed countries by choosing an environmentally damaging production process. However, given the history of resource depletion and environmental degradation in developed countries, developing countries may well be seen as providing a benefit to developed countries by protecting a resource, such as forests, which developed countries themselves did not protect within their own borders in the past. The term 'externality' here is not meant as a value judgment on this issue, but rather is

wages, child labor, hazardous work conditions, or health impacts of pesticides. Recently passed 'no sweatshop' labeling legislation in the United States is an example of a process-discriminatory trade policy pursuing social objectives [Washington Post, 1997]. I show how the optimal policy depends on the type of consumer concern.

Deriving the optimal trade policies to affect the behavior of other countries is important not only as a policy guideline, but also as an evaluation tool of existing policies. In particular, it can serve as a basis for assessing target countries' concerns that current policies reflect protectionist rather than environmental considerations.

The outline of the paper is as follows. Part 2 gives a short review of the related economic literature and outlines the contribution of the paper. Part 3 describes the basic model and its assumptions. Part 4 presents some preliminary results, including the equilibrium in the alternative market and the optimal policy under perfect information. Part 5 derives the home country's optimal policy under asymmetric information. Section 5.1. analyzes the optimal process-discriminatory policy. Section 5.2. discusses the optimal non-discriminatory policy and bans as corner solutions to the optimal process-discriminatory policy. Part 6 analyzes the effect of imperfect information on the optimal policy. Part 7 describes how the optimal policy could be implemented in reality. Part 8 discusses the effects of alternative market conditions and the type of the consuming country's concerns on the optimal trade policy. Part 9 concludes.

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used to denote the economic relationship at hand, namely the fact that one agent's actions (positively or negatively) affect another agent's payoffs.

2. Contribution to the Literature

Several papers on optimal non-discriminatory trade policy in the presence of transnational externalities exist. In a two good - two country model, Markusen (1975) shows that if production of one good causes transnational pollution in fixed proportion to output the optimal unilateral policy involves: (1) setting a Pigouvian tax on domestic production equal to the domestic external cost per unit of output, and (2) an import tariff on the polluting good which is higher than the standard optimal tariff. Panagariya et al. (1993) derive a similar result in a slightly more general model.

Both studies assume that all imports of the good must be treated equally, independent of how environmentally damaging their production is. However, eco-certification is a way to discriminate between imports on the basis of the way in which they were produced. So, although one country cannot tax pollution in another, it can tax pollution imbedded in its imports. If monitoring were costless, process-discriminatory trade policies would be generally preferable to non-discriminatory policies.

Copeland (1993) generalizes Markusen's model to allow for process-discriminatory policies. He shows that the affected country would always prefer to use a pollution content tax, in which imports are taxed at a rate contingent on the amount of pollution generated during production. He also shows that such a tax is equivalent to a non-discriminatory tariff combined with a process-standard.

Ludema and Wooton (1994) show that in Nash Equilibrium between an exporting, polluting country and an importing country affected by pollution, the exporting country might voluntarily introduce environmental policy in order to capture a larger share of the gains from trade. They also show that the importing country will impose a process standard limiting imports to products which use clean production processes.

All of the existing models assume that the importing country can perfectly observe the exporting country's environmental technology choice. However, in the real world environmental impacts of production are difficult to observe [e.g., Barbier, 1994]. The model presented below explicitly incorporates asymmetric information regarding environmental technology choice and the possibility of costly monitoring.

Moreover, the existing literature focuses on the case of two countries, thereby ignoring the fact that the producing country may be able to sell to an alternative market where consumers are not concerned about environmental effects. In reality, such alternative markets usually do exist. For example, a large proportion of tropical timber production is exported to Japan and many developing countries which do not exhibit a significant concern about the effect of timber imports on tropical deforestation [Ghazali and Simula, 1994; Joint German-Indonesian Initiative, 1996]. The model described below incorporates a third country which represents such an alternative market and explicitly analyzes how the concerned country's optimal policy varies with the conditions in the alternative market. Moreover, the effect of the type of consumer concern on the optimal policy is also discussed.

3. Assumptions

Consider the following stylized presentation of the problem. A single, physically homogeneous good is produced with two technologies: an environmentally 'sound' (sustainable) technology and an environmentally 'unsound' (unsustainable) alternative. Unsound production affects a public good (e.g., biodiversity or dolphin populations).

There are three countries: The 'home country' consumes the product as well as valuing the public good. For simplicity, and to exclude protectionism, I assume that the home country does not produce the good, and therefore imports all its consumption. The 'foreign country' only produces, and the 'third country' only consumes the product. The third country is also referred to as the 'alternative market'. Neither the foreign nor the third country value the public good.

The foreign country can produce each unit of output either soundly or unsoundly. The foreign country's constant unit costs of sound and unsound output are denoted by C_s and C_u, respectively. Sound production is more costly than unsound production, i.e.,

$$C_s > C_u. \tag{A1}$$

The foreign country exports to the home country and the third country. Because the third country does not value the public good and sound production is more costly, the third country imports only unsound goods. Let y denote foreign exports to the third country. Let Y denote total exports by the foreign country to the home country, and let α denote the proportion of these exports which is sound. Letting Y_u and Y_s denote the home country's unsound and sound imports, respectively, we have

$$\alpha = \frac{Y_s}{Y} = 1 - \frac{Y_u}{Y}, \tag{A2}$$

and $$Y_u + Y_s = Y. \tag{A3}$$

Equations (A3) and (A4) imply that there is a direct correspondence between Y and α and Y_u and Y_s. We can therefore phrase the problem in terms of Y and α or in terms of Y_u and Y_s. The two options will be used interchangeably below, depending on which is more intuitive.

$v(X)$ and $w(x)$ denote the valuation function of consumers in the home country and the third country, respectively, where X and x denote total imports by the two countries. Utility is increasing at a decreasing rate in consumption, so that

$$v'(X) > 0, v''(X) \leq 0, w'(x) > 0, w''(x) \leq 0. \tag{A4}$$

In equilibrium, we have

$X=Y$ and $x=y$. (A5)

Unsound production deteriorates a public good. The home country's valuation of this cost is $m(Y_u + \beta y))$, where

$m'(Y_u + \beta y) \geq 0$, and $m''(Y_u + \beta y) \geq 0$ (A6),

and β denotes the proportion of third-country imports affecting environmental quality as valued by the home country, ($0 \leq \beta \leq 1$). This formulation allows for different type's of pollution and home-country concerns. If $\beta=1$, all unsound production, regardless of where it is consumed, affects the aspect of environmental quality valued by home-country consumers. This is the case, for example, if we consider tropical timber imports and the home country cares about tropical forest stands. Many other cases of production pollution fall into this category. If $\beta=0$, only consumption in the home country affects the public good valued by consumers in that country. This is the case of consumption pollution as well as health or safety concerns, or when consumers care only about the 'moral implications' of their own contribution to environmental damages rather than about damages *per se*. $0<\beta<1$ allows for mixed cases, such as for example, the case where consumption of the good causes water pollution which spills over to some extent from the third country to the home country.

The home country costlessly observes its total imports Y, but not their composition of sound and unsound products. The home country—or a labeling agency funded by it—can monitor the foreign country's technology choice at a cost. For simplicity, I assume that this monitoring cost is az, where z is the endogenous probability of detecting the true value of α, and a is a positive constant. For example, with probability z, the home country could take a random sample of the foreign country's exports to the home country and calculate the percentage of sound exports in the sample, denoted by $\dot{\alpha}$. With unbiased sampling, we have $\dot{\alpha}=\alpha$, so that z is not only the probability of being monitored but also the probability of detecting the true value of α.[3] Note that z is a choice variable for the home country.

I assume that the home country can act unilaterally without facing retaliation from the foreign country. Under this assumption the home country's policy choice can be modeled as a mechanism-design problem. Generally, the home country chooses a contract (Y, α^R, $\dot{\alpha}$, z, B, B^*), where α^R is the home country's request regarding the percentage of total output which is sound, $\dot{\alpha}$ is the estimate of α provided by monitoring, B is the payment to the foreign country for total imports of Y if $\dot{\alpha}=\alpha^R$ or if not monitored, and B^* is the total payment to the foreign country if $\dot{\alpha}\neq\alpha^R$. Note that under asymmetric information, the home country cannot directly contract on the quantities of sound and unsound imports, (i.e. on α). Instead, it can specify a desired level of the proportion of total imports from sound production (α^R) and can make its payment conditional on monitoring results ($\dot{\alpha}$). The foreign country chooses its actual level of sound and unsound exports to the home country (α), and it can either accept or reject the contract. If it rejects, it trades only with the third country. The home country does not interact with the third country directly.

[3] The results rely on the assumption that z represents both the probability of being monitored and the probability of being detected. This formulation is somewhat restrictive, but is made for simplicity. Alternatively, one might consider the case where the home country monitors only supposedly sound output. In that case, if z is the probability of being monitored, the foreign country can affect the probability of being discovered cheating by deciding how many of the supposedly sound units to cheat on. Then the probability of being detected would be given by a hypergeometric function, significantly complicating the results.

4. Preliminary Results

The home country's policy is limited by the foreign country's sovereignty. The foreign country decides whether to accept or reject the home country's offer, and it chooses how much to sell to the third country. Both the foreign and the third country take the home country's actions as given. In the simple case at hand, foreign exports to the third country will be determined by the intersection of demand and supply in the alternative market. Thus, y solves

$$w'(y) = C_u$$

Let the solution be denoted as $\bar{y}$. Figure 1 portrays this solution. Note that, as a consequence of constant marginal costs, the alternative-market equilibrium is independent of the home country's imports. This simplifies the case at hand considerably. In this case, the only effect of the alternative market on the home country's policy is that $\bar{y}$ affects total and marginal environmental damages considered by the home country.[4] Figure 1 shows that the level of $\bar{y}$ depends on the conditions in the alternative market and on production costs. In particular, the less elastic the demand in the alternative market and the lower are the costs of unsound production, the larger is $\bar{y}$.

Furthermore, under the assumption of constant marginal production costs, the foreign country's profits from selling to the alternative market are zero, regardless of how much it sells to the home country. Therefore, the foreign country's reservation utility, i.e., its profits from rejecting the home country's offer and selling only to the third country, is

[4] The assumption of perfectly elastic supply in the foreign country (constant marginal cost) ignores the issue that the home country and the third country may compete for foreign exports. With increasing marginal costs, a decrease in home-country imports reduces the price of the good in the alternative market, thereby increasing imports by the third country. Thus, the equilibrium in the alternative market will depend on the home country's optimal policy. In particular, the home country's policy may become less effective, as part of its

zero.

Finally, it is interesting to consider the case of perfect information as a baseline for comparison. For mnemonic simplicity, I shall refer to the situation when the home country has perfect information about the foreign country's technology choices as the 'first best'. With perfect information, the home country can contract directly on the level of sound and unsound imports. That is, it can directly contract on α in addition to Y. Equivalently, it can directly choose its levels of sound and unsound imports, Y_u and Y_s. There is no need for monitoring. The home country's objective then is to maximize its own surplus taking the foreign country's alternatives into account:

$$\max_{Y_u, Y_s, B} \quad v(Y_u + Y_s) - m(Y_u + \beta\bar{y}) - B^5 \tag{1}$$

$$\text{s.t.} \quad B - C_u Y_u - C_s Y_s \geq 0. \tag{2}$$

Constraint (2) is the participation constraint for the foreign country. It recognizes that the home country's choice of policy is limited by the foreign country's sovereignty and requires that the foreign country be no worse off trading with the home country under the contract (B, Y, α) than otherwise.

Constraint (2) always binds: Suppose it did not; the home country could then always reduce B while maintaining feasibility and raise the value of its objective function. Therefore, we can solve (2) for B and substitute into (1). The Kuhn-Tucker conditions are:

$$v'(Y_u + Y_s) - m'(Y_u + \bar{y}) - C_u \leq 0,\ Y_u \geq 0, \tag{3.1}$$

$$v'(Y_u + Y_s) - C_s \leq 0,\ Y_s \geq 0, \tag{3.2}$$

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own import reductions will be substituted by increased consumption in the alternative market. This aspect of the problem is ignored here for simplicity.

At an interior solution for Y_u and Y_s, we have

$$v'(Y_u + Y_s) = C_u + m'(Y_u + \beta\bar{y}) = C_s. \qquad (4)$$

Let the first-best solution be denoted by superscripts 0.

The case of an interior solution, is shown graphically in figure 2. The home country equates its marginal utility to the marginal social cost of each of its two supply sources: foreign unsound production and foreign sound production. The marginal social cost of sound imports is marginal production cost (C_s), while that of unsound imports includes marginal production costs (C_u) as well as marginal environmental damage (m'). The relevant marginal social cost curve of imports is the lower one of the two curves, represented in the graph as a thick line. The home country imports unsound goods up to the point where marginal social cost of unsound imports equal marginal social cost of sound imports. From that point on, the home country imports sound goods at constant marginal cost of C_s, up to the point where marginal utility equals C_s.

Social welfare in the home country, denoted by W^0, is given by:

$$W^0 = v(Y_u^0 + Y_s^0) - m(Y_u^0 + \beta\bar{y}) - C_u Y_u^0 - C_s Y_s^0 \qquad (5)$$

In the case of an interior solution, W^0 can be represented graphically in figure 2a) by the area between the demand curve and the relevant marginal social cost curve (area *abcd* in the graph).

[5] Here and in all the following objective functions of the home country there is an implicit assumption that the home country is better off under its optimal contract than doing nothing. That is, it is assumed that the maximized value of the home country's objective function is greater than or equal to zero.

5. The home country's optimal policy with asymmetric information

5.1. The optimal process-discriminatory policy

With asymmetric information, (also referred to as the second best), the home country's problem is as explained in part 3 of this paper. The home country observes the total quantity imported and—at a cost of az—sets up (or supports) a certification agency which monitors the proportion of sound production with a probability of detection z. In general, this is a process-discriminatory policy because it distinguishes between sound and unsound imports. In appendix A, I show that the home country's problem can be reduced to:

$$\max_{Y_u, Y_s, B, B^*, z} \quad v(Y_u + Y_s) - m(Y_u + \beta\bar{y}) - B - az \tag{6.1}$$

s.t.

$$B - C_u Y_u - C_s Y_s \geq 0, \tag{6.2}$$

$$B - C_u Y_u - C_s Y_s \geq zB^* + (1 - z)B - C_u(Y_u + Y_s), \tag{6.3}$$

$$0 \leq z \leq 1. \tag{6.4}$$

Constraint (6.2) is the participation constraint, as before. It is shown formally in appendix A that the home country always at least weakly prefers the foreign country to do as requested, i.e. to choose $\alpha = \alpha^R$ (or equivalently, choose Y_u and Y_s as requested by the home country), than to cheat. Therefore, constraint (6.3) is an incentive compatibility constraint insuring that the foreign country is no worse off producing Y_s units soundly than cheating. Because sound production is more costly, the incentive to cheat will lie in claiming unsound products as sound. The foreign country must be no worse off producing Y_s units soundly than producing all output unsoundly and risking detection. The incentive compatibility constraint in (6.3) simplifies to

$$z(B - B^*) \geq (C_s - C_u)Y_s. \tag{7}$$

The left-hand side of (7) shows the expected loss from cheating, i.e., the change in payment if detected multiplied by the probability of detection. The right-hand side of (7) represents the gains from cheating, given by the cost savings from producing all output unsoundly.

Lemma 1: If $z=0$, then $Y_s=0$ and any $B^* \geq 0$ solves the home country's problem. If $z>0$ then $B^*=0$.

Proof: If $z=0$, the incentive compatibility constraint, using the first part of the lemma, becomes $(C_s-C_u)Y_s \leq 0$. This implies $Y_s=0$. In this case, B^* drops out of the home country's problem, and thus, any value of B^* solves the problem. To show that $B^*=0$ when $z>0$, suppose to the contrary that $B^*>0$. Then, we can always lower B^* in inequality (7), thereby increasing $B-B^*$, and then lower z while maintaining feasibility and increasing the value of the objective function. Q.E.D.

Lemma 1 implies that without monitoring the home country cannot enforce a positive level of sound imports. This implies that without monitoring the foreign country is better off always producing unsoundly and can never be induced to produce soundly. Economically speaking, we have

<u>Result 1:</u> No potential for process-discriminatory trade policy without certification (monitoring) exists. Rather, the case of a corner solution where $z=0$, and thereby $Y_s=0$, represents the case of a non-discriminatory policy: the home country realizes that without monitoring all output will be unsound and thus treats all output the same.

The optimal non-discriminatory policy can therefore be analyzed as a special case, (a corner solution where $Y_s=0$), to the optimal process-discriminatory policy. This special case is presented in section 5.2. Without monitoring the home country does not import sound products. Therefore, the foreign country has no incentive to cheat and thus the payment in the case of cheating (B^*) is irrelevant. However, with a positive level of monitoring, lemma 2 implies that the home country's optimal policy is to pay zero in the case of cheating. In other words, the optimal punishment in the case of cheating is to withhold all payment, paying zero instead of B. Therefore, without loss of generality, we can rewrite the incentive compatibility constraint as

$$zB \geq (C_s - C_u) Y_s. \tag{8}$$

Lemma 2: In any solution to the problem defined in (6.1) to (6.4),

$$zB = (C_s - C_u) Y_s.$$

(9)

Proof: Suppose to the contrary that $zB > (C_s - C_u) Y_s$. Then, because $a > 0$, we can always reduce z while maintaining feasibility and decreasing the value of the objective function. Therefore, this cannot be optimal. Q.E.D.

Lemma 2 states that the incentive compatibility constraint always binds—imperfect information is always costly. And except for the pathological case where the first best involves the incentive compatibility constraint binding coincidentally, the first best is not attainable.

Finally, we have

Lemma 3: In any solution to the problem defined in (6.1) to (6.4), $z<1$.

Proof: Suppose to the contrary, that $z=1$. Then, substituting for z in (9) and substituting into the participation constraint (6.2), we get

$$0 \geq C_u (Y_u + Y_s).$$

For any positive level of imports ($Y_u+Y_s>0$), this is a contradiction and thus it must be that $z<1$. For zero imports ($Y_u=Y_s=0$) it is easily seen that $z=0$ satisfies all constraints and yields a higher value of the objective function than $z=1$. Q.E.D.

Interestingly, lemma 3 implies that it is never optimal to monitor perfectly. Intuitively, the potential loss from cheating is zB. The payment required to compensate the foreign country for its production costs is large enough to prevent cheating at a monitoring intensity of less than one. Solving the incentive compatibility constraint in (9) for the monitoring intensity, we get

$$z = \frac{(C_s - C_u)Y_s}{B}. \tag{10}$$

The monitoring intensity required for incentive compatibility is increasing in the potential cost savings from cheating ($(C_s-C_u)Y_s$), and decreasing in the payment (B). The latter happens because the withdrawal of the payment acts as a punishment for cheating. Therefore, the higher is the payment, the higher also the expected loss from cheating and thus the lower the monitoring intensity required to deter cheating.

Substituting for z from (10) and noticing that (10) implies $z\geq 0$, the home country's problem can be rewritten:

$$\max_{Y_u, Y_s} \quad v(Y_u + Y_s) - m(Y_u + \beta y) - I(Y_u, Y_s) \tag{11.1}$$

where

$$I(Y_u, Y_s) \equiv \left\{ \min_B B + a\frac{C_s - C_u}{B} Y_s : B \geq C_u Y_u + C_s Y_s \right\}. \tag{11.2}$$

This representation allows for solving the problem stepwise. $I(Y_u, Y_s)$ represents minimum import costs, excluding environmental damages. In what follows, I first examine the second stage, i.e. the minimization of import costs, and then analyze the rest of the problem.

Import costs

Let us now examine import costs in detail by solving the problem in (11.2). Note that it is no longer clear a priori whether the participation constraint is binding. In the first best, the only function of the payment (B) was to ensure the foreign country's participation by compensating it for its production costs. There was no reason to pay any more than that. With imperfect information, the payment (B) has an additional function. To see this, recall that in the case of cheating, the foreign country loses B and instead receives zero. Thus, the loss of payment, in fact, acts as a punishment. In order to prevent the foreign country from cheating, the gains from cheating, $(C_s-C_u)Y_s$, must be outweighed by the potential loss from cheating (zB). Therefore, the home country has two mechanisms to increase the potential loss from cheating. It can either monitor more intensely (increase z) or pay more in the case of compliance (increase B). Both of these mechanisms are costly to the home country. We would expect the home country to choose z and B so that the marginal cost of the two is equal, as long as the participation constraint is still satisfied. If increasing the monitoring intensity is relatively costly, we would expect that the home country chooses a relatively large payment, which may well exceed the level required for participation. To show this formally, let us first focus on the minimization of import costs in (11.2). The corresponding Kuhn-Tucker conditions are:

$$1-a\frac{(C_s-C_u)Y_s}{B^2}\geq 0, \quad B\geq C_uY_u+C_sY_s. \tag{12}$$

Intuitively, increasing B by one unit increases total import costs directly by 1. But increasing B also increases the punishment in case of cheating and thereby lowers the level of z necessary to maintain incentive compatibility (by $\frac{(C_s-C_u)Y_s}{B^2}$). Thus, monitoring costs fall by $a\frac{(C_s - C_u)Y_s}{B^2}$. If at the minimum payment required by the participation constraint the costs of increasing B outweigh the benefits, i.e.,

$$1 > a\frac{(C_s - C_u)Y_s}{[C_uY_u + C_sY_s]^2} \tag{13}$$

a corner solution exists at $B = C_uY_u + C_sY_s$. The participation constraint is binding. Then, as in the case of an exogenous fine, the foreign country receives only its reservation payoffs, and all surplus is extracted by the home country. Note that (13) implies that the participation constraint is more likely to bind when monitoring costs (a) are low. As expected, when monitoring costs are low the payment is less important in deterring cheating (in the sense that the monitoring intensity is high). Therefore the optimal payment to deter cheating is likely to be less than the amount required for participation. In Appendix B, I further examine the conditions for the participation constraint to be binding. I show that this is more likely when the cost of unsound production (C_u) is large, the cost increase from sound production (C_s-C_u) is small, the optimal percentage of sound imports in total imports $\left(\frac{Y_s}{Y_u + Y_s}\right)$ is small, and the optimal monitoring intensity is large. This is intuitive. A high value of C_u causes a high level of payment required for participation, while the other factors all reduce the incentives to cheat, thereby reducing the payment required for incentive compatibility.

If (13) does not hold, the foreign country's optimal payment is determined by the economic tradeoff between a higher payment and a lower probability of detection. The optimal payment which maintains incentive compatibility at least cost, denoted by $\bar{B}$ and defined by

$$a\frac{(C_s - C_u)Y_s}{\overline{B}^2} = 1,$$

$$\text{or} \qquad \overline{B} = \sqrt{a(C_s - C_u)Y_s}, \tag{14}$$

is large enough to assure the foreign country's participation. Because the participation constraint is not binding, the foreign country's net payoffs under the process-discriminatory policy are strictly greater than its reservation payoffs (zero).

We can summarize these results as

$$B = max\{C_u Y_u + C_s Y_s; \overline{B}\}, \tag{15}$$

and

$$I(Y_u, Y_s) = \begin{cases} C_u Y_u + C_s Y_s + a\dfrac{(C_s - C_u)Y_s}{C_u Y_u + C_s Y_s} & if \quad \overline{B} \le C_u Y_u + C_s Y_s, \\ \\ \overline{B} + a\dfrac{(C_s - C_u)Y_s}{\overline{B}} & if \quad \overline{B} \ge C_u Y_u + C_s Y_s, \end{cases}$$

When thé payment which minimizes import costs ($\overline{B}$) is too small to ensure participation by the foreign country, (the participation constraint binds), import costs are composed of production costs and monitoring costs. When the payment which minimizes import costs is large enough to ensure participation, (participation constraint not binding), import costs are composed of that payment ($\overline{B}$) plus monitoring costs. Production costs no longer enter. Let us now analyze marginal import costs. Taking the derivatives with respect to Y_u and Y_s and simplifying, we get

$$I_u(Y_u, Y_s) \equiv \frac{\partial I(Y_u, Y_s)}{\partial Y_u} = \begin{cases} C_u - a\dfrac{(C_s - C_u)Y_s}{(C_u Y_u + C_s Y_s)^2} C_u & if \quad \overline{B} < C_u Y_u + C_s Y_s, \\ 0 \quad if \quad \overline{B} > C_u Y_u + C_s Y_s, \end{cases} \tag{16.1}$$

and

$$I_s(Y_u,Y_s) \equiv \frac{\partial I(Y_u,Y_s)}{\partial Y_s}$$

$$= \begin{cases} C_s + a\left[-\dfrac{(C_s-C_u)Y_sC_s}{(C_uY_u+C_sY_s)^2} + \dfrac{(C_s-C_u)}{C_uY_u+C_sY}\right] = C_s + a\dfrac{(C_s-C_u)Y_uC_u}{(C_uY_u+C_sY_s)^2} & \text{if} \quad \bar{B} < C_uY_u + C_sY_s, \\ a\dfrac{(C_s-C_u)}{\bar{B}} = \dfrac{a(C_s-C_u)}{Y_s} & \text{if} \quad \bar{B} > C_uY_u + C_sY_s. \end{cases} \qquad (16.2)$$

The intuition behind these expressions is as follows. When the participation constraint binds ($\bar{B} < C_uY_u + C_sY_s$), marginal import costs include marginal production costs and marginal monitoring costs. In the case of unsound imports, marginal monitoring costs are negative: An increase in unsound imports increases the payment to the foreign country required to assure participation (by C_u). Since the punishment, if found cheating, is a loss of this payment, an increase in unsound imports increases the expected loss from cheating. These incentive gains permit a reduction in the monitoring intensity (by $\frac{(C_s-C_u)Y_s}{(C_uY_u+C_sY_s)^2}\hat{C}_u$) and, consequently, in monitoring costs (by $a\frac{(C_s-C_u)Y_s}{(C_uY_u+C_sY_s)^2}C_u$). This effect reduces the marginal cost of unsound imports (excluding environmental damages) below production costs. For sound imports, the same effect holds, but is counteracted by an additional effect. The larger the quantity of sound imports, the larger the gains from cheating, $(C_s\text{-}C_u)Y_s$. This effect tends to increase the level of monitoring required for incentive compatibility, increasing monitoring costs by $a\frac{(C_s-C_u)}{C_uY_u+C_sY_s}$. The combined effect on the probability of detection can be simplified to $\frac{(C_s-C_u)C_uY_u}{[C_uY_{ul}+C_sY_s]^2}>0$. So, the net effect of an increase in sound imports is to increase monitoring costs by requiring a larger probability of detection.

When the participation constraint does not bind, the payment to the foreign country is no longer determined by production costs but rather by the trade-off between increasing the payment and increasing the monitoring intensity to maintain incentive compatibility. Therefore, marginal production costs no longer enter marginal import costs directly. Marginal import costs then consist only of marginal monitoring costs. They are independent of Y_u because unsound imports have no effect on the foreign country's incentives to cheat. An increase in sound imports increases the gains from cheating, therefore requiring a higher monitoring intensity and raising monitoring costs by

$$a\frac{(C_s - C_u)}{\overline{B}}.$$

Using inequality (13) in the case where the participation constraint binds, and the fact that $\overline{B} > C_u Y_u + C_s Y_s$ when the participation constraint does not bind, it is easily seen that

$$0 \leq I_u \leq C_u \text{, and } I_s \geq C_s. \tag{17}$$

At an interior solution, ($Y_u>0$, $Y_s>0$), the inequalities in (17) hold strictly.

Thus, imperfect information decreases the marginal costs of unsound imports (excluding environmental damages) below production costs and increases the marginal costs of sound imports above production costs. This result is independent of whether the participation constraint binds or not.

We can now return to the home country's problem of choosing its sound and unsound imports optimally. Intuitively, we would again expect the home country to choose imports to equate marginal benefits to marginal costs. As in the first best, marginal benefits are given by the marginal utility from consumption. However, marginal costs may now include not only production costs and (in the case of unsound imports) marginal environmental damages, but also monitoring costs. In fact, the Kuhn-Tucker conditions for the home country's problem in (11.1) are:

$$v'(Y_u + Y_s) - m'(Y_u + \beta\bar{y}) - I_u(Y_u, Y_s) \leq 0, \quad Y_u \geq 0, \tag{18.1}$$

$$v'(Y_u + Y_s) - I_s(Y_u, Y_s) \leq 0, \quad Y_s \geq 0, \tag{18.2}$$

and at an interior solution we have:

$$v'(Y_u + Y_s) = I_u(Y_u, Y_s) + m'(Y_u + \beta\bar{y}) = I_s(Y_u, Y_s) \tag{19}$$

These conditions differ from those for the first-best solution, (equations (3.1) through (4)), only in that foreign marginal production costs (C_u and C_s) are replaced by marginal import costs (I_u and I_s).

5.2. Nondiscriminatory Policy and Bans as Special Cases

As seen in result 1, the optimal non-discriminatory policy is a special case of the optimal process-discriminatory policy. More specifically, the former is a corner solution of the latter where $Y_u>0$, but $z=0$ and thereby $Y_s=0$. The home country finds it optimal not to monitor and accept that all imports will be unsound.

Note that when $Y_s=0$, then from (14) we have that $\bar{B}=0$. When all imports are unsound there is no incentive to cheat and thus no role for a positive payment in achieving incentive compatibility. In fact, the incentive compatibility constraint holds trivially in this case. This implies that the participation constraint always binds, because, just as in the first best, the only role of the payment is to assure participation. Economically speaking, the optimal non-discriminatory policy extracts all surplus from the foreign country, only leaving the foreign country its reservation utility of zero. This is interesting because we saw that under a process-discriminatory policy it is possible that the foreign country's net payoffs under the process-discriminatory policy are strictly greater than its reservation payoffs (zero). Thus, we have

Result 2: Non-discriminatory policies extract all surplus from the foreign country; process-discriminatory policies—to deter cheating at least cost—can involve greater returns to the foreign country. Therefore, the foreign country always weakly prefers a process-discriminatory policy over a non-discriminatory policy.

Result 2 helps explain why producing countries voluntarily design their own certification systems when faced with the threat of non-discriminatory policies. For example, in response to trade restrictions on tropical timber in the United States and Europe, several developing countries (including Brazil and Indonesia) are designing national timber certification systems. The compliance of these systems with international standards is assured by the Forestry Stewardship Council, which was founded by a variety of environmental NGOs and consumer organizations. The African Timber Organization has adopted an initiative for a regional certification system, with financial support from the European Union (Garba, 1996). Similarly, the threat of trade restrictions by the European Union on Colombian flowers based (at least officially) on environmental and worker-safety concerns, has caused discussion in Colombia about the possible implementation of an eco-label for flowers (Gaviria et al.).

The condition for the optimal second-best policy to be non-discriminatory ($Y_s=0$ and $Y_u>0$) is that marginal benefits from sound imports, evaluated at zero sound imports, are less than marginal social costs:

$$v'(Y_u) < I_s(Y_u,0) = C_s + a\frac{C_s - C_u}{C_u Y_u}, \tag{20.1}$$

where $v'(Y_u) = I_u(Y_u,0) + m'(Y_u + \beta\bar{y}) = C_u + m'(Y_u + \beta\bar{y})$. (20.2)

Examination of (20.1) yields

__Result 3:__ The optimal second-best policy is more likely to be non-discriminatory when the home country's demand for the good is relatively elastic, the unit cost of sound production is high, the unit cost of unsound production is low, and increasing the monitoring intensity is relatively costly (a is large).

It had been argued that the costs of information collection and dissemination have decreased over time, leading to an increased role for mechanisms based on the disclosure of pollution information (see, for example, Tietenberg, 1998). Result 3 confirms this argument for the case of trade policies and consumer actions. High monitoring costs can explain why, in the past, non-discriminatory policies were predominantly used. A reduction of monitoring costs over time may explain the current trend towards process-discriminatory policies.

When the optimal policy is non-discriminatory, ($Y_s=0$, $Y_u>0$), the condition for the optimal level of unsound imports is given by equation (20.2). The home country equates marginal benefits to marginal production costs plus marginal environmental damages. Let the optimal non-discriminatory policy be denoted by Y_u^2. This policy is demonstrated in figure 3.

Bans on all imports from the foreign country are frequently observed in reality, (e.g., the U.S. ban on all tuna imports from Mexico). An import ban is only optimal in the case of a corner solution to the home country's problem where both $Y_s=0$ and $Y_u=0$.

Intuitively, we would expect this to happen when both monitoring costs and environmental damages from consumption in the alternative market are very high while the product is not essential to the home country, so that the home country prefers to not consume anything. Formally, a total ban on imports requires that, in addition to the conditions for $Y_s=0$ which were discussed above, the marginal social costs of unsound imports, evaluated at zero imports, exceed marginal benefits:

$$v'(0) < C_u + m'(\beta\bar{y}). \tag{21}$$

This is more likely the larger are production costs, the greater are marginal environmental damages, the more is consumed by the third country, the more environmental damaging are exports to the third country, and the less essential the good to consumers. Only under these conditions, can a complete import ban, such as observed in the case of tuna, be justified on purely environmental motives. If these conditions are not likely to hold, a case might be made for concern that current policies are motivated by protectionism.

Finally, we may be interested in the case of a ban on unsound imports only. This is the case, for example, of a ban or boycott on all timber from unsustainable forestry, as observed in practice. Intuitively, we would expect such a ban to be optimal when environmental damages from the alternative market are large while monitoring costs are not. Formally, the condition for such a corner solution where $Y_u=0$, but $Y_s>0$ is that marginal social costs of unsound imports evaluated at zero unsound imports exceed marginal benefits:

$$v'(Y_s) < m'(\beta\bar{y}) + I_u(0,Y_s), \tag{22}$$

where $v'(Y_s) = I_s(0,Y_s)$,

$$I_u(0,Y_s)=\begin{cases} C_u - a\dfrac{(C_s-C_u)}{C_s^{\,2}Y_s}C_u & if \quad \bar{B}<C_sY_s, \\ 0 \quad if \quad \bar{B}>C_sY_s, \end{cases}$$

and $$I_s(Y_u,Y_s)=\begin{cases} C_s & if \quad \bar{B}<C_sY_s, \\ \sqrt{\dfrac{a(C_s-C_u)}{Y_s}} & if \quad \bar{B}>C_sY_s. \end{cases}$$

6. The effect of imperfect information

Let superscripts *1* denote the optimal process-discriminatory policy (the second best). Under this policy, social welfare, denoted by W^1, is

$$W^1 = v(Y_u^1 + Y_s^1) - m(Y_u^1 + \beta\bar{y}) - I(Y_u^1, Y_s^1).$$

The second-best problem is identical to the first best except that the former involves an additional non-negative term subtracted from the maximand and an additional constraint. Since the additional term, az, is non-negative, Le Chatelier's principle implies that welfare is at least as high under perfect information (W^0) as under imperfect information (W^1).

In the case of a non-discriminatory policy, the home country's social welfare with the optimal non-discriminatory policy, denoted as W^2 is:

$$W^2 = v(Y_u^2) - m(Y_u^2 + \beta\bar{y}) - C_uY_u^2.$$

W^2 is shown as the triangular area *ade* in Figure 3, and, for the case of an interior solution for the first-best case, the welfare loss due to imperfect information is represented by the triangle *bce*.

Figure 3 also shows that unsound imports under a non-discriminatory policy are larger than unsound imports in the first best and smaller than total imports in the first best. Intuitively, we would expect a similar result in comparing all process-discriminatory policies to the first best. As shown in the previous section (inequality (17)), imperfect information leads to an increase in the marginal social costs of sound imports and a decrease in the marginal social costs of unsound imports. The home country will try to equate marginal benefits to marginal social costs of each type of imports. We would expect the lower marginal social costs of unsound imports to result in an increase in unsound imports as compared to the first best. Moreover, the higher marginal social costs of sound imports are likely to result in a lower level of sound imports than in the first best. At the optimum, marginal benefits will be equated to the marginal social costs of sound imports. Therefore, we would expect total imports to be less in the second best than in the first best. For the case of an interior solution, these results are shown formally below:

__Result 4:__ ***For an interior solution, total imports are larger in the first best than in the second best:***

$$Y_u^1 + Y_s^1 \leq Y_u^0 + Y_s^0 \quad \forall\, Y_u^1, Y_s^1, Y_u^0, Y_s^0 > 0..$$

Proof:From equations (4), (19) and inequality (17) it follows that

$$v'\left(Y_u^1 + Y_s^1\right) = I_s \geq v'\left(Y_u^0 + Y_s^0\right) = C_s. \tag{23}$$

Therefore, result 4 follows from the concavity of v.

__Result 5:__ ***For an interior solution, unsound imports are smaller in the first best than in the second best:***

$$Y_u^1 \geq Y_u^0 \quad \forall\, Y_u^1, Y_s^1, Y_u^0, Y_s^0 > 0.$$

Proof: From equations (4), (19), and inequality (17) it follows that

$$v'\left(Y_u^1 + Y_s^1\right) - m'(Y_u^1 + \beta\bar{y}) = I_u \leq v'\left(Y_u^0 + Y_s^0\right) - m'(Y_u^0 + \beta\bar{y}) = C_u. \tag{24}$$

Combining inequalities (23) and (24) we get:

$$0 \leq v'\left(Y_u^1 + Y_s^1\right) - v_1'\left(Y_u^0 + Y_s^0\right) \leq m'(Y_u^1 + \beta\bar{y}) - m'(Y_u^0 + \beta\bar{y})$$

Result 5 follows from the convexity of m.

Result 6: ***For an interior solution, sound imports are larger in the first best than in the second best:***

$$Y_s^1 \leq Y_s^0 \quad \forall\, Y_u^1, Y_s^1, Y_u^0, Y_s^0 > 0.$$

Proof: Result 6 follows directly from the combination of results 4 and 5.

In summary, results 4 through 6 state that imperfect information increases unsound imports, and decreases sound imports as well as total imports as compared to the first best.

7. Implementing the Optimal Policy

So far we have analyzed the home country's optimal policy in terms of a very general mechanism, namely a payment B in case of compliance. It is desirable to analyze whether the optimum can be implemented through more realistic trade policies or consumer actions. In doing so we will focus on an interior solution for simplicity.

Let us first consider implementing the optimum through trade policies. The optimal process-discriminatory policy in the case of an exogenous fine can be implemented through a domestic price *p*, a unit tariff *t* on unsound imports, a certification fee *f*, a fixed import subsidy b, and by setting up a certification agency which monitors sound production with probability z^1. The foreign country, given this policy, solves

$$\max_{Y_u, Y_s} \quad (p-t)Y_u + (p-f)Y_s - C_u Y_u - C_s Y_s - \text{b}.$$

The Kuhn-Tucker conditions are:

$$(p-t) - C_u \leq 0, \quad Y_u \geq 0, \tag{25.1}$$

$$(p-f)-C_s \le 0, \quad Y_s \ge 0. \tag{25.2}$$

Comparing conditions (25) to the conditions for the home country's problem, (conditions (18)), we see that the home country's optimal policy can be implemented by choosing

$$p = v'(Y_u^I + Y_s^I), \tag{26.1}$$

$$t = m'(Y_u^I + \beta\bar{y}) + I_u - C_u, \text{ and} \tag{26.2}$$

$$f = I_s(Y_u^I, Y_s^I) - C_s. \tag{26.3}$$

Moreover, the total payment in this case is

$$B = (p-t)Y_u + (p-f)Y_s + b,$$

which has to satisfy equation (15). Using the conditions for an interior solution in (19) and the values for p, t, and f, in (26.1-3), we find that the import subsidy has to satisfy

$$b = \begin{cases} 0 & \text{if } \bar{B}^I < C_u Y_u^I + C_s Y_s^I \\ \bar{B}^I - C_u Y_u^I + C_s Y_s^I & \text{if } \bar{B}^I > C_u Y_u^I + C_s Y_s^I. \end{cases}$$

Thus, if the participation constraint binds, the optimal policy does not require any fixed payment (b) to the foreign country. However, if the participation constraint does bind, a positive payment is required. This could take the form, for example, of the home country directly supporting environmentally sound projects through technology transfers. (Alternatively, the home country could essentially subsidize labeling by charging a total labeling fee of $-b+fY_s$.)

In order to satisfy the condition that the payment in the case of cheating (B^*) is equal to zero, the certification fee has to be refundable. Because a process-discriminatory tariff may be in violation of the WTO, the home country government could also charge a uniform consumption tax of t on all goods and lower the certification fee to f-t.

Similarly, the optimal non-discriminatory policy can be implemented through a *per unit* Pigouvian tariff of $m'(Y_u^2 + \beta\bar{y})$ on all imports, or by restricting imports to Y_u^2. This is equivalent to Markusen's result. Interestingly, however, under a process-discriminatory policy with positive levels of both sound and unsound imports, equation (26.2) and inequality (17) imply that the optimal tariff on unsound imports is less than the Pigouvian tariff. This happens because with costly monitoring the payment for unsound imports yields an incentive against cheating, thereby reducing monitoring costs.

Finally, let us consider implementing the home country's optimal policy through consumer action rather than trade policies. Suppose the aggregate consumer fully internalizes the environmental damages caused by unsound production[6] and realizes that eco-labeling, if set up optimally, is a reliable indicator for the environmental impacts of the good. Then the consumers demand for the good will be differentiated in the following way. Her demand for sound goods will be given by $v'(Y_u + Y_s)$ while the demand for unsound goods will be $v'(Y_u + Y_s) - m'(Y_u + \beta\bar{y})$. There may generally be two different market prices: one for those goods labeled as sound (P_s) and another for unlabeled goods (P_u). One way to implement the optimal policy through consumer action and voluntary eco-labeling by firms is the following. Suppose the home-country government pays a general consumption subsidy of s, and sets up an eco-labeling agency which issues licenses to label the good as sound at a per unit labeling fee $\bar{f}$ and monitors with probability z^1. It also subsidizes sound production abroad by paying $\tilde{b}$ (for example in form of technological transfers). There would be little grounds for complaints against such a policy under WTO

[6] This assumption ignores the potential problem of free-riding. If the environmental quality aspect of concern is a public good, then each individual consumer may not internalize the full effect of her unsound

rules. Given this policy, the aggregate consumer chooses her consumption to set

$$v'(Y_u + Y_s) = P_s\text{-}s \text{ and } v'(Y_u + Y_s) - m'(Y_u + \beta\bar{y}) = P_u\text{-}s. \qquad (27)$$

The aggregate firm chooses its output to

$$\max_{Y_u, Y_s} \; P_u Y_u + (P_s - f)Y_s - C_u Y_u - C_s Y_s + b.$$

The Kuhn-Tucker conditions are:

$$P_u - C_u \leq 0, \quad Y_u \geq 0, \qquad \text{and} \qquad (P_s - f) - C_s \leq 0, \quad Y_s \geq 0.$$

Therefore, in equilibrium we would expect the following prices to result:

$$P_u = C_u, \text{ and } P_s = f + C_s.$$

Substituting these prices into the consumer's decision in (27) and comparing to the condition for the optimal policy (equality (19)), we see that the conditions for the optimum to result in the market is:

$$s = C_u - I_u(Y_u^I, Y_s^I) > 0, \text{ and } \tilde{f} = I_s(Y_u^I, Y_s^I) - C_s + s > 0.$$

It is also easily verified that $\tilde{b} = b$.

Implementing the optimal policy through consumer action generally requires some government intervention in addition to the setting up of a voluntary eco-labeling, for example in form of a consumption subsidy and, if the participation constraint does not bind, a direct payment to support sound production.

8. Effects of Alternative Market Conditions and Type of Home-Country Concerns

The objective of this part is to analyze how the home country's optimal policy is affected by the conditions in the alternative market and by the type of pollution and home-

consumption on the environment. This is not a problem in the case of health or safety effects or for purely moral concerns about contributing to the problem. Also, possible aggregation problems are ignored here.

country concerns. Let us first consider conditions in the alternative market. The only way in which the alternative market affects the home country's policy in this model is through their consumption of unsound goods, $\bar{y}$, which causes environmental damages valued by the home country. Since environmental damages are assumed to be convex, marginal damages increase as $\bar{y}$ increases. An increase in marginal environmental damages raises the marginal social costs of unsound imports and implies a decrease in these imports. Therefore, using the results from part 4 of this paper, the less elastic the demand in the alternative market and the lower the costs of unsound production, the higher is the optimal tariff on unsound goods, and, thus, the smaller are unsound imports by the home country. This also implies that ignoring the environmental effects of foreign exports to the alternative market leads to a level of unsound imports by the home country that is higher than optimal.

Let us now consider the effect of the type of pollution and home-country concern on the optimal process-discriminatory policy. These aspects affect the home country's policy through the value of β. By the same argument as above, an increase in β increases the marginal environmental damages as valued by the home country, thereby increasing the optimal tariff on unsound goods and reducing the optimal level of unsound imports. Therefore, the level of unsound imports will be smaller in cases of pure production pollution than in cases of consumption pollution, health or safety effects, or where consumers care only about the moral implications of contributing to the problem rather than the problem itself.

9. Conclusions

This paper has presented a model of the optimal policy choice of a country which is concerned about the environmental, social, or health impacts of the products it imports. In contrast to the existing literature, the model allowed for a hidden action problem caused by the costliness of monitoring production abroad as well as for the existence of an alternative market and different types of concerns.

The results indicate that imperfect information is generally costly and reduces the optimal level of total imports as well as sound imports and raises the optimal level of unsound imports, as compared to the case of perfect information. The optimal process-discriminatory policy involves imperfect monitoring and withdrawal of all payments in the case of cheating.

It was shown that the optimal non-discriminatory policy is a corner solution to the case of the optimal process-discriminatory policy. Therefore, the use of a non-discriminatory policy is only optimal when the home country's demand is very elastic, sound production is very costly, unsound production costs are very low, and/or increased monitoring is very costly. The decrease in the costs of monitoring and information provision over time may therefore explain the observed shift from non-discriminatory to process-discriminatory policies. Similarly, bans on unsound or all imports, as often observed in practice, are only optimal under the restrictive conditions of a corner solution. When these conditions do not hold, there may be grounds for suspecting that current policies are motivated by protectionism rather than environmental or social concerns.

Furthermore, we find that the target country always (weakly) prefers a process-discriminatory over a non-discriminatory policy, possibly explaining why producing country establish their own eco-certification agencies when faced with the threat of non-discriminatory policies.

When the optimal policy is non-discriminatory, it can be implemented through a Pigouvian import tariff, which is consistent with previous studies. The optimal process-discriminatory policy can be implemented through a tariff on unsound imports and a certification (eco-labeling) fee. However, the optimal tariff in this case is lower than the Pigouvian tariff. This is due to the fact that unsound imports by increasing the volume of trade that might be lost if found cheating yield incentive gains which allow a reduction in monitoring costs. The optimal process-discriminatory policy could also be implemented through consumer action when consumers internalize the environmental impacts of unsound production. To achieve the home country optimum, such consumer action might be complemented by the setup of an appropriate eco-labeling agency, a consumption subsidy, and sometimes direct payments to producers (e.g., in form of technological transfers).

The optimal policy depends on the type of consumer concern and the conditions in the alternative market. In the case of consumption pollution, health and safety concerns, or when consumers care about their own contribution to the problem rather than about the problem itself, consumption in the alternative market does not affect environmental damages as valued by the home country. In these cases, the optimal tariff on unsound goods is lower and the home country imports more unsound products than in the case of production pollution. Moreover, the less elastic demand in the alternative market and the less costly unsound production, the higher is the optimal tariff on unsound imports and the lower the optimal level of these imports.

Several aspects have been consciously left out of the present analysis and provide opportunities for future research. First, one may want to consider how the model changes when marginal production costs are increasing rather than constant. In that case, the equilibrium in the alternative market will depend on the home country's policy. A reduction in home-country imports will lower the price in the alternative market and increase consumption by the third country. Therefore, the home country, in choosing its optimal policy, would have to consider its effects on third-country consumption. To the extent that the home country values the environmental effects of foreign exports to the alternative market, the home country's policy would be less effective in reducing total pollution. This may yield an additional incentive to use process-discriminatory policies rather than non-discriminatory policies and would generally make the home country's policy more expensive.

Another obvious extension would be to allow for production of the good within the home country. We would expect this to introduce an incentive to use trade policies not only for environmental or social reasons, but also for protectionist motives. In general, we would expect the home country to import less than justified by environmental or social motives only.

One might also consider more general monitoring mechanisms, in which the foreign country can affect the probability of being detected by choosing its optimal cheating behavior. Finally, we may want to consider the case where there is more than one producing country, thereby allowing for effects such as competitive advantage. The present model can serve as a basis for all of these extensions.

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Appendix A

To show that the setup of the home country's problem presented in the text is correct, consider the complete structure of the game as presented in figure 4. In the first stage, the home country offers a contract (Y, α^R, $\hat{\alpha}$, z, B, B^*) to the foreign country. The foreign country either rejects, in which case both country's receive zero payoffs, or it accepts, in which case it can choose to comply with the contract (choose $\alpha=\alpha^R$) or not ($\alpha\neq\alpha^R$). If the foreign country does not comply, it is discovered cheating with probability z.

We will solve this game backwards, i.e., starting with the foreign country's optimal response, and then deriving the home country's optimal policy given that optimal response by the foreign country.

If the foreign country complies with the contract, it does not matter whether it is monitored. It receives a certain net return of

$$B - C_u(1-\alpha^R)Y - C_s\alpha^R Y.$$

If the foreign country does not comply with the contract, it chooses α to maximize its expected net returns, given that it may be detected cheating and receive B* instead of B. The foreign country's problem then is to

$$\max_{\alpha} \quad z[B^* - C_u(1-\alpha)Y - C_s\alpha Y] + (1-z)[B - C_u(1-\alpha)Y - C_s\alpha Y] \quad s.t. \quad 0 \le \alpha \le 1.,$$

or

$$\max_{\alpha} \quad zB^* + (1-z)B - C_uY - \alpha(C_s - C_u)Y \quad s.t. \quad 0 \le \alpha \le 1.$$

The foreign country's objective function is strictly decreasing in α. Therefore, it will choose $\alpha=0$. In other words, the foreign country's optimal strategy when cheating is to produce all output unsoundly, since doing so yields a cost saving of C_s-C_u per unit of supposedly sound output and does not change the probability of being detected (z). Thus, if the foreign country accepts the contract, it will comply with it when the profits from doing so exceed the profits from cheating optimally, i.e., when

$$B - C_u(1-\alpha^R)Y - C_s\alpha^R Y \ge zB^* + (1-z)B - C_uY,$$

or equivalently, when

$$z(B - B^*) \ge (C_s - C_u)\alpha^R Y \qquad \text{(B1)}$$

and cheat otherwise. (B1) is the same as the incentive compatibility constraint in the text (inequality (7)). Moreover, the foreign country will accept the contract only if the profits from doing so exceed its reservation utility of zero, i.e.,

$$\max\left\{zB^* + (1-z)B - C_u Y,\ B - C_u(1-\alpha^R)Y - C_s\alpha^R Y\right\} \geq 0 .$$

The home country chooses its optimal policy taking the foreign country's optimal response into account. The home country can either accept that the foreign country cheats or it can induce overcompliance. Let δ denote an indicator variable which is equal to zero when the foreign country cheats and equal to one when the foreign country complies with the contract. The home country's problem can then be written as:

$$\max_{\substack{Y,\alpha^R,z,\\ B,B^*,\delta}} v(Y) - az - (1-\delta)\left[m(Y+\beta\bar{y}) + zB^* + (1-z)B\right] - \delta\left[m((1-\alpha^R)Y+\beta\bar{y}) - B\right]$$

s.t. $B - C_u(1-\alpha^R)Y - C_s\alpha^R Y \geq 0$ and (B1) if δ=1,

$zB^* + (1-z)B - C_u Y \geq 0$ if δ=0.

Note that if δ=1, the problem is identical to the formulation in the text. Therefore, it remains to show that the home country will never strictly prefer δ=0 over δ=1. Consider the home country's problem when choosing δ=0:

$$\max_{\substack{Y,\alpha^R,z,\\ B,B^*}} v(Y) - az - \left[m(Y+\beta\bar{y}) + zB^* + (1-z)B\right]$$

s.t. $zB^* + (1-z)B - C_u Y \geq 0,$ (B2)

Inequality (B2) binds. To see this, suppose it did not bind. Then we could lower B while maintaining feasibility and increasing the objective function. Thus, (B2) becomes

$z(B-B^*) = B - C_u Y.$ (B3)

Substituting into the objective function, the home country's problem simplifies to

$$\max_{Y,\alpha^R,z} v(Y) - az - m(Y+\beta\bar{y}) - C_u Y,$$

Since the objective function is strictly decreasing in z, the optimum involves choosing $z=0$. From (B3), we then have

$$B=C_uY. \tag{B4}$$

B* and α^R drops out of the home country's problem and, thus, any values of B* and α^R maximize the home country's objective function. These results are intuitive. When the home country expects the foreign country to cheat, it realizes that the foreign country will choose to produce only unsound goods, independent of α^R and B*. Therefore, the level of these variables are irrelevant. Moreover, the home country has no reason to monitor since doing so is costly and does not affect the foreign country's behavior.

The home country's problem simplifies to

$$\max_{Y} v(Y) - m(Y + \beta\bar{y}) - C_u Y, \tag{B5}$$

which as shown in section 5.2. is exactly identical to the corner solution to the home country's problem when δ=1, where $z=Y_s=0$.

In summary, we have shown that the home country's problem when δ=0 reduces to the problem in (B5). This is the same as a corner solution to the home country's problem when δ=1. Therefore, without loss of generality, we can reduce the home problem to the case of δ=1, as was done in the text. Q.E.D.

Appendix B

The home country's problem in (6.1-4), using $B^*=0$, can be rewritten as

$$\max_{Y_u, Y_s, z} \quad v(Y_u + Y_s) - m(Y_u + \beta\bar{y}) - az \tag{B6}$$

$$-\left\{ min\ B : B \geq C_u Y_u - C_s Y_s \ and\ B \geq \frac{(C_s - C_u)Y_s}{z} \right\}.$$

Focusing on the latter part of the problem, we see that the participation constraint binds if it is stricter that the incentive compatibility constraint, i.e., if

$$C_u Y_u - C_s Y_s \geq \frac{(C_s - C_u)Y_s}{z}. \tag{B7}$$

Evaluating at the optimal values of Y_u, Y_s, and z, and rearranging condition (B7) we get

$$(C_s - C_u)Y_s^I + C_u\left(Y_u^I + Y_s^I\right) \geq \frac{(C_s - C_u)Y_s^I}{z^I}$$

$$\Rightarrow C_u\left(Y_u^I + Y_s^I\right) \geq (C_s - C_u)Y_s^I\left(\frac{1}{z^I} - 1\right)$$

$$\Rightarrow \frac{1 - z^I}{z^I}\frac{Y_s^I}{Y_u^I + Y_s^I} \leq \frac{C_u}{C_s - C_u}. \tag{B8}$$

Condition (B8) shows that the participation constraint is more likely to bind when C_u is large, C_s-C_u is small, the percentage of sound imports in total imports is small, and z is large.

Figure 1: Equilibrium in the Alternative Market

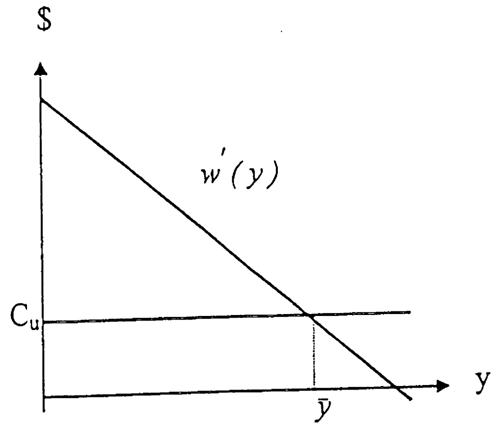


Figure 2: First-Best Policy (Interior Solution)

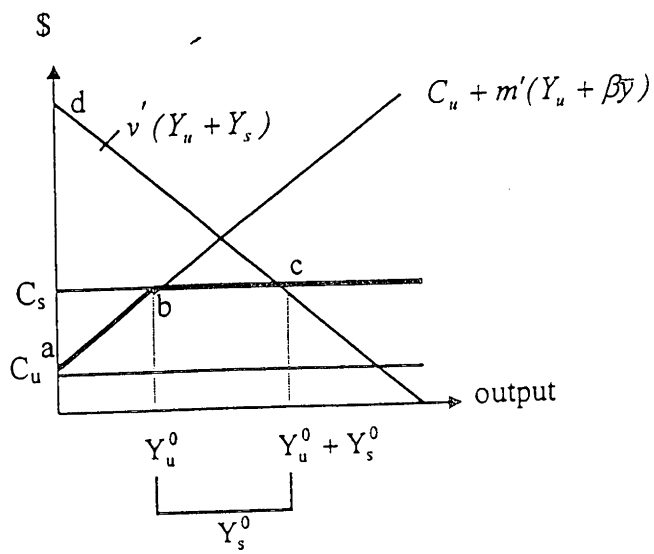


Figure 3: Optimal Non-Discriminatory Policy

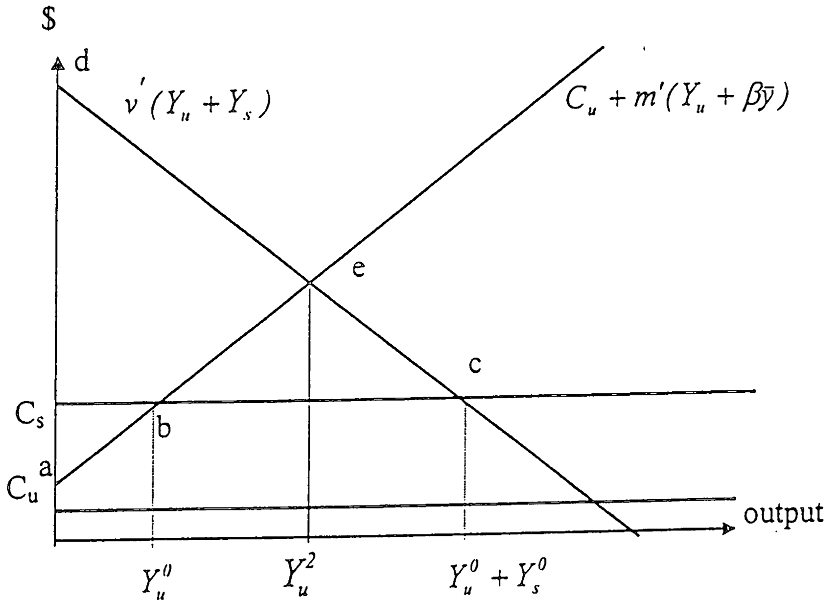
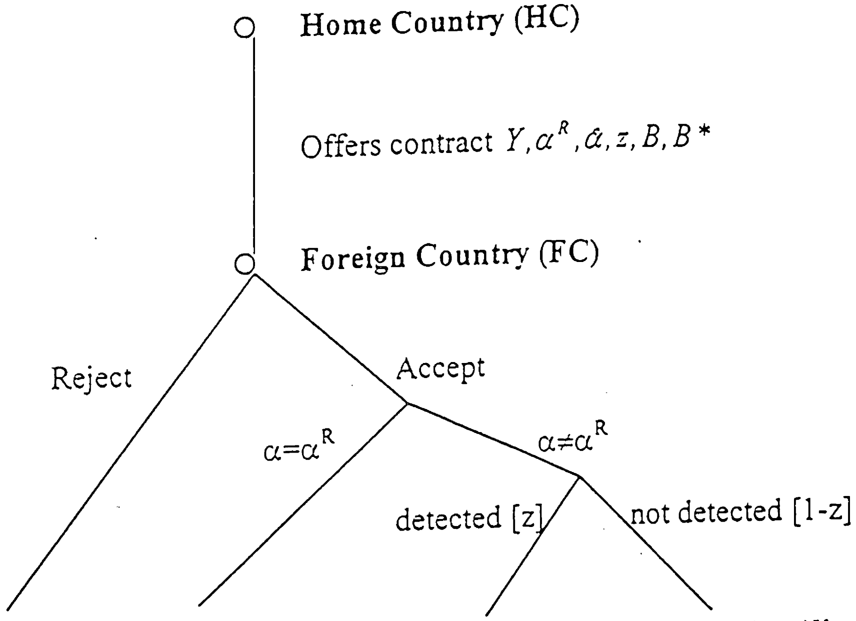


Figure 4: Structure of the Game



Payoffs:				
FC:	0	$B - C_u(1-\alpha^R)Y - C_s\alpha^R Y$	$B^* - C_u(1-\alpha)Y - C_s\alpha Y$	$B - C_u(1-\alpha)Y - C_s\alpha Y$
HC:	0	$v(Y) - m((1-\alpha^R)Y + \beta\bar{y}) - B$	$v(Y) - m((1-\alpha)Y + \beta\bar{y}) - B^*$	$v(Y) - m((1-\alpha)Y + \beta\bar{y}) - B$