ESSAYS ON

TRADE AND ENVIRONMENT

by

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A dissertation submitted for the degree of dr.oecon.

To my parents

Acknowledgements

This thesis has been written with extensive help and support from a number of people. I would like to take this opportunity to express my deep gratitude to some of them.

Jan I. Haaland has been my supervisor during this three and a half year period. I am grateful to him for his generous support. His searching questions and thoughtful comments have greatly improved the quality of my work. I would also like to thank the two other members of the dissertation committee, Agnar Sandmo and Anthony J. Venables, for their valuable advice and encouragement.

My most sincere thanks go to my two good friends, Bertil Tungodden and Svein Aage Aanes, who have provided the greatest support each and every step of the way towards the completion of this thesis. I have learnt a lot from them. In our numerous discussions – during countless lunches as well as pleasant parties – they have generously shared their great intellectual talent with me. I am grateful for that, and for their wonderful friendship.

I would also like to express my thankfulness to my other colleagues at the Department of Economics at NHH for creating a stimulating working environment. A special thanks to Karen Helene Midelfart Knarvik and Jostein Tvedt, with whom I have been sharing an office over the last year and a half. Studying has been an enjoyable affair in their friendly company. A special word of thanks also to Anne Liv Scrase for valuable assistance on my language. Financial support from the Norwegian Research Council is greatly appreciated.

I gratefully dedicate this thesis to my mother and father. Their continuous forethought and support has been of great value.

My final gratitude goes to my daughter, Janne, and my wonderful wife, Åse-Berit. For their love and encouragement, I am deeply indebted.

Bergen, April 1995,

Ottar Mæstad

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Introduction

1. Background

The aim of this thesis is to shed some light on the interplay between trade policy and environmental policy, and on the relationship between trade and environmental problems. This subject matter raises a number of interesting and challenging questions, both from a theoretical and practical perspective.

With but a few exceptions, the theory of trade policy has been developed without explicit attention to the presence of environmental problems. The theory of environmental policy, on the other hand, has evolved mainly within the framework of a closed economy, i.e., an economy without external trade. Neither of these traditions can be said to provide an appropriate representation of reality in a world where environmental problems abound, and where the integration of the world economy is constantly deepened. By uniting these theoretical traditions in a common framework, we would be able to investigate the interplay between trade policy and environmental policy (e.g., do the restrictions on the use of trade measures in international trade agreements affect the incentives to implement environmental policy? May it be efficient to use trade policy in order to achieve environmental objectives?[1])

Related to these policy issues is the question of how trade and trade liberalizations affect the extent of environmental problems. It is frequently maintained, especially by environmentalists, that free international trade enhances the exploitation of environmental resources: trade liberalizations are regularly accused of increasing the level of production and consumption, leading to more pollution, more waste, and a more rapid depletion of natural resources.

Obviously, these assertions cannot represent insights of universal validity about the relationship between trade and environmental degradation. First, it is perfectly possible to realize the gains

[1] A few contributions have proceeded along these lines, see Baumol (1971), Markusen (1975), Anderson (1992a), Rauscher (1991), Siebert (1979), Krutilla (1991), and Conrad (1993).

from trade otherwise than by increasing the consumption of resource-intensive commodities (one possibility would be to have more leisure time). Secondly, trade liberalizations may change the pattern of production so that more is produced by relatively clean production processes, and less by heavily polluting ones.[2]

These objections notwithstanding; suppose we were able to establish as an empirical fact that trade liberalization tends to cause a more rapid depletion of environmental resources. Would this fact be of any significance for economic policy if trade liberalization at the same time proved to enhance overall welfare? This question draws the attention towards the controversy between those who consider environmental protection to be only a means to improve human welfare, and those who claim that environmental protection is an end in itself. This controversy reflects a deep conflict on basic value judgements and illustrates that there is considerable disagreement on the normative foundation of environmental decision-making. The public debate on trade and environment issues has to some extent been marked by such disagreement on basic value judgements. It is a great challenge to find ways to deal with these value conflicts in social choices on environmental issues, including trade decisions affecting the environment.

In recent years, the issue of trade and environment has been put on the agenda of several international organizations (e.g., OECD and WTO (previous GATT)). A major concern in these organizations has been to clarify the status of trade provisions used in order to achieve environmental objectives (or, so-called *green* trade policy). Green trade policy is already incorporated in a number of international environmental agreements (e.g., the Montreal Protocol on the protection of the ozone layer). Countries that take unilateral steps towards solving environmental problems, seem especially eager to implement protective trade measures. Furthermore, a number of countries have used (or have suggested to use) green trade policy in order to influence environmental management in other nations (cf. the use of timber trade restrictions to reduce tropical deforestation).

It has been asked whether these are legitimate reasons to implement green trade policy. If they are, a revision of international trade agreements may be required to accommodate the need for green trade provisions. If not, the international community should probably dispose of this kind of inappropriate trade policy.

This thesis takes this latter problem as its point of departure. The first three essays are about the use of trade policy for the purpose of alleviating specific environmental problems. The fourth essay elaborates on why conflicting views on environmental ethics represent a challenge to the

[2]For theoretical studies of the relationship between trade and environmental degradation, see Pethig (1976), Siebert (1977), and Asako (1979). For empirical contributions, see Anderson (1992b).

welfare economic approach to environmental decision-making. The fifth, and final, essay elucidates some mechanisms through which trade may affect the extent of environmental degradation.

2. Outline

The first two essays are normative studies of the use of green trade policy. The first essay – *The Legitimacy of Green Trade Policy* – discusses whether there might be legitimate reasons for using trade provisions for environmental purposes. It is argued that if trade provisions are the most accurate instrument available to alleviate the global efficiency costs of environmental externalities, that might constitute *one* such legitimate reason. A main result is that countries that take unilateral steps towards solving environmental problems, may have a legitimate reason to implement green trade policy. One interpretation of this result is that incomplete international environmental agreements (i.e., agreements that are not signed by all affected countries) normally should include some kind of trade provisions in order to enhance the efficiency of the agreement.

Other aspects of the use of green trade policy are illuminated as well. It is shown which circumstances that would make green trade policy an efficient instrument to deal with environmental problems that originate in a foreign country. Moreover, it is argued that green trade policy may enhance efficiency even when such measures are implemented by small countries that are unable to influence world market prices. Finally, the essay discusses some of those ethical dilemmas that may arise when trade policy is used to affect foreign environmental management.

One problem with the implementation of unilateral environmental policy is that polluting industries may escape such regulations by moving abroad. The second essay – *Unilateral Environmental Policy with Mobile Producers* – elucidates the implications of producer mobility for the efficient design of incomplete international environmental agreements. It has been argued that unilateral environmental regulations should be relaxed if the sources of pollution are prone to move abroad. My analysis lends support to this argument. Furthermore, it is shown that the presence of producer mobility provides one additional argument for implementing green trade policy. This does not imply, however, that efficient unilateral environmental policy should be designed to *avoid* relocations. A certain outflow of firms may be an efficient equilibrium outcome.

The third essay – *Trade Policy and Tropical Deforestation* – is a study of the environmental consequences of trade restrictions on tropical timber and timber products. This is an interesting

issue, because a number of countries have proposed to implement green trade policy in this field, and because some critical voices have maintained that such trade restrictions in fact may turn out to exacerbate, rather than alleviate, environmental problems.

The tropical forests provide a series of environmental benefits. My study concentrates on the role of tropical forests as a reservoir of biodiversity and genetic material and as a sink of carbon, regulating the balance between atmospheric and terrestrial carbon compounds. It is argued that in order to predict how these environmental variables are affected by timber trade restrictions, we cannot rely on the standard models for optimal forest management. Due to the short concession periods in tropical forestry, the incentives to ensure regrowth are heavily diluted. I therefore suggest that tropical forestry is most appropriately described as a *mining* activity. Different ways of formulating the mining activity are pursued: with *simultaneous* harvest, all logging fields in a concession area are logged simultaneously in order to extract the most valuable timber first. With *sequential* harvest, on the other hand, the loggers finish logging in one field before they move on to the next. In both models, timber trade restrictions are shown to reduce total logging and to contribute to the protection of biodiversity. The effect on the storage of carbon is more uncertain, though.

The governments' response to timber trade restrictions is analysed as well. It has been argued that timber trade restrictions might actually lead to *more* deforestation, because they will make forestry unprofitable and thus induce conversion of forest land into alternative uses. I show that this reasoning may be wrong. It is true that trade restrictions are likely to reduce profits in forestry. This does not imply, however, that less profit will be extracted in each and every logging field. In fact, there is a possibility that profit extracted in the most profitable fields will increase, because it may become profitable to harvest more trees in these areas. The incentives to convert forest land into alternative uses are therefore not necessarily strengthened.

The essay is closed by a brief discussion of the environmental consequences of timber trade restrictions if tropical forestry were conducted more in accordance with the principles prescribed by traditional forestry economics, rather than as a mining activity.

The normative analysis in essays one and two assumes that a well-defined measure of the benefits and costs of environmental protection is available. This is by no means a trivial assumption, since the normative foundation of environmental decision-making is under considerable debate. In the fourth essay – *Ethics and Environmental Decision-making* – I illuminate how the ethical dilemmas involved in environmental decision-making might influence the way we think of normative environmental economics. It is argued that the picture drawn of human preferences in standard economic theory is unable to do justice to the significance of

moral reasoning in people's lives. This problem might be overcome, though, by adding further structure to the preference map. Alternative ways of incorporating moral reasoning into the structure of preferences are discussed, and based on such an extended preference structure, I provide a critical examination of some standard procedures for revelation and aggregation of environmental preferences. The methods used in order to reveal preferences in normative economics are criticized for emphasizing too strongly the normative status of preferences revealed by choice, and for being unable to reveal the different nature of personal interests and moral judgements. With respect to preference aggregation, I argue that the standard aggregation procedures are too insensitive to the quality of the arguments that support the value judgements behind people's environmental preferences. No general solution to these problems is offered, but it is argued that public discussion on environmental value judgements might be a useful device in improving both the process of preference revelation and the process of preference aggregation.

The last part of the essay is devoted to a more specific discussion of some of the ethical dilemmas that arise in environmental decision-making. One of the issues addressed is the question of what we owe to future generations if their preferences are shaped by what they receive from us. Moreover, I discuss the implications for normative environmental economics of some unconventional ethical views, saying that the moral community should be extended beyond human beings to include animals and other living creatures as well.

In the final essay – *Trade, Morality, and the Environment* – I explore some mechanisms, other than prices, through which trade may affect the extent of environmental degradation. Three different ideas are pursued, each originating from the acknowledgement of social morality as a potentially important device for the alleviation of environmental problems. The first question debated is how human interaction in trade affects the social bonds that hold a society together. It is argued that trade is a potential source of both social integration and social disintegration, but that the strong legitimacy that self-interested behaviour has come to enjoy in economic life, probably has been a threat to the social outcome of exchange. More specifically, I argue that the habitual pursuit of (narrow) self-interest in trade over time may have weakened people's perception of the moral dimensions of exchange. This is important in an environmental context: if the environmental costs that we impose on each other through our market choices are not perceived as deserving any moral concern, that is likely to enhance the extent of environmental problems.

The essay proceeds by assuming that some agents are committed to take environmental responsibility. A possible consequence of such a commitment is that consumers become sensitive to information about production processes. They may, by way of illustration, discard

products that are made by highly polluting production processes, and go for "green" products instead. A requirement, though, for being able to exercise such environmental responsibility is that information about production processes are available at a reasonable cost. I argue that trade probably will increase the consumers' costs of obtaining such information, by making it more difficult to trace the consequences of our consumer choices. Furthermore, trade may reduce the probability that consumers are (unintentionally) exposed to environmentally relevant information. Finally, these information problems are difficult to overcome through ecolabelling, because the producers will be unwilling to provide information about environmental *mis*management.

The essay is closed by a discussion of the relationship between trade liberalizations, competitive pressure, and the possibility of firms to take voluntary environmental responsibility. Trade liberalizations are generally believed to have a pro-competitive effect. Moreover, it is often asserted that strong competition will force the firms to adopt profit-maximization as their objective. This seems to imply that trade liberalizations may reduce the possibilities of voluntary environmental protection. I argue that this is not necessarily the case. Stronger competition through trade liberalizations may in some cases reduce the marginal costs of voluntary environmental protection.

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The Legitimacy of Green Trade Policy*

1. Introduction

Are there legitimate reasons to use trade policy in order to solve environmental problems? This question has gained considerable political attention during the last few years. The discussion has been inspired by a series of proposals and attempts to use trade policy for environmental purposes. One example is the US ban on import of yellow-fin tuna from Mexico, allegedly imposed because the catching methods of Mexican tuna fishers are harmful to dolphins. Other examples include the proposal, set forth by the Netherlands, to impose a ban on the import of tropical timber, and the use of trade provisions in environmental agreements (e.g., the Montreal Protocol on the reduction of ozone-threatening substances); in fact, 17 of the current 127 environmental agreements include trade provisions of some kind.[1]

The use of green trade policy has been accused of being illegitimate for at least two reasons. First, some of the trade measures that have been invoked for environmental purposes seem to violate present GATT rules.[2] By way of illustration, the trade restrictions in the Montreal Protocol discriminate between the signatories of the agreement and the non-signatory countries. It is questionable whether this criterion for discrimination is justified under the present interpretation of the non-discrimination principles in the GATT.[3] Secondly, it has been maintained that green trade policy is illegitimate, because other available measures generally are more efficient for the purpose of solving environmental problems.[4]

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*For their comments on earlier drafts of this paper, I am grateful to Jan I. Haaland, Agnar Sandmo, Robert Stavins, Bertil Tungodden, Anthony J. Venables, Martin Weitzman, and the participants at seminars at Harvard University and the Norwegian School of Economics and Business Administration.

[1]GATT (1992).

[2]See Sorsa (1992).

[3]Article XX of the GATT states those circumstances that give a legitimate reason to depart from the general principle of non-discrimination.

[4]See Subramanian (1992).

This paper does not address the relationship between green trade policy and the present GATT rules. The GATT was designed without any special attention to the presence of environmental problems, in particular not environmental problems with an international dimension. It is more interesting, therefore, to ask to which extent the new demand for trade measures in the environmental field should be accommodated by the GATT (or the WTO) in the future. This paper does not provide a definite answer to this question, but it illuminates some of the considerations that will be relevant in a more complete assessment of this issue. The main focus of my analysis is on the relationship between green trade policy and economic efficiency. This focus is chosen because the promotion of economic efficiency serves as an important justification for the efforts to liberalize world trade through the GATT, as well as through other international trade agreements. An alternative justification for free trade is provided by the libertarian argument. Some brief comments are made on the implications of this argument for the legitimacy of green trade policy as well.

Green trade policy may be used either as a *market instrument*, influencing prices and quantities directly, or as a *political instrument*, aiming at a change in foreign environmental policies. The proposal to restrict the US import of Norwegian fish-products because of Norwegian whaling is an example of the use of green trade policy as a political instrument. In some cases, trade provisions perform both a market function and a political function simultaneously. The trade provisions of the Montreal Protocol, for instance, affect production and consumption directly. At the same time, they induce non-signatories to join the agreement. In this paper, I leave the political aspect of green trade policy aside and concentrate instead on the use of such policies as a market instrument.

In evaluating alternative ways of correcting market failures, economists often use as a rule of thumb that the efficient policy is to impose regulations directly at the source of the problem. According to this rule, green trade policy is not an efficient policy alternative unless trade is the direct source of environmental problems. It is hard to find examples where this is the case, and trade measures are therefore probably not needed in order to implement efficient environmental policies. It would be somewhat hasty, though, to conclude against this background that green trade policies should be considered illegitimate in general. Many environmental problems have a transborder character. In these cases, some of the sources of a country's environmental problems will be located outside the jurisdiction of its government. If, at the same time, the government of the source country is unwilling to use its regulatory power for the sake of people in other countries, we easily arrive in a situation with insufficient environmental regulations directly at the source of the problem. The question then arises whether the use of green trade policies might be an appropriate second best response in order to correct for such market failures.

Being a victim of transborder environmental problems is but one reason why a country may be concerned with foreign environmental policies. When a foreign government disregards the environmental harm imposed upon a group of citizens in its own country, or upon future generations, another government with more altruistic preferences may want to use some measures in order to prevent such environmental infringements. A similar situation arises when a country is concerned about foreign environmental policy because of disagreement as to which environmental ethics that should serve as the normative foundation for environmental regulations. In the absence of more direct instruments of dealing with such situations, green trade policy might be invoked as a second best alternative.

It may be objected, though, that there will be no need for green trade policy in any of these cases if side-payments are being used. If foreign governments receive appropriate compensation, they will be willing to implement first best environmental regulations, taking into account all externalities imposed upon other countries. In practice, however, there seem to be vast political difficulties involved in the negotiation of international environmental agreements of this kind. Historically, there has been a broad international consensus that the economic responsibility of pollution resides by the polluters.[5] It is no easy matter to make a complete turn on this issue and require instead that the victims compensate the polluters for the implementation of environmental regulations. Moreover, when several nations are involved in the negotiation of international environmental agreements, there are incentives for individual nations to be free-riders on the environmental efforts of others. For these as well as other reasons, international environmental agreements will often be incomplete. Either may some nations refuse to sign the agreement, or, if the agreement is designed in order to make it acceptable for all countries involved, the substance of the agreement may be so weak that the environmental problems will not be solved. With incomplete environmental agreements, second best measures may be called for in order to improve the efficiency of the agreement. This paper shows that green trade policy might be an interesting policy alternative in such cases.

The possibility of using green trade policy as a substitute for first best environmental policy was first discussed by Baumol (1971). He showed that a country that suffers from transborder externalities may utilize trade policy in order to change international prices so that transborder pollution is reduced. A more formal analysis of this issue was done by Markusen (1975). Markusen used a general equilibrium model to derive the optimal tax structure for a country that suffers from environmental externalities from both domestic and foreign production.

[5]The Polluter Pays Principle was approved at the 1972 Stockholm Conference.

In contrast to previous studies, the aim of this analysis is not primarily to characterize the optimal policy for a particular country. The underlying problem here is how to design international conventions that regulate the use of trade measures for environmental purposes. Therefore, the following analysis will not take place within a framework of purely national objectives. Instead, I shall adopt a global point of view and discuss whether green trade policy can be defended from such a broad normative perspective. Furthermore, this study differs from previous ones by not being confined to environmental problems generated on the production side of the economy. Environmental problems caused by consumption activities will be addressed as well. This paper also provides some new insights about the properties of trade provisions as a second best instrument of environmental regulation.

In Section 2, the normative foundation of the analysis is presented and defended. The basic model is introduced in Section 3. I discuss the use of green trade policy in the case of dirty production in Section 4, and the case of dirty consumption is addressed in Section 5. That section also includes an application of the results to the use of trade provisions in a possible future climate agreement, and to the use of trade provisions in the Montreal Protocol. Finally, in Section 6, I debate some of the ethical dilemmas that may arise when trade policy is used in order to reduce environmental degradation in other countries.

2. Normative foundations

The conclusions I am going to draw about the legitimacy of green trade policy are of course no stronger than the normative foundation of the analysis. There is considerable disagreement as to what constitutes an appropriate normative theory when it comes to questions involving economics and environment. Some environmentalists would maintain that green trade policy is legitimate whenever trade provisions reduce environmental degradation. But many people find this view unacceptable, because it ignores other effects of green trade policy on human welfare. Furthermore, there is some disagreement about how distributional effects should be taken into account in assessing the legitimacy of green trade policy. A real concern in the discussions about green trade policy has been that such measures are likely to hurt low-income countries. Some people would claim that green trade policies cannot be legitimate if they have such consequences.

This shows that any normative criterion for assessing the legitimacy of green trade policy will be controversial. No attempt will be made here to find the "right" criterion. My choice of normative framework is closely linked to the limited purpose of this study; to illuminate considerations that will be relevant for the treatment of green trade policy in international trade agreements. It will probably not be too controversial, then, to choose a normative framework

which is based on the motivations behind the international trade agreements themselves. Although some disagreement certainly prevails as to what is the real purpose of international trade agreements, it is probably fair to say that two of the main concerns behind the efforts to liberalize world trade have been 1) the argument about *economic efficiency* (i.e., that free trade promotes an economically efficient allocation of resources), and 2) the *libertarian* argument (i.e., that free trade is a natural consequence of people's right to engage in voluntary transactions).[6] In the following, I shall assess the legitimacy of green trade policy from the perspective of economic efficiency. Before moving to that discussion, however, some brief comments will be made on the libertarian position and its implications for the legitimacy of green trade policy.

Consider first the libertarian view on the need for environmental regulations in general. Libertarians usually accept that the state should protect people's rights to life, liberty, and property.[7] Pollution may indeed hurt both people's life and their property. But is pollution then a rights violation that should be prohibited? Libertarians disagree on this issue. According to Rothbard, pollution is simply wrong. The libertarian remedy against pollution is therefore "to enjoin anyone from injecting pollutants into the air, [water, and soil,] and thereby invading the rights of persons and property. Period."[8] Nozick seems to disagree, though. He goes in fact rather far towards recommending a traditional cost-benefit analysis of environmental problems, at least when pollution only affects property.[9] Nozick thus seems reluctant to prohibit pollution that falls short of a utilitarian optimal level of pollution. We can conclude, however, that libertarians regard pollution as a problem, and that they advocate environmental regulations that are *at least* as strong as would be prescribed by utilitarian standards.

The next question is whether libertarians would accept trade restrictions as a means of environmental regulation. Trade restrictions violate people's right to non-interference in voluntary exchange. A crucial question is therefore whether it can be legitimate to violate one right in order to avoid other rights violations.

Nozick argues that the weighing of rights against each other is morally unacceptable.[10] He claims that the libertarian rights are side-constraints imposed on anyone's goal-seeking behaviour. These side-constraints remain effective even if an action could have improved the

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[6]A forceful defence of the libertarian position is provided by Nozick (1974). Adam Smith (1776), and a number of economists after him, have advocated the economic efficiency argument.
[7]See Machan (1983), among others. For an exception from this general rule, see Rothbard's (1970) discussion of libertarian anarchism.
[8]M. Rothbard, *The Great Ecology Issue*; quoted in Wenz (1988, p. 65). See also Machan (1984).
[9]Nozick (1974, pp. 79-81).
[10]*Ibid.* pp. 26-33.

state of affairs, for instance by reducing the violation of rights. On this view, green trade policy is illegitimate, regardless of its potentially positive effects on the environment.

Other authors have criticized Nozick's seemingly rigid position and argued that a system that recognizes the libertarian rights should also incorporate criteria for weighing rights violations against each other when such violations are interdependent.[11] However, there is no guidance in these contributions as to what are the appropriate weights to employ when evaluating the legitimacy of green trade policy.

To summarize, although libertarians agree that pollution is bad, the libertarian view seems to offer no clear-cut answer about the legitimacy of trade policy as a means of environmental regulation. Some libertarians would clearly condemn green trade policy, while others would be less resolute and recommend a balancing of the different rights violations involved when assessing the legitimacy of such policies.

For the rest of this paper, the use of green trade policy will be addressed from the perspective of economic efficiency. The allocation of resources is said to be efficient if it is impossible, through the use of available policy instruments, to make anyone better off without making anyone else worse off. Insofar as trade provisions are required in order to achieve efficiency in the global economy (e.g., because more direct environmental regulations are unavailable), it will be claimed that there is *a legitimate reason* for implementing green trade policy.

This criterion for assessing the legitimacy of green trade policy is a rather restrictive one. It requires that trade provisions are used for environmental purposes only when such measures clearly are more efficient than other available instruments. Moreover, by using the global economy as the reference point, trade policies that change the distribution of income between countries without improving economic efficiency will be considered illegitimate. This implies, for instance, that it will be illegitimate to implement purely protectionist trade policies.

In assessing the efficiency of green trade policy, the efficiency indicator employed will be aggregate consumer and producer surplus, adjusted for environmental costs and public income. Assuming that the marginal social utility of income is the same everywhere, this efficiency indicator might as well be interpreted as a measure of the social welfare. This will be assumed to be the case in the following, and I will therefore talk alternately about efficiency and welfare. (This formulation seems difficult to defend, however, if there is no mechanism (e.g., a public authority) that secures an optimal distribution of income.)

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[11] Sen (1982).

Environmental benefits and costs are included in the welfare measure in the same way as other benefits and costs. This may seem to imply that the present normative framework assumes that the environment has nothing but instrumental value, i.e., value derived solely from considerations about human welfare. This is not the case, however. If nature is assumed to possess inherent value, i.e., value that extends beyond nature's contribution to human welfare, it will in principle be possible to include such values as well in the measure of environmental costs and benefits. What I have called a welfare measure should then be reinterpreted as a measure of overall "goodness", where goodness will consist of both human welfare and inherent value in nature.[12]

3. The model

A simple partial equilibrium model will be used to illuminate the relationship between green trade policy and economic efficiency. I assume that the world consists of two (groups of) countries; the *home* country and the *foreign* country. One homogenous good is produced and consumed in both countries, and the good is traded freely across the border. Perfect competition prevails in all markets.

Consumption decisions are derived from utility-maximization. Let p_d be the consumption price in the home country, let P be the foreign price, and let $v(p_d)$ and $V(P)$ denote the aggregate indirect utility functions for the consumers in the home and the foreign country.[13]

Producers are assumed to maximize profits. Let p_s denote the producer price in the home country. The foreign producer price equals the foreign consumer price P. The aggregate maximum profit in the two countries will be represented by the profit functions $\pi(p_s)$ and $\Pi(P)$.

Consumption or production may pollute the environment.[14] The amount of pollution is assumed to have no effect on the level of demand or supply. Furthermore, I assume that environmental costs are proportional to the level of production (or consumption). Abatement possibilities are thus not explicitly modelled. It is straightforward, though, to redefine the model to allow for abatement through technological change. It is also possible to apply the

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[12]Note that inherent value is not the same as existence value, as this concept usually is defined. Existence value refers to the welfare effects of the mere existence of certain natural objects, and is thus just a special kind of instrumental value. See Mæstad (1995a) [Essay 5 of this thesis] for more about ethical views that acknowledge the inherent value of nature.

[13]The income arguments in the indirect utility functions are suppressed, because income is assumed to be exogenous.

[14]"Pollution" is used for expositional reasons only and refers to all kinds of environmental damage.

following results to a situation with abatement possibilities through factor substitution (see Appendix A).

When one of the countries imposes some kind of green trade policy, the other country will not be allowed to retaliate. If the use of green trade policy causes a trade war, it is unlikely that economic efficiency will be enhanced. It is crucial, therefore, that international conventions prohibit counter-measures against legitimate trade provisions. How to establish such conventions is, of course, a difficult political problem. Since green trade policy in many cases will be a substitute for a more comprehensive international environmental agreement, it is important to avoid that governments resort to the use of trade policy before making a serious attempt to negotiate such an agreement. On the other hand, if some countries refuse to sign the agreement in order to free ride on the environmental efforts of other countries, it may seem unreasonable that the signatories shall not be allowed to make the agreement more efficient by means of trade policy. The political challenge is to establish conventions that are able to distinguish between these cases.

Assume that the foreign government is reluctant to implement appropriate environmental regulations, for instance because most of the costs of pollution generated in the foreign country accrue to the citizens of the home country. Assume also that the home country has made serious, but unsuccessful, attempts to arrive at an agreement with the foreign country about the implementation of appropriate regulations. The home country is thus left to do the best of the situation unilaterally. The only way the home country can reduce the excessive foreign pollution is by influencing world market conditions through taxes or subsidies (or other equivalent measures) on domestic consumption or production, or through taxes or subsidies on international trade. (Notice that there is some redundancy of policy instruments here. A trade tax can for example be duplicated by the combination of a consumption tax and a production subsidy (at the same rate as the trade tax). Similarly, the combination of a consumption tax and a production tax can be duplicated by the combination of a trade tax/subsidy and either a tax/subsidy on consumption or a tax/subsidy on production. Hence, it suffices to look at only one policy instrument in addition to trade provisions.)

Let T denote trade taxes (or subsidies) implemented by the government of the home country. T should be interpreted as a tariff per unit of imports if the home country is an importer, and as a per unit export subsidy if it is an exporter. Furthermore, t will denote a tax per unit of production in the home country. Demand and supply are assumed to be independent of government revenues.

Equilibrium prices are determined by the condition that world consumption shall equal world production. By Roy's identity, the demand function in the home country can be written as $-v'(p_d)$.[15] Similarly, the foreign demand function will be $-V'(P)$. By Hotelling's lemma, the respective supply functions can be written $\pi'(p_s)$ and $\Pi'(P)$. Equilibrium prices will then be determined by the condition

$$-v'(p_d)-V'(P)=\pi'(p_s)+\Pi'(P), \tag{1}$$

where the prices are related as follows;

$$p_d=p_s+t=P+T. \tag{2}$$

Standard assumptions apply to the slopes of demand and supply functions; demand is a non-increasing and supply is a non-decreasing function of prices ($v'',V'',\pi'',\Pi'' \geq 0$).

4. Dirty production

Consider the case where pollution is caused by dirty production processes. Let e and E denote the external environmental costs per unit of production in the home country and the foreign country. The total external costs are then $e\pi'(p_s)+E\Pi'(P)$.[16]

The presence of external environmental costs causes an inefficient allocation of resources. As is well known, efficiency can be restored by imposing Pigouvian taxes[17] on production in both countries. Such a tax structure, with production taxes equal to e in the home country and E in the foreign country, will henceforth be denoted *the first best tax structure*. Note that the first best tax structure does not involve any trade provisions. The reason is simply that Pigouvian taxes correct the externalities at their source, and it is production, not trade, that is the source of environmental damage in this model.

The global welfare function W is defined as

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[15]The marginal utility of income is assumed to be constant and equal to one in both countries.

[16]A serious problem when trying to arrive at international solutions to environmental problems is that the countries may disagree on the magnitudes of environmental costs. By assuming that environmental costs are well known, I ignore those problems here.

[17]After Pigou (1920). Notice that I use "Pigouvian tax" about a tax that takes into account all relevant categories of environmental values. Since the inherent value of nature may be included among these, the current interpretation of a Pigouvian tax is somewhat broader than the traditional one, which is tied exclusively to human welfare.

$$W = \underbrace{v(p_d)+V(P)}_{\text{Consumer surplus}} + \underbrace{\pi(p_s)+\Pi(P)}_{\text{Profits}} - \underbrace{\left(e\pi'(p_s)+E\Pi'(P)\right)}_{\text{Environmental costs}} + \underbrace{t\pi'(p_s)+T\left(-v'(p_d)-\pi'(p_s)\right)}_{\text{Government income}}. \quad (3)$$

The efficient use of green trade policy can be found by maximization of W with respect to the two available policy instruments, t and T, subject to the conditions imposed by Eqs. (1) and (2).

By using the properties of Eq. (2), the first order conditions can be written as

$$\begin{aligned} &v'\left(\frac{\partial P}{\partial T}+1\right)+V'\frac{\partial P}{\partial T}+\pi'\left(\frac{\partial P}{\partial T}+1\right)+\Pi'\frac{\partial P}{\partial T}-e\pi''\left(\frac{\partial P}{\partial T}+1\right)-E\Pi''\frac{\partial P}{\partial T} \\ &+t\pi''\left(\frac{\partial P}{\partial T}+1\right)+(-v'-\pi')+T(-v''-\pi'')\left(\frac{\partial P}{\partial T}+1\right)=0, \end{aligned} \quad (4a)$$

$$\begin{aligned} &v'\frac{\partial P}{\partial t}+V'\frac{\partial P}{\partial t}+\pi'\left(\frac{\partial P}{\partial t}-1\right)+\Pi'\frac{\partial P}{\partial t}-e\pi''\left(\frac{\partial P}{\partial t}-1\right)-E\Pi''\frac{\partial P}{\partial t} \\ &+\pi'+t\pi''\left(\frac{\partial P}{\partial t}-1\right)+T\left(-v''\frac{\partial P}{\partial t}-\pi''\left(\frac{\partial P}{\partial t}-1\right)\right)=0. \end{aligned} \quad (4b)$$

By using the properties of Eq. (1), Eqs. (4a) and (4b) can be rewritten as

$$T(V''+\Pi'')\frac{\partial P}{\partial T}+t\pi''\left(\frac{\partial P}{\partial T}+1\right)=e\pi''\left(\frac{\partial P}{\partial T}+1\right)+E\Pi''\frac{\partial P}{\partial T}. \quad (5a)$$

$$T(V''+\Pi'')\frac{\partial P}{\partial t}+t\pi''\left(\frac{\partial P}{\partial t}-1\right)=e\pi''\left(\frac{\partial P}{\partial t}-1\right)+E\Pi''\frac{\partial P}{\partial t}. \quad (5b)$$

These are the fundamental conditions for an efficient second best solution to the present environmental problem. The left hand side of Eqs. (5a) and (5b) can be interpreted as the efficiency costs of a marginal increase in, respectively, the trade tax and the environmental tax. The first order conditions state that these efficiency costs should be balanced against the environmental gains that can be reaped by means of such taxes. Solving the system (5a) and (5b) with respect to the tax parameters yields[18] (see Appendix B)

[18]Note that the solution for T is not an explicit solution, since the foreign price P depends on the tax rates.

$$t = e,$$

$$T = E\frac{\Pi''(P)}{V''(P)+\Pi''(P)}. \tag{6}$$

This formula for the second best tax structure shows that the efficient unilateral environmental policy is to implement a combination of a domestic environmental tax and either an import tariff (if the home country is an importer) or an export subsidy (if the home country is an exporter). The second best tax structure is characterized by what might be called a separation property:

PROPOSITION 1

In the second best solution, the domestic environmental tax is used exclusively to deal with pollution generated in the home country. Trade provisions are used exclusively to deal with pollution generated abroad.

It should come as no surprise that a domestic production tax is the most efficient instrument for the regulation of domestic production. There is simply no other policy instrument that is closer to the source of the problem. Less obvious, perhaps, is the result that trade policy is the most efficient instrument the home country can use in order to reduce foreign pollution. An import tax (export subsidy) reduces (increases) the home country's import demand (export supply) and thus makes the world market price decline. This price fall induces foreign producers to reduce their production and pollution. However, the same effect could be obtained by relaxing domestic environmental regulations (which is equivalent to subsidizing home country producers), since foreign producers then would lose market shares to home country producers. So why are such (environmental) subsidies inferior to trade provisions?

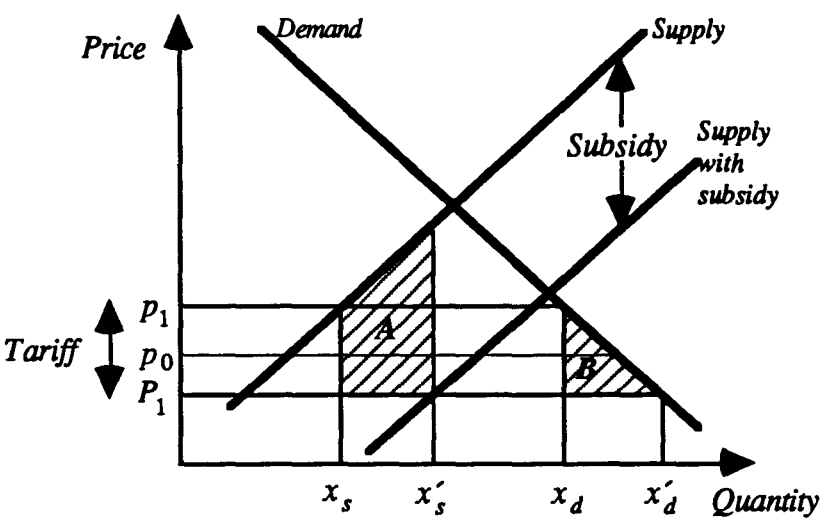

Fig. 1.

Fig. 1 explains. The figure depicts supply and demand curves in the home country, which is assumed to be an importer. p_0 is the initial equilibrium price. Assume that the home country imposes an import tariff, and that the domestic price then rises from p_0 to p_1, while the world market price falls to P_1 (causing a reduction in foreign pollution). After the tariff has been imposed, the import quantity equals $(x_d - x_s)$.

In order to compare the relative efficiency of import taxes and domestic production subsidies, impose a production subsidy with exactly the same effect on foreign production and pollution as the import tariff. To accomplish this, the production subsidy must be large enough to reduce imports to the same level as with the import tariff. Otherwise, the world market price would not fall to P_1. We know that in the absence of trade provisions, the consumer price will equal the world market price. Hence, with a production subsidy that reduces the world market price to P_1, the quantity x_d' is consumed in the home country. Having determined the level of consumption, the level of production needed to be sustained by the subsidy can be determined by the condition that import quantities shall be identical in the two cases, i.e., $x_d - x_s = x_d' - x_s'$.

Since the domestic consumer price declines as the producer subsidy increases, the import-reducing effect of the subsidy is partly offset by an increase in domestic consumption. This implies that both consumption and production must be greater with a production subsidy than in the case of a tariff in order to get the same effect on foreign production and pollution. Compared to a tariff, therefore, a production subsidy creates an additional efficiency loss on the production side. This efficiency loss (area A), arises because domestic production costs are higher than the world market price. On the consumption side, on the other hand, there will be an efficiency gain from using a production subsidy instead of a tariff. The gain (area B in the figure) is due to the fact that consumers now can buy the good at the world market price, without any distortionary tariffs. This efficiency gain will, however, be dominated by the efficiency loss on the production side ($A > B$). *Proof:* Since import quantities must be identical in the two cases, i.e., $x_d - x_s = x_d' - x_s'$, it follows that the bottom lines of the two areas A and B must be of equal length, i.e., $x_s' - x_s = x_d' - x_d$. Furthermore, we know that the consumer price at quantity x_d is equal to the producer price at quantity x_s. Then, since supply is increasing and demand is falling in the price, A will be greater than B.

In this example, trade policy and production subsidies have identical effects on supply and demand in the foreign country. Hence, Fig. 1 explains why trade policy is more efficient than domestic production subsidies for the purpose of reducing foreign production and pollution. (Note that since the choice between these policies makes no difference to the foreign country, this argument shows that trade policy is the most efficient instrument from the home country's point of view as well.)

Some further properties and implications of the second best tax structure will be presented in the following. The use of green trade policy when only home country production is polluting, is discussed in Section 4.1. In Section 4.2, the case of pollution in foreign production only is analysed. Some special results related to the case of pollution in both countries are presented in Section 4.3. In Section 4.4, I pursue an alternative interpretation of the second best tax structure, and in Section 4.5, I comment on the relation between the second best tax structure and the optimal tax structure from the home country's point of view.

4.1 Only home country production is polluting

To be precise, when saying that only home country production is polluting, I shall mean that it is only home country producers who do not face the full environmental costs of production. In the model, this situation can be described as the case of $e > 0$ and $E = 0$. (Note that since our normative criterion is a measure of global welfare, the model does not distinguish between domestic and international environmental problems. The externalities created by domestic producers may therefore be interpreted either as a pure domestic environmental problem or as a unidirectional transborder pollution problem.)

If the home country tries to curb pollution through environmental regulations, domestic firms that are exposed to international competition will lose ground relative to foreign firms. Within the present normative framework, though, this is not a legitimate reason for protecting domestic industries by means of trade policy.

PROPOSITION 2
It will be inefficient to use green trade policy in order to solve an environmental problem that is created exclusively by domestic producers.

The result is quite obvious, indeed. The fact that domestic producers lose market shares to foreign firms in the wake of this kind of environmental regulations only reflects their lack of a real comparative advantage. Environmental costs are real costs that producers must be able to bear to justify their existence.

4.2 Only foreign production is polluting

When environmental values are not fully internalized in foreign production costs, environmental problems may arise both in the foreign country and in the home country. If there is no transborder pollution, there is a local foreign environmental problem. If some of the pollution

hurts the home country, we have an example of a unidirectional international externality. Within the present framework, both situations can be modelled by setting $e = 0$ and $E > 0$. Eq. (6) shows that if first best Pigouvian taxes are not available, trade provisions may be called for in order to improve economic efficiency in this situation:

PROPOSITION 3

When environmental values are not internalized in the foreign costs of production ($E > 0$), the home country has a legitimate reason to use green trade policy .

In an undistorted competitive economy, any trade provisions would lead to inefficiency.[19] However, when inefficiencies are already present because of environmental externalities, the efficiency costs of trade provisions must be balanced against their potential environmental benefits. Import tariffs or export subsidies will cause the foreign price to fall. Hence, foreign production and pollution decline. This is clearly beneficial from an environmental point of view. It is also beneficial from an overall efficiency point of view, because there is too much pollution at the outset, and because the marginal efficiency loss of trade provisions is zero when starting from $T = 0$.[20]

Note that the internalization of environmental values is no guarantee that pollution ceases. Within the present normative framework, a positive amount of pollution might be desirable, including for instance transborder pollution. The fact that one country is harmed by transborder pollution is therefore not in itself a reason that can justify the use of green trade policy. The lack of appropriate foreign environmental policies must also be verified.

Trade policy is the most efficient instrument the home country can use in order to reduce foreign pollution, because this is the instrument that most closely imitates first best Pigouvian taxes, implemented by the foreign government. In order to see how closely the first best solution can be approximated by the second best tax structure, it will be illuminating to take a closer look at the properties that distinguish trade provisions from first best environmental regulations. The fundamental difference between these policy alternatives is that trade provisions do not create a wedge between the foreign producer and consumer prices, whereas a Pigouvian tax does. Consequently, trade provisions fail to adjust *both* foreign production and consumption in the right direction. By lowering the foreign price, trade provisions will induce foreign consumption to increase, at the same time as foreign production and pollution decrease. This "crowding out" effect implies that it normally will be impossible to reduce both foreign

[19]When all environmental costs are internalized, free trade will typically lead to an efficient allocation of resources. See Anderson (1992), Pethig (1976), Siebert (1977), among others.
[20]See Eq. (5a).

consumption and production to their first best levels by means of green trade policy. Hence, green trade policy is bound to be no more than a second best solution to environmental problems.

There is a special case, though, to which I now turn, where this conclusion does not hold. Consider a market with no foreign consumption. Each unit of reduced imports to the home country then translates one by one into reduced foreign production. In this situation, an import tariff will have exactly the same effects as a tax imposed directly on foreign production. In fact, trade provisions have this "first best property" whenever foreign consumption is irresponsive to price changes.

PROPOSITION 4

When foreign demand is completely inelastic, trade policy is a first best instrument to deal with environmental problems caused by foreign production.

The degree to which trade provisions are able to resemble first best environmental regulations is reflected in the formula for the second best tax structure (Eq. (6)). When foreign demand is completely inelastic ($V'' = 0$), making trade provisions equivalent to first best taxes, the efficient trade tax or subsidy is equal to the first best Pigouvian tax. More generally, the second best tax formula shows that:

PROPOSITION 5

The efficient green trade taxes (or subsidies) are never greater than the first best Pigouvian tax. The efficient green trade taxes (or subsidies) increase as foreign demand becomes less price elastic, and when foreign supply becomes more price elastic.

The factor multiplied by E in Eq. (6) can be interpreted as the slope of the foreign supply curve, divided by the slope of the foreign export supply curve. This term is smaller than one, unless foreign demand is completely inelastic. The role of this fraction is to reflect that, due to the crowding out effect via foreign consumption, trade policy is a more costly means of environmental protection than a direct tax at the source of the problem. The less elastic is the foreign demand curve, the smaller is the crowding out effect, the closer does trade policy resemble the first best tax, and the greater are the efficient trade provisions.

The slope of the foreign supply curve plays a dual role in determining the magnitude of the efficient trade provisions. First, for a given fall in the foreign price, the decline in foreign production and pollution will be greater with an elastic foreign supply curve. On the other hand, an elastic supply curve implies that it becomes more costly for the home country to reduce the

foreign price, since the foreign export supply curve then will be relatively elastic. When the foreign supply curve has the same slope as the foreign export supply curve, these effects neutralize each other. However, this does not happen as long as foreign demand responds to price changes. In that case, the first effect dominates, making the efficient trade provisions increase with the slope of the foreign supply curve ($\Pi'' = 0$ implies that $T = 0$. When Π'' goes to infinity, T approaches the Pigouvian tax rate (E)).

Note that although the efficient trade tax (or subsidy) approaches E when foreign marginal costs are constant ($\Pi'' \rightarrow \infty$), this does not imply that trade policy is a first best instrument in that case. The reason why the efficient trade provisions are equal to the Pigouvian tax rate is that there will be no crowding out effect via foreign consumption, simply because the foreign price is fixed by the horizontal foreign supply curve. In order to reach first best quantities, however, it is not sufficient that foreign consumption is *not* stimulated in the *wrong* direction; it must be stimulated in the *right* direction as well! Only an inelastic foreign demand curve makes such price signals superfluous and turns trade policy into a first best instrument.

This discussion has implications for the relationship between the use of green trade policy and the home country's ability to influence world market prices:

PROPOSITION 6

The home country may have a legitimate reason to implement green trade policy even though it is unable to influence the world market price.

In standard models of international trade, countries that are unable to influence world market prices have nothing to gain from the use of trade policy.[21] This result is not necessarily valid when there are environmental externalities. The discussion above showed that even if the foreign price is fixed by a constant foreign marginal cost of production, green trade policy may enhance efficiency. Although trade provisions have no effect on the foreign price in this case, they nevertheless have a direct effect on the quantity produced. Only when the reason for the given world market price is a very elastic foreign demand curve, green trade policy will be useless (and therefore inefficient). But in that case, it is the large crowding out effect via foreign consumption, rather than the given world market price, that is the real source of the problem.

PROPOSITION 7

The efficient green trade policy is determined independently of the volume of international trade.

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[21] See Dixit and Norman (1980), among others.

It is sometimes maintained that green trade policy is useless when there is no international trade. This is a fallacy. To be sure, when there is no international market at all, i.e., if there are insurmountable impediments to trade, or if only one country produces and consumes the good, trade policies are useless. But no trade is not necessarily a consequence of obstacles to trade. No trade can arise in a free trade equilibrium. It is the structure of the market, therefore, rather than the volume of trade in itself, that is important for the effectiveness of green trade policy.

An interesting property of the second best tax structure is discovered by comparing the resulting equilibrium quantities with the corresponding quantities in the first best equilibrium:

PROPOSITION 8

Assume that foreign demand and supply functions are linear. The second best tax structure will then lead to the same volume of trade as in the first best equilibrium. Moreover, the levels of consumption and production in the home country will be identical to first best quantities.

Proof: Consider how the first best and the second best tax structures affect the price faced by home country producers and consumers. Let p denote the initial equilibrium price (before the implementation of environmental policies),[22] and let Δp be the equilibrium price change.

The linearity assumptions imply that $V''' = \Pi''' = 0$. By using a Taylor expansion, the equilibrium condition (see Eq. (1)) after the implementation of a first best environmental tax (equal to E) can then be written[23]

$$\sum_{n=0}^{\infty} -v^{(n+1)}(p)\frac{\Delta p^n}{n!} - V'(p) - \Delta p V''(p) = \sum_{n=0}^{\infty} \pi^{(n+1)}(p)\frac{\Delta p^n}{n!} + \Pi'(p) + (\Delta p - E)\Pi''(p). \tag{8}$$

By using Eq. (1), Eq. (8) can be simplified to

$$\sum_{n=1}^{\infty}\left[-v^{(n+1)}(p) - \pi^{(n+1)}(p)\right]\frac{\Delta p^n}{n!} - \Delta p\left[V''(p) + \Pi''(p)\right] = -E\Pi''(p). \tag{9}$$

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[22] Subscripts are suppressed since $p_d = p_s$ in this case. It is straightforward to show that the result is valid when home country production is polluting as well.

[23] $f^{(n)}$ denotes the nth-order derivative of the function f.

Eq. (9) provides an implicit expression for the effect of first best environmental policy on equilibrium prices. A similar expression is obtained when trade provisions are used as a substitute for a first best environmental tax:

$$\sum_{n=1}^{\infty}\left[-v^{(n+1)}(p)-\pi^{(n+1)}(p)\right]\frac{\Delta p^n}{n!}-\Delta p\left[V''(p)+\Pi''(p)\right]=-T\left[V''(p)+\Pi''(p)\right]. \qquad (10)$$

The left hand sides of Eqs. (9) and (10) are identical if Δp is the same in the two cases. By inserting the expression for efficient trade provisions from Eq. (6) into Eq. (10), it is easily seen that the right hand sides then are identical as well. The proposition then follows straightforwardly.

This result has both theoretical and practical significance. From a theoretical point of view, it is interesting to note that it is efficient to sustain first best quantities in some parts of the economy in a second best equilibrium. This property seems counter-intuitive against the background of traditional second best results in public finance. From a practical point of view, the result can be useful insofar as politicians have more knowledge about first best quantities than about the magnitudes of the expressions in the second best tax formula. With knowledge about first best quantities, politicians can be sure that there is a legitimate reason to implement further trade provisions until these quantities are reached (provided, of course, that the assumptions of the present model are valid).

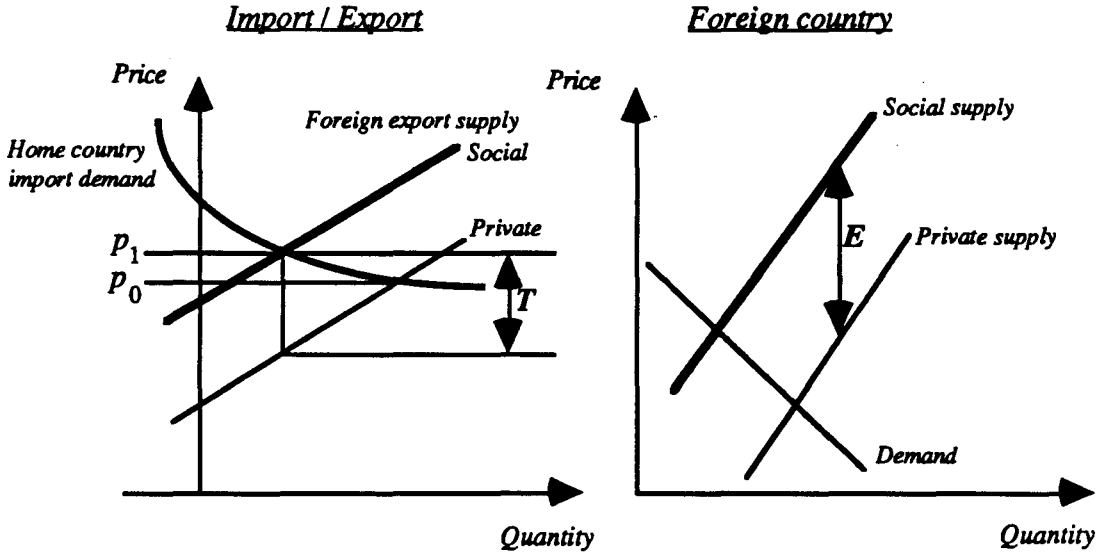

Fig. 2.

The result is illustrated in Fig. 2. Supply and demand in the home country are represented by the home country's import demand curve. Similarly, the foreign export supply curve is deduced from foreign supply and demand functions. The presence of environmental externalities is

shown by drawing a foreign social supply curve. This curve represents the quantities that would be produced if all environmental values were internalized. The environmental externality is reflected in the difference between the social and private foreign export supply curves as well.

Without any government interventions, the equilibrium price would be p_0. A first best environmental tax in the foreign country would shift foreign supply from the private to the social supply curves. The first best equilibrium price p_1 can be found at the intersection between the home country's import demand curve and foreign social export supply curve.

Let the home country impose an import tariff. The tariff can be represented as a wedge between the home country's import demand curve and the foreign private export supply curve. The marginal efficiency costs of the tariff are equal to the size of this wedge. These costs must be balanced against the environmental benefits of the trade restrictions. In the second best solution, the tariff T shall equal $E\Pi''/(V''+\Pi'')$. When foreign demand and supply functions are linear, this expression corresponds exactly to the vertical distance between the social and the private export supply curves. Hence, marginal benefits and costs of further trade restrictions are equalized at the first best trade volume. The import tariff T will cause an increase in the price in the home country to p_1, which is the first best equilibrium price. Hence, the second best solution involves first best quantities in the home country. Due to the tariff, however, the foreign price is lower than p_1, and foreign consumption and production thus exceed the first best quantities.

4.3 Production is polluting in both countries

I now turn to the case where production is polluting in both countries ($e>0, E>0$). Reciprocal international environmental problems, such as acid rain, would fall in this category, but, within the present framework, the analysis would be no different if the environmental problems involved were domestic to each country. Of course, the conclusions drawn in the preceding sections about the properties of the second best tax structure will be valid in this case as well. In this section, I focus on some additional properties with particular relevance when there is pollution in both countries.

It is important to note that the efficient trade provisions, as prescribed by Eq. (6), presuppose that the home country at the same time internalizes the full environmental costs of domestic production, including the costs that might fall on foreigners. Although the formula for efficient green trade policy is independent of e, it is thus not independent of environmental policy in the home country. In order to see this more clearly, assume that the home country internalizes only

a fraction of its environmental externalities by setting $t = \alpha e$, where $\alpha \in [0,1]$. Given this partial internalization, the efficient trade provisions can be expressed as[24]

$$\tilde{T} = (\alpha - 1)e\frac{\pi''(p_s)}{v''(p_d) + \pi''(p_s)} + E\frac{\Pi''(P)}{V''(P) + \Pi''(P)}. \qquad (11)$$

The first term in this expression is negative if $\alpha < 1$. *Ceteris paribus*, therefore, the partial internalization of externalities in home country production makes $\tilde{T}$ smaller than the trade provisions prescribed by Eq. (6), indicating that the efficiency enhancing potential of trade provisions has been reduced. The reason is quite obvious. The primary effect of trade provisions in a partial equilibrium model like ours, is to *reallocate* production and consumption between countries (although some effects on the aggregate level of economic activity are conceivable as well). When only foreign production is polluting, there are some unambiguous environmental benefits to be reaped from a reallocation of production from the foreign country to the home country. But if home country producers pollute as well, these environmental gains are obviously reduced. Indeed, with equally polluting production processes, there is no environmental reason for reallocating production between the countries. Therefore, $\tilde{T}$ in Eq. (11) tends to be close to zero when $e = E$ and there is no environmental policy in the home country ($\alpha = 0$).

When the home country starts to internalize environmental values (α increases), the efficiency enhancing potential of trade policy increases ($\tilde{T}$ is increasing in α[25]). Note, however, that there is still no *environmental* reason for reallocating production from the foreign country to the home country. In other words, the reason for these trade provisions must be found in general considerations about economic efficiency, apart from environmental concerns. The argument goes like this: unilateral environmental taxes create a wedge between marginal costs of production in the two countries. This leads to inefficiency. A possible way to alleviate this inefficiency would be to reduce the environmental tax in the home country. But such a policy would exacerbate environmental problems. By using trade provisions instead, it is possible to reduce the gap between marginal costs of production, without boosting pollution (since the primary effect of trade provisions is to reallocate production). To be sure, trade provisions would introduce an additional distortion by raising the consumer price in the home country above the international price. But as far as efficiency is concerned, we would rather prefer to have a small distortion in both production and consumption, than to have one major distortion

[24]The expression is obtained from Eq. (5a), while making use of the properties of Eqs. (1) and (2).
[25]To be sure, trade provisions may alter the equilibrium slopes of demand and supply curves. In theory, such effects might more than offset the direct effect of α on $\tilde{T}$.

in either of the two. The reason is that the efficiency loss is convex in the 'size' of the distortion.

Implicit in this discussion, there is a result that should be stated explicitly:

PROPOSITION 9

A country that takes unilateral steps towards solving an environmental problem where both countries are polluters ($e > 0$, $E > 0$), has a legitimate reason to use green trade policy.

This result is highly relevant for the negotiation of incomplete international environmental agreements. It implies that when not all affected parties are signatories to the agreement, it will often be efficient to add some kind of trade provisions to the agreement. Since these trade provisions take the form of import tariffs or export subsidies, we can conclude that unilateral environmental regulations can legitimately be accompanied by trade measures that protect the competitiveness of domestic producers.

One issue that sometimes is discussed in connection with unilateral efforts to solve international environmental problems is the so-called *leakage effect*. Generally speaking, the term leakage refers to the possibility that environmental regulations in some countries may induce greater pollution in other places. This may happen through several channels. In the present model, leakage will occur insofar as environmental regulations in the home country induce the world market price to rise, thus causing foreign production and pollution to increase.[26] In popular discussions, it is sometimes maintained that when leakage is a problem, unilateral environmental regulations should be avoided. At least, unilateral taxes should be far below their first best levels. The present analysis refutes this view:

PROPOSITION 10

Leakage effects should be handled by means of trade policy, not through reductions in unilateral environmental taxes.

This result follows directly from the separation property (see Proposition 1). Whenever we are concerned with the amount of foreign pollution, it is more efficient to use trade provisions than domestic production subsidies (or domestic environmental taxes below the Pigouvian level).

[26]In Felder and Rutherford (1993), there is leakage through factor substitution as well. Leakage may also occur through the movement of firms. This problem is addressed in Mæstad (1995b). For a discussion of leakage effects in a model of imperfect competition, see Conrad (1993).

4.4 An alternative interpretation

In many cases, the implementation of efficient green trade policies is likely to violate present GATT rules. Note, however, that the second best tax structure alternatively can be implemented by substituting a consumption tax for the trade provisions, provided appropriate adjustments are made in the production tax.[27] In this way, it may be possible to circumvent the regulations of the GATT.

In order to maintain the second best tax structure without using trade provisions, a consumption tax and a production subsidy must be implemented at the same rate as the original trade tax (or subsidy). The resulting net tax on home country producers is then the Pigouvian tax (e), minus a subsidy at the rate of the efficient green trade provisions. This shows that an alternative interpretation of the effect of the green trade provisions, compared to first best environmental regulations, is that they shift taxes from the producer side and over to the consumers. Define the *total tax rate* as the sum of the consumption tax t_c and the net production tax t_p (where t_c is defined as the difference between the consumer price and the world market price, and t_p is the difference between the world market price and the producer price).

PROPOSITION 11

The total tax rate $(t_p + t_c)$ in the second best tax structure is equal to the Pigouvian tax rate in the home country (e). In the second best solution, part of the total tax should be implemented as a consumption tax, rather than as a production tax.

While trade provisions reduce the effective environmental tax on domestic producers below the Pigouvian level (e), they increase the tax on domestic consumption correspondingly. Hence, the total tax in the second best solution will be the same as in the first best solution.

If the second best tax structure entails a net subsidy to domestic producers, the tax scheme may violate certain GATT rules and induce countervailing measures. This is most likely to happen when e is relatively small. However, when home country production generates large externalities, the second best tax structure will entail a net tax on domestic producers. By omitting direct environmental taxes on production, the home country can then provide implicit subsidies to its producers and thus easily circumvent the GATT rules. In fact, the second best tax structure can under certain circumstances be implemented without any other measure than a consumption tax:

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[27]The optimal mix between consumption and production regulations in an incomplete climate agreement is discussed by Hoel (1993).

PROPOSITION 12

The second best tax structure can be implemented without any other policy instrument than a consumption tax in the home country if $e = E\Pi''/(V'' + \Pi'')$.

In this case, the implicit production subsidy in the efficient green trade provisions exactly offsets the Pigouvian tax in the home country. Consequently, the second best tax structure entails no net tax or subsidy on home country producers, and a consumption tax equal to $E\Pi''/(V'' + \Pi'')$ is all that is needed to attain the second best solution.

This shows that it may be difficult to design rules that prevent the use of green trade policy, or other equivalent policy measures. In particular, it is easy to circumvent prohibitions against the subsidy element of trade provisions when there are externalities in production in the home country. In fact, to uphold *status quo* in this case is the same as to subsidize domestic producers. It remains to be discussed, however, whether it really is in the interest of the home country to implement the policy prescribed by the second best tax formula.

4.5 The optimal policy of the home country

In order to determine what kind of policy the home country would prefer, we need to be specific about the motivational forces of the government of the home country. The usual approach, which will be employed here as well, is to assume that the government maximizes the welfare of domestic citizens. Let α be the share of domestic pollution that bothers people in the home country, and let β denote the share of foreign pollution that they consider to be a problem. The welfare function of the home country can then be written:

$$w = v(p_d) + \pi(p_s) - \left(\alpha e\pi'(p_s) + \beta E\Pi'(P)\right) + t\pi'(p_s) + T\left(-v'(p_d) - \pi'(p_s)\right) \tag{12}$$

The optimal tax structure can be found by maximization of w with respect to the tax parameters t and T, subject to the conditions imposed by Eqs. (1) and (2).

By using the properties of Eq. (2), we obtain the following first order conditions:

$$\begin{aligned} &v'\left(\frac{\partial P}{\partial T}+1\right)+\pi'\left(\frac{\partial P}{\partial T}+1\right)-\alpha e\pi''\left(\frac{\partial P}{\partial T}+1\right)-\beta E\Pi''\frac{\partial P}{\partial T} \\ &+t\pi''\left(\frac{\partial P}{\partial T}+1\right)+(-v'-\pi')+T(-v''-\pi'')\left(\frac{\partial P}{\partial T}+1\right)=0, \end{aligned} \tag{13a}$$

$$v'\frac{\partial P}{\partial t}+\pi'\left(\frac{\partial P}{\partial t}-1\right)-\alpha e\pi''\left(\frac{\partial P}{\partial t}-1\right)-\beta E\Pi''\frac{\partial P}{\partial t}$$
$$+\pi'+t\pi''\left(\frac{\partial P}{\partial t}-1\right)+T\left(-v''\frac{\partial P}{\partial t}-\pi''\left(\frac{\partial P}{\partial t}-1\right)\right)=0. \tag{13b}$$

By using Eq. (1) and its properties, the first order conditions can be rewritten as

$$T(V''+\Pi'')\frac{\partial P}{\partial T}+t\pi''\left(\frac{\partial P}{\partial T}+1\right)=\alpha e\pi''\left(\frac{\partial P}{\partial T}+1\right)+\beta E\Pi''\frac{\partial P}{\partial T}+(V'+\Pi')\frac{\partial P}{\partial T}, \tag{14a}$$

$$T(V''+\Pi'')\frac{\partial P}{\partial t}+t\pi''\left(\frac{\partial P}{\partial t}-1\right)=\alpha e\pi''\left(\frac{\partial P}{\partial t}-1\right)+\beta E\Pi''\frac{\partial P}{\partial t}+(V'+\Pi')\frac{\partial P}{\partial t}. \tag{14b}$$

By solving this system with respect to the tax parameters (see Appendix C), the optimal tax structure can be expressed as[28]

$$\hat{t}=\alpha e,$$
$$\hat{T}=\beta E\frac{\Pi''(P)}{V''(P)+\Pi''(P)}+\frac{V'(P)+\Pi'(P)}{V''(P)+\Pi''(P)}. \tag{15}$$

Eq. (15) confirms that the separation property is valid also when the tax structure is evaluated from the perspective of the home country. Trade policy is simply the most efficient instrument available to the home country for the purpose of reducing foreign pollution.

There are two notable differences between the second best tax structure and the optimal taxes from the home country's point of view. First, the home country may not take all environmental costs into account. For instance, it may ignore the pollution that affects only foreigners. Second, the home country has an incentive to implement trade policy that is motivated from considerations about terms of trade. Eq. (15) shows that the terms of trade component enters the tax formula additively, and that its size is inversely related to the elasticity of the foreign export supply.[29]

[28]Markusen (1975) and Rauscher (1991) have obtained similar results.

[29]The inverse elasticity rule is well known from the theory of optimal trade policy (see Dixit and Norman (1980), among others). In the theory of public finance, this result is known as the Ramsey rule, after the work of Ramsey (1927).

PROPOSITION 13

The optimal trade provisions from the home country's point of view may be greater or smaller than the efficient green trade provisions. The optimal domestic environmental tax is smaller than (or equal to) the Pigouvian tax rate.

Denote as *protectionist trade policy* those trade provisions that are motivated from terms of trade considerations. Eq. (15) shows that protectionist trade policy will involve an import tariff or an export tax. Hence, for an importing home country, environmental and protectionist considerations pull in the same direction; towards import tariffs. The incentives of protectionist interests to join the green wave should thus be obvious.

However, we cannot conclude, against this background, that the optimal import tariff (Eq. (15)) will be greater than the efficient import tariff (Eq. (6)), because β may be smaller than one. This happens if there are externalities in foreign production that do not bother the home country (e.g., externalities that hurt foreigners only). This shows that if the foreign country has not solved its local environmental problems, there is less reason to be concerned about misuse of green trade policy for protectionist purposes.[30]

There is yet another reason why the optimal trade provisions may deviate from the trade provisions that would maximize economic efficiency in the global economy. This concerns the possibility that α is smaller than one, and thus that the optimal environmental tax in the home country is smaller than the first best Pigouvian tax. We know that with less than full internalization of the externalities in domestic production, the efficiency enhancing potential of trade provisions is normally reduced (see Eq. (11)). This implies that the trade provisions that would be efficient, given the optimal environmental tax $\hat{t}$, probably will be smaller in magnitude than the trade provisions prescribed by Eq. (6) (as long as α is smaller than one).

Furthermore, we notice that for an exporting country, protectionist motives and environmental motives pull the optimal trade provisions in opposite directions. This leads to the paradoxical result that the *absence* of trade provisions may in fact be a way of implementing a protectionist policy, and it illustrates once more that regulations against green trade policy and protectionist trade policy might be very difficult to enforce.[31]

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[30]Notice that when the exact magnitude of βE is difficult to verify, the home country may disguise its protectionist motives by attempting to exaggerate the magnitudes of β and/or E.

[31]It should be noted, however, that with imperfect competition, protectionist trade policy may involve export subsidies rather than export taxes (see Brander and Spencer (1985)). In that case, environmental and protectionist considerations will probably pull in the same direction for exporting countries as well.

PROPOSITION 14

The optimal trade provisions for a price taking country are not greater than the trade provisions in the second best solution.

A price taking country is per definition unable to influence its terms of trade, and the country has therefore no incentive to implement protectionist trade policy. A price taker is not necessarily a quantity taker, though. Since it is the quantity effects that matter for the desirability of green trade policy, it may be optimal for a price taker to implement some kind of green trade policy (see Proposition 6). But in the absence of any protectionist motives, these optimal trade provisions will clearly be no greater than the trade provisions in the second best solution.

5. Dirty consumption

So far, it has been assumed that environmental problems are caused by dirty production processes. But many important international environmental problems are caused by pollution at the consumption (or disposal) stage. The major reason for the threat of global warming, for instance, is the consumption (or burning) of fossil fuels, and not the production (or the extraction) itself.

Let e and E denote the environmental externalities per unit of consumption in the home country and in the foreign country. The first best solution to these environmental problems would be to tax consumption in both countries in accordance with the respective marginal environmental damages. Insofar as the climate problem is concerned, however, such a solution is quite unrealistic. Most likely, if any agreement about significant reductions in CO_2-emissions is arrived at in the foreseeable future, the number of signatories will be rather limited. The question then arises whether the signatories legitimately can apply trade policy in order to enhance the efficiency of the agreement, in a similar way as trade provisions are already being used in the Montreal Protocol.

When consumption is polluting, total environmental costs are $-ev'(p_d) - EV'(P)$. The measure of global economic welfare can then be written as

$$W = \underbrace{v(p_d) + V(P)}_{\text{Consumer surpluses}} + \underbrace{\pi(p_s) + \Pi(P)}_{\text{Producer surpluses}} - \underbrace{\left(-ev'(p_d) - EV'(P)\right)}_{\text{Environmental costs}} + \underbrace{t\pi'(p_s) + T\left(-v'(p_d) - \pi'(p_s)\right)}_{\text{Government income}}. \quad (16)$$

The second best tax structure is obtained by maximizing this expression with respect to the tax parameters t and T, subject to the restrictions imposed by Eqs. (1) and (2).[32] The first order conditions are found to be

$$T(V''+\Pi'')\frac{\partial P}{\partial T}+t\pi''\left(\frac{\partial P}{\partial T}+1\right)=-ev''\left(\frac{\partial P}{\partial T}+1\right)-EV''\frac{\partial P}{\partial T}, \tag{17a}$$

$$T(V''+\Pi'')\frac{\partial P}{\partial t}+t\pi''\left(\frac{\partial P}{\partial t}-1\right)=-ev''\frac{\partial P}{\partial t}-EV''\frac{\partial P}{\partial t}. \tag{17b}$$

The second best tax structure can be written as follows (see Appendix D)

$$\begin{aligned} t &= e, \\ T &= e-E\frac{V''(P)}{V''(P)+\Pi''(P)}. \end{aligned} \tag{18}$$

The symmetry between this tax structure and the second best tax structure in the model with production externalities is perhaps more easily seen if we reinterpret the taxes in Eq. (18) in terms of a consumption tax and trade provisions. By letting t_c denote a consumption tax, Eq. (18) can be rewritten as

$$\begin{aligned} t_c &= e, \\ T &= -E\frac{V''(P)}{V''(P)+\Pi''(P)}. \end{aligned} \tag{19}$$

This latter formulation of the second best tax structure will be used in the following.

PROPOSITION 15

In the case of consumption externalities, efficient green trade policy should take the form of import subsidies and export taxes.

In order to reduce foreign consumption, the home country must try to raise the foreign price. This is accomplished most efficiently by an increase in the home country's import demand, either by subsidizing imports or by taxing exports. Hence, consumption externalities require trade provisions of the opposite sign compared to production externalities.

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[32]Some readers may be surprised that I have not specified any consumption tax in Eq. (16). The reason, as I have explained earlier, is that the consumption tax is redundant when we use the combination of a production tax and trade provisions.

In addition to the change in the sign of the trade provisions, the main difference from the case of production externalities is that the roles of the foreign supply and demand curves have been exchanged. Thus, in the present problem, the parallel result to Proposition 4 would be that the second best tax structure is equivalent to first best taxes when foreign *supply* is completely inelastic (and so on for the other results as well).

5.1 An incomplete climate agreement

To be somewhat more specific, assume that what has been defined as the home country is a group of countries that have signed an agreement to reduce their CO_2-emissions. We might, for instance, imagine that the OECD countries have decided to internalize the full (i.e. the global) costs of their consumption of fossil fuels.[33] According to Eq. (19), the OECD countries cannot then legitimately impose import restrictions on fossil fuels in order to accomplish their emission goals. Quite the contrary; the efficient policy from a global point of view is to *subsidize* the imports of fossil fuels from non-signatory countries. (Such a policy will benefit the OECD countries as well, but the conventional terms of trade argument will tend to make their optimal import subsidy smaller than the efficient one from a global point of view.[34])

Fig. 3 illustrates how the combination of internal consumption taxes in the OECD region and import subsidies on fossil fuels from non-signatories may work. At the outset, before any environmental policies are implemented, the equilibrium is determined by the intersection of the *private* import demand curve of the OECD countries and the *private* export supply curve of the non-signatories. The international price is p_0. With a unilateral internalization of the consumption externalities in the OECD region, the import demand from this region will shift down to the *social* import demand curve. Consequently, the international price of fossil fuels will fall to p_1. This price fall causes a decline in total production (and consumption) of fossil fuels. However, the total reduction of consumption is *smaller* than the consumption reduction in the OECD countries, because the decline in the world market price of fossil fuels will induce non-signatory countries to consume more. This is the leakage effect; unilateral environmental taxes lead to more pollution from other countries.

Since unilateral consumption taxes reduce total consumption and, thereby, reduce the emissions of greenhouse gasses, such taxes will promote economic efficiency. However, as Eq. (18) shows, efficiency may be further enhanced by implementing a subsidy on the imports of fossil

[33]In this discussion, fossil fuels are treated as a homogenous good that is traded freely in a perfectly competitive market. Although these are unrealistic assumptions, the general points of my discussion will probably carry over to a more general setting.

[34]This follows from the same type of argument that was applied in section 4.4. See also Golombek *et.al* (1993).

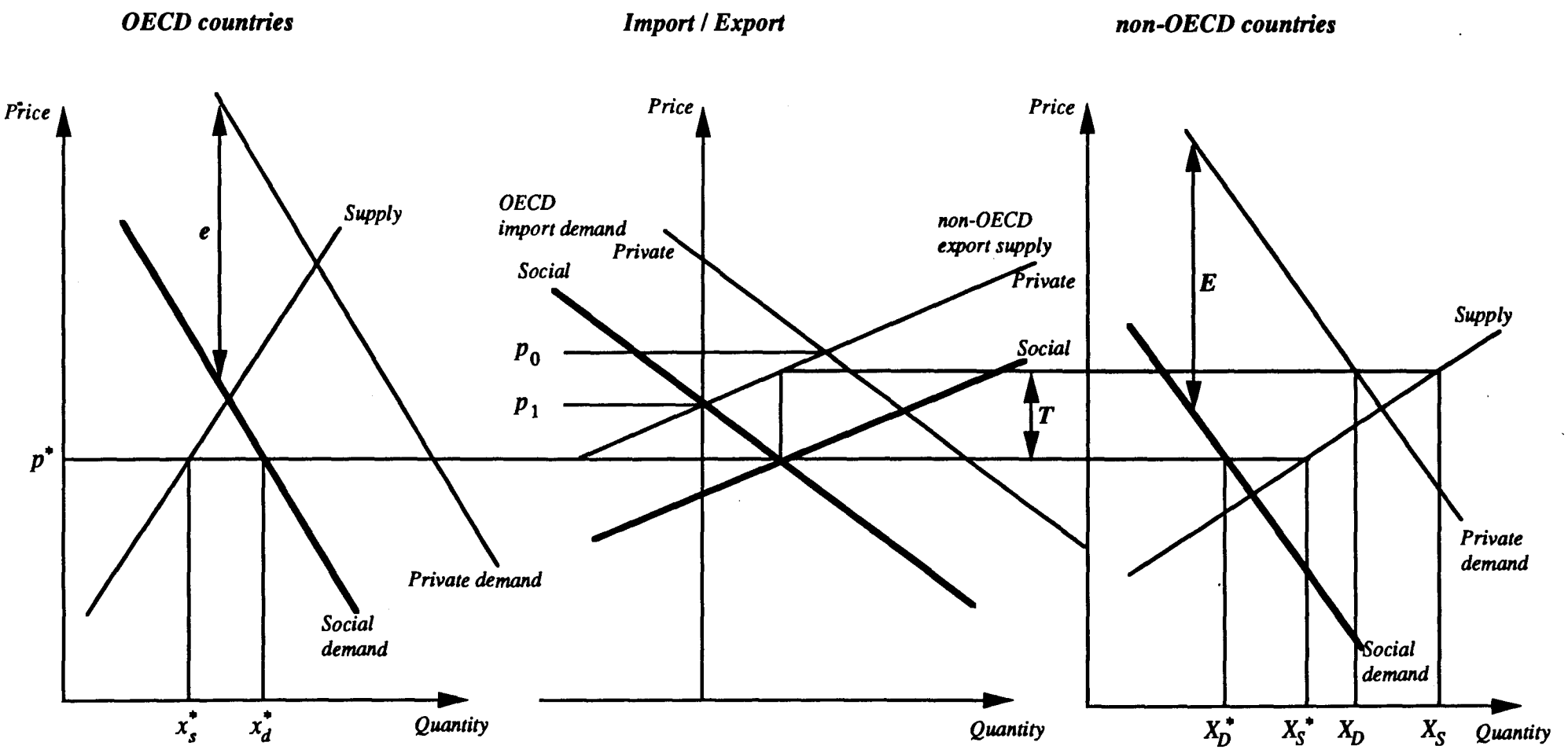
OECD countries
Import / Export
non-OECD countries
Price
Supply
e
Private demand
Social demand
p^*
x_s^*
x_d^*
Quantity
Price
OECD import demand
Private
Social
p_0
p_1
non-OECD export supply
Private
Social
T
Quantity
Price
E
Supply
Private demand
Social demand
X_D^*
X_S^*
X_D
X_S
Quantity

Fig. 3.

fuels as well.[35] Admittedly, the environmental gains from an import subsidy on fossil fuels will be small. The primary effect of such a subsidy will be to reallocate consumption of fossil fuels from non-signatories to OECD countries. The desirability of the import subsidy must therefore stem from concerns about other efficiency considerations: in the absence of a full internalization of environmental costs outside the OECD, the price of fossil fuels to the importers in the OECD countries will exceed the marginal social costs of imports. (This is illustrated in Fig. 3 by a *social* foreign export supply curve which lies everywhere to the right of (or below) the *private* foreign export supply.) This implies that the willingness to pay for a marginal increase in the imports of fossil fuels exceeds the marginal social costs. Therefore, it is possible to enhance efficiency by stimulating the imports of fossil fuels.

The equilibrium price in the first best solution (p^*) is found at the intersection between the social import demand and export supply curves. With linear foreign demand and supply functions, the efficient import subsidy will reduce the import price to p^*, thus inducing first best quantities of production and consumption in the OECD countries (x_s^*, x_d^*) (see Proposition 8). The world market price of fossil fuels in the second best solution will then exceed p^* by the size of the import subsidy. Hence, production and consumption outside the OECD (X_S, X_D) will exceed their first best quantities (X_S^*, X_D^*).

It should be underscored that the recommendation to subsidize the imports of fossil fuels is based on the rather unrealistic assumption that trade policies do not influence the number of signatories to the international agreement on carbon emissions. Import subsidies towards non-signatories will benefit the exporters of fossil fuels and weaken their incentives to join the agreement. (By way of illustration, the incentives for the OPEC countries to remain outside a future climate agreement will be strengthened if the OECD countries subsidize their imports of oil.) Moreover, we should be aware of the perverse distributional effects that import subsidies might have in relation to the oil-importing countries outside the OECD.[36]

5.2 The Montreal Protocol

The Montreal Protocol for the protection of the ozone-layer is an example of an incomplete international environmental agreement containing trade provisions against non-signatories. The main trade provisions are 1) a ban on the import of controlled substances 2) a ban on the import

[35]By way of illustration, the model used by Golombek *et al.* (1993) suggests that in order for the OECD countries to reduce the global emissions of CO_2 by 15%, the efficient policy from a global point of view would be to impose a consumption tax in the range of 100 USD per ton of carbon, combined with an import subsidy of approximately 20 USD per ton of carbon.

[36]See Felder and Rutherford (1993) for another discussion of the possibility to use trade provisions in order to reduce leakage related to unilateral reductions in CO_2 emissions.

of products *containing* controlled substances 3) a possible future ban on products *made by* controlled substances.[37] The purpose of this section is to illustrate how the framework of the previous analysis might be used to evaluate the efficiency of these trade provisions.

It is important to note that the aim of the Montreal Protocol is a complete phasing out of the controlled substances in all countries. In the long run, therefore, the first best solution would involve no trade in the products listed above. Our analysis has shown that a second best solution that incorporates the use of green trade policy, will tend to bring trade volumes to their first best levels (Proposition 8). In a long run perspective, therefore, the import bans in the Montreal Protocol might very well turn out to be efficient measures to sustain a second best solution to this problem.

It may be objected that since signatory countries are exporters of many of the affected products, it is not sufficient to ban imports in order to attain first best trade volumes. In the long run, however, this is not a relevant objection, since the Montreal Protocol regulates the production in signatory countries directly. When production ceases, exports will of course cease as well.

A further question is whether the trade bans are efficient policy instruments during the transition period, i.e., in those years when the controlled substances are being phased out. There is no reason to believe that the first best trade volume is zero as long as it is considered to be desirable to maintain a positive level of production and consumption. Most likely, therefore, the import restrictions in the Montreal Protocol are more restrictive than the efficient trade provisions during the transition period. In fact, for products in category one and two, the second best tax structure would prescribe import *subsidies* rather than import restrictions, since these are products that pollute at the consumption stage. Admittedly, import subsidies would make it more difficult for the signatories to achieve a given reduction in their own emissions. For the sake of economic efficiency, however, it is better that the signatories relax their emission quotas slightly and subsidize imports, rather than pursuing their original emission goals by means of import restrictions.

Furthermore, it might be asked why only imports, and not exports, is regulated during the phase out period. According to our results, the export of products in category one and two should be restricted in a second best solution.

Based on this brief (and surely somewhat superficial) analysis, the two most notable weaknesses of the Protocol from an efficiency point of view seem to be that regulations on exports are too lax, while import regulations are too strict during the phase out period. Are

[37] St. prp. nr. 90 (1987-88).

these trade provisions then motivated by protectionist considerations?[38] They might be, but I would like to emphasize that other explanations are conceivable as well. Could the lack of export taxes be explained by a desire to avoid perverse distributional effects between developed and developing countries? Are the strong import restrictions implemented to avoid a movement of firms from signatory to non-signatory countries? Or are they used in order to induce countries to sign the agreement? These may of course be good reasons for adopting the particular trade provisions of the Montreal Protocol.

6. International responsibility without international externalities?

This study has shown that the efficiency of green trade policy is closely tied to the presence of externalities in foreign consumption or production. But it is not a requirement for efficiency that these externalities affect the welfare of home country citizens. Consequently, there may be a legitimate reason to implement trade restrictions against a country that fails to implement regulations against local environmental problems.

It may be objected that trade provisions in the absence of international externalities are nothing but paternalistic impositions of environmental standards on other countries. Differences in environmental standards might be a completely rational response to differences in preferences, income levels and environmental endowments between countries. Therefore, the use of green trade policy to regulate local foreign pollution must be considered illegitimate.

This criticism does not apply to the conclusions of the present analysis, however. When foreign pollution affects foreign citizens only, I have assumed that the size of the externality E should be evaluated by the environmental preferences of the foreign country, not based on the priorities of the home country. Hence, the model does not allow for any paternalist check on the environmental preferences of foreigners. The reason why there nevertheless may be a legitimate reason to use green trade policy in the case of local foreign pollution is that the foreign government may disregard the environmental preferences of its own citizens. What this study supports, then, is that the home country takes the interests of foreign victims of pollution into account when imposing green trade provisions. That is altruism, not paternalism.

In addition to the concern with the foreign victims of pollution, people may worry about local foreign pollution because they believe that nature has inherent value. The belief that nature has inherent value is often accompanied by an assertion that humans have moral obligations towards nature. Theories of environmental ethics differ with respect to the specific moral

[38]Note that the oligopolistic nature of this industry may make the Brander and Spencer argument for export subsidies highly relevant in this case.

responsibilities that they ascribe to humans. But at the heart of these theories, there is a duty of non-interference, combined with some rules for when this duty can be overridden by other relevant moral considerations.[39] It would certainly seem arbitrary to confine such a duty by national borders. If nature has inherent value, unwarranted encroachments upon nature do not lose their moral significance simply because they occur in other countries. Therefore, ethical theories that ascribe inherent value to nature may give a legitimate reason, or perhaps even define a moral obligation, to act so as to reduce local pollution in a foreign country.

This is indeed the same kind of reasoning that has been used to legitimize trade boycotts for the protection of human rights (cf. the international boycotts of South-Africa and Iraq). There is an important difference, though, between interventions for the sake of human rights and interventions for the sake of nature. To see this difference, it will be useful to distinguish between the concepts of *moral failure* and *ethical disagreement*. If the foreign country does not internalize the inherent value of nature, the reason may be that foreigners simply reject the very idea of inherent value in nature. This is ethical disagreement. But the lack of internalization of environmental values may also be due to a failure to take the consequences of their own ethical views. This is moral failure.

Both moral failure and ethical disagreement can be the cause of interventions against foreign conduct. But interventions seem to be easier to defend in the case of moral failure than in the case of ethical disagreement, because the latter would involve an imposition of an ethical view on another country. Since the inherent value of humans is more widely accepted than the inherent value of nature, interventions for the sake of the environment are more likely to fall in the category of ethical disagreement than interventions for the protection of human rights. It may therefore be difficult to defend the use of trade policy to protect the "rights of nature" simply by reference to the use of such measures when human rights are violated.

The distinction between moral failure and ethical disagreement seems to be of some significance when considering comprehensive trade boycotts, designed to force other countries to change their policies. I would argue, however, that this distinction is irrelevant for assessing the legitimacy of the efficiency enhancing trade provisions that have been discussed in this paper. To implement the trade provisions prescribed by this analysis is more appropriately described as *taking the consequence of one's own ethical view*, rather than as imposing an ethical view upon others. If one claims that nature has inherent value, one cannot be morally indifferent about the treatment of nature in foreign countries. And if the production of a commodity is banned in the home country because of the inherent value of nature, it would by morally reprehensible to import the very same product from abroad, simply because it is foreign nature

[39]See Nash (1989) for a good overview of different views on our moral obligations towards nature.

and not the home country's nature that is being destroyed. Some kind of trade provisions is therefore a natural consequence of differences in ethical views between countries. It is interesting to note in this connection that the efficient trade provisions tend to induce the same level of production and consumption in the home country as would result if the ethical views of the home country were universally accepted (see Proposition 8). The efficient solution thus seems appealing from the point of view of environmental ethics as well.

7. Concluding remarks

The main conclusion of this paper is that the lack of internalization of environmental values in a country may give other countries a legitimate reason to use green trade policy, because such policies will enhance economic efficiency in the global economy. Although examples can be found where the use of green trade policy is equivalent to first best environmental regulations, green trade policy is usually no more than a second best solution. This implies that efficiency could be further enhanced if all countries would implement full Pigouvian taxes. In theory, such a solution can make all countries better off if the countries sign international environmental agreements that specify appropriate side-payments. But the vast difficulties in the negotiations of such agreements might nevertheless make green trade policy an interesting alternative in practice, in particular when some countries take unilateral steps towards solving environmental problems.

Efficiency enhancing green trade provisions do not always involve trade restrictions. As is shown Table 1, trade restrictions are justified for an *importing* country if there are externalities in foreign *production*, and for an *exporting* country if there are externalities in foreign *consumption*. In other cases, green trade policy should aim at an expansion, rather than a contraction, of the volume of international trade. Note, however, that these recommendations are based on the presumption that the use of trade provisions is accompanied by the implementation of full Pigouvian taxes in the country in question.

Source of externality / *Home country is*	*Foreign production externality*	*Foreign consumption externality*
Importer	**Restrict trade** (Import tariff)	**Expand trade** (Import subsidy)
Exporter	**Expand trade** (Export subsidy)	**Restrict trade** (Export tax)

Table 1.

Countries that use green trade policy to promote economic efficiency may run into conflict with the principle of non-discrimination in the GATT. For instance, it may be efficient to discriminate between countries with different environmental policies, and between products that are identical in all respects, except that they are produced with production processes with different pollution-intensity. The discriminating trade provisions of the Montreal Protocol clearly demonstrate this problem. Thus, there seems to be a need to establish international conventions that accommodate the use of trade provisions in incomplete environmental agreements. At the same time, it will be important to ensure that such conventions are able to prevent retaliating trade measures and other protectionist policies.

Appendix A

Green trade policy and abatement possibilities through factor substitution

If there are no abatement possibilities through factor substitution, a tax on output is equivalent to an emission tax. Since trade provisions affect output quantities directly, and do not influence relative factor prices, the assumption of fixed proportions clearly enhance the ability of trade provisions to resemble first best environmental regulations. However, it is possible in theory to resemble an input tax with an output tax by making the output tax a function of the factor use. In this appendix, I show how this might be done. Thus, I also show that the results of this paper can be applied when there are abatement possibilities through factor substitution, provided certain informational requirements are met.

Assume that each firm produces an output X by a polluting input z and a vector of non-polluting inputs $\mathbf{y}$, where the production possibilities are described by the production function $X = F(\mathbf{y}, z)$. The external cost of pollution is E per unit of z. The factor prices of $\mathbf{y}$ and z are $\mathbf{v}$ and w, respectively. Firm profits are then

$$\Pi = PF(\mathbf{y}, z) - \mathbf{v}\mathbf{y} - wz. \tag{A.1}$$

A profit maximizing firm will use an inefficiently high quantity of the polluting input, since the firm does not take into account the costs of pollution. It is well known that efficiency can be restored by imposing a Pigouvian tax E per unit of z. The profits would then be

$$\Pi = PF(\mathbf{y}, z) - \mathbf{v}\mathbf{y} - (w + E)z. \tag{A.2}$$

An output tax that induces the same change in the profit function as the Pigouvian tax, will of course ensure efficiency in the factor use as well. By imposing a tax Ez/X per unit of output, the profit function can be written

$$\begin{aligned} \Pi &= \left(P - E\frac{z}{X}\right)F(\mathbf{y}, z) - \mathbf{v}\mathbf{y} - wz, \\ &\Updownarrow \\ \Pi &= PF(\mathbf{y}, z) - \mathbf{v}\mathbf{y} - (w + E)z. \end{aligned} \tag{A.3}$$

This shows that an output tax, depending on both the marginal environmental costs and on the quantity of the polluting input, can fully replace the Pigouvian tax. The assumption of fixed

proportions is therefore not restrictive when it is possible to implement trade provisions as a function of the factor use. Such policies might be difficult to implement in practice, however.

Appendix B

Eqs. (5a) and (5b) can be written as

$$\begin{bmatrix} (V''+\Pi'')\dfrac{\partial P}{\partial T} & \pi''\left(\dfrac{\partial P}{\partial T}+1\right) \\ (V''+\Pi'')\dfrac{\partial P}{\partial t} & \pi''\left(\dfrac{\partial P}{\partial t}-1\right) \end{bmatrix} \begin{bmatrix} T \\ t \end{bmatrix} = \begin{bmatrix} E\Pi''\dfrac{\partial P}{\partial T}+e\pi''\left(\dfrac{\partial P}{\partial T}+1\right) \\ E\Pi''\dfrac{\partial P}{\partial t}+e\pi''\left(\dfrac{\partial P}{\partial t}-1\right) \end{bmatrix}. \tag{B.1}$$

By using Cramer's rule, we obtain

$$\begin{aligned} t &= \frac{\begin{vmatrix} (V''+\Pi'')\dfrac{\partial P}{\partial T} & E\Pi''\dfrac{\partial P}{\partial T}+e\pi''\left(\dfrac{\partial P}{\partial T}+1\right) \\ (V''+\Pi'')\dfrac{\partial P}{\partial t} & E\Pi''\dfrac{\partial P}{\partial t}+e\pi''\left(\dfrac{\partial P}{\partial t}-1\right) \end{vmatrix}}{\begin{vmatrix} (V''+\Pi'')\dfrac{\partial P}{\partial T} & \pi''\left(\dfrac{\partial P}{\partial T}+1\right) \\ (V''+\Pi'')\dfrac{\partial P}{\partial t} & \pi''\left(\dfrac{\partial P}{\partial t}-1\right) \end{vmatrix}} \\ &= \frac{(V''+\Pi'')\left[E\Pi''\dfrac{\partial P}{\partial t}\dfrac{\partial P}{\partial T}+e\pi''\left(\dfrac{\partial P}{\partial t}-1\right)\dfrac{\partial P}{\partial T}-E\Pi''\dfrac{\partial P}{\partial T}\dfrac{\partial P}{\partial t}-e\pi''\left(\dfrac{\partial P}{\partial T}+1\right)\dfrac{\partial P}{\partial t}\right]}{(V''+\Pi'')\pi''\left[\dfrac{\partial P}{\partial T}\left(\dfrac{\partial P}{\partial t}-1\right)-\dfrac{\partial P}{\partial t}\left(\dfrac{\partial P}{\partial T}+1\right)\right]} \\ &= e. \end{aligned} \tag{B.2}$$

By inserting this expression into Eq. (5a), it is easily seen that

$$T = E\frac{\Pi''}{V''+\Pi''}. \tag{B.3}$$

Appendix C

Eqs. (14a) and (14b) can be written

$$\begin{bmatrix} (V''+\Pi'')\dfrac{\partial P}{\partial T} & \pi''\left(\dfrac{\partial P}{\partial T}+1\right) \\ (V''+\Pi'')\dfrac{\partial P}{\partial t} & \pi''\left(\dfrac{\partial P}{\partial t}-1\right) \end{bmatrix} \begin{bmatrix} T \\ t \end{bmatrix} = \begin{bmatrix} \alpha e\pi''\left(\dfrac{\partial P}{\partial T}+1\right)+\beta E\Pi''\dfrac{\partial P}{\partial T}+(V'+\Pi')\dfrac{\partial P}{\partial T} \\ \alpha e\pi''\left(\dfrac{\partial P}{\partial t}-1\right)+\beta E\Pi''\dfrac{\partial P}{\partial t}+(V'+\Pi')\dfrac{\partial P}{\partial t} \end{bmatrix}. \tag{C.1}$$

Using Cramer's rule, we obtain

$$\begin{aligned} t &= \frac{\begin{vmatrix} (V''+\Pi'')\dfrac{\partial P}{\partial T} & \alpha e\pi''\left(\dfrac{\partial P}{\partial T}+1\right)+\beta E\Pi''\dfrac{\partial P}{\partial T}+(V'+\Pi')\dfrac{\partial P}{\partial T} \\ (V''+\Pi'')\dfrac{\partial P}{\partial t} & \alpha e\pi''\left(\dfrac{\partial P}{\partial t}-1\right)+\beta E\Pi''\dfrac{\partial P}{\partial t}+(V'+\Pi')\dfrac{\partial P}{\partial t} \end{vmatrix}}{\begin{vmatrix} (V''+\Pi'')\dfrac{\partial P}{\partial T} & \pi''\left(\dfrac{\partial P}{\partial T}+1\right) \\ (V''+\Pi'')\dfrac{\partial P}{\partial t} & \pi''\left(\dfrac{\partial P}{\partial t}-1\right) \end{vmatrix}} \\ &= \frac{(V''+\Pi'')\alpha e\pi''\left[\left(\dfrac{\partial P}{\partial t}-1\right)\dfrac{\partial P}{\partial T}-\left(\dfrac{\partial P}{\partial T}+1\right)\dfrac{\partial P}{\partial t}\right]}{(V''+\Pi'')\pi''\left[\dfrac{\partial P}{\partial T}\left(\dfrac{\partial P}{\partial t}-1\right)-\dfrac{\partial P}{\partial t}\left(\dfrac{\partial P}{\partial T}+1\right)\right]} \\ &= \alpha e. \end{aligned} \tag{C.2}$$

By inserting this expression into (14a), it is immediately seen that

$$T = \beta E\frac{\Pi''}{V''+\Pi''}+\frac{V'+\Pi'}{V''+\Pi''}. \tag{C.3}$$

Appendix D

Eqs. (17a) and (17b) can be written

$$\begin{bmatrix} (V''+\Pi'')\dfrac{\partial P}{\partial T} & \pi''\left(\dfrac{\partial P}{\partial T}+1\right) \\ (V''+\Pi'')\dfrac{\partial P}{\partial t} & \pi''\left(\dfrac{\partial P}{\partial t}-1\right) \end{bmatrix} \begin{bmatrix} T \\ t \end{bmatrix} = \begin{bmatrix} -ev''\left(\dfrac{\partial P}{\partial T}+1\right)-EV''\dfrac{\partial P}{\partial T} \\ -ev''\dfrac{\partial P}{\partial t}-EV''\dfrac{\partial P}{\partial t} \end{bmatrix}. \tag{D.1}$$

Using Cramer's rule, we obtain

$$\begin{aligned} t &= \frac{\begin{vmatrix} (V''+\Pi'')\dfrac{\partial P}{\partial T} & -ev''\left(\dfrac{\partial P}{\partial T}+1\right)-EV''\dfrac{\partial P}{\partial T} \\ (V''+\Pi'')\dfrac{\partial P}{\partial t} & -ev''\dfrac{\partial P}{\partial t}-EV''\dfrac{\partial P}{\partial t} \end{vmatrix}}{\begin{vmatrix} (V''+\Pi'')\dfrac{\partial P}{\partial T} & \pi''\left(\dfrac{\partial P}{\partial T}+1\right) \\ (V''+\Pi'')\dfrac{\partial P}{\partial t} & \pi''\left(\dfrac{\partial P}{\partial t}-1\right) \end{vmatrix}} \\ &= \frac{(V''+\Pi'')\left[-ev''\dfrac{\partial P}{\partial t}\dfrac{\partial P}{\partial T}+ev''\left(\dfrac{\partial P}{\partial T}+1\right)\dfrac{\partial P}{\partial t}\right]}{(V''+\Pi'')\pi''\left[\dfrac{\partial P}{\partial T}\left(\dfrac{\partial P}{\partial t}-1\right)-\dfrac{\partial P}{\partial t}\left(\dfrac{\partial P}{\partial T}+1\right)\right]} \\ &= e\frac{v''\dfrac{\partial P}{\partial t}}{\pi''\left(-\dfrac{\partial P}{\partial T}-\dfrac{\partial P}{\partial t}\right)}. \end{aligned} \tag{D.2}$$

Implicit differentiation of Eq.(1) with respect to t and T, while making use of the properties of Eq. (2), yields

$$\begin{aligned} \frac{\partial P}{\partial t} &= \frac{-\pi''}{-v''-V''-\pi''-\Pi''}, \\ \frac{\partial P}{\partial T} &= \frac{v''+\pi''}{-v''-V''-\pi''-\Pi''}. \end{aligned} \tag{D.3}$$

By inserting (D.3) in (D.2), we obtain

$$t = e\frac{\nu''(-\pi'')}{\pi''\left(-(\nu''+\pi'')-(-\pi'')\right)} = e. \tag{D.4}$$

By inserting (D.4) into Eq. (17a), the expression for T can be written

$$T = -e\frac{(\nu''+\pi'')\left(\frac{\partial P}{\partial T}+1\right)}{(V''+\Pi'')\frac{\partial P}{\partial T}} - E\frac{V''}{V''+\Pi''}. \tag{D.5}$$

By using (D.3), we obtain

$$\begin{aligned} T &= -e\frac{(\nu''+\pi'')(\nu''+\pi''-\nu''-V''-\pi''-\Pi'')}{(V''+\Pi'')(\nu''+\pi'')} - E\frac{V''}{V''+\Pi''} \\ &= e - E\frac{V''}{V''+\Pi''}. \end{aligned} \tag{D.6}$$

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-3-

Unilateral Environmental Policy with Mobile Producers*

1. Introduction

For some time now we have been witnessing a process towards a closer integration of the world economy. Commodities, capital, and labour move more freely between many countries today than they used to a few decades ago. The North American Free Trade Agreement (NAFTA), the completion of the Uruguay-round, and the economic integration in Europe are recent examples of the reduced significance of national borders in economic life.

The break down of obstacles to trade and factor movements may erode the ability of national governments to impose effective economic regulations. When moving becomes easier, it also becomes easier to escape domestic taxes and regulations. With regard to environmental policy, it has been a concern that if the sources of pollution are mobile, some of them will probably respond to unilateral environmental regulations by moving abroad. Unilateral environmental policy will thus tend to be ineffective, at least from a global point of view. (Whether they are ineffective from a national point of view as well, will depend on the kind of environmental problems involved. In the case of global pollutants, i.e., emissions that cause the same harm wherever their sources are located, a relocation of the sources of pollution is meaningless both from a global and a national environmental point of view. With local pollutants, on the other hand, a country may find it desirable to induce polluting firms to move abroad. This is the case of *NIMBY*, or *Not In My Back Yard.*)

During the NAFTA negotiations, the problems in connection with implementation of unilateral environmental policy in an integrated economy were brought to the discussion table by environmentalist groups. First, there was a concern that lower trade barriers between the countries in North America would induce pollution-intensive firms in the USA and Canada to move their plants across the Mexican border, thus escaping relatively tough domestic

*For their comments on earlier drafts of this paper, I am grateful to Jan I. Haaland, Agnar Sandmo, Bertil Tungodden, and Anthony J. Venables.

environmental regulations. Secondly, they claimed that the increased openness would put the US environmental regulations under pressure by industry groups. Businesses would tend to argue, out of considerations about fair competition, that in an integrated economic system, environmental standards should be harmonized. The concern was that the standards then would tend towards a lowest common denominator.

The problems with unilateral environmental regulations will, of course, be avoided if all countries agree to coordinate their environmental efforts, for instance by implementing full Pigouvian taxes[1] to correct for environmental externalities. In a competitive economy, the resulting equilibrium (henceforth the *first best equilibrium*) is known to be Pareto-efficient.[2] In theory, therefore, all countries can be made better off through cooperation, provided appropriate side-payments are granted. However, due to the immense difficulties involved in the negotiations of international environmental agreements, it may be difficult to make significant progress in internalizing environmental values without some kind of unilateralism. (Note that unilateralism includes the case where a limited *group* of countries takes unilateral steps towards solving environmental problems as well.) We then need to know what such a unilateral, second best approach should look like, compared to the first best solution.

Some people argue that the problems with unilateral environmental regulations in open economies imply that such regulations should be laxer than if environmental problems were solved through coordinated efforts. Others, such as the environmentalist groups during the NAFTA process, maintain that instead of relaxing domestic environmental regulations, trade liberalizations should be avoided in order to make unilateral measures more effective. In this paper, I investigate the interplay between unilateral environmental policy and trade policy in an open economy where the source of pollution is mobile. I assume that a group of countries has decided to take unilateral steps towards solving environmental problems, and I discuss which mix of trade policy and environmental policy in these countries that would be the most efficient one.

The major aim of the analysis is to identify economic considerations that may be relevant in the design of international conventions governing the use of trade and environmental policies. In the following, I will therefore use a normative criterion that takes into account the effects of economic policies on people in all countries involved. This implies that purely protectionist trade policy and *NIMBY* environmental policy (i.e., policies used in order to gain at the expense of other countries), will be regarded as inefficient. I leave to future work to spell out the optimal trade and environmental policies from a national point of view.

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[1]After Pigou (1920).

[2]This is the First Theorem of Welfare Economics. For applications to the case of environmental problems in open economies, see Siebert (1977) and Anderson (1992).

Only a few contributions have discussed the design of environmental policy in the presence of international factor mobility. Markusen *et.al* (1993) analyse optimal environmental policy with mobile firms in a model with local pollution and imperfect competition. In Markusen *et.al* (1992), the analysis is extended to incorporate strategic interactions between governments in the design of environmental policies. Copeland (1994) briefly discusses environmental policy reforms in small open economies in the presence of international factor mobility.

This paper differs from previous literature by approaching the issue from a global, rather than a national, point of view. Furthermore, unlike Markusen *et.al*, I will include international environmental problems in the analysis, and both trade measures and traditional environmental regulations will be assumed to be available policy instruments. This enhances the scope of the analysis considerably. Unlike Copeland (1994), who discusses gradual policy reform, this analysis leads to a characterization of the efficient tax structure. Moreover, this paper is not confined to the case of a small open economy; large country considerations are included as well.

The basic model is presented in Section 2. In Section 3, I derive a characterization of the efficient tax structure in the case of unilateral environmental efforts. The properties of this tax structure is elaborated in Section 4, and in Section 5, I pursue an alternative interpretation of the results. Some special cases are discussed in Section 6. In Section 7, the results of the paper are illustrated by some numerical examples.

2. The model

Assume there are two countries (or two groups of countries), consuming and producing a single homogeneous good. The total number of firms, N, is exogenously given; n firms are located in the home country, and $(N-n)$ firms operate from the foreign country. (I will treat n as a continuous variable.) All firms are price-takers. The production technology will be assumed to be country specific. This implies that when a firm moves abroad, it adopts the technology of foreign firms. (A more realistic model would have to incorporate that technology often is *firm* specific to some degree.) Moreover, I will assume that the location of firms has no impact on factor prices.

Producer prices are denoted p_s and P in the home country and the foreign country, respectively. The conditions for profit maximization define the profit functions, $\pi(p_s)$ and

$\Pi(P)$. By Hotelling's lemma, aggregate supply functions can be expressed as $n\pi'(p_s)$ and $(N-n)\Pi'(P)$.

Utility maximizing behaviour defines the aggregate indirect utility functions $v(p_d)$ and $V(P)$, where p_d is the consumer price in the home country and P is the foreign consumer price. Income is assumed to be exogenous, and the income arguments of the indirect utility functions are therefore suppressed. By Roy's identity, demand functions can be expressed as $-v'(p_d)$ in the home country and $-V'(P)$ in the foreign country.[3]

I assume a fixed amount of environmental damage per unit of production. The external environmental costs per unit of output are e in home country production and E in foreign production. The total external costs of production are then $en\pi'(p_s)+E(N-n)\Pi'(P)$.

The equilibrium of the model is established through a three stage sequence of events. At the first stage, the government of the home country commits itself to an environmental tax t per unit of domestic production and a trade tax T per unit of imports (T should be interpreted as an export subsidy if the home country is an exporter). Next, observing the tax parameters, the producers calculate whether it is profitable to move. In calculating the profitability of moving, the producers compare the profit difference between the two locations with their individual moving costs.[4] The relocation of firms might in itself influence prices and profits. In order to calculate equilibrium profit levels correctly, the producers must therefore be able to foresee how many firms that will move, i.e., the distribution of moving costs must be common knowledge. I will assume that this is the case, because it simplifies the analytics considerably. At the third stage, after relocations have taken place, the good is produced and offered for sale.

Apart from the trade provisions (T), the good is traded freely between the countries. Equilibrium prices are determined by the condition that imports in the home country must equal foreign exports;

$$-v'(p_d)-n\pi'(p_s)=V'(P)+(N-n)\Pi'(P), \tag{1}$$

where the prices are related as follows

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[3]The marginal utility of income is assumed to be constant and equal to one in both countries. The assumption of a constant marginal utility of income can be defended by reference to the partial nature of the present model.

[4]With a non-zero discount rate, it must of course be taken into account that benefits and costs from a relocation may accrue at different points of time. In the model, I assume that costs and benefits are already appropriately discounted.

$$p_d = p_s + t = P + T. \tag{2}$$

The structure of moving costs in the home country (h) and in the foreign country (f) is summarized by the distribution functions,

$$f^i = f^i(k) \qquad i = h, f, \tag{3}$$

with the associated cumulative distributions functions

$$F^i = F^i(k) \qquad i = h, f. \tag{4}$$

$f^i(\tilde{k})$ is the number of firms in country i with moving costs $\tilde{k}$, while $F^i(\tilde{k})$ is the number of firms in country i with moving costs in the range $[\underline{k}, \tilde{k}]$, where $\underline{k}$ is the moving cost for the most mobile producer. (For simplicity, $\underline{k}$ is assumed to be identical in the two countries.)

Let the function $\hat{\pi}(p_s, P)$ denote the profit advantage of being located in the home country;

$$\hat{\pi}(p_s, P) \equiv \pi(p_s) - \Pi(P). \tag{5}$$

Moving occurs if the value of this profit difference exceeds a firm's moving costs. The total movement of firms, as a function of profit differences, can be characterized by the change in the number of firms in the home country (Δn) as follows:

$$\Delta n = \begin{cases} F^f(\hat{\pi}(p_s, P)), & \text{if } \hat{\pi}(p_s, P) > \underline{k} \\ 0, & \text{if } \hat{\pi}(p_s, P) \in [-\underline{k}, \underline{k}]. \\ -F^h(-\hat{\pi}(p_s, P)), & \text{if } \hat{\pi}(p_s, P) < -\underline{k} \end{cases} \tag{6}$$

Define the moving propensity $n_{\hat{\pi}}$ as the change in the number of home country firms after a *marginal* increase in the home country's profit advantage, i.e., $n_{\hat{\pi}} \equiv dn/d\hat{\pi}$. The moving propensity can be calculated from Eq. (6);

$$n_{\hat{\pi}} = \begin{cases} f^f(\hat{\pi}(p_s, P)), & \text{if } \hat{\pi}(p_s, P) > \underline{k} \\ 0, & \text{if } \hat{\pi}(p_s, P) \in [-\underline{k}, \underline{k}]. \\ f^h(-\hat{\pi}(p_s, P)), & \text{if } \hat{\pi}(p_s, P) < -\underline{k} \end{cases} \tag{7}$$

When a firm moves to another country, moving costs materialize. Total moving costs K will be a function of the price structure (p_s, P) in the following way:

$$K(p_s,P)=\begin{cases}\int_{\underline{k}}^{\hat{\pi}(p_s,P)} k\cdot f^f(k)dk, & \text{if } \hat{\pi}(p_s,P)>\underline{k}\\ 0, & \text{if } \hat{\pi}(p_s,P)\in[-\underline{k},\underline{k}].\\ \int_{\underline{k}}^{-\hat{\pi}(p_s,P)} k\cdot f^h(k)dk, & \text{if } \hat{\pi}(p_s,P)<-\underline{k}\end{cases} \tag{8a}$$

Later in the analysis, we will need to know how moving costs change after marginal changes in the price structure. Partial differentiation of Eq. (8a) with respect to the price variables yields:

$$\frac{\partial K}{\partial p_s}=\begin{cases}\hat{\pi}f^f(\hat{\pi})\dfrac{\partial\hat{\pi}}{\partial p_s}, & \text{if } \hat{\pi}>\underline{k}\\ 0, & \text{if } \hat{\pi}\in\langle-\underline{k},\underline{k}\rangle,\\ -\hat{\pi}f^h(-\hat{\pi})\dfrac{-\partial\hat{\pi}}{\partial p_s}, & \text{if } \hat{\pi}<-\underline{k}\end{cases} \tag{8b}$$

and

$$\frac{\partial K}{\partial P}=\begin{cases}\hat{\pi}f^f(\hat{\pi})\dfrac{\partial\hat{\pi}}{\partial P}, & \text{if } \hat{\pi}>\underline{k}\\ 0, & \text{if } \hat{\pi}\in\langle-\underline{k},\underline{k}\rangle.\\ -\hat{\pi}f^h(-\hat{\pi})\dfrac{-\partial\hat{\pi}}{\partial P}, & \text{if } \hat{\pi}<-\underline{k}\end{cases} \tag{8c}$$

3. The second best tax structure

Suppose the home country is concerned with the lack of foreign environmental regulations. They have made unsuccessful attempts to negotiate an international agreement, aiming at the implementation of full Pigouvian taxes. The home country now considers to implement unilateral environmental regulations, and we want to know which tax structure the home country then should implement in order to attain a second best solution. Should domestic producers be protected by means of trade provisions? Should domestic environmental taxes be lower than the Pigouvian tax rate in order to avoid that firms move abroad? These are the kind of questions that will be addressed in the following.

The normative criterion of the analysis will be the maximization of *global* welfare, defined as aggregate consumer and producer surplus, with appropriate adjustments made for environmental costs, moving costs, and government income.[5] The second best tax structure can then be found as the solution to the following problem[6]

$$\max_{t,T} W \equiv \underbrace{v(p_d)+V(P)}_{\text{Consumer surplus}} + \underbrace{n\pi(p_s)+(N-n)\Pi(P)-K(p_s,P)}_{\text{Profits}} - \underbrace{\left(en\pi'(p_s)+E(N-n)\Pi'(P)\right)}_{\text{Environmental costs}} + \underbrace{tn\pi'(p_s)+T\left[-v'(p_d)-n\pi'(p_s)\right]}_{\text{Government income}}. \tag{9}$$

Let $\hat{\pi}_i$ denote the change in the home country's profit advantage, caused by a marginal change in tax parameter i;

$$\hat{\pi}_i \equiv \frac{\partial \hat{\pi}}{\partial p_s}\frac{\partial p_s}{\partial i}+\frac{\partial \hat{\pi}}{\partial P}\frac{\partial P}{\partial i} = \pi'(p_s)\frac{\partial p_s}{\partial i}-\Pi'(P)\frac{\partial P}{\partial i}, \quad i=t,T. \tag{10}$$

By using Eq. (10) and the properties of Eq. (2), the first order conditions of the problem in Eq. (9) can be written

$$\begin{aligned} &v'\left(\frac{\partial P}{\partial T}+1\right)+V'\frac{\partial P}{\partial T}+(\pi-\Pi)n_{\hat{\pi}}\hat{\pi}_T+n\pi'\left(\frac{\partial P}{\partial T}+1\right)+(N-n)\Pi'\frac{\partial P}{\partial T} \\ &-\left(\frac{\partial K}{\partial p_s}\frac{\partial p_s}{\partial T}+\frac{\partial K}{\partial P}\frac{\partial P}{\partial T}\right)-e\frac{\partial(n\pi')}{\partial T}-E\frac{\partial((N-n)\Pi')}{\partial T} \\ &+t\frac{\partial(n\pi')}{\partial T}+(-v'-n\pi')+T\frac{\partial(-v'-n\pi')}{\partial T}=0, \end{aligned} \tag{11a}$$

$$\begin{aligned} &v'\frac{\partial P}{\partial t}+V'\frac{\partial P}{\partial t}+(\pi-\Pi)n_{\hat{\pi}}\hat{\pi}_t+n\pi'\left(\frac{\partial P}{\partial t}-1\right)+(N-n)\Pi'\frac{\partial P}{\partial t} \\ &-\left(\frac{\partial K}{\partial p_s}\frac{\partial p_s}{\partial t}+\frac{\partial K}{\partial P}\frac{\partial P}{\partial t}\right)-e\frac{\partial(n\pi')}{\partial t}-E\frac{\partial((N-n)\Pi')}{\partial t} \\ &+n\pi'+t\frac{\partial(n\pi')}{\partial t}+T\frac{\partial(-v'-n\pi')}{\partial t}=0. \end{aligned} \tag{11b}$$

Eqs. (11a) and (11b) can be substantially simplified. By utilizing Eqs. (7), (8b), and (8c), the expression

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[5]The normative foundation of this approach is more fully elaborated in Mæstad (1994) [Essay 2 of this thesis].

[6]Notice that when using a global welfare measure, we do not need to worry about which country that benefits from the profit of the respective firms. In a study of the optimal policy from a national point of view, we would have to decide whether profits earned abroad should be ascribed to the home or the foreign country.

$$n_{\hat{x}}\hat{\pi}_i(\pi-\Pi)-\left(\frac{\partial K}{\partial p_s}\frac{\partial p_s}{\partial i}+\frac{\partial K}{\partial P}\frac{\partial P}{\partial i}\right), \qquad i=t,T \tag{12a}$$

can be written on the following form:

$$\begin{Bmatrix} f^f(\hat{\pi})\hat{\pi}_i(\pi-\Pi) \\ 0 \\ f^h(-\hat{\pi})\hat{\pi}_i(\pi-\Pi) \end{Bmatrix} - \begin{Bmatrix} \hat{\pi}f^f(\hat{\pi})\left(\frac{\partial\hat{\pi}}{\partial p_s}\frac{\partial p_s}{\partial i}+\frac{\partial\hat{\pi}}{\partial P}\frac{\partial P}{\partial i}\right) \\ 0 \\ \hat{\pi}f^f(-\hat{\pi})\left(\frac{\partial\hat{\pi}}{\partial p_s}\frac{\partial p_s}{\partial i}+\frac{\partial\hat{\pi}}{\partial P}\frac{\partial P}{\partial i}\right) \end{Bmatrix}, \qquad i=t,T. \tag{12b}$$

All three expressions in (12b) are zero by definition (see Eqs. (5) and (10)). The reason is our assumption that the producers are able to calculate equilibrium profits correctly. When this is the case, there are no distortions in the moving decisions; in equilibrium, the marginal profit of further relocations is zero. These considerations are therefore irrelevant for the design of the tax structure.

By using the properties of Eq. (1), the first order conditions can then be written,

$$T\frac{\partial(V'+(N-n)\Pi')}{\partial T}+t\frac{\partial(n\pi')}{\partial T}=e\frac{\partial(n\pi')}{\partial T}+E\frac{\partial((N-n)\Pi')}{\partial T}, \tag{13a}$$

$$T\frac{\partial(V'+(N-n)\Pi')}{\partial t}+t\frac{\partial(n\pi')}{\partial t}=e\frac{\partial(n\pi')}{\partial t}+E\frac{\partial((N-n)\Pi')}{\partial t}. \tag{13b}$$

The left hand side of Eqs. (13a) and (13b) can be interpreted as the efficiency costs of a marginal increase in, respectively, a trade tax and an environmental tax. The first order conditions state that these efficiency costs should be balanced against the environmental gains achieved by means of such taxes. By solving the system (13a) and (13b) with respect to the tax parameters, we obtain (see Appendix A)

$$t=e-E\frac{V''}{n\pi''}\lambda\frac{\pi'}{\Pi'}, \tag{14a}$$

$$T=E\frac{V''\lambda+(N-n)\Pi''}{V''+(N-n)\Pi''}, \tag{14b}$$

where λ is defined as

$$\lambda \equiv \frac{n_{\hat{x}} \Pi'^2 n\pi''}{\left[V'' + (N-n)\Pi''\right]\left(n\pi'' + n_{\hat{x}}\pi'^2\right) + n_{\hat{x}}\Pi'^2 n\pi''}, \quad \in [0,1]. \tag{14c}$$

Eqs. (14a-c) characterize the second best tax structure, i.e., the efficient tax structure when the home country implements environmental policies unilaterally.

4. Properties of the second best solution

4.1 General discussion

The lack of internalization of environmental values creates incentives for the producers to maintain an inefficiently high level of production. One major objective of the tax policy is therefore to reduce output per firm in the home country, as well as in the foreign country. Furthermore, the external costs of production may induce an inefficient pattern of firm location, in particular when the external costs differ between countries. A second objective of the tax policy is therefore to improve the efficiency of the location pattern.

As is well known, the implementation of full Pigouvian taxes in both countries will ensure an efficient level of output per firm. But will Pigouvian taxes lead to an efficient location pattern as well? The location pattern is said to be efficient when it is impossible, through further relocations, to reduce aggregate production costs, including the costs incurred through relocation itself. With constant marginal environmental costs, as in the present model, Pigouvian taxes make each firm bear exactly the total environmental costs that it generates. Profit differences between home country firms and foreign firms will then reflect differences in *social* costs of production. Therefore, profit maximizing firms will move abroad if and only if there are real differences in social costs of production *and* the value of these cost differences is greater than the moving costs. Hence, Pigouvian taxes will lead to an efficient location pattern.[7]

The implementation of first best Pigouvian taxes influences moving incentives in two distinct ways. First, if there are differences in marginal environmental costs between countries, the taxes create a wedge between the producer prices. More specifically, the producer price in the home country will exceed the foreign producer price by the amount $E-e$. In addition, and perhaps less obviously, the taxes may create profit differences simply by reducing the overall *level* of producer prices. A marginal reduction in the producer price has a greater negative

[7]In a model with non-linear environmental costs, Pigouvian taxation will not necessarily ensure an efficient location pattern, because the total tax payment may deviate from the environmental costs created by the firm. In order to ensure efficiency, the governments would need to implement non-linear tax schemes. Note as well that quotas will not normally ensure efficiency in the location pattern either.

impact on profits in firms with a high level of output than in firms that produce less (cf. Hotelling's lemma). Therefore, if the size of firms differs between countries, Pigouvian taxes may create moving incentives even if $E = e$. We need to keep both these effects in mind in the following.

Elsewhere, I have investigated the properties of the second best tax structure in a model without producer mobility.[8] In that case, the formula for the second best taxes was shown to be[9]

$$\begin{aligned} t &= e, \\ T &= E\frac{(N-n)\Pi''}{V''+(N-n)\Pi''}. \end{aligned} \tag{15}$$

This tax structure is obtained as a special result in the present model when the moving propensity is zero ($n_{\hat{x}} = 0 \Rightarrow \lambda = 0$). The formula is characterized by what might be called a separation property. The home country should use a domestic environmental tax to deal with the excessive output per firm in the home country. The tax rate should equal the Pigouvian rate. Pollution generated in the foreign country, on the other hand, should be handled solely by means of trade policy. The rate of import tariffs (or export subsidies) should be lower than the first best Pigouvian tax rate (E). This is due to the second best nature of trade provisions as a means to reduce output per firm in the foreign country. Trade provisions that lower the foreign producer price will inevitably stimulate foreign consumption, since foreign consumers and producers face the same price. This "crowding out" effect via foreign consumption makes it impossible to attain the first best solution by unilateral efforts in the home country.

The tax structure prescribed by Eq. (15) will affect moving incentives. From Eq. (2), we know that $p_s - P = T - t$, i.e., the difference between producer prices can be inferred directly from the difference between the respective tax rates. By rewriting the formula for T in Eq. (15) as $E - EV''/(V'' + (N-n)\Pi'')$, we see that the difference between producer prices in the second best solution with immobile firms can be written as

$$p_s - P = E - e \underbrace{-E\frac{V''}{V''+(N-n)\Pi''}}_{\text{Second best distortion}}. \tag{16}$$

[8]Mæstad (1992, 1994).

[9]That model did not specify the number of firms, but focused directly on aggregate supply functions. This fact has been taken into account in the formulation of Eq. (15) by multiplying individual supply functions by the term $(N-n)$.

Due to what I have called the *second best distortion*, $p_s - P$ (i.e., the price advantage of producers in the home country) is smaller in the second best solution than in the first best solution. This suggests that second best taxes give stronger incentives to leave the home country than first best taxes. Note, however, that it is generally not possible to infer the magnitude of moving incentives, defined in terms of *profit* differences, directly from *price* differences. As I shall argue in the following, though, there are strong reasons to believe that it suffices to look at the price difference for our current purpose.

Before drawing conclusions about profit differences based on information about price differences, we need to know the price levels. So what do we know about price levels in the second best equilibrium, compared to the first best? First, we know that the foreign producer price is higher (or equal to) the first best price level ($P^{SB} \geq P^{FB}$). The reason is that it is costly to implement second best policy instruments in order to regulate pollution originating in a foreign country. The level of pollution in the second best equilibrium will therefore be at least as high as in the first best equilibrium (which is equivalent to saying that the second best producer price will be at least as high as the first best).

What do we then know about the producer price in the home country? It can be shown that if foreign supply and demand functions are linear in prices, the first best and the second best producer prices in the home country will be identical ($p_s^{SB} = p_s^{FB}$).[10] But if P is the only price that changes, it follows straightforwardly that a change in the price differences will reflect the direction of change in the profit difference as well.

But what if foreign supply and demand functions are non-linear? Since $P^{SB} \geq P^{FB}$, it follows that if $p_s^{SB} \leq p_s^{FB}$, we could still use the price difference as an indicator of profit differences: if $p_s - P$ is smaller due to higher P and lower p_s, that must imply that the profit difference is smaller as well (because profits are increasing in prices).

The only situation we need to care about is therefore the case when the home country producer price is *higher* in the second best than in the first best solution ($p_s^{SB} > p_s^{FB}$). Due to the convexity of the profit function, there is a possibility that when both p_s and P are higher than in the first best solution, the profit difference $\pi(p_s) - \Pi(P)$ may be greater, even though $p_s - P$ is smaller than in the first best. Fig. 1 illustrates.

[10] See Proposition 8 in Mæstad (1994) [Essay 2 of this thesis].

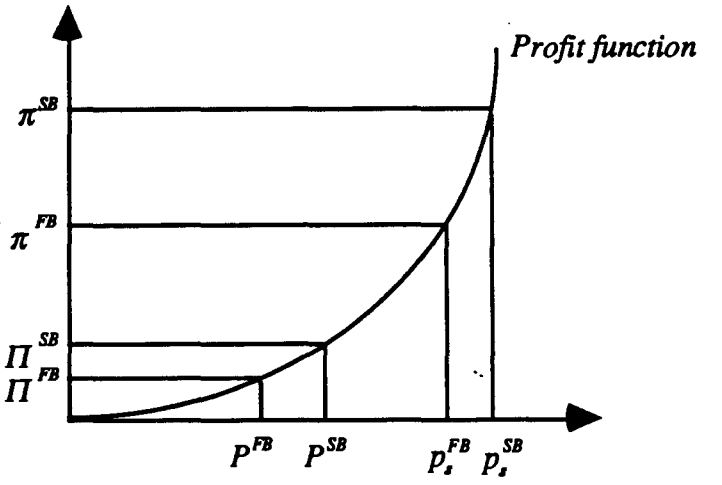

Fig. 1.

The situation depicted in the figure ($\hat{\pi}^{SB} > \hat{\pi}^{FB}$) does not arise if $P^{SB} > p_s^{SB}$. The convexity of the profit function, combined with the requirement that $(p_s - P)^{SB} < (p_s - P)^{FB}$, then imply that the profit advantage of home country producers is smaller (more negative) in the second best solution than in the first best.

Assuming that $p_s^{SB} > P^{SB}$, which circumstances will then be conducive to the situation depicted in Fig. 1? Those are: 1) a high P^{SB} relative to P^{FB}, and 2) a high $(p_s - P)^{SB}$ relative to $(p_s - P)^{FB}$.

A high P^{SB} relative to P^{FB} must reflect that the second best policy instruments are relatively costly to use. This is the case when the foreign demand curve is relatively flat (V'' large implies that there is a large crowding out effect via foreign consumption) and/or when $\Pi'' = 0$ (implying that environmental policy in the foreign country is useless). Under these circumstances, it follows from Eq. (15) that T is zero. The only policy instrument in use in the second best solution is then an environmental tax in the home country. The only thing that happens in moving from the second best to the first best equilibrium, is therefore that a production tax is implemented in the foreign country. When the foreign demand curve is horizontal and/or the foreign supply curve is vertical, this policy will not have any effect on prices in the home country. Hence, $p_s^{SB} = p_s^{FB}$, and we can conclude that the situation depicted in Fig. 1 does not arise.

Consider next what would make $(p_s - P)^{SB}$ large relative to $(p_s - P)^{FB}$. There are two possibilities. The first is that $V'' = 0$. But in that case, trade policy would be a first best instrument to regulate foreign production. Therefore, $P^{SB} = P^{FB}$, and the situation in Fig. 1 cannot arise.

The other possibility is that Π'' is very large. In that case, with constant marginal costs in the foreign country, it follows from Eq. (15) that T should equal E. Such a tariff would have exactly the same effect on prices in the home country as a first best Pigouvian tax in the foreign country (p_x would increase by E). Hence, $p_x^{SB} = p_x^{FB}$, and we can be confident that information about profit differences can be inferred from the price difference in this case as well.

This suggests that in equilibrium, the relative magnitude of price differences ($p_x - P$) is likely to be a reliable indicator of the relative magnitude of the corresponding profit differences ($\hat{\pi}$). The insights obtained thus far can be summarized as follows:

PROPOSITION 1

Since it is costly to use trade provisions in order to reduce the output per firm in the foreign country, the second best solution normally entails a distortion of moving incentives. Most likely, the incentives to stay in (or move to) the home country will be too weak.

The distortion of moving incentives is of course no problem as long as moving costs are prohibitive. When firms are mobile, though, the second best tax structure should be adjusted in order to avoid a too heavy outflow of firms from the home country. In the following, those extra moving incentives called for in the presence of producer mobility will be referred to as *compensating moving incentives*. The least costly way of implementing compensating moving incentives would be to use direct money transfers. When such transfers are being used, the efficient unilateral environmental policy would still be as prescribed by Eq. (15). However, if the set of available policy instruments is confined to producer taxes and trade provisions, as is assumed in this analysis, the least costly way of implementing compensating moving incentives is prescribed by Eqs. (14a-c).

PROPOSITION 2

Compensating moving incentives should be implemented partly through higher import tariffs (or higher export subsidies) and partly through reduced domestic environmental taxes. Compensating moving incentives enter the tax formula additively.

The additive structure of the second best tax formula shows that the mobility of firms does not have any direct impact on the significance of those factors that determined the second best tax structure in the case without mobility. Hence, the starting point for an efficient unilateral environmental policy should still be the implementation of a full Pigouvian tax in the home country, combined with some trade provisions in order to reduce pollution

generated in the foreign country. The effects of producer mobility on the second best tax structure are thus 1) to reduce the second best environmental tax in the home country somewhat below the Pigouvian level, and 2) to strengthen the argument for using import tariffs (or export subsidies) as one element in unilateral environmental policy.

These conclusions provide some support to the argument that unilateral environmental regulations should not be as tough as the regulations in a coordinated effort, involving all the affected countries. Furthermore, the conclusions lend some support to the claim that one should be careful not to liberalize international trade too much in a world where environmental values are not appropriately internalized in all countries.

A common objection against unilateral environmental policy is that unilateral efforts will lead to increased pollution in other countries. Such effects are often referred to as *leakage*. In the present model, leakage may occur through two different channels. First, there is leakage through price effects: environmental regulations of home country producers will reduce aggregate supply and hence contribute to an increase in the world market price of the good. Foreign producers will respond to this price change by increasing their production (and hence their pollution). Secondly, there may be leakage through the movement of firms out of the home country.

It appears to be a common understanding that in order to avoid excessive leakage effects, unilateral environmental taxes should be kept at a low level. Eqs. (14a-c) show, however, that the use of green trade policy in some cases may be a more efficient way of dealing with leakage problems:

PROPOSITION 3

Price leakage should be handled by means of import tariffs or export subsidies. Leakage through the movement of firms should be dealt with through a combination of such trade provisions and a reduction of the domestic environmental tax below the Pigouvian tax rate.

Trade provisions are the most efficient instrument available for the purpose of reducing foreign prices, and thus for the purpose of mitigating price leakage as well. When it comes to leakage through the relocation of firms, neither of the policy alternatives stands out as generally preferable to the other, and both instruments should therefore be used in order to alleviate such leakage effects.

4.2 More about moving incentives

I shall now take a closer look at the properties of the compensating moving incentives in the second best tax formula. First, I am going to make some comments on the aggregate compensating moving incentives, and then, in the second part of this section, I will discuss which factors that determine the efficient distribution of compensating moving incentives between trade provisions and reduced environmental taxes in the home country.

Again, I shall focus on the difference between producer prices in the home country and the foreign country to get an impression of the moving incentives created by the second best tax structure. The price difference can be found directly from Eqs. (14a-c) by utilizing the fact that $p_x - P = T - t$:

$$p_x - P = E - e - \underbrace{E\frac{V''}{V''+(N-n)\Pi''}}_{\text{Second best distortion}} + \underbrace{E\frac{V''}{V''+(N-n)\Pi''}\gamma}_{\text{Compensating moving incentives}}. \tag{17a}$$

where γ is defined as

$$\gamma \equiv \frac{[V''+(N-n)\Pi'']n_{\hat{x}}\pi'\Pi' + n_{\hat{x}}\Pi'^2 n\pi''}{[V''+(N-n)\Pi'']\left(n\pi'' + n_{\hat{x}}\pi'^2\right) + n_{\hat{x}}\Pi'^2 n\pi''}. \tag{17b}$$

Eq. (17a) shows that the total compensating moving incentives are proportional to the second best distortion of moving incentives. If foreign demand is completely inelastic ($V'' = 0$), there is no regulatory inefficiency from using trade provisions rather than a direct environmental tax in the foreign country. T should then be equal to the Pigouvian tax rate E (see Eq. (14b)). In that case, there will be no second best distortion of moving incentives, implying that neither will there be any need for compensating moving incentives. We can conclude:

PROPOSITION 4

The degree of producer mobility is irrelevant for the design of efficient unilateral environmental policy if the foreign demand curve is completely inelastic ($V'' = 0$).

Assuming that V'' is non-zero, the degree of mobility matters for the design of unilateral environmental policy:

PROPOSITION 5

When the moving propensity ($n_{\#}$) increases, compensating moving incentives should be strengthened to induce more firms to move to (or to stay in) the home country (provided foreign demand is price responsive ($V'' > 0$)).

It is easily seen from Eq. (17b) that γ is increasing in $n_{\#}$, implying that compensating moving incentives should be made stronger as the moving propensity increases. The reason is quite obvious: when firms become more mobile, the effect of the second best distortion on the location pattern will become more significant. Consequently, the importance of giving compensating moving incentives is enhanced.

It is of some interest to ask whether the second best distortion should be completely offset by compensating moving incentives when the moving propensity approaches infinity.[11] From Eq. (17b), we obtain

$$\lim_{n_{\#}\to\infty} \gamma = \frac{[V'' + (N-n)\Pi'']\pi'\Pi' + \Pi'^2 n\pi''}{[V'' + (N-n)\Pi'']\pi'^2 + \Pi'^2 n\pi''}. \tag{18}$$

Eq. (18) shows that γ tends to be close to one when the moving propensity is high, suggesting that the second best distortion should be neutralized in this case.

PROPOSITION 6

When the moving propensity becomes very high, the difference between producer prices in the second best solution should equal the difference between marginal environmental costs (i.e., $p_s - P = E - e$), provided all firms are of the same size (i.e., $\pi' = \Pi'$).

When the moving propensity is high, small distortions in moving incentives may create big distortions in the location pattern. Therefore, when firms are highly mobile, it is important to keep the profit difference in the second best solution close to the first best profit difference. When all firms have the same size, the first best profit difference is obtained by keeping the same difference between producer prices as in the first best equilibrium ($E - e$).

Note that the *level* of producer prices generally is higher in the second best solution. In the general case, this might imply that $(p_s - P)^{SB}$ should differ from $(p_s - P)^{FB}$ in order to make $\hat{\pi}^{SB}$ equal to $\hat{\pi}^{FB}$. When all firms have the same size, however, a shift in the price level has the same effect on profits in all firms (Hotelling's lemma). In this case, therefore, the first best profit differences will be obtained when $p_s - P = E - e$.

[11] See Section 6.2 for a further discussion of the case of perfect mobility.

To use environmental subsidies and trade provisions, rather than direct transfers, in order to change the location pattern will not be without costs. Some efficiency costs will have to be incurred. By reducing the environmental tax in the home country below the Pigouvian tax rate, output per firm will become inefficiently high. *Ceteris paribus*, the significance of this distortion is greater the greater the slope of the aggregate supply curve in the home country ($n\pi''$). Similarly, trade provisions will prevent the realization of the full benefits from free international trade. The slope of the foreign export supply curve ($V''+(N-n)\Pi''$) is important for the magnitude of this efficiency loss. As is seen from Eq. (17b), both $n\pi''$ and $V''+(N-n)\Pi''$ appear in the expression for the efficient level of compensating moving incentives. Assume for the moment that $\pi' \approx \Pi'$, implying that we can (roughly) compare the magnitude of profit differences by comparing the corresponding price differences. In this case, we observe from Eq. (17b) that $\gamma < 1$ is smaller than one. Moreover, γ is decreasing in the slope of the aggregate supply curve in the home country ($n\pi''$), as well as in the slope of the foreign export supply curve ($V''+(N-n)\Pi''$):

PROPOSITION 7

Since it is costly to use trade provisions and environmental subsidies to create moving incentives, it will normally be inefficient to give firms in the home country full compensation for their relative profit disadvantage in the second best solution. The efficient level of compensation will tend to decline with an increase in the slopes of the home country supply curve and the foreign export supply curve.

Having determined the efficient level of compensating moving incentives, it remains to be decided how these incentives should be apportioned between environmental subsidies and protective trade measures. Let t_{CMI} and T_{CMI} denote compensating moving incentives that are implemented through environmental subsidies and trade provisions, respectively. Eqs. (14a-c) show that the second best tax structure holds the following property;

$$\frac{t_{CMI}}{T_{CMI}} = \frac{V''+(N-n)\Pi''}{n\pi''}\frac{\pi'}{\Pi'}. \tag{19}$$

Eq. (19) can be understood as an expression of the relative costs and benefits of the respective tax instruments. When the supply by home country producers is highly responsive to price changes ($n\pi''$ is large), implying that there are substantial efficiency costs connected to giving environmental subsidies, a greater share of compensating moving incentives should be implemented through protective trade measures. Similarly if the foreign export supply curve is flat (i.e., $V''+(N-n)\Pi''$ is large): trade policy is then a relatively costly policy

instrument, implying that a greater share of the moving incentives ought to be given through environmental subsidies.

The term π'/Π' in Eq. (19) may be interpreted as a representation of the relative benefits of the respective tax instruments. When $\pi'(p_s)/\Pi'(P)$ is high, a marginal change in p_s will have a relatively great impact on the profit difference (and thus on the moving incentives), compared to a marginal change in P. This implies that it will be relatively efficient to create moving incentives by changing the level of p_s. And since environmental subsidies are the most efficient instrument available for the purpose of changing p_s, a high ratio of π' to Π' will imply that a large share of the moving incentives should be given through such subsidies.

4.3 The location pattern

One of the main objections against unilateral environmental efforts is that they may lead to unproductive, or even counter-productive, changes in the pattern of firms' locations. This analysis has shown that some of this scepticism can be supported by reference to arguments about economic efficiency: it is efficient to supplement unilateral environmental policies by measures that strengthen the incentives to stay in, or move to, the home country. This does not imply, though, that the incentives to stay in the home country should be equally strong in the second best solution as in the first best solution.

PROPOSITION 8

Efficient unilateral environmental policy may induce a location pattern with fewer home country firms than in the first best solution.

Since the second best tax structure does not normally compensate fully for the second best distortion in moving incentives (see Proposition 7), the second best location pattern will normally differ from the location pattern in the first best solution. If the implementation of compensating moving incentives is costly (e.g., if $n\pi''$ is large), fewer firms will be located in the home country in the second best solution than in the first best solution.

Efficient unilateral environmental policy may thus imply that some home country firms will find it profitable to move abroad, but the movement of firms may go in the opposite direction as well. This is easily seen from Eq. (17a): if the pollution-intensity is significantly greater in the foreign country than in the home country ($E >> e$), the producer price in the second best solution will be highest in the home country ($p_s > P$). This is due to the fact that in this situation, it is efficient for the home country to impose strong protective trade measures, combined with significant environmental subsidies to domestic firms. Consequently, foreign

firms may find it profitable to leave their country. But, as is stated in Proposition 8, an even greater number of firms might move to the home country if first best taxes were implemented.

Now, consider the case where the cost function is the same in all countries, and where the costs of pollution are independent of the source of emissions ($e = E$). We know that in this case, there will be no relocation of firms in a first best solution. Therefore;

PROPOSITION 9

If all firms have the same cost function and are equally polluting ($e = E$), efficient unilateral environmental policy will induce firms to move out of the home country.

Proof: A sufficient condition for having $\hat{\pi} < 0$ when all firms have the same cost functions is that $p_s < P$. Eq. (17a) shows that a necessary and sufficient condition for having $p_s < P$ when $e = E$ is that $\gamma < 1$. Suppose $\gamma \geq 1$. Eq. (17b) shows that we then must have $\Pi' > \pi'$. But this implies that $p_s < P$, which is incompatible with $\gamma \geq 1$. Hence, $\gamma < 1$, and the proposition follows straightforwardly.

It would be tempting to maintain that if firms are equally polluting in all countries, environmental policy is inappropriately strict if firms leave the home country. Does it not seem more rational, in this case, to induce foreign firms to move to the home country instead? After all, they would then be made subject to more efficient regulatory policies than if they stayed abroad, and from an environmental point of view, it does not matter where they are located!

This reasoning is defective, though, at least when environmental subsidies and trade provisions are being used to change the location pattern. The present analysis shows that it is efficient to maintain unilateral environmental regulations at a level that induces domestic firms to leave, even if there are no environmental gains from such a relocation, and even though the firms thereby move to countries with relatively poor environmental regulations. The costs of such relocations are more than outweighed by the environmental gains from maintaining relatively strict environmental standards in the home country.

Indeed, the effectiveness of a strict unilateral environmental policy may dwindle as the moving propensity increases. If most home country firms respond by leaving the country, rather than by reducing their production and pollution, the environmental gains from unilateral measures will be more modest. In section 6.2, I discuss the implications of a very high degree of mobility for the second best tax structure.

5. An alternative interpretation

The use of green trade policy is highly controversial. To ban the use of such measures may be very ineffective, though, since a tax structure (t,T) always can be duplicated through a combination of a producer tax/subsidy and a consumer tax in the home country.[12] Let (t_p,t_c) denote the second best tax structure, expressed as a combination of production and consumption taxes in the home country (where these tax rates are defined as deviations from the world market price). In the second best solution, t_c will equal T, and t_p will equal $t-T$ (where (t,T) is given by Eqs. (14a-c)). Hence, the *sum* of domestic environmental tax rates in a second best optimum, (t_p+t_c), will be equal to t in Eq. (14a), while the *distribution* of the total tax between the consumer side and the producer side can be inferred from the expression for T in Eq. (14b). This is so because import tariffs (or export subsidies) effectively reduce any environmental tax on domestic producers by the same rate as the trade provisions, due to the inherent subsidy element in these trade measures. The other effect of import tariffs (or export subsidies) is to impose a tax on domestic consumers, also here at the same rate as the trade provisions themselves.

This reasoning leads to the following alternative description of the second best solution: if the home country implements unilateral measures to solve environmental problems involving externalities in production, the efficient tax structure from a global point of view will be given by a combination of a consumption tax and a production tax in the home country. In the case of immobile producers, the sum of these production and consumption taxes should equal the full Pigouvian tax in the home country, i.e., $t_p+t_c=e$. The most efficient distribution of the tax between the production side and the consumption side will be determined by the first term in Eq. (14b), which is the second best trade provision with immobile producers,

$$E\frac{(N-n)\Pi''}{V''+(N-n)\Pi''}. \tag{20}$$

What are the consequences of mobility for (t_p,t_c)? First, since we know that t_p+t_c will be equal to the production tax t in Eq. (14a), we can conclude:

PROPOSITION 10

The sum of unilateral consumption and production taxes should be lower than the Pigouvian tax rate when firms are mobile, i.e., $t_p+t_c<e$.

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[12] See Mæstad (1994) [Essay 2 of this thesis].

This result is explained by the need to give compensating moving incentives. Furthermore, we know from Eq. (14b) that higher trade provisions should be implemented when mobility is high. This implies that the consumption tax should be *higher* in the case of mobile firms than in the case of immobile firms. But since the sum of consumption and production taxes should be reduced, the production tax must now be lower than if producers where immobile. Not only must it be lower; the reduction in t_p has to be greater than the increase in t_c in order to create the appropriate moving incentives. (Notice that if e is small compared to E, t_p might turn out to be negative, implying that home country producers should receive a net subsidy in the second best solution.)

Alternatively, these results might be stated as follows. When producers are immobile, the implementation of Pigouvian taxes in the home country will create leakage through price effects (i.e., foreign pollution increases because unilateral environmental taxes lead to higher international prices). The efficient way to deal with these leakage effects is to transform part of the Pigouvian tax on the production side into a consumption tax. This policy counteracts leakage effects, without reducing the overall strength of environmental regulations.

With mobile firms, the traditional Pigouvian tax will have an additional leakage effect through the movement of firms out of the home country. Unlike the leakage through international price changes, the relocation effect should not be handled simply by shifting the Pigouvian tax from the producer to the consumer side. The ambitions of unilateral environmental regulations should be moderated as well. Therefore, the rise in the consumption tax should only partially offset the decline in the production tax, making the sum of the tax rates lower than the Pigouvian tax rate.

6. Some special cases

6.1 Constant marginal costs

Assume there are constant marginal costs of production in the foreign country. The second best tax structure in this situation can be found by letting Π'' approach infinity. By taking the limits of Eqs. (14a) and (14b), we obtain

$$\lim_{\Pi'' \to \infty} t = e, \tag{21a}$$

$$\lim_{\Pi'' \to \infty} T = E. \tag{21b}$$

PROPOSITION 11

When there are constant marginal costs in the foreign country, t should equal the Pigouvian tax rate for the home country, and T should equal the Pigouvian tax rate for the foreign country. The second best tax structure will be independent of the degree of mobility.

When foreign marginal costs are constant, the international price is fixed. Hence, no matter what the home country does, the level of foreign consumption remains unchanged. Thus, green trade policy does not lead to any crowding out effect via foreign consumption. Reductions in the home country's import demand will reduce foreign production one by one. Therefore, there is no reason why the import tariff (or export subsidy) should deviate from E. Consequently, there is no second best distortion of moving incentives, and thus no need for any compensating moving incentives. Neither is there any reason why the environmental tax in the home country should deviate from the Pigouvian tax rate.

Note that the leakage effects of unilateral environmental policy are particularly severe when there are constant marginal costs in the foreign country; any reductions in home country production and pollution will simply be replaced one by one by a higher foreign output. But once again we observe that there are better ways of dealing with this problem than by avoiding unilateral environmental efforts. Instead of such a defensive approach, traditional Pigouvian regulations should be supplemented by green trade policy in order to deal with the leakage problems. The intuitive explanation goes like this: while reductions in home country production are offset by more foreign production, there will be no leakage effects of reductions in home country consumption, since foreign consumption is fixed. The best the home country can do in order to reduce world output and pollution is therefore to tax domestic consumers instead of domestic producers. This is exactly what is achieved by adding import tariffs (or export subsidies) to existing environmental taxes on domestic production.

These results have implications for environmental policy in small open economies. Eqs. (21a) and (21b) show that unilateral environmental regulations may enhance economic efficiency even if the regulations are implemented by price-taking countries with highly mobile firms, and even though there are no environmental gains to be reaped from the relocation of firms.

It is easy to show that these results are still valid if we add the assumption that marginal costs are constant in the home country as well. I shall close this section with the case where marginal costs are constant *only* in the home country. Letting π'' approach infinity in Eqs. (14a) and (14b) yields,

$$\lim_{\pi'' \to \infty} t = e, \tag{22a}$$

$$\lim_{\pi'' \to \infty} T = E\frac{V''\lambda + (N-n)\Pi''}{V'' + (N-n)\Pi''} < E. \tag{22b}$$

PROPOSITION 12

When marginal costs are constant in the home country only, the Pigouvian tax should be implemented in the home country. The rate of import tariffs (or export subsidies) should be lower than the foreign Pigouvian tax rate, though.

In contrast to the case of constant marginal costs in the foreign country, the use of trade provisions will now lower the international price, and crowding out effects will arise through foreign consumption. Therefore, there will be distortions in the moving incentives as well. However, since the supply curve in the home country is infinitely elastic, all compensating moving incentives should be implemented through trade provisions (see Eq. (19)). Hence, home country producers should be taxed at the Pigouvian rate, even if the moving propensity is very large.

6.2 Perfect mobility

What does the efficient unilateral environmental policy look like if firms are perfectly mobile between countries? "Perfect mobility" should here be understood as the case when moving costs are zero in all firms. Then there will be a single switching point, so that when $\hat{\pi} > 0$, all firms will be located in the home country, while $\hat{\pi} < 0$ will cause a complete escape from the home country.

In order to simplify the discussion, assume that all firms have identical cost functions. This implies that the switching point will be where $p_s = P$, or equivalently, where $T = t$. Hence, for all $T > t$, all firms will move to the home country, while $t > T$ will cause all firms to migrate to the foreign country. In other words, if unilateral policy shall not lead to very drastic changes in the location pattern, domestic environmental taxes must be exactly of the same magnitude as the import tariffs (or the export subsidies). Since the tax structure $t = T$ has exactly the same consequences as a *consumption tax* at the rate T, we can conclude:

PROPOSITION 13

When there is perfect mobility, and all firms have the same cost function, other taxes than a pure consumption tax will induce all firms to locate in one country.

Consider the case where all producers are equally polluting ($e = E$). This implies that it is irrelevant where production takes place, at least from an environmental point of view. In this case, there is no reason to change the location pattern. Now, if the home country taxes domestic producers, all of them will move abroad. There will be no benefits of such regulations. This analysis has shown, however, that it is efficient to combine unilateral environmental regulations with some protective trade measures in order to induce foreign firms to produce less. After implementing such trade provisions, the home country can tax domestic producers at the same rate as these trade provisions without being concerned that they will leave. But since green trade policy generally is inferior to first best environmental regulations in the foreign country, the tariff rates should be lower than the Pigouvian tax rate in the foreign country. The environmental tax in the home country must therefore also be lower than the Pigouvian rate in the second best solution.

The second best tax structure with perfect mobility is obtained from Eqs. (14a-c) by letting $n_{\hat{x}}$ approach infinity. Consider first the effect of perfect mobility on λ:

$$\lim_{n_{\hat{x}} \to \infty} \lambda = \frac{\Pi'^2 n\pi''}{[V'' + (N-n)\Pi'']\pi'^2 + \Pi'^2 n\pi''}. \tag{23}$$

By using Eq. (23), the second best tax structure can be written on the following form:

$$t = e - E\frac{V''}{n\pi''}\lambda\frac{\pi'}{\Pi'}, \tag{24a}$$

$$T = E - E\frac{V''}{n\pi''}\lambda\left(\frac{\pi'}{\Pi'}\right)^2. \tag{24b}$$

PROPOSITION 14

When there is perfect mobility, and all firms have the same profit functions and are equally polluting ($e = E$), the rate of efficient unilateral environmental taxes is equal to the rate of the accompanying protective trade provisions.

Proof: The result follows from two contradictions. Assume first that $t > T$. Eqs. (24a-b) show that for this to be the case, π'/Π' must be smaller than $(\pi'/\Pi')^2$, which implies that π' must be greater than Π'. By the assumption of identical profit functions, this requires that $p_x > P$, which contradicts the assumption of $t > T$.

Assume instead that $t < T$. By the same line of reasoning as above, it is easy to show that for this to be the case, p_s must be smaller than P. This establishes yet another contradiction, and the proposition then follows straightforwardly.

Proposition 14 should be contrasted with Proposition 9, which stated that when mobility is less than perfect, it is efficient to let some firms move to the foreign country, even if $e = E$. In that case, the movement of some firms was more than outweighed by the environmental gains from reduced output in the remaining firms. When firms are perfectly mobile, though, there is no longer such a trade-off; it is impossible to achieve environmental gains by regulating domestic firms more strongly than foreign firms are regulated. Thus, when firms are perfectly mobile, the effectiveness of unilateral environmental efforts is limited by the effectiveness of green trade policy in regulating foreign firms. But we notice once again that even if firms are extremely mobile, it is nevertheless efficient to implement some kind of unilateral environmental policy.

If mobility puts certain constraints on what can be achieved through unilateral environmental efforts when $e = E$, unilateral policies may be correspondingly more effective when there are great differences between e and E. When the pollution intensity differs greatly between countries, substantial environmental gains can be reaped by moving firms to the country with the cleanest technology. When firms are highly mobile, this change in location pattern can easily be achieved through unilateral measures.

Consider the case where $e << E$. It may then be desirable to implement a tax structure that gives home country firms a significant profit advantage. But if $\hat{\pi} > 0$, the equilibrium moving propensity is zero, even if firms are perfectly mobile (all firms have already moved, implying that further increases in the profit advantage have no effect on the location of firms). The efficient tax structure is therefore no longer given by Eqs. (24a-b), but rather by Eq. (15), which is the second best tax structure when there is no mobility! A similar situation may arise when $E << e$, if all firms then are located in the foreign country in the second best solution.

7. A numerical example

This study has shown that there are gains to be made from unilateral environmental policy, even if firms are mobile between countries. The aim of this section is to give an idea of how close unilateral policies may bring us to the first best solution. We know that the answer to this question is highly dependent on the slope of the foreign demand curve. When foreign demand is completely inelastic, the use of green trade policy may be a perfect substitute for

first best policies. The numerical example in this section illustrates that there may be significant gains from second best policies, even though foreign demand is rather elastic.

The assumptions

I assume that there are identical profit functions in both countries;

$$\pi(p_s) = 0.5p_s^2 \quad \text{and} \quad \Pi(P) = 0.5P^2.$$

The number of firms (N) is assumed to be 200 (with 100 firms in each country at the outset). This implies that the aggregate supply functions are

$$n\pi' = np_s,$$
$$(N-n)\Pi' = (200-n)P.$$

Demand functions are assumed to be

$$-v' = 1000 - 100p_d,$$
$$-V' = 600 - 100P.$$

Moving costs are described by the cumulative distribution function

$$F^i(k) = 10k, \quad i = h, f.$$

Hence, for each unit of profit difference between the countries, ten firms will find it profitable to move.

I shall consider two kinds of environmental problems. In case 1, it will be assumed that there are no externalities in home country production ($e = 0$), whereas foreign firms pollute ($E = 2$). In case 2, all firms are assumed to be equally polluting ($e = E = 2$). In both examples, the outcome of the second best policy will be compared with the initial equilibrium and with the first best equilibrium. I will also make calculations for the case of immobile producers in order to see how mobility affects the results.

Case 1. Only foreign firms pollute

In this example, the first best policy would be to implement a producer tax equal to 2 in the foreign country. The efficient unilateral environmental policy is given by the following tax structure (see Eqs. (14a)-(14c)):

Case 1a: Immobile firms: $t = 0$ $T = 1.00$

Case 1b: Mobile firms: $t = -0.43$ $T = 0.95$

It may be somewhat surprising that the second best trade tax should be reduced when we move to a situation with higher mobility. Shouldn't some compensating moving incentives be added instead? The answer is that there *are* compensating moving incentives incorporated in this trade tax. The reason why T declines is that some firms move to the home country. (See Eq. (14b) for the effect on T of reduced $(N-n)$. In this example, the compensating moving incentives given through trade provisions will not be large enough to offset this effect. (Note that a significant portion of the compensating moving incentives should be implemented through producer subsidies in the home country.)

The following tables summarize the consequences of the different policies on some key variables, including the measure of global welfare (W), aggregate pollution, the location pattern, and the consumer and producer prices in the home and the foreign country.

Case 1a. Only foreign firms pollute. Immobile firms.

Policy	W[13]	*Pollution*	n	p_d	p_s	P_D	P_S
Initial	100.0	800	100	4.00	4.00	4.00	4.00
Second best	101.8	700	100	4.50	4.50	3.50	3.50
First best	105.4	500	100	4.50	4.50	4.50	2.50

Case 1b. Only foreign firms pollute. Mobile firms.

Policy	W	*Pollution*	n	p_d	p_s	P_D	P_S
Initial	100.0	800	100	4.00	4.00	4.00	4.00
Second best	110.1	298	154	4.18	4.61	3.23	3.23
First best	113.3	158	164	4.18	4.18	4.18	2.18

In this example, the initial elasticity of foreign demand is –2. Nevertheless, unilateral environmental policy has a significant positive effect on both welfare and the environment. This is seen most clearly in the case of mobile producers, but even when producers are

[13]Initial welfare levels are normalized to 100.

immobile, unilateral policy will be able to bring us 33% of the distance towards the first best solution, both in terms of pollution levels and in terms of overall welfare.[14]

With an environmental problem of this kind, the ability of the home country to achieve something unilaterally is greatly enhanced by mobility. When only foreign firms pollute, producer relocations will be part of the first best outcome, because this is an indirect way of substituting cleaner technologies for more dirty ones. In the first best solution, 64% of the foreign producers would move. These relocations will of course enhance the potential benefits of environmental policies. In the example, mobility causes more than a doubling of the overall benefits from implementing first best environmental policy. Perhaps even more interesting is the observation that over 76% of this benefit can be reaped by unilateral environmental policy. And with regard to the amount of pollution, unilateral policies will bring us as much as 78% of the way towards the first best outcome.

In passing, we notice that our calculations confirm Proposition 8: there are fewer firms in the home country in the second best solution than in the first best solution. This result is confirmed in the next example as well.

Case 2. All firms are equally polluting

When all firms are equally polluting ($e = E = 2$), the first best policy will be to implement a production tax equal to 2 in both countries. If this outcome is not obtained, and the home country wants to take unilateral steps towards solving the problem, the second best tax structure will be as follows:

Case 2a: Immobile firms:	$t = 2.00$	$T = 1.00$
Case 2b: Mobile firms:	$t = 1.54$	$T = 1.26$

Mobility causes a reduction in the second best environmental tax and an increase in the rate of import tariffs (or export subsidies). Key variables are reported in the following tables.

[14]Ratio-scale comparability of welfare levels must be possible in order for such statements about welfare to make sense.

Case 2a. All firms are equally polluting. Immobile firms.

Policy	*W*	*Pollution*	*n*	p_d	p_s	P_D	P_S
Initial	100.0	1,600	100	4.00	4.00	4.00	4.00
Second best	105.0	1,400	100	5.00	3.00	4.00	4.00
First best	110.0	1,200	100	5.00	3.00	5.00	3.00

Case 2b. All firms are equally polluting. Mobile firms.

Policy	*W*	*Pollution*	*n*	p_d	p_s	P_D	P_S
Initial	100.0	1,600	100	4.00	4.00	4.00	4.00
Second best	103.8	1,449	90	5.01	3.47	3.75	3.75
First best	110.0	1,200	100	5.00	3.00	5.00	3.00

In this example, each country initially contributes the same amount to the environmental problem. If there is no mobility, the second best solution entails that the home country goes half the way towards the first best outcome. It seems as if the home country should solve its share of the problem, so to speak. (Note that there is no leakage in equilibrium; the use of green trade policy exactly offsets the leakage effects that would arise with unilateral Pigouvian taxation in the home country.)

In contrast to the previous case, there are no environmental gains to be reaped from a change in the location pattern in this example, because the pollution intensity is the same everywhere. In fact, mobility will be a constraint on the ability to solve environmental problems when e is close to E. That is why the second best policy in the latter example brings us closest to the first best outcome when firms are immobile. Moreover, the figures show that some firms respond to the efficient unilateral environmental policy by moving to the foreign country. This confirms the result stated in Proposition 9.

8. Concluding remarks

I have shown that there are gains to be made from unilateral environmental policy, even if firms are mobile between countries. When the mobility of firms increases, however, unilateral environmental taxation should become more modest in order to avoid too heavy distortions in the location pattern.

Efficient unilateral environmental policy normally involves some kind of trade provisions in order to protect the competitiveness of home country firms. The reasons for employing green

trade policy in a second best solution are strengthened by the mobility of firms. Hence, the analysis lends some support to those who claim that a liberal world trading system may be undesirable when environmental values are internalized in some, but not all, countries.

The efficiency enhancing potential of unilateral environmental policies should not draw our attention away from the fact that even more is to be gained from international conventions where all countries agree to implement first best environmental regulations. But such solutions will probably have other distributional implications. We should be aware that some countries might prefer unilateral policies to comprehensive international environmental agreements. It is quite possible that the demand for extensive transfers of resources from rich to poor countries in the negotiations of international environmental agreements will make the rich countries more interested in unilateral solutions than in comprehensive agreements. This is one of the further issues that should be carefully addressed before designing international rules and conventions that govern the implementation of unilateral environmental policies, and in particular the use of green trade policy.

Appendix A

Eqs. (13a) and (13b) can be written on the following form,

$$\begin{bmatrix} \dfrac{\partial(V'+(N-n)\Pi')}{\partial T} & \dfrac{\partial n\pi'}{\partial T} \\ \dfrac{\partial(V'+(N-n)\Pi')}{\partial t} & \dfrac{\partial n\pi'}{\partial t} \end{bmatrix} \begin{bmatrix} T \\ t \end{bmatrix} = \begin{bmatrix} e\dfrac{\partial n\pi'}{\partial T} + E\dfrac{\partial(N-n)\Pi'}{\partial T} \\ e\dfrac{\partial n\pi'}{\partial t} + E\dfrac{\partial(N-n)\Pi'}{\partial t} \end{bmatrix}. \tag{A.1}$$

By using Cramer's rule to solve for t, we obtain

$$t = \frac{\begin{vmatrix} \partial(V'+(N-n)\Pi')/\partial T & e\,\partial(n\pi')/\partial T + E\,\partial((N-n)\Pi')/\partial T \\ \partial(V'+(N-n)\Pi')/\partial t & e\,\partial(n\pi')/\partial t + E\,\partial((N-n)\Pi')/\partial t \end{vmatrix}}{\begin{vmatrix} \partial(V'+(N-n)\Pi')/\partial T & \partial(n\pi')/\partial T \\ \partial(V'+(N-n)\Pi')/\partial t & \partial(n\pi')/\partial t \end{vmatrix}}$$

$$= \frac{\dfrac{\partial(V'+(N-n)\Pi')}{\partial T}\left(e\dfrac{\partial n\pi'}{\partial t} + E\dfrac{\partial(N-n)\Pi'}{\partial t}\right) - \dfrac{\partial(V'+(N-n)\Pi')}{\partial t}\left(e\dfrac{\partial n\pi'}{\partial T} + E\dfrac{\partial(N-n)\Pi'}{\partial T}\right)}{\dfrac{\partial(V'+(N-n)\Pi')}{\partial T}\dfrac{\partial n\pi'}{\partial t} - \dfrac{\partial(V'+(N-n)\Pi')}{\partial t}\dfrac{\partial n\pi'}{\partial T}}$$

$$= e + E\frac{\dfrac{\partial(V'+(N-n)\Pi')}{\partial T}\dfrac{\partial(N-n)\Pi'}{\partial t} - \dfrac{\partial(V'+(N-n)\Pi')}{\partial t}\dfrac{\partial(N-n)\Pi'}{\partial T}}{\dfrac{\partial(V'+(N-n)\Pi')}{\partial T}\dfrac{\partial n\pi'}{\partial t} - \dfrac{\partial(V'+(N-n)\Pi')}{\partial t}\dfrac{\partial n\pi'}{\partial T}}. \tag{A.2}$$

Rewrite the expression in (A.2) as $t = e + E\dfrac{A}{D}$. Writing out the terms in A yields,

$$A = \left[V''\frac{\partial P}{\partial T} + (N-n)\Pi''\frac{\partial P}{\partial T} - \Pi' n_{\hat{x}}\hat{\pi}_T\right]\left[-\Pi' n_{\hat{x}}\hat{\pi}_t + (N-n)\Pi''\frac{\partial P}{\partial t}\right]$$
$$-\left[V''\frac{\partial P}{\partial t} + (N-n)\Pi''\frac{\partial P}{\partial t} - \Pi' n_{\hat{x}}\hat{\pi}_t\right]\left[-\Pi' n_{\hat{x}}\hat{\pi}_T + (N-n)\Pi''\frac{\partial P}{\partial T}\right] \tag{A.3}$$

$$= V''\Pi'\left(\frac{\partial P}{\partial t}n_{\hat{x}}\hat{\pi}_T - \frac{\partial P}{\partial T}n_{\hat{x}}\hat{\pi}_t\right).$$

By using Eq. (10), we obtain

$$A = V''\Pi'\left[\frac{\partial P}{\partial t}n_{\hat{x}}\left(\pi'\left(\frac{\partial P}{\partial T}+1\right)-\Pi'\frac{\partial P}{\partial T}\right)-\frac{\partial P}{\partial T}n_{\hat{x}}\left(\pi'\left(\frac{\partial P}{\partial t}-1\right)-\Pi'\frac{\partial P}{\partial t}\right)\right]$$

$$= V''\Pi' n_{\hat{x}}\pi'\left(\frac{\partial P}{\partial t}+\frac{\partial P}{\partial T}\right). \tag{A.4}$$

Writing out the terms in D yields,

$$\begin{aligned} D = &\left[V''\frac{\partial P}{\partial T}+(N-n)\Pi''\frac{\partial P}{\partial T}-\Pi' n_{\hat{x}}\hat{\pi}_T\right]\left[\pi' n_{\hat{x}}\hat{\pi}_t+n\pi''\left(\frac{\partial P}{\partial t}-1\right)\right] \\ &-\left[V''\frac{\partial P}{\partial t}+(N-n)\Pi''\frac{\partial P}{\partial t}-\Pi' n_{\hat{x}}\hat{\pi}_t\right]\left[\pi' n_{\hat{x}}\hat{\pi}_T+n\pi''\left(\frac{\partial P}{\partial T}+1\right)\right] \end{aligned}$$

$$\begin{aligned} = &\left[V''+(N-n)\Pi''\right]\left[\frac{\partial P}{\partial T}\left(\pi' n_{\hat{x}}\hat{\pi}_t-n\pi''\right)-\frac{\partial P}{\partial t}\left(\pi' n_{\hat{x}}\hat{\pi}_T+n\pi''\right)\right] \\ &+\Pi' n_{\hat{x}}n\pi''\left[\hat{\pi}_t\left(\frac{\partial P}{\partial T}+1\right)-\hat{\pi}_T\left(\frac{\partial P}{\partial t}-1\right)\right]. \end{aligned} \tag{A.5}$$

By using Eq. (10), we obtain

$$\begin{aligned} D = &\left[V''+(N-n)\Pi''\right]\left\{n\pi''\left(-\frac{\partial P}{\partial T}-\frac{\partial P}{\partial t}\right)+\pi' n_{\hat{x}}\left[\frac{\partial P}{\partial T}\left(\pi'\left(\frac{\partial P}{\partial t}-1\right)-\Pi'\frac{\partial P}{\partial t}\right)\right.\right. \\ &\left.\left.-\frac{\partial P}{\partial t}\left(\pi'\left(\frac{\partial P}{\partial T}+1\right)-\Pi'\frac{\partial P}{\partial T}\right)\right]\right\} \\ &+\Pi' n_{\hat{x}}n\pi''\left[\left(\frac{\partial P}{\partial T}+1\right)\left(\pi'\left(\frac{\partial P}{\partial t}-1\right)-\Pi'\frac{\partial P}{\partial t}\right)-\left(\frac{\partial P}{\partial t}-1\right)\left(\pi'\left(\frac{\partial P}{\partial T}+1\right)-\Pi'\frac{\partial P}{\partial T}\right)\right] \end{aligned} \tag{A.6}$$

$$= \left[V''+(N-n)\Pi''\right]\left(n\pi''+n_{\hat{x}}\pi'^2\right)\left(-\frac{\partial P}{\partial T}-\frac{\partial P}{\partial t}\right)+n_{\hat{x}}\Pi'^2 n\pi''\left(-\frac{\partial P}{\partial T}-\frac{\partial P}{\partial t}\right).$$

By combining the expressions in (A.2), (A.4), and (A.6), the second best environmental tax can be written as

$$t = e - E\frac{V''\Pi' n_{\hat{x}}\pi'}{\left(V'' + (N-n)\Pi''\right)\left(n\pi'' + n_{\hat{x}}\pi'^2\right) + n_{\hat{x}}\Pi'^2 n\pi''}. \tag{A.7}$$

Next, solve for T in Eq. (A.1). By using Cramer's rule, we obtain

$$T = \frac{\begin{vmatrix} e\partial(n\pi')/\partial T + E\partial((N-n)\Pi')/\partial T & \partial(n\pi')/\partial T \\ e\partial(n\pi')/\partial t + E\partial((N-n)\Pi')/\partial t & \partial(n\pi')/\partial t \end{vmatrix}}{\begin{vmatrix} \partial(V' + (N-n)\Pi')/\partial T & \partial(n\pi')/\partial T \\ \partial(V' + (N-n)\Pi')/\partial t & \partial(n\pi')/\partial t \end{vmatrix}}$$

$$= E\frac{\dfrac{\partial(N-n)\Pi'}{\partial T}\dfrac{\partial n\pi'}{\partial t} - \dfrac{\partial(N-n)\Pi'}{\partial t}\dfrac{\partial n\pi'}{\partial T}}{D} \tag{A.8}$$

$$= E\frac{B}{D}.$$

We know from Eq. (A.6) what D looks like. B can be written as:

$$\begin{aligned} B = &\left[-\Pi' n_{\hat{x}}\hat{\pi}_T + (N-n)\Pi''\frac{\partial P}{\partial T}\right]\left[\pi' n_{\hat{x}}\hat{\pi}_t + n\pi''\left(\frac{\partial P}{\partial t} - 1\right)\right] \\ &-\left[-\Pi' n_{\hat{x}}\hat{\pi}_t + (N-n)\Pi''\frac{\partial P}{\partial t}\right]\left[\pi' n_{\hat{x}}\hat{\pi}_T + n\pi''\left(\frac{\partial P}{\partial T} + 1\right)\right] \\ = &(N-n)\Pi''\left[\frac{\partial P}{\partial T}\left(\pi' n_{\hat{x}}\hat{\pi}_t - n\pi''\right) - \frac{\partial P}{\partial t}\left(\pi' n_{\hat{x}}\hat{\pi}_T + n\pi''\right)\right] \\ &+\Pi' n_{\hat{x}} n\pi''\left(\hat{\pi}_t\left(\frac{\partial P}{\partial T} + 1\right) - \hat{\pi}_T\left(\frac{\partial P}{\partial t} - 1\right)\right). \end{aligned} \tag{A.9}$$

It is easily seen from Eq. (A.5) and the calculations in (A.6) that B can be rewritten as

$$B = (N-n)\Pi''\left(n\pi'' + n_{\hat{x}}\pi'^2\right)\left(-\frac{\partial P}{\partial T} - \frac{\partial P}{\partial t}\right) + n_{\hat{x}}\Pi'^2 n\pi''\left(-\frac{\partial P}{\partial T} - \frac{\partial P}{\partial t}\right). \tag{A.10}$$

Hence, the formula for the second best trade provisions can be stated as

$$T = E\frac{(N-n)\Pi''\left(n\pi'' + n_{\hat{x}}\pi'^2\right) + n_{\hat{x}}\Pi'^2 n\pi''}{\left(V'' + (N-n)\Pi''\right)\left(n\pi'' + n_{\hat{x}}\pi'^2\right) + n_{\hat{x}}\Pi'^2 n\pi''}. \tag{A.11}$$

The expression in Eq. (A.11) can be split into two parts; one part reflecting the second best trade provisions in a model without mobile firms, and a second part showing the additional factors that are due to mobility. When there is no movement of firms ($n_{\hat{x}} = 0$), the second best trade provisions have the format

$$T = E\frac{(N-n)\Pi''}{V''+(N-n)\Pi''}. \tag{A.12}$$

Subtracting the term in (A.12) from the expression in (A.11) leads to the following decomposition of Eq. (A.11),

$$\begin{aligned} T = {} & E\frac{(N-n)\Pi''}{V''+(N-n)\Pi''} \\ & +E\frac{V''}{V''+(N-n)\Pi''}\left(\frac{n_{\hat{x}}\Pi'^2 n\pi''}{(V''+(N-n)\Pi'')(n\pi''+n_{\hat{x}}\pi'^2)+n_{\hat{x}}\Pi'^2 n\pi''}\right). \end{aligned} \tag{A.13}$$

By defining λ as

$$\lambda \equiv \frac{n_{\hat{x}}\Pi'^2 n\pi''}{[V''+(N-n)\Pi''](n\pi''+n_{\hat{x}}\pi'^2)+n_{\hat{x}}\Pi'^2 n\pi''}, \tag{A.14}$$

the second best tax structure can be formulated as

$$\begin{aligned} t &= e - E\frac{V''}{n\pi''}\lambda\frac{\pi'}{\Pi'}, \\ T &= E\frac{(N-n)\Pi''+V''\lambda}{V''+(N-n)\Pi''}. \end{aligned} \tag{A.15}$$

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Trade Policy and Tropical Deforestation*

1. Introduction

Tropical deforestation is by many considered to be among the most serious examples of ecological disruption in our world. Since the World Commission on Environment and Development identified reduced deforestation as one of our greatest environmental challenges, the protection of tropical rain forests has become a major concern for the international community. During the summit meeting in Rio in 1992, this very issue was in fact one of the main points on the agenda. There are many reasons why deforestation in general, and tropical deforestation in particular, is considered an ecological problem. Some of these reasons relate to local environmental factors, such as increased soil erosion and siltation of rivers and lakes: the forest protects the soil from heavy rainfall. In addition, the forest regulates the amount of run-off water. Where the trees are removed, the rivers will get bigger in the rain season and smaller in the dry season. Hence, deforestation may cause both increased flooding and more severe droughts.

There are other local environmental consequences of deforestation as well, but my attention here will be devoted first and foremost to those environmental benefits that the tropical forests provide for people in other countries. More specifically, I will concentrate on the role of the tropical rain forest as (1) a reservoir of biodiversity and genetic material, and (2) a sink of carbon, regulating the balance between terrestrial and atmospheric carbon compounds. Certainly, tropical deforestation can be regarded an international environmental problem for other reasons as well, for instance, because of some purely psychological externalities related to the existence of tropical forests. Without dismissing such concerns out of hand, I shall leave them untreated in this context.

*For their comments on earlier drafts of this paper, I am grateful to Arild Angelsen, Jan I. Haaland, Agnar Sandmo, Bertil Tungodden, and Anthony J. Venables.

According to the most recent estimates, 0.8% of tropical forests is deforested each year.[1] This amounts to an area close to 14 million hectares a year, which, by way of illustration, is about half the area of Norway. However, certain qualifications need to be kept in mind when interpreting these numbers. Measurements of deforestation are heavily influenced by the definitions employed. The numbers above are based on the very strict FAO definition of deforestation, namely; "the change of land use or depletion of crown cover to less than 10%". Obviously, the extent of forest modification or biomass reduction is seriously underestimated by using these numbers. According to the Brundtland Commission, a further area of 10 million hectares is grossly disrupted annually.[2] Available evidence thus suggests that if deforestation continues like now, very large portions of the tropical forests may be severely damaged or outright eliminated within a few decades from now.

The international community has made it a goal to avoid that these prospects come true. Considerable effort has therefore been undertaken in order to identify the causes of deforestation. The Brundtland Commission pointed out the trade in tropical timber as one reason for tropical deforestation.[3] Others have disputed this view by arguing that trade restrictions on tropical timber might in fact increase deforestation.[4] This disagreement notwithstanding, several Western countries have proposed restrictions on the trade in tropical timber as a means of forest preservation. For example, local government bans on the use of tropical timber have been implemented in some countries (e.g. Germany and the Netherlands); the US Congress has considered bills that restrain imports of tropical timber[5]; product labelling has been implemented in Austria and is under consideration in Germany; the Netherlands has adopted a policy of importing only sustainably managed tropical timber by 1995, and is considering product labelling and quantitative restrictions as a means to achieving this objective. The United Kingdom is being urged by environmental groups to do the same.[6]

The aim of this paper is to shed some light on the possible environmental consequences of restrictions in the trade of tropical timber and timber products. The first point I want to stress is that since tropical forests serve multiple environmental objectives, the design of appropriate trade restrictions may involve some difficult trade-offs between competing considerations. Section 2 of this paper is therefore devoted to a discussion of how deforestation is related to the loss of biodiversity on the one hand, and to the increase in atmospheric CO_2 on the other.

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[1]FAO (1993)
[2]WCED (1988, p. 151).
[3]WCED (1988, p. 68 and p. 154). See also ITTO (1993) for a discussion of this issue.
[4]Barbier and Rauscher (1993).
[5]Vincent (1990).
[6]ITTO (1993, p. 90).

The discussion continues in Section 3 with a brief overview of the arguments that have been raised in the debate about the relationship between trade restrictions on tropical timber and deforestation. I identify a number of weaknesses in how this issue has been analysed, and in Section 4, I suggest an alternative approach. The main features of this framework are: 1) a careful distinction between timber extraction from timber plantations and timber production as a mining activity, 2) an explicit formulation of the facts that tropical forests consist of a heterogeneous collection of trees and that the harvest costs may vary from field to field, 3) a separate treatment of the decisions of governments and the decisions of logging companies. Within this framework, it will be shown that the environmental consequences of trade restrictions on tropical timber and timber products probably are more beneficial than suggested by previous economic analysis.

2. Deforestation as an international environmental problem

Tropical moist forests cover only 7% of the land surface of the earth. But these areas contain an excessive share of the biological diversity of this planet. There is a great deal of uncertainty attached to the estimates of the number of species contained in tropical forests, but a rough suggestion, appearing in several publications, is that between 50 and 90 per cent of the species are to be found here.[7] Some of these species will probably become important resources for humans in the future, for instance in the manufacturing of medicines. A great share of these benefits are likely to accrue to people outside the tropics. This makes the preservation of biodiversity an international concern.

To take a step further and establish that the loss of biodiversity constitutes an environmental problem, we need to clarify why the market mechanism is incapable of securing adequate supply of this good. The most obvious reason why markets fail in this respect is perhaps the lack of property rights. There are no international rules that define property rights to genetic material. (As a matter of fact, some people would oppose the very establishment of such rules on ethical grounds.) Consequently, tropical countries lack economic incentives to pay as much attention to the biodiversity issue as would be appropriate from a Pareto efficiency point of view.

The threat to biodiversity in the tropical forests is not over-exploitation but habitat destruction. Empirical observations have established that the number of species (within a given taxonomic group) in an area increases with the size of the area.[8] Thus, the best we can do in order to preserve biodiversity in the tropical forests will probably be to leave the forest untouched.

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[7]See WCED (1988, p. 151).
[8]See Barrett (1989) for some alternative explanations of this observation.

Admittedly, this may seem like a too extreme claim, because most of the species that are potentially valuable to humans would clearly be able to survive in areas that are far smaller than the present forest area. The problem, though, is that we simply do not know where the valuable species are located. If the species were evenly distributed across the area, we could make use of a substantial portion of the forest without hurting future possibilities to take advantage from its biological diversity. Unfortunately, we do not know whether the species are distributed like this. Rather, great biodiversity has been identified in small spots. A single tree in the Amazon, for instance, was found to shelter 43 ant species.[9] (This is a greater diversity than exists in all the British Isles.) I therefore conclude that biological diversity probably is better served by leaving the forest alone, than by exploiting it.[10]

Next, consider the role of tropical forests in the carbon cycle. Substantial uncertainty still exists as to how increases in the concentration of atmospheric CO_2 will affect our environment. It is beyond the scope of this paper to address those issues. I shall take for granted that it is desirable to reduce the emissions of CO_2 to the atmosphere. Due to the high density of biomass in the tropical forests, they account for 55% of the organic carbon in the world.[11] Next to the combustion of fossil fuels, deforestation is the main source of CO_2-emissions. Deforestation is estimated to account for 1.6±1.0 billion tons of carbon per year, whereas fossil fuels account for 5.4±0.5 billion tons of carbon per year.[12]

From a carbon emission perspective, some forms of deforestation are worse than others. Deforestation is most detrimental when it is caused by forest burning. Trees that are burnt release their carbon content to the atmosphere immediately. The same is not true for traditional logging activities. To cut a tree does in itself not release any carbon. And if the tree is transformed into durable products, no carbon will be released for a long time. Quite the contrary, if the logged over area is made available for new trees, logging could in fact increase the total storage of carbon in forests and forest products. According to this reasoning, therefore, the global climate could be better served by logging the tropical forests than by leaving them untouched. In that case, the best policy from a climate point of view would conflict with the best policy with regard to diversity protection.

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[9]Repetto and Gillis (1988, p. 12).

[10]This conclusion is supported by empirical research by biologists who have estimated the relation between species diversity and area. The species-area relation is usually expressed in the form $S = \alpha A^{\beta}$, where S is the number of species, A is area, and α and β are parameters. β can be interpreted as the elasticity of biological diversity with respect to area and has been estimated by Diamond and May (1981) to be in the range 0.18 - 0.35. In a study by Connor and McCoy (1979), the average elasticity is estimated to 0.31, but their results indicate that the range of elasticities may be quite large. (In fact, they have documented examples of both $\beta > 1$ and $\beta < 0$.)

[11]Kasa (1993).

[12]Figures are from the IPCC (International Panel on Climate Change) assessment, 1990. See Döös (1991, p. 35).

However, the picture I have just sketched is over-simplified. First, only a small portion of the trees that are cut are converted into durable products. The carbon content of root systems, leaves and branches may constitute as much as 50% of the total carbon content in a tree. High temperatures and humidity in the rain forests will ensure that these parts release their carbon within a relatively short time period after logging. Moreover, a study of the utilization of old-growth temperate forests shows that only 42% of the stem wood carbon is converted into products like lumber and plywood with a life span of more than five years.[13] Tropical forest products are by their very nature even less suited for durable products. Hence, it seems fair to say that no more than 20% of the carbon content of a tropical tree can be expected to be bound in products after five years. And since the forest will need many decades to regain 80% of its volume, we can conclude that logging will cause the CO_2 concentration in the atmosphere to increase, at least within a short and medium time horizon.

Another important fact is that the carbon density in a production forest is far lower than in a virgin forest. According to Schroeder, it is not unreasonable to assert that an area being transformed from virgin forest to a forest plantation will have its carbon content reduced by two thirds.[14] This carbon loss must be compensated by an increased stock of tree products if the conversion of virgin forest to forest plantations shall be beneficial from a carbon storage point of view.

In practice, there are relatively few timber plantations in the tropics. Instead, forests are logged in accordance with so-called selective management systems. This implies that clear cutting seldom occurs in a production forest. Rather, a few trees are harvested in each area. This practice is very damaging for the storage of carbon in the forest, because a large portion of the vegetation is damaged in order to harvest a few trees. We know already that only a small portion of the trees is converted into durable products. By adding that only 10 to 20 per cent of the standing volume in an area is removed for commerce, and that 30 to 50 per cent of the trees are destroyed or fatally damaged during logging, we realize that logging may cause large releases of carbon to the atmosphere through accelerated depletion and decomposition of the biomass.[15]

This does not imply, however, that *reduced* timber extraction in an area necessarily causes less damage to the forest. When fewer trees are removed for sale, some of the trees that are left

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[13]See Schroeder (1991, p. 10).
[14]Schroeder (1991, p. 9).
[15]Repetto and Gillis (1988, p. 6). According to Barrett (1989), it has been reported that in West Malaysia, the taking of 3% of the forest results in a loss of 50% of the trees, and that on the island of Borneo, the extraction of one tree causes the loss of 17 others.

behind may simply become destroyed rather than being left untouched. We know for sure that as the utilization of the forest approaches 100%, forest destruction must eventually approach zero. Hence, with a positive forest damage at lower levels of utilization, there has to be a range in which reduced logging causes *more* damage to the forest. Fig. 1 illustrates:

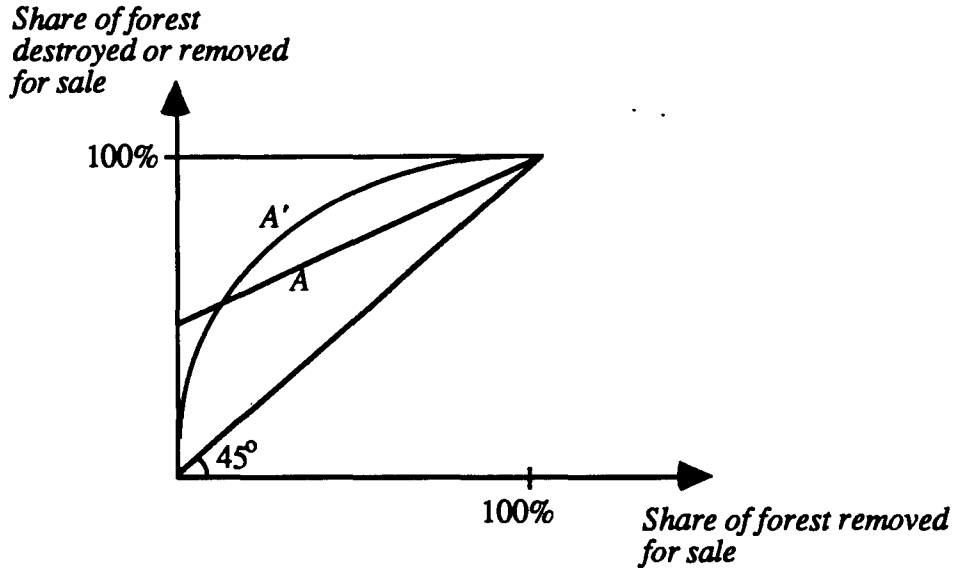

Fig. 1.

The curves *A* and *A'* show alternative ways in which total forest degradation may be related to the amount of logging in a given area. The share of the forest that is destroyed as a result of logging appears as the distance between either *A* or *A'* and the 45 degree line. The intersection between *A* and *A'* is meant to reflect the present situation in many tropical forests; 10-20% of the forest being logged, and 30-50% being destroyed or damaged. The figure shows that as logging is reduced from its present level, forest damage may either increase or decrease depending on whether *A* or *A'* is the most accurate description of reality. In the case of *A'*, reduced logging will lead to less forest damage, whereas the opposite will happen in the case of *A*.

Against this background, we can conclude that there is a quite complex relation between deforestation and forest degradation on one hand, and the concentration of carbon dioxide in the atmosphere on the other. What we have seen is that; 1) the irreversible clearance of forests, either through burning or logging, causes a net release of carbon; 2) to reduce logging *and* leave the trees untouched will reduce carbon emissions in the foreseeable future; 3) if reduced logging causes increased forest damage, which may be the case with the current management systems in the tropical forests, the impact on carbon storage of reduced logging is more uncertain.

3. Previous studies

The existing literature on the relationship between timber trade and deforestation suffers from several shortcomings. The most notable weakness is the lack of reliable empirical insight into the causalities of the problem. In this respect, this study does no better than the others. Another shortcoming in previous studies is that the attention is focused on deforestation as such, and very little is said about the relationship between deforestation and the environmental variables that we are concerned about. The previous section attempted to make slight progress on this issue, but more empirical research is definitely needed here as well.

Regarding the relationship between timber trade and deforestation, the basic hypothesis has been that timber trade boosts the demand for timber, inducing more logging and accelerated deforestation. Trade restrictions would counteract this development by forcing timber prices to fall. This hypothesis has been challenged on at least three accounts: 1) It is false because it ignores that forest land has alternative uses. The forest is better protected by high timber prices than by low prices, since high prices make forestry profitable and prevent conversion of the forest land into agricultural or industrial uses.[16] In addition, higher prices will provide incentives for a better management of the existing forest. 2) The hypothesis might be correct if there were substantial trade in tropical timber. But in fact, only a small portion of trees cut is sold in the international market. Hence, trade restrictions will be ineffective.[17] 3) Although trade restrictions may have some desirable effects, they will clearly be inefficient means of environmental protection in this context. Regulations should be imposed directly on the undesirable activities.

This last criticism is a general, and valid, criticism against the use of green trade policy. Such measures are generally no more than a second best policy alternative. However, when the sources of an environmental problem are located outside the jurisdiction of the victim countries, it is far from obvious that first best policies are available. As I have shown elsewhere, trade policy may be the most efficient policy alternative under such circumstances.[18] Moreover, I have pointed out the crucial role of the slope of the demand curve in the source countries for the efficiency of second best trade policies. In our present context, this implies that if a fall in timber prices in the wake of trade restrictions stimulates consumption in other parts of the world, including the tropical countries themselves, it becomes more costly to achieve our environmental objectives through trade measures. I will have nothing to add about this issue here; my present concern will only be with the *environmental* consequences of trade policies, not with considerations about overall efficiency.

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[16]Vincent (1990), Swanson (1993), Schulz (1993), Barbier and Rauscher (1993), ITTO (1993), among others.
[17]ITTO (1993).
[18]Mæstad (1992, 1994). [Essay 1 of this thesis].

Next, consider the objection that trade in tropical timber is so limited that any trade restrictions will be ineffective. According to some sources, only 6% of total tropical non-coniferous roundwood production enters the international trade.[19] These figures differ substantially from the FAO statistics which indicate that 14% of the timber production in tropical countries was exported in 1990.[20] The importance of international trade in tropical timber is thus highly uncertain. What is quite clear, however, is that the significance of international trade differs substantially between countries. While Brazil exports almost nothing, Indonesia and other South-East Asian countries export quite a lot. Thus, trade restrictions may work in some countries but fail in others. By way of illustration, Barbier *et.al* have estimated that an import ban would reduce Indonesian log production by 28%, sawnwood production by 11%, and plywood production by 44%.[21]

Another crucial point to bear in mind in this context is that the *structure* of the market is more important for the effectiveness of trade policies than the actual volume of trade. To take an extreme example; if the timber market were a true international market, and temperate timber were substitutable for tropical timber, it would *in principle* be possible by means of trade interventions (export subsidies) to eliminate all timber production in the tropics, even though trade volumes were negligible at the outset. Hence, the most interesting feature of the market structure for the effectiveness of trade measures is not the actual volume of trade, but the degree of openness to international competition.

The timber extraction for international trade may be more damaging to the environment than some of the domestic consumption. In the tropical countries, the timber is used mainly as fuelwood. But rural people do not normally cut whole trees for this purpose. Instead they collect dead branches, or they take branches from growing trees. Such practices are far less detrimental to the local environment and to biodiversity than highly mechanized logging activities.[22] This seems to provide yet another reason to be concerned with the international trade in tropical timber.

But should timber trade be encouraged or restricted in order to reduce deforestation? Will not trade restrictions prove to be counter productive? This was the first objection raised above, and it was supported by a seemingly convincing theoretical argument. However, as my analysis in Section 4 will demonstrate, the argument is not necessarily valid. Although trade restrictions will reduce the overall profitability of forestry, it is not obvious that profits will be reduced in

[19]Bourke (1992), see ITTO (1993, p. 6).
[20]See ITTO (1993), table 2.5a.
[21]Barbier *et.al* (1993), table 9.
[22]See Lewis and Berry (1988) and Hansen (1993).

all areas, and particularly not, as I shall argue below, in those areas where the forest is threatened by agricultural expansion.

Another important fact to keep in mind, in particular with regard to the South-East Asian countries, is that shifting cultivators (i.e., small scale farmers who regularly slash and burn the forest to make the land available for agriculture) are responsible for a major share of forest conversion.[23] Shifting cultivators rarely clear virgin forests, though. Such areas are simply inaccessible with the poor equipment of these farmers. Rather, the forest is often made accessible by well-equipped logging companies while making their way into the forest. Thus, logging may be a precondition for conversion of forests into agricultural land.[24] If restrictions on timber trade keep the loggers away from the forest, this area might therefore become *less* attractive for alternative uses like slash and burn cultivation.

Finally, in discussions about the threat of forest conversion, it is important to note that tropical forests are for the most part publicly owned. Although public ownership is not strictly enforced in most places, governments play a crucial role in decisions about allocation of land to different activities. This is important to bear in mind, since the motives of governments may differ substantially from those of individual citizens. In Brazil, where the largest programme for conversion of forests into agricultural land has been implemented, the motives of the government were not economic. In fact, the cattle ranches have been a major money drain for the state through high subsidies. Forests were cleared for political rather than economic reasons; in order to strengthen territorial control and gain political support from the business community.[25] Similar factors are important for understanding forest conversion in Indonesia and other South-East Asian countries as well. Therefore, the motives of governments should be carefully identified before drawing definite conclusions about the consequences of trade restrictions on the allocation of land.

The only theoretical analysis of the relationship between trade policy and deforestation that I am aware of, is the study by Barbier and Rauscher (1993).[26] They use a standard bio-economic model where the growth of the forest is a function of the stock. A representative decision maker derives utility from the consumption of timber and the consumption of an imported good. In addition, the forest *stock* may have a positive impact on the level of utility (e.g., because of

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[23]In the Amazon, much of the forest conversion has been related to the establishment of large-scale farming (e.g., cattle ranches).
[24]Kasa (1993), ITTO (1993).
[25]Kasa (1993).
[26]A couple of articles have touched more explicitly upon the relationship between trade restrictions and the biodiversity problem (Swanson (1993) and Schulz (1993)). Both studies approach the question through a traditional bio-economic model which takes into account the interplay between the harvest of the species and the population dynamics. These studies have only limited relevance for the preservation of biodiversity in the tropical forests because they assume that we have identified those species that we want to preserve.

environmental goods). A result from their analysis is that if the decision maker does *not* derive any utility from the stock of forest, trade policies will not affect deforestation. The optimal equilibrium forest stock will then be determined solely by the interest rate and the growth function.[27] If, on the contrary, the mere size of the forest stock matters to the decision maker, trade restrictions will lead to a change in the optimal forest stock, the direction of the change depending on the degree of import dependency.[28] The most valuable insight from the Barbier/Rauscher study is probably that import dependency might "force" a country to exploit its forest resources more heavily when the export earnings have been reduced by trade restrictions.

Their approach is open to several criticisms, however. First, the forest is treated as a homogenous resource, both from an economic and an environmental perspective. For example, no attention is paid to the fact that the harvest of virgin forests may be more damaging to the environment than logging in other parts of the forest. The most natural interpretation of the optimal forest stock in their model is that it corresponds to an optimal *density* of the forest. Following this interpretation, the optimal policy will be to convert *the entire forest* into production forest with a particular density. Such a policy may be very damaging to biological diversity, and perhaps to the carbon content of the forest as well. In addition, there are *economic* reasons for concentrating timber production to a more limited area.

Furthermore, I have some doubts about the relevance of the bio-economic model in this context. It is true that the forest will grow after trees are removed (provided the area is not used for some other purpose). But I am not so sure that this fact is taken into account by the decision makers. The forest is harvested by loggers with very short concession periods. Poore *et.al* (1989) found that concessions in Asia were issued for periods of 21 to 25 years, even though the minimum realistic felling cycle is 30-35 years and the rotation 60-70 years.[29] This implies that profit maximizing loggers will probably not take future growth into account. It could be objected that the governments, through regulations of the logging activity, try to induce the loggers to behave as if future growth mattered. Although this probably is true in some cases, it is reasonable to believe that even the governments have very diluted incentives to be concerned with future growth. The reason is that only a few of the species in the forest are commercially valuable. When a tree is cut, the spot will most likely become inhabited by non-commercial species. Such growth is irrelevant from a strictly economic perspective.

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[27]In this case, the optimal forest stock is determined so that its value growth is equal to the interest rate. The value growth is independent of the *level* of prices and is therefore also independent of trade restrictions.
[28]In the model, import dependency is formulated as a high elasticity of marginal utility with respect to imported consumption goods.
[29]ITTO (1993, p. 48).

Based on these arguments, I suggest that most tropical forestry should be modelled as a *mining activity*, implying that the biological growth of the forest can be disregarded. Only on those rare occasions where governments are engaged in replanting programmes and the running of timber plantations, we need to care about biological processes to understand behaviour.

4. An alternative framework

The main actors determining the extent of tropical deforestation are logging companies, shifting cultivators, and governments. Governments award timber concessions to logging companies for a limited period of time. I assume that within the concession area, the loggers are free to decide when and where to mine the forest. The impact of trade restrictions on the behaviour of logging companies within a given concession area is the topic of Section 4.1. Government decisions about allocation of land to different purposes and their running of timber plantations are discussed in Section 4.2. The behaviour of shifting cultivators is not explicitly modelled, but I assume throughout the paper that logging is a precondition for their access to the forest.

4.1 Loggers

A lot of timber concessions are already awarded in the tropics, and many of them will not expire until a couple of decades from now. Therefore, irrespective of the impact of trade restrictions on future concession awards, their impact on existing logging activities will be of crucial importance to their effectiveness.

Divide each concession area into N equally sized logging fields. All logging fields will be assumed to contain the same stock of trees, but there may be differences in costs between the fields due to differences in transport distances or some other differences in accessibility. Marginal costs of logging in field i will be denoted $\bar{c}^i$, and will be assumed to be constant. The logging fields will be indexed in accordance with marginal logging costs so that $\bar{c}^i \leq \bar{c}^{i+1}$.

The stock of trees in virgin or old-growth forests differs substantially from the forest stock on a timber plantation. Each logging field contains a number of different commercial species with different qualities. The price received for a tree will depend on these qualities. Let us assign a quality index q to each tree, giving the most valuable tree the lowest quality index number. Furthermore, let α be an indicator of the kind of trade policy that has been implemented against tropical timber and timber products. Trade restrictions will appear as a negative shift in α, and it will be assumed that such a policy causes a reduction in timber prices. The price $\hat{p}$ of a tree

can now be expressed as a function $\hat{p}(q,\alpha)$, which is non-increasing in q and increasing in α.[30]

Logging companies are assumed to be profit maximizers in their decisions about 1) how much to harvest in each logging field and 2) the time profile of the harvest. I assume that loggers must accept timber prices as given. (Note that the marginal revenue in each logging field nevertheless will decline with the amount of timber extracted, due to the differences in tree qualities.)

With constant marginal costs and a discount rate greater than zero, the optimal harvest pattern will be to finish all harvest in the first period. However, this conclusion does not square with empirical evidence on the logging pattern over time. I am therefore going to assume that the loggers face some kind of capacity constraint, inducing (or forcing) them to disperse their efforts over time. Various ways of formulating this capacity constraint will be demonstrated.

With a positive discount rate, the loggers will prefer to harvest the most valuable trees across the concession area before they cut less valuable species. Such a harvest pattern, which I will call *simultaneous harvest* (simultaneous across several logging fields), is not necessarily feasible, however. It is arguable that since logging often causes great damage to remaining trees in the forest, it will be more profitable to finish the harvest in one field before moving on to the next. Such a harvest pattern will be denoted *sequential harvest*. Both harvest procedures will be discussed in the following. Which procedure that is chosen will depend partly on the technology (more heavy machinery will cause greater damage to the forest, thus making sequential harvest a more attractive alternative) and partly on government regulations. In Indonesia, for instance, simultaneous harvest, or "creaming" as it is usually called, is prohibited. However, such regulations do not seem sufficient to prevent loggers from engaging in such practices.

I shall make a couple of assumptions about the price function in order to ease the exposition. First, it will be assumed that the quality index is normalized so that the most valuable tree has the index number $q=1$, the second most valuable tree has the index number $q=2$, and so on. This implies that there is a one to one correspondence between the number of trees harvested in a field and the quality index of the marginal tree. Furthermore, I will assume that trade restrictions affect timber prices proportionally, i.e., the price of each tree will be assumed to decline with the same percentage amount.[31] These assumptions imply that the marginal income

[30]Government regulations on logging, for instance regulations on the minimum dimensions of harvested timber, will affect the shape of this price function.

[31]The assumption about a proportional price reduction might perhaps seem somewhat arbitrary. Trade restrictions may be implemented in a number of different ways, including trade policies that discriminate between different species. It is therefore impossible to determine *a priori* how trade restrictions will affect relative timber prices. Something like a proportional decline in timber prices might perhaps be achieved through the use of *ad*

in logging field i can be written as the function $\hat{p} = \alpha p(H^i)$, where H^i is the total harvest in logging field i.

If the time constraint, defined by the length of the concession period, does not bind, and if there is no discounting, implying that the loggers are indifferent between sequential and simultaneous harvest, the optimal H^i is given by the condition[32]

$$\alpha p(H^i) \leq \bar{c}^i, \qquad H^i \geq 0, \qquad H^i\left[\alpha p(H^i) - \bar{c}^i\right] = 0, \quad \forall i. \tag{1}$$

This condition says that in logging fields with positive harvests, the price of the marginal tree shall equal the marginal harvest cost. A logging field will be left untouched if $\alpha p(H^i) < \bar{c}^i$ at all harvest levels. Moreover, in decisions about whether to open a new field or not, the loggers will take into account the fixed costs of building new roads and other infrastructures. These costs are not explicitly modelled, but they will be kept in mind throughout the analysis.

The simple rule in Eq. (1) needs to be modified, though, when the concession period is binding and/or when future profits are discounted. The appropriate modification will differ depending on whether logging occurs simultaneously or sequentially.

a. Simultaneous harvest

Simultaneous harvest involves the possibility to take out some valuable trees in one logging field, then move on to another field, before returning to the starting point to continue the harvest there. If the loggers discount future profits, it will be profitable, *ceteris paribus*, to first cut the trees that contribute most to profits. Since each logging field contains both low valued and high valued species, this implies that the loggers will prefer to shift their logging activity back and forth among different fields. (Strictly speaking, what they would want to do when there is no economy of scale in logging, as I have assumed here, is to disperse their efforts across all profitable logging fields and literally speaking log all fields simultaneously.)

In order to avoid that all profitable trees are harvested in the first period, we need to introduce some kind of capacity constraint. This will be done by assuming that the harvest cost in a given period is an increasing and convex function of the total harvest in that period. This is a "soft"

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valorem tariffs, but other patterns are conceivable as well. For our purpose it does not matter whether prices decline proportionally, under-proportionally, or over-proportionally. What turns out to be significant, however, is whether trade restrictions cause a greater *absolute* decline in the price of high quality timber than in the price of low quality timber. A number of different trade policies might affect the price structure in this way, and the assumption of proportionality should be seen merely as an approximation to all kinds of trade policies causing prices to decline most significantly (in absolute terms) for the most valuable timber.

[32]Both the total harvest and the quality index will be treated as continuous variables.

capacity constraint which may reflect, for instance, that as the machinery is more heavily utilized, the costs of maintenance and repair per unit harvested will increase. Let h_t^i denote the harvest in logging field i in period t. The capacity constraint can then be formulated as a cost function $c\left(\sum_{i=1}^{N} h_t^i\right)$, with the assumed properties $c' > 0$, $c'' > 0$. The total logging costs in period t can now be written as

$$\sum_{i=1}^{N} \bar{c}^i h_t^i + c\left(\sum_{i=1}^{N} h_t^i\right). \tag{2}$$

The income from logging field i in period $\hat{t}$ can be found as the area under the marginal revenue curve between the *pre*-period aggregate harvest X ($X \equiv \sum_{t=1}^{\hat{t}-1} h_t^i$) and the *post*-period aggregate harvest Y ($Y \equiv \sum_{t=1}^{\hat{t}} h_t^i$). Total income from logging in period $\hat{t}$ can now be written

$$\sum_{i=1}^{N} \int_{X}^{Y} \alpha p(h)dh. \tag{3}$$

Let $\bar{T}$ be the length of the concession period, and let r be the discount rate. The present value profit in the concession area can then be written

$$\pi\left(h_1^1,..,h_1^N,..,h_{\bar{T}}^1,...,h_{\bar{T}}^N\right) = \sum_{t=1}^{\bar{T}} (1+r)^{-t} \left[\sum_{i=1}^{N} \left(\int_{X}^{Y} \alpha p(h)dh - \bar{c}^i h_t^i\right) - c\left(\sum_{i=1}^{N} h_t^i\right)\right]. \tag{4}$$

The decision problem facing the logging companies is to choose the harvest levels in each period and for all logging fields so that (4) is maximized.

A two period, two logging field model

In order to simplify the presentation, it will be assumed that the concession is awarded for only two periods ($\bar{T} = 2$), and that a concessions area contains only two logging fields ($N = 2$). Furthermore, notation will be simplified by letting H_t denote the total harvest in period t (i.e., $H_t \equiv h_t^1 + h_t^2$) and letting H^i denote the total harvest in logging field i during the whole concession period (i.e., $H^i \equiv h_1^i + h_2^i$). The maximization problem can then be stated as:

$$\max_{h_1^1,h_1^2,h_2^1,h_2^2} \pi \equiv (1+r)^{-1}\left[\sum_{i=1}^{2}\left(\int_0^{h_1^i} \alpha p(h)dh - \bar{c}^i h_1^i\right) - c(H_1)\right] + (1+r)^{-2}\left[\sum_{i=1}^{2}\left(\int_{h_1^i}^{H^i} \alpha p(h)dh - \bar{c}^i h_2^i\right) - c(H_2)\right]. \tag{5}$$

The first order conditions are

$$h_1^1: \ \left(\alpha p(h_1^1) - \bar{c}^1 - c'(H_1)\right)(1+r)^{-1} + \alpha\left(p(H^1) - p(h_1^1)\right)(1+r)^{-2} = 0, \tag{6a}$$

$$h_1^2: \ \left(\alpha p(h_1^2) - \bar{c}^2 - c'(H_1)\right)(1+r)^{-1} + \alpha\left(p(H^2) - p(h_1^2)\right)(1+r)^{-2} = 0, \tag{6b}$$

$$h_2^1: \ \alpha p(H^1) - \bar{c}^1 - c'(H_2) = 0, \tag{6c}$$

$$h_2^2: \ \alpha p(H^2) - \bar{c}^2 - c'(H_2) = 0. \tag{6d}$$

Observation 1 (Logging pattern I)

The total harvest during the concession period will be greater in logging fields with low harvest costs than in fields with high harvest costs.

Proof: Eqs. (6c) and (6d) together imply that $\alpha p(H^1) - \bar{c}^1 = \alpha p(H^2) - \bar{c}^2$ in optimum. Since the logging fields are indexed so that $\bar{c}^1 \leq \bar{c}^2$, it follows that $\alpha p(H^2) \geq \alpha p(H^1)$. The result then follows straightforwardly.

Observation 2 (Time profile)

The optimal harvest per period is declining over time.

Proof: By combining Eqs. (6a) and (6c), we obtain

$$\left(\alpha p(h_1^1) - \bar{c}^1 - c'(H_1)\right)(1+r)^{-1} = \left(\alpha p(h_1^1) - \bar{c}^1 - c'(H_2)\right)(1+r)^{-2}. \tag{7a}$$

Eq. (7a) says that logging in field one in period one should continue until the discounted profit of felling another tree is equal to the discounted profit of harvesting this tree in the next period instead. Eq. (7a) may be rearranged to yield[33]

$$r = \frac{c'(H_1) - c'(H_2)}{\alpha p(h_1^1) - \bar{c}^1 - c'(H_1)}. \tag{7b}$$

[33]A similar expression can be obtained by combining Eqs. (6b) and (6d).

Eq. (7b) is a version of the Hotelling Rule for optimal extraction of resources over time.[34] Eq. (6a) shows that the denominator is positive; hence, the nominator must be positive as well. The convexity of the capacity cost function then ensures that $H_1 > H_2$.

Because of discounting, the postponement of some of the harvest to later periods will be unprofitable, unless this move is accompanied by an (expected) increase in timber prices or a decrease in costs. Since timber prices are assumed given, marginal costs must decline from one period to the next. The only way to accomplish this is by letting the total harvest per period decline over time.

Trade restrictions on tropical timber

A stepwise approach will be used to investigate the consequences of trade restrictions for the pattern and the time profile of timber extraction. The first step will be to suppress the time dimension by setting $r = 0$. This will be helpful in order to see how trade restrictions affect the logging pattern across fields with different harvest costs. The next step is to assume that there is only one logging field. This will help us to see how trade restrictions affect the time profile of logging in a given area.

If $r = 0$, the first order conditions (6a)-(6d) are reduced to the four conditions

$$\alpha p\left(H^i\right) - \bar{c}^i - c'\left(H_t\right) = 0, \quad i = 1,2 \text{ and } t = 1,2. \tag{8}$$

With a zero discount rate, the time of harvest is no longer a relevant concern. Then, since the capacity cost is assumed to be convex, it will be optimal to disperse the logging activity as evenly as possible over the concession period. Hence, $H_1 = H_2$ in optimum, implying that $H_t = \left(H^1 + H^2\right)/2$. The first order conditions can therefore be written

$$\alpha p\left(H^i\right) - \bar{c}^i - c'\left(\left(H^1 + H^2\right)/2\right) = 0, \quad i = 1,2. \tag{9}$$

Differentiation of Eq. (9) with respect to the trade policy parameter α yields:

PROPOSITION 1

If there is no discounting, trade restrictions that cause timber prices to decline proportionally will lead to:

a) Reduced total logging.

[34]See, for instance, Dasgupta and Heal (1979). Usually, the Hotelling Rule is formulated with variable prices over time. In the present model, only costs are allowed to change.

b) Reduced logging in the least profitable logging area.

c) Increased or reduced logging in the most profitable logging area.

d) Possibly, a greater part of the concession area being left untouched.

Proof: See Appendix A.

Trade restrictions lead to reduced total logging, because some trees that were previously profitable to harvest now become unprofitable. But in addition to this general tendency towards reduced logging, trade restrictions cause a shift in logging activities from high cost to low cost logging fields. The reason is as follows: in optimum, the price received from cutting another tree is higher in a high cost logging field than in a low cost field, $p(H^1) < p(H^2)$ (see Observation 1). Therefore, a proportional price fall will have a greater negative impact on the margin in high cost fields. (The same will hold true for all kinds of trade restrictions leading to a greater absolute decline in the price of high value timber than in the price of low value timber.) The consequence is that the relative profitability changes to the advantage of low cost logging fields. This point is illustrated in Fig. 2.

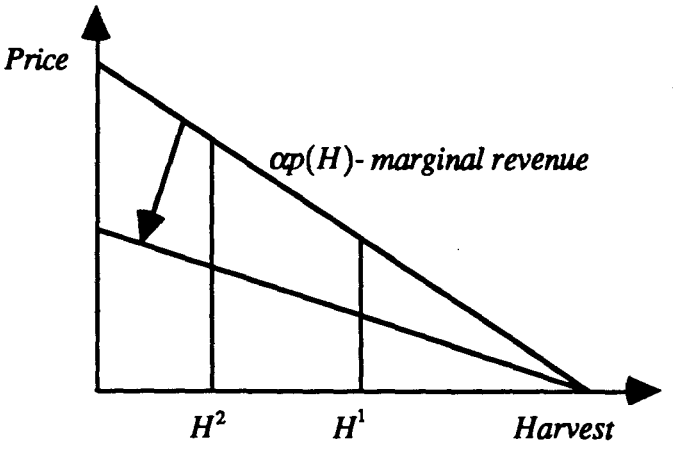

Fig. 2.

In low cost logging fields, the reallocation of logging activities from high cost to low cost fields counteracts the general tendency to reduce logging in all fields. The net effect on logging is therefore ambiguous in low cost fields. In high cost fields, on the contrary, the two effects reinforce each other. Hence, logging is unambiguously reduced there. In some high cost fields, logging may cease completely. And in marginal logging fields, where logging has not yet started, the forest may remain untouched because of the trade restrictions. (This latter effect will become even more pronounced when we take into account the costs of building infrastructure to make new fields accessible.)

Next, consider the impact of trade restrictions on the logging profile over time. Assume that there is only one logging field (field 1). The relevant first order conditions are then (6a) and (6c).

PROPOSITION 2

If there is only one logging field in a concession area, trade restrictions that cause timber prices to decline will lead to:

a) Reduced total logging during the concession period.

b) A reallocation of logging activity from the first to the second period.

Proof: See Appendix B.

As in the previous case, there is a general tendency towards reduced logging because of lower prices. In addition, trade restrictions cause a change in the optimal logging profile over time. Some of the logging activity will be postponed to the second period. In the first period, this effect reinforces the general tendency to reduce logging, causing first period logging to fall unambiguously. The two effects work in opposite directions in the second period, though.

The reason why it is optimal to postpone some logging to later periods is that, due to discounting, reduced prices cause a greater decline in near future profits than in distant future profits. This effect is apparent in Eq. (7a), where a price reduction will have a stronger negative impact on the left hand side than on the right hand side. In order to restore an optimal time profile, marginal costs must decline more in the near future than in the distant future. This implies that $c'(H_1)$ must decrease relative to $c'(H_2)$. Hence, it is optimal to increase H_2 relative to H_1. (Since $H_1 > H_2$ at the outset (see Observation 2), trade restrictions thus contribute to a more even logging activity during the concession period.)

Which conclusions can be drawn about the effect of timber trade restrictions in the complete two period, two field model? Based on a stepwise approach, it has been shown that a restrictive trade policy contributes to 1) reduced total harvest, 2) reallocation of logging activity from high cost to low cost logging fields, 3) postponement of logging into the future, and 4) reduced pressure on the virgin forest. These forces will, of course, be present in the complete model as well. To exercise comparative statics on the complete model would, in addition, make us able to draw more exact conclusions about the magnitudes of h_1^1, h_2^1, h_1^2 and h_2^2. But for our purposes, it is not required to move to this low level of aggregation. I therefore leave to future work to spell out the comparative statics of the complete model in greater detail.[35]

[35]A proof that the general conclusions of this section carry over to the complete model in the case of constant p' and c'' is available from the author on request.

Before discussing the environmental consequences of those changes in optimal logging behaviour that have been identified, let us see whether the results carry over to a model of sequential harvest.

b. Sequential harvest

Simultaneous harvest may not always be technically feasible, and it may be economically undesirable. Heavy machinery will destroy much of the forest while the loggers make their way from one place to another. If the costs of using less damaging equipment are greater than the gain from sweeping over the concession area in order to harvest the most valuable trees first, the logging companies will log the area sequentially, finishing logging in one field before moving on to the next.[36] Before starting the harvest in one field, the loggers must then decide which trees shall be utilized and which shall be discarded. To utilize a greater share of the forest is time-consuming. Since future profit is discounted, it might therefore be profitable to abandon some trees with a positive, but low, price-cost margin in order to move more quickly to the next logging field, where more high value timber is available.

In this section, the capacity constraint is modelled simply by assuming that the per period logging capacity is fixed and equal to $\overline{H}$. The total harvest in logging field i, H^i, is equal to $T^i\overline{H}$, where T^i is the number of periods that the loggers stay in field i. In the following, the fixed capacity is normalized to 1, implying that $H^i = T^i$.

Total income from logging in field i is $\int_0^{H^i} \alpha p(h)dh$. But unlike the simultaneous harvest model, where the most valuable timber is harvested first, all kinds of different qualities will be harvested in each period. Assuming that trees with different qualities are evenly distributed within each logging field, income per period in a field will be constant (and equal to the average income per period in that field). The harvest cost per period in logging field i is $\overline{c}^i$, and the constant per period profit in logging field i can thus be expressed as

$$\overline{\pi}^i = \frac{\int_0^{H^i} \alpha p(h)dh}{T^i} - \overline{c}^i. \qquad (10)$$

[36] An alternative explanation why sequential harvest may be preferable is that the loggers may be unable to finance the rapid building of new roads and other infrastructure required for simultaneous harvest. Moreover, the logging companies may be instructed by public authorities to harvest sequentially, as is the case in Indonesia.

By utilizing the fact that $H^i = T^i$, the complete continuous time maximization problem can be formulated as follows[37]

$$\max_{H^1,..,H^N} \pi(H^1,..,H^N) \equiv \overline{\pi}^1(H^1)\int_0^{H^1} e^{-rt}dt + \overline{\pi}^2(H^2)\int_{H^1}^{H^1+H^2} e^{-rt}dt + ... + \overline{\pi}^N(H^N)\int_{\sum_{i=1}^{N-1}H^i}^{\sum_{i=1}^{N}H^i} e^{-rt}dt, \tag{11}$$

$$s.t.\ \sum_{i=1}^{N} H^i \leq \overline{T}.$$

A two logging field model

To simplify the analysis, I will assume that there are only two logging fields ($N = 2$). The maximization problem can then be formulated as

$$\max_{H^1,H^2} \pi(H^1,H^2) \equiv \overline{\pi}^1(H^1)\int_0^{H^1} e^{-rt}dt + \overline{\pi}^2(H^2)\int_{H^1}^{H^1+H^2} e^{-rt}dt, \tag{12}$$

$$s.t.\ H^1 + H^2 \leq \overline{T}.$$

The Lagrangian corresponding to this problem is

$$L = \pi(H^1,H^2) + \lambda\left[\overline{T} - H^1 - H^2\right]. \tag{13}$$

Assuming that the time constraint is binding, the first order conditions are (H^i has been replaced by T^i where this seems appropriate):

$$H^1:\ \overline{\pi}^1 e^{-rT^1} + \frac{\partial \overline{\pi}^1}{\partial H^1}\int_0^{T^1} e^{-rt}dt - \overline{\pi}^2\left(e^{-rT^1} - e^{-r(T^1+T^2)}\right) - \lambda = 0, \tag{14a}$$

$$H^2:\ \overline{\pi}^2 e^{-r(T^1+T^2)} + \frac{\partial \overline{\pi}^2}{\partial H^2}\int_{T^1}^{T^1+T^2} e^{-rt}dt - \lambda = 0, \tag{14b}$$

$$\lambda:\ \overline{T} - T^1 - T^2 = 0. \tag{14c}$$

The first two terms in Eqs. (14a) and (14b) show the increase in profits from a marginal increase in the harvest in logging fields one and two, respectively. To harvest more in a field implies that some low quality trees that previously were discarded, will be utilized. $\partial\overline{\pi}^i/\partial H^i$ is therefore negative. In optimum, the incremental profit in the last logging field in the sequence

[37] In this model, the logging fields are indexed in accordance with their order in the sequence.

shall equal the shadow value of the time constraint (λ) (see Eq. (14b)). In fields earlier in the sequence, the incremental profit shall be greater than λ, because there is an additional cost involved in increasing the harvest in such fields. This cost is a time cost that arises because it is impossible to increase the harvest in a field without staying in the field for a longer period of time. But to stay longer implies that profits from the remaining logging fields will be earned at a later date. The third term in Eq. (14a) reflects this cost.

Note that if the time constraint is binding, increased logging in the first field will not only imply that the harvest from the second field is postponed. It will have to decline as well. By combining Eqs. (14a) and (14b), we see more clearly how this consideration enters the first order conditions

$$\left[\overline{\pi}^1 - \overline{\pi}^2\right]e^{-rT^1} + \frac{\partial \overline{\pi}^1}{\partial H^1}\int_0^{T^1} e^{-rt}dt - \frac{\partial \overline{\pi}^2}{\partial H^2}\int_{T^1}^{T^1+T^2} e^{-rt}dt = 0. \qquad (15)$$

The first term shows the gain from staying one additional period in field 1 (at the expense of time spent in field 2), assuming that $\overline{\pi}^1$ and $\overline{\pi}^2$ do not change. The effect of the changes in $\overline{\pi}^1$ and $\overline{\pi}^2$ is displayed by the two last terms; the second term reflecting the cost of reduced profit per period in field 1, and the third one reflecting the gain from higher $\overline{\pi}^2$ as logging in field 2 declines.

Observation 3 (Logging pattern II)
If $\overline{c}^i = \overline{c}^j$, $\forall i,j$, it is optimal to log the fields more and more intensively as one proceeds through the forest.

Proof: Assume that $\overline{c}^1 = \overline{c}^2$ and $H^1 = H^2$, implying that $\overline{\pi}^1 = \overline{\pi}^2$ and $\partial\overline{\pi}^1/\partial H^1 = \partial\overline{\pi}^2/\partial H^2$. As is seen from Eq. (15), this cannot be an optimal logging pattern, since the left hand side will be negative. Now assume that $H^1 (=T^1)$ is increased (and H^2 is held constant or increased by a smaller amount than H^1). It is easily seen that this will make the left hand side of Eq. (15) even more negative (the first term will become negative, the second will become more negative, and the third will become less positive). Hence, a necessary condition for optimum is that $H^1 < H^2$.

If the loggers harvest the same amount in each field when the marginal costs are identical across the fields, the profit per period will be the same throughout the harvesting sequence. To see that this cannot be an optimal logging pattern, let the logger take a unit of time that was previously used in field one and use it in field two instead. Since the logger now moves more quickly through field one, his profit per period will become slightly higher in the beginning of the sequence. Profit per period will decline correspondingly at the end of the sequence (when field

two is harvested), implying that a marginal reallocation of logging efforts will leave total profits unchanged. However, since more of the profit is earned at an earlier date, discounted profits will increase.

Observation 4 (Logging pattern III)
When marginal harvest costs are increasing over the sequence, the harvest in low cost fields may be greater or smaller than the harvest in high cost fields.

In low cost fields, a greater number of trees are candidates for logging than in high cost fields. This provides a reason for staying longer and harvesting more in a low cost field than in a high cost field. However, as was shown in Observation 3, the time cost induces the loggers to harvest less in the fields early in the sequence. Which effect that will dominate depends on the discount rate and on the magnitude of the difference in marginal harvest costs between the fields.

Observations 3 and 4 show that sequential harvest may induce a logging pattern that is very different from the logging pattern with simultaneous harvest (cf. Observation 1). With simultaneous harvest, it is only differences in marginal harvest costs that can make it desirable to change the logging pattern from field to field. Here, the total harvest in a field is affected by the field's place in the harvesting sequence as well.

Trade restrictions on tropical timber

The effects of trade restrictions on the logging of tropical timber will depend somewhat on whether the length of the concession period is a binding constraint. If logging capacity is abundant relative to the amount of commercial trees in the concession area, it might be profitable to finish logging before the end of the concession period (because of discounting).[38] With short concession periods, on the other hand, the length of the concession period is likely to bind. By total differentiation of the first order conditions (14a) through (14c) with respect to the trade policy parameter α, we obtain:

PROPOSITION 3
If the length of the concession period is binding, trade restrictions that cause a proportional decline in timber prices will lead to:

a) No change in total logging.

b) Reduced logging in the high cost field.

[38]Note that if the discount rate is high, it may be profitable to finish the sequence before the end of the concession period even though many trees with a positive price-cost margin then must be discarded in the course of the sequence.

c) Increased logging in the low cost field.

d) No change in the logging pattern if $\bar{c}^1 = \bar{c}^2$.

e) Possibly, a greater part of the concession area being left untouched.

Proof: See Appendix C.

The result that total harvest is unaffected by trade restrictions is, of course, due to the assumption about fixed capacity. If the loggers somehow are unable to expand their production capacity as much as they want to, the marginal profit will be positive. In that case, we should not expect timber trade restrictions to reduce logging (unless timber prices decline so much that the capacity constraint ceases to bind). However, if the capacity constraint had been modelled as in the simultaneous harvest model, i.e., by increasing marginal costs in total logging per period, we would probably obtain that trade restrictions cause a reduction in total timber extraction in the present model as well.

As in the simultaneous harvest model, trade restrictions do not cause any reallocation of logging activity between the fields when $\bar{c}^1 = \bar{c}^2$. In short, the optimal logging pattern remains unchanged if the price reduction causes marginal profits to decline by the same amount in both fields. When $\bar{c}^1 = \bar{c}^2$, marginal *incomes* are identical in optimum. A proportional price fall, which will lead to a proportional decline in marginal incomes, will therefore cause the same reduction in marginal profits in both fields. Otherwise when $\bar{c}^1 \neq \bar{c}^2$: marginal income then has to be higher in the high cost field in optimum (in order to equalize marginal profits). A proportional price fall will therefore cause a greater reduction in marginal income in the high cost field, leading to a change in relative marginal profitability in favour of the low cost field. This explains why logging activity is reallocated to the low cost field in the wake of timber trade restrictions. (Note that it is not important for this result that trade restrictions induce a *proportional* price reduction. The crucial point is that the marginal income declines most (in absolute terms) in the field where the marginal income is highest at the outset, i.e., in the high cost field).

In those fields where it is optimal to reduce the logging activity, logging may cease completely. More virgin forest may thus be left unexploited. This effect will be reinforced when taking into account the costs of building infrastructure to make new fields accessible.

PROPOSITION 4

If the length of the concession period is non-binding, trade restrictions that cause a proportional decline in timber prices will lead to:

a) Reduced logging in the last field in the sequence.

b) Reduced or increased logging in the first field in the sequence. Logging in this field is reduced if $\bar{c}^1$ is not very low relative to $\bar{c}^2$.
c) Reduced total logging if $\bar{c}^1$ is not very low relative to $\bar{c}^2$.
d) Possibly, a greater part of the concession area being left untouched.

Proof: See Appendix D.

In both fields there is a general tendency to reduce logging when prices fall. However, in the first field in the sequence, there is a counteracting effect. Part of the harvest cost in this field is the cost of postponing the harvest in subsequent fields (see the last term in Eq. (14a)). This cost is reduced as the price fall causes profits in subsequent fields to decline. When $\bar{c}^1 < \bar{c}^2$, this counteracting effect may be so strong that trade restrictions lead to increased logging in the first field. Once more, then, we observe that trade restrictions may cause increased logging in low cost fields.

In the last field in the sequence, there is no such counteracting effect, and logging is therefore unambiguously reduced. This has the further implication that trade restrictions may cause less of the concession area to be exploited, thus preserving more of the virgin forest.

When the length of the concession period does not bind, we would expect reduced timber prices to have an unambiguous negative effect on total logging. I have not been able to attain this conclusion as a general result in the present model, however. The reason being, once more, the constraints that sequential harvest imposes upon the logging pattern. What drives the marginal profit to zero (in all fields except the last one in the sequence) is not a low level of profit in the fields as such, but the costs of postponing the harvest in subsequent fields. Since trade restrictions will cause these costs to decline, there is a theoretical possibility that total logging may increase. Numerical simulations suggest, though, that we make no great mistake by assuming that total logging will be reduced in this case as well.

Environmental implications

From an environmental point of view, the most significant conclusion of the preceding analysis is that trade restrictions will probably make the loggers leave more of the virgin forest unexploited. With a positive species-area relationship, this implies that trade restrictions on tropical timber and timber products will promote the protection of biodiversity in the tropical forests. This effect has been overlooked in many previous studies of this issue.

Furthermore, it has been shown that logging may increase in low cost logging fields, implying that timber trade restrictions have an ambiguous impact on aggregate profit in such fields (prices decline and quantity increases). This insight is important for the discussion about the effect of trade restrictions on the allocation of land between forestry and competing activities. As will be demonstrated in Section 4.2, the reallocation of logging activities from high cost to low cost fields will counteract (and may under certain circumstances neutralize) the tendency to convert forest land into alternative uses in the wake of trade restrictions on tropical timber. This result gives reason to be more optimistic about the environmental effects of timber trade restrictions than what appears to be the prevailing view in the literature.

Another result from the analysis is that trade restrictions may make it profitable to postpone some logging to later periods. This will probably slow down the eradication of potentially valuable species. To retard this process is beneficial from an environmental point of view, because there is an option value involved in postponing the destruction of genetic material. Furthermore, given the enormous amount of uncertainty attached to the greenhouse problem and the high costs of reducing the concentration of carbon-dioxide in the atmosphere, there is an option value related to the postponing of carbon emissions as well. It remains to be discussed, however, whether trade restrictions on tropical timber will reduce or increase carbon emissions.

Since the models I have used here do not capture the complexity of the relationship between logging and the storage of terrestrial carbon compounds, they can, of course, give no definite answer to the question of how timber trade restrictions will affect carbon storage. However, the insights we have obtained about the relationship between trade restrictions and logging activities display more clearly which conditions that must be satisfied in order for timber trade restrictions to be able to reduce the level of carbon emissions.

An important conclusion in this paper is that trade restrictions are likely to reduce total logging in a forest that is mined.[39] In those fields where logging ceases completely, this change will probably cause reduced carbon emissions in the foreseeable future. With the low conversion rates of tropical trees into durable products, it is unlikely that the growth of new trees in an area that has been logged will be able to compensate for the carbon loss from the trees that have been removed.

More uncertainty attaches to the effect on carbon storage in those fields where logging does not cease. Since reduced logging in such fields may cause a greater share of the trees to be damaged

[39]In models where biological processes are taken into account by the decision makers, the effect of trade restrictions on total logging tends to be ambiguous. See Barbier and Rauscher (1993, p. 7).

or destroyed, carbon emissions may in fact increase. The picture is further complicated by the fact that logging is not necessarily reduced in all fields, but may increase in some low cost fields. To draw any definite conclusions about the effect of timber trade restrictions on carbon storage in inframarginal fields is therefore impossible without careful empirical analysis.

Finally, we need to consider the effect of the change in logging pattern on the behaviour of shifting cultivators. Reduced logging and less intrusion of logging companies into virgin forest will make it more costly for shifting cultivators to convert forest land into agricultural uses. This will probably slow down the slashing and burning of forest land and will therefore be beneficial from a carbon storage point of view. However, the opposite effect may be observed in low cost fields where logging may increase. And the development in the low cost fields is perhaps what is most significant for the behaviour of shifting cultivators, since it seems reasonable to assume that the fields with low harvest costs correspond pretty well to the fields where agriculture is most profitable.

4.2 Governments

Several authors have underscored the importance of public policies for the extent of tropical deforestation.[40] Governments affect deforestation through the allocation of land to competing activities, through regulations of logging companies, through various kinds of taxes and subsidies, and through direct involvement in forest management (e.g., in reforestation activities and the running of timber plantations). In the following, I shall concentrate on the question of how timber trade restrictions will affect the allocation of land between forestry and competing activities, particularly agriculture. In addition, I shall have something to say about how timber trade restrictions will affect the management of timber plantations, i.e., forests that are planted and harvested according to traditional principles for forestry in temperate regions.

The allocation of land

The standard objection against timber trade restrictions has been that by making forestry less profitable, more forest land will be converted into agricultural uses. In practice, much deforestation has been caused by such forest conversion. According to Repetto and Gillis, clearance of forests for cattle ranching accounted for 70% of deforestation in Brazil up to 1980.[41] In other areas, forest conversion by shifting cultivators is held as the main reason for deforestation. I am going to argue, however, that it is not obvious that timber trade restrictions

[40]Repetto and Gillis (1988), among others.
[41]Repetto and Gillis (1988, p. 34).

will promote the conversion of forest land into agricultural uses. Counteracting forces may be at work.

Assume that a tropical country has available a given amount of land ($\bar{L}$) that can be allocated to agriculture (A) or forestry (F). Since the tropical forests are publicly owned, the government has a direct impact on the allocation of forest land through the awarding of timber concessions and public decisions about forest conversion. In addition, the government may influence this allocation through the incentives they give to private agents (e.g., shifting cultivators).

In order to focus exclusively on the economic dimension of the land allocation problem, it will be assumed that the government is a profit maximizer.[42] Furthermore, I assume that land is a heterogeneous resource. I have argued that profits in forestry may vary from field to field, and that some fields do not seem to be worth exploiting at all. The land is heterogeneous from an agricultural point of view as well. Not only are there increased costs of transportation when production takes place farther away from the cities; there is ample reason to believe that the soil in many areas that today are covered by tropical forest, is simply ill-suited for permanent agriculture. Most nutrients in tropical forests are located in the forest itself or in the ground cover. When trees are removed, most nutrients disappear. Much fertilizing is therefore needed in order to sustain permanent agriculture in tropical forests. Alternatively, if the land is left to natural fallow, as is done by shifting cultivators, very long fallow periods are needed for the soil to regenerate its fertility.[43] Hence, agriculture in these areas tends to be rather unprofitable.[44]

The assumptions made about the profitability of different land uses are summarized in Fig. 3. The heterogeneity of land is reflected in different profit levels for each unit of land. I assume that the ranking of different land units in terms of profitability is independent of whether the land is used for forestry or agriculture; some units of land are simply more fertile and more accessible than others, irrespective of what is grown. The profit per unit of land can thus be shown by two declining profit curves along the same land scale. Furthermore, I assume that forestry is profitable in a larger area than agriculture, partly because forestry normally is less demanding in terms of accessibility, and partly because of the high costs of agricultural

[42]Needless to say, this is a strong simplification. The allocation of land is, of course, heavily influenced by political consideration as well. By way of illustration, timber concessions have for a long time been used in Indonesia as an award to retired military leaders, thus being utilized by the government to secure its power (Kasa, 1993).

[43]Lewis and Berry (1988, p. 143) report from their study of African rain forests that after 2-4 years of agricultural utilization, a fallow period of 8-19 years is needed in order to regenerate fertility.

[44]This is clearly demonstrated by the large subsidies needed to induce forest conversion in Brazil.

production in areas that presently are covered by tropical forest. Finally, I assume that there are some areas (not the least fertile ones) in which agriculture is more profitable than forestry.[45]

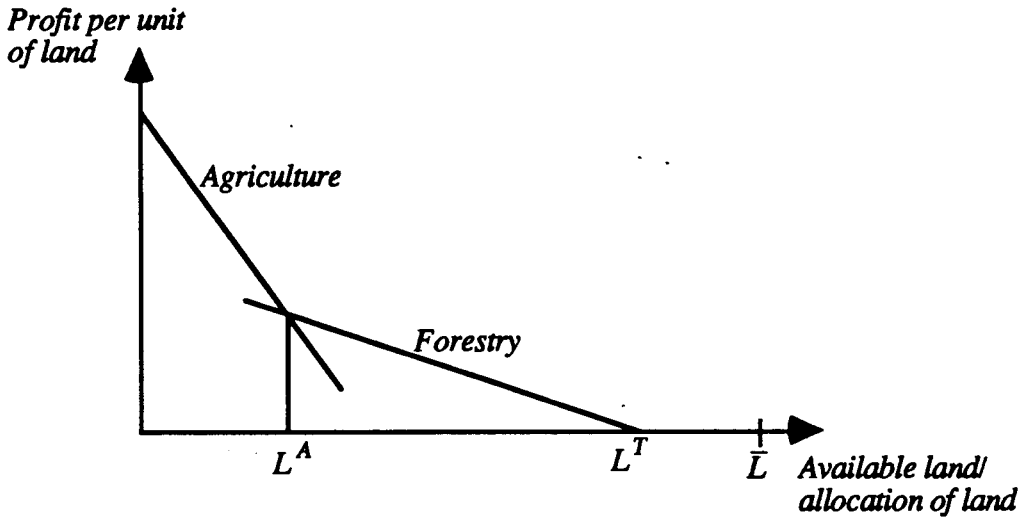

Fig. 3.

Given these assumptions, the optimal allocation of land between forestry and agriculture can be found at the intersection between a pair of profit curves as in Fig. 3. In optimum, L^A units of land are allocated to agriculture and $L^T - L^A$ units are allocated to forestry, where L^T is the total amount of land in use.

As shown in the figure, some of the available land may simply be left untouched (e.g., as virgin forest). The analysis in Section 4.1 demonstrated that timber trade restrictions would tend to reduce L^T and thus contribute to less intrusion into virgin forests. I am now going to discuss how such trade restrictions will affect L^A.[46]

Let $v^i(L)$ denote the profit that can be obtained on land unit L in the alternative uses ($i = A,F$). The government's decision problem can then be formulated as

$$\max_{L^A}\left[\int_0^{L^A} v^A(y)dy + \int_{L^A}^{L^T} v^F(\alpha,y)dy\right], \qquad s.t.\ L^T \le \bar{L}, \tag{16}$$

[45]Fig. 3 might be extended to allow for several intersections between the profit curves. That would not affect the main conclusions of this discussion.

[46]Note that if there are capacity constraints in forestry, implying that some profitable fields will not be harvested, we need to take into account that a new frontier between agriculture and forestry may affect the frontier between forestry and virgin forests as well. Such effects are ignored in the following.

where α is the parameter reflecting timber trade policies. It will be assumed that the land constraint is non-binding (i.e., there are still some unexploited areas). The first order condition is then

$$v^A(L^A) = v^F(\alpha, L^A), \tag{17}$$

saying that the frontier between agriculture and forestry should be determined so that the marginal profit in agriculture should equal the profit per unit of land in the most profitable logging field.

The effect of trade restrictions on the optimal allocation of land can now be found by implicit differentiation of Eq. (17) with respect to α;

$$\frac{dL^A}{d\alpha} = \frac{\dfrac{\partial v^F(\alpha, L^A)}{\partial \alpha}}{\dfrac{\partial v^A(L^A)}{\partial L^A} - \dfrac{\partial v^F(\alpha, L^A)}{\partial L^A}}. \tag{18}$$

From the assumptions about the profit curves (or from the second order condition), we know that the denominator is negative. Hence, $dL^A/d\alpha$ will have the opposite sign of the profit change in the most profitable logging field. Let us therefore return to the framework of Section 4.1 and take a closer look at the effect of timber trade restrictions on the level of profit. The profit in field i was defined as[47]

$$\pi^i = \int_0^{H^i(\alpha)} \hat{p}(y, \alpha)dy - \bar{c}^i H^i(\alpha). \tag{19}$$

By differentiation of Eq. (19) with respect to α, we obtain

$$\frac{\partial \pi^i}{\partial \alpha} = \int_0^{H^i} \frac{\partial \hat{p}}{\partial \alpha} + \left(\hat{p}(H^i, \alpha) - \bar{c}^i\right)\frac{dH^i}{d\alpha}. \tag{20}$$

We know that $\partial \hat{p}/\partial \alpha > 0$ and $\hat{p}(H^i, \alpha) - \bar{c}^i \geq 0$, with strict inequality when the loggers are capacity constrained. The sign of $\partial H^i/\partial \alpha$ is ambiguous (see Propositions 1, 3, and 4); in the most profitable logging fields, there is a possibility that total harvest may increase after timber trade restrictions have been imposed (i.e., $\partial H^i/\partial \alpha$ may be negative).

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[47]For simplicity, it has been assumed that the discount rate is zero and that the capacity cost is not a function of the harvest volume (i.e., there is only a fixed capacity constraint).

PROPOSITION 5

If the loggers are capacity constrained, timber trade restrictions have an ambiguous effect on the profit extracted from the most profitable logging fields. Hence, the impact on the optimal allocation of land between agriculture and forestry is ambiguous as well.

Since the price-cost margin is positive when there are capacity constraints, a higher harvest volume in the low cost fields will contribute positively to profits. Whether this profit increase is able to outweigh the profit loss from lower timber prices depends, *inter alia*, on the magnitude of the term $\partial\hat{p}/\partial\alpha$ at the various tree quality levels. It is easy to show that the net effect on profits may be positive. This is most readily seen by recalling that more of the concession area may be left untouched in the wake of timber trade restrictions (see Propositions 1 and 4). Although total profits will be reduced when prices fall, the remaining profit may thus be extracted from a smaller area. Profit per unit of land does therefore not necessarily decline.[48]

The general insight from this analysis is that since timber trade restrictions may cause a reallocation of logging activities from less profitable to more profitable logging fields, the decline in profits will not necessarily be very great in the most profitable fields. If the threat of agricultural expansion is most severe in these logging fields, as might well be the case, we should be less concerned about forest conversion in the wake of timber trade restrictions than we otherwise would be. (Note that since this conclusion is based on the existence of capacity constraints, we might expect that the conclusion is valid only in the short run. However, since capital markets are poorly developed in many tropical countries, the "short run" may turn out to be rather long indeed.)

The management of timber plantations

So far in this paper, tropical forestry has been modelled as a mining activity. I would like to close my discussion by commenting on how timber trade restrictions might affect tropical forestry if instead the forest were managed as a timber plantation where the decision makers have a long run perspective and therefore take into account that the forest is a growing resource. Although a rather small portion of the tropical forests is presently managed as timber plantations, this focus may still be relevant for several reasons. First, tropical countries are

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[48]It might be objected that since the possible ambiguity in Proposition 5 does not arise unless $\hat{p}(H^i,\alpha) > \bar{c}^i$, we ought to bring into the analysis that L^T may be a function of L^A. In general, a positive price-cost margin on the marginal logging field will give a reason to increase L^A (the cost of moving the logging activity further into the forest would be lower). When timber prices decline, however, this reason to increase L^A becomes weaker, thus reinforcing the ambiguity stated in Proposition 5.

being urged by many to base their timber production on sustainable management of secondary forest rather than on mining of virgin forest. Secondly, since virgin forests will eventually disappear if logging continues at today's rate, the importance of secondary forest is likely to increase in the foreseeable future.

The main economic decision on a timber plantation is to determine at which age to harvest the trees. This problem, usually called the optimal rotation problem, has been thoroughly discussed in the forestry literature, and my discussion here will not deviate much from standard expositions.[49]

In order to stress that the decision makers have a long term perspective on forest management, assume that they are profit maximizers with an infinite time horizon. Let c_p denote the planting cost for a single tree.[50] The volume of a tree which was planted T years ago is given by the function $h(T)$, $h' > 0$. The price (p) and the harvest cost (c) per volume unit are both assumed to be constant (and thus independent of the age of the tree). The discounted profit from planting a tree and harvesting it after T years is then $(p-c)h(T)e^{-rT} - c_p$. Since the optimal rotation period must be identical for all rotations, the discounted profit over an infinite time horizon can be written

$$\begin{aligned}\pi(T) &= \left[(p-c)h(T)e^{-rT} - c_p\right]\left[1 + e^{-rT} + e^{-r2T} + ...\right] \\ &= \frac{(p-c)h(T)e^{-rT} - c_p}{1-e^{-rT}}.\end{aligned} \tag{21}$$

By differentiation of Eq. (21) with respect to T, we obtain the following first order condition for the optimal rotation period[51]

$$(p-c)h'(T) = r(p-c)h(T) + r\pi(T). \tag{22}$$

The interpretation of Eq. (22) is that a tree shall be cut when the value growth of the tree per period equals the costs of a one period delay in the harvest; the latter including both the cost of postponing the harvest of the current rotation and the cost of postponing all future rotations.

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[49]See, for instance, Johansson and Löfgren (1985) and Samuelson (1976).

[50]Regrowth may be secured either through replanting or through some kind of managed "natural" regrowth, where non-commercial species are removed in order to promote the growth of high-valued species. c_p denotes the costs of any such management activities.

[51]This is the Faustman optimal rotation period. See Johansson and Löfgren (1985, p. 80).

PROPOSITION 6[52]

Timber trade restrictions leading to lower timber prices will increase the optimal rotation period.

Proof: The effect of trade restrictions on the optimal rotation period can be found by differentiation of Eq. (22) with respect to p. By utilizing the fact that $\partial\pi/\partial T = 0$ in optimum, we obtain

$$\frac{dT}{dp} = \frac{rh(T) - h'(T) + \dfrac{rh(T)e^{-rT}}{1-e^{-rT}}}{(p-c)h'' - r(p-c)h'} = \frac{rc_p}{(p-c)^2(1-e^{-rT})(h''-rh')} < 0. \tag{23}$$

The second order condition implies that the denominator is negative, and Proposition 6 then follows straightforwardly.

Environmental implications

Longer rotation periods will have implications for the storage of carbon in the forest. If we make the extreme assumption that all carbon in a tree is released into the atmosphere once the tree is cut, the greatest average storage of carbon is obtained by maximizing the average volume of the forest per unit of time. The average amount of carbon stored in the timber plantation will then be greater the longer the rotation periods, simply because the average size of the trees then will be larger (remember that $h' > 0$). Hence, if these premises are correct, timber trade restrictions will be beneficial from an environmental point of view.

If we go to the other extreme, though, and assume instead that the carbon in the harvested trees is stored forever in durable products, it is no longer important to have much carbon stored in the forest. In this case, the forest is environmentally important only as a carbon absorber, not as a storage unit. The maximal total storage of carbon in tree products will be obtained by keeping the average growth in the forest (per unit of time) as high as possible. This implies that we should choose T so as to maximize $h(T)/T$. The average growth is maximized by the rotation period T_G given by

$$T_G = \frac{h(T_G)}{h'(T_G)}, \tag{24}$$

[52]For a similar result, see Johansson and Löfgren (1985, pp. 81-82).

which can be interpreted as the time when the current annual increment $h'(T)$ equals the mean annual increment $h(T)/T$. (T_G is thus the rotation period that gives the *Maximal Sustainable Yield*). By comparing Eq. (24) with the expression for the optimal economic rotation period (Eq. (22)), we see that it is generally unclear whether the optimal rotation period is shorter or longer than the period that would maximize average growth. If the optimal rotation period T^* is longer than T_G, timber trade restrictions will lead to reduced average growth in the forest and thus cause a reduction in total carbon storage.[53]

This implies that at our current level of abstraction, no unambiguous conclusion about the effect of trade restrictions on carbon storage in timber plantations can be drawn. Available evidence indicates, however, that the duration of tree products is very short in tropical forestry. Therefore, our best guess would be that the hypothesis of immediate carbon release is closer to the truth than the hypothesis of infinite duration of tree products. This suggests that timber trade restrictions are likely to have a positive effect on the storage of carbon in timber plantations.

A word of caution is needed before closing this discussion. I have assumed here that the area used for timber plantations is unaffected by timber trade restrictions. However, such trade policies might very well reduce the optimal size of timber plantations, thereby counteracting any of the possible positive effects on carbon storage that we identified above. But once we bring up the issue of land allocation, we need to specify the alternative uses of the plantation area as well. Will it be converted into agricultural land, or will it simply be left for natural growth? If the latter is the case, the reduced size of timber plantations is not necessarily detrimental from an environmental point of view. I leave to future work to analyse the implications of timber trade restrictions in a model where land is allocated optimally to agriculture, timber plantations, and logging of virgin and old-growth forests.

5. Concluding remarks

The tropical forests provide a series of environmental benefits to the global community. In this study, I have focused on the forest as a source of biological richness and as a place for carbon absorption and storage. We have seen that there are complex relations between the activities in the forest and the respective environmental variables at issue. Hence, we cannot expect trade restrictions on tropical timber and timber products to become more than a crude instrument for attaining our environmental objectives.

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[53]Assuming that $h'' < 0$, it follows from Eqs. (22) and (24) that $T^* > T_G$ when

$$\frac{1}{T_G}h(T_G) > rh(T^*) + r\frac{\pi(T^*)}{p-c}.$$

This inequality will be satisfied at low discount rates.

This qualification notwithstanding, the present study is probably more optimistic about the effects of trade restrictions on tropical timber than several other studies of the same problem.[54] For example, I have pointed out that trade restrictions might have positive effects on the protection of virgin forest. Maybe this is the main objective of the trade measures that have been proposed in Western countries? After all, the connection between timber extraction and carbon storage is somewhat unclear, and the global community possesses other, more efficient measures to deal with the greenhouse problem (albeit the distribution of costs will be different with other policy instruments). Otherwise in regard to biological diversity: this is a unique feature of the tropical forests, and has to be dealt with there. For this purpose, it has been shown that timber trade restrictions might be a useful instrument.

Furthermore, I have demonstrated that the concern about conversion of forests into agricultural land in the wake of timber trade restrictions may be somewhat exaggerated. Lower timber prices do not necessarily cause large profit reductions in the most profitable logging fields, because logging companies may increase their extraction in such fields. This effect is likely to counteract the conversion pressure.

I would also like to underscore the importance of distinguishing between governments and private actors. Although most of this study has assumed profit maximizing behaviour, there is ample reason to believe that governments at least will be heavily influenced by other objectives as well. These objectives need to be identified before making recommendations about the implementation of timber trade restrictions. Moreover, we should be aware that there are psychological mechanisms involved in international politics that are not captured by standard assumptions about the effects of economic incentives on government behaviour. R. M. Stern, among others, has argued convincingly along these lines:

> There is also reason to doubt that even draconian trade policies such as embargoes can ever be very effective in changing the behaviour of foreign governments and their constituencies. Trade can have powerful effects. But when used as a weapon, it seems more likely to generate resistance, rather than fear, in the hearts of the victims... On the other hand, it is conceivable that trade policy might be more successful in influencing policies abroad if it were oriented toward providing positive rather than negative incentives in the political sphere.[55]

Finally, I would like to mention an issue that may have received too little attention in this study; the possibility to implement discriminating trade measures. It might be desirable, from an

[54]See ITTO (1993), Barbier and Rauscher (1993), and Vincent (1990).
[55]Quoted in Blackhurst and Subramaninan (1992, p. 261).

environmental point of view, to discriminate either between different countries, or between timber from different sources within each country. For instance, it might be expedient to restrict imports from South-East Asia, while encouraging imports from Brazil, because the forest land seems to be more seriously threatened from alternative uses in Brazil. (Such discrimination is likely to conflict with existing GATT rules, though.)

More interesting, perhaps, is the possibility to discriminate between timber from different sources within a country. Trade restrictions should encourage tropical countries to rely less on the mining of virgin forest, and more on the sustainable management of secondary forest. It has been estimated that if all timber production in the tropics were from timber plantations, a given timber production could be sustained on only 15-20% of the area used for production today.[56] Although this estimate probably is an optimistic one, it indicates that a more extensive use of timber plantations might substantially reduce the intrusion into the virgin forest. To stimulate the substitution of timber plantations for traditional forest mining therefore seems desirable from an environmental point of view.

[56]Long and Johnson (1981). See Repetto and Gillis (1988, p. 75).

Appendix A

Differentiate the first order conditions in Eq. (9) with respect to α, assuming that the initial value of α is one. We obtain

$$\begin{bmatrix} \frac{\partial p}{\partial H^1} - \frac{1}{2}c'' & -\frac{1}{2}c'' \\ -\frac{1}{2}c'' & \frac{\partial p}{\partial H^2} - \frac{1}{2}c'' \end{bmatrix} \begin{bmatrix} \frac{dH^1}{d\alpha} \\ \frac{dH^2}{d\alpha} \end{bmatrix} = \begin{bmatrix} -p(H^1) \\ -p(H^2) \end{bmatrix}. \tag{A.1}$$

Solving this system with respect to $dH^1/d\alpha$ yields

$$\frac{dH^1}{d\alpha} = \frac{-\frac{\partial p}{\partial H^2}p(H^1) + \frac{1}{2}c''\left(p(H^1) - p(H^2)\right)}{\frac{\partial p}{\partial H^1}\frac{\partial p}{\partial H^2} - \frac{1}{2}c''\left(\frac{\partial p}{\partial H^1} + \frac{\partial p}{\partial H^2}\right)}. \tag{A.2}$$

The sign of this expression is ambiguous; it is positive when $c'' = 0$, and it becomes negative when $c'' \to \infty$, since $p(H^1) < p(H^2)$ (see Observation 1). Hence, the impact of timber trade restrictions on the total harvest in the most profitable logging field is unclear.

By solving (A.1) with respect to $dH^2/d\alpha$, we obtain

$$\frac{dH^2}{d\alpha} = \frac{-\frac{\partial p}{\partial H^1}p(H^2) + \frac{1}{2}c''\left(p(H^2) - p(H^1)\right)}{\frac{\partial p}{\partial H^1}\frac{\partial p}{\partial H^2} - \frac{1}{2}c''\left(\frac{\partial p}{\partial H^1} + \frac{\partial p}{\partial H^2}\right)} > 0. \tag{A.3}$$

Timber trade restrictions (reduced α) will thus lead to an unambiguous decline in logging in the least profitable field. If the price fall is large enough, the optimal H^2 will fall to zero, implying that a previously profitable field will be left untouched.

By combining Eqs. (A.2) and (A.3), it is easily seen that trade restrictions will reduce the total harvest unambiguously;

$$\frac{dH^1}{d\alpha} + \frac{dH^2}{d\alpha} = \frac{-\left(\frac{\partial p}{\partial H^2}p(H^1) + \frac{\partial p}{\partial H^1}p(H^2)\right)}{\frac{\partial p}{\partial H^1}\frac{\partial p}{\partial H^2} - \frac{1}{2}c''\left(\frac{\partial p}{\partial H^1} + \frac{\partial p}{\partial H^2}\right)} > 0. \tag{A.4}$$

Appendix B

Differentiate the first order conditions (6a) and (6c) with respect to α. By normalizing the initial value of α to one, we obtain (superscripts are suppressed since we consider only one logging field)

$$\begin{bmatrix} p'(h_1)-c''(h_1)+\dfrac{p'(H)-p'(h_1)}{(1+r)} & \dfrac{p'(H)}{(1+r)} \\ p'(H) & p'(H)-c''(h_2) \end{bmatrix} \begin{bmatrix} \dfrac{dh_1}{d\alpha} \\ \dfrac{dh_2}{d\alpha} \end{bmatrix} = \begin{bmatrix} -p(h_1)-\dfrac{p(H)-p(h_1)}{(1+r)} \\ -p(H) \end{bmatrix}. \quad \text{(B.1)}$$

Solving (B.1) with respect to $dh_1/d\alpha$ and $dh_2/d\alpha$ yields (after some algebraic manipulation)

$$\frac{dh_1}{d\alpha} = \frac{[rp(h_1)+p(H)]\dfrac{c''(h_2)}{1+r}}{|D|} - \frac{p(h_1)p'(H)\dfrac{r}{1+r}}{|D|} > 0, \quad \text{(B.2)}$$

$$\frac{dh_2}{d\alpha} = \frac{p(H)\left[c''(h_1)-p'(h_1)\dfrac{r}{1+r}\right]}{|D|} + \frac{p(h_1)p'(H)\dfrac{r}{1+r}}{|D|}, \quad \text{(B.3)}$$

where $|D| = p'(h_1)(p'(H)-c''(h_2))\dfrac{r}{1+r} - p'(H)\left(c''(h_1)+\dfrac{c''(h_2)}{1+r}\right)+c''(h_1)c''(h_2) > 0$. The first term both in Eq. (B.2) and in Eq. (B.3) is positive. These terms reflect the general tendency to reduce logging in the wake of timber trade restrictions. To the last term in Eq. (B.2), which is positive, there corresponds a negative term in Eq. (B.3). These terms reflect that it is optimal to reallocate some logging activity from the first to the second period.

It follows straightforwardly from Eqs. (B.2) and (B.3) that optimal total logging is reduced ($dh_1/d\alpha + dh_2/d\alpha > 0$).

Appendix C

Differentiate the first order conditions (14a) through (14c) with respect to α, assuming that the initial value of α is one. After making use of the relations

$$\frac{\partial \overline{\pi}^i}{\partial \alpha} = \overline{\pi}^i + \overline{c}^i, \text{ and } \frac{\partial^2 \overline{\pi}^i}{\partial H^i \partial \alpha} = \frac{\partial \overline{\pi}^i}{\partial H^i}$$

in addition to the first order conditions themselves, we obtain the following system

$$\begin{bmatrix} N_1 & -r\lambda & -1 \\ -r\lambda & N_2 & -1 \\ -1 & -1 & 0 \end{bmatrix} \begin{bmatrix} dH^1/d\alpha \\ dH^2/d\alpha \\ d\lambda/d\alpha \end{bmatrix} = \begin{bmatrix} -\lambda - \overline{c}^2 e^{-r(T^1+T^2)} - (\overline{c}^1 - \overline{c}^2)e^{-rT^1} \\ -\lambda - \overline{c}^2 e^{-r(T^1+T^2)} \\ 0 \end{bmatrix}, \tag{C.1}$$

where

$$N_1 = 2\frac{\partial \overline{\pi}^1}{\partial H^1} e^{-rT^1} - r\overline{\pi}^1 e^{-rT^1} - r\overline{\pi}^2 \left(e^{-r(T^1+T^2)} - e^{-rT^1} \right) + \frac{\partial^2 \overline{\pi}^1}{\partial (H^1)^2} \int_0^{T^1} e^{-rt} dt, \tag{C.2}$$

$$N_2 = 2\frac{\partial \overline{\pi}^2}{\partial H^2} e^{-r(T^1+T^2)} - r\overline{\pi}^2 e^{-r(T^1+T^2)} + \frac{\partial^2 \overline{\pi}^2}{\partial (H^2)^2} \int_{T^1}^{T^1+T^2} e^{-rt} dt. \tag{C.3}$$

From the second order condition we know that the determinant of the bordered Hessian ($|D|$) is positive. Using Cramer's Rule, we obtain

$$\frac{dH^1}{d\alpha} = \frac{(\overline{c}^1 - \overline{c}^2)e^{-rT^1}}{|D|}, \tag{C.4}$$

$$\frac{dH^2}{d\alpha} = \frac{-(\overline{c}^1 - \overline{c}^2)e^{-rT^1}}{|D|}. \tag{C.5}$$

Eqs. (C.4) and (C.5) show that 1) $dH^1/d\alpha + dH^2/d\alpha = 0$, 2) $\partial H^i/\partial \alpha > 0$ iff $\overline{c}^i > \overline{c}^j$, $i \neq j$, and 3) $dH^1/d\alpha = dH^2/d\alpha = 0$ iff $\overline{c}^1 = \overline{c}^2$.

Appendix D

When the time constraint does not bind, $\lambda = 0$. By total differentiation of the first order conditions (14a) and (14b) with respect to α, assuming that the initial value of α is one, we obtain

$$\begin{bmatrix} N_1 & 0 \\ 0 & N_2 \end{bmatrix} \begin{bmatrix} dH^1/d\alpha \\ dH^2/d\alpha \end{bmatrix} = \begin{bmatrix} -\bar{c}^2 e^{-r(T^1+T^2)} - (\bar{c}^1 - \bar{c}^2) e^{-rT^1} \\ -\bar{c}^2 e^{-r(T^1+T^2)} \end{bmatrix}, \tag{D.1}$$

where N_1 and N_2 are given by the expressions in Eqs. (C.2) and (C.3). By utilizing the first order conditions, it is possible to show that $N_1 < 0$ and $N_2 < 0$. The solution to the system (D.1) is then

$$\frac{dH^1}{d\alpha} = \frac{-\bar{c}^2 e^{-r(T^1+T^2)} - (\bar{c}^1 - \bar{c}^2) e^{-rT^1}}{N_1}, \tag{D.2}$$

$$\frac{dH^2}{d\alpha} = \frac{-\bar{c}^2 e^{-r(T^1+T^2)}}{N_2} > 0. \tag{D.3}$$

The sign of $dH^1/d\alpha$ is ambiguous. Eq. (D.2) shows that $dH^1/d\alpha < 0$ when $\bar{c}^1 = 0$, and that $dH^1/d\alpha > 0$ when $\bar{c}^1$ is not very low relative to $\bar{c}^2$. In the latter case, $dH^1/d\alpha + dH^2/d\alpha$ must obviously be positive as well, implying that timber trade restrictions will reduce the optimal total logging.

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Ethics and Environmental Decision-making*

1. Introduction

How should I live in order to have a good life? And how should I live to contribute to creating a good society? From times immemorial, man has been struggling with these profound questions. Although they do not normally occupy the most prominent place of our consciousness, every now and then these questions rise to the surface with renewed intensity, urging us to take a step back from our daily pursuits and evaluate our way of life from a broader perspective.

Increasing environmental stress and the uncovering of advancing ecological imbalances during the last few decades seem to have inspired some people to revise their judgements of how man ought to live. For example, environmentalists frequently claim that there is something irrational or wrong with the traditional conception of a good life in our society. The Western culture, they maintain, has become obsessed with the consumption of commodities. Moreover, the idea of insatiable wants, which has penetrated public policy (and has been adopted as a central premise in economic theory), is by many seen as incompatible with the good life; a good life cannot be lived unless we manage to control our wants and be content with what we have.

Furthermore, the threats of ecological disruption have challenged traditional conceptions of what it involves to live morally. Our moral responsibilities towards future generations have been reinterpreted in the light of binding resource constraints. Moreover, it is being asked, with increasing urgency, whether our moral responsibilities extend beyond the community of human beings. Is it morally all right to exploit animals for human purposes? Or is the killing of animals in need of moral justification? Some go even further and ask whether morality binds upon our

*For their comments on earlier drafts of this paper, I am grateful to Jan I. Haaland, Agnar Sandmo, Amartya Sen, Gaute Torsvik, and Bertil Tungodden.

treatment of all living creatures, including plants. These questions represent a serious challenge to conventional moral thinking.

Against this background, it seems reasonable to assume that ethical reasoning will play a prominent role in environmental decision-making. As I shall argue in this paper, though, the traditional procedures for revealing and aggregating preferences in environmental economics have been quite insensitive to the role of ethical reflection in people's lives. The reason for these defects can probably be traced back to the extraordinarily simple picture of human beings that is drawn in the underlying theory; *Homo Economicus* is characterized by a single, fixed preference ordering. It is difficult indeed to see how this structure might reasonably capture man's struggling with the eternal question "how should I live?". It is also difficult to see how we might do justice to the different natures of private tastes and ethical judgements within this framework. By adding further structure to the preference map, we might become better suited to search for more appropriate mechanisms to reveal environmental preferences – mechanisms that pay more careful attention to the ethical dilemmas involved in environmental decision-making.

The first part of this paper is devoted to a discussion of how a more careful attention to the ethical dimensions of environmental decision-making might influence the way we think of normative environmental economics. In Section 2, I explain why the standard picture of human preferences in economic theory is too simple to do justice to the significance of ethical reasoning in people's lives. Some alternative ways of adding further structure to the preference map are discussed in Section 3. In Section 4, I debate the implications of taking environmental ethics more seriously for the revelation and aggregation of environmental preferences.

A main proposition in the first part of the paper is that even perfect knowledge about individual welfare functions may be an insufficient informational basis for environmental decision-making. This claim is substantiated in the second part of the paper, where I point out how the *welfarist* view (i.e., the view that only personal utilities matter for social choice) is challenged by judgements of our responsibilities towards future generations (Section 6), towards animals (Section 7), and towards other living creatures (Section 8).

I

2. What is wrong with *Homo Economicus*

The axiomatic starting point of economic theory is that each person has a complete and transitive preference ordering. This preference ordering is used for a number of different

purposes in economic analysis; it is used to describe the foundation of people's actual choices and behaviour, to represent their private interests and their welfare, and to express their judgements of what should be done.

The theory of revealed preference illustrates the close connection between choice and the concept of preference in economic theory.[1] The theory relies on the axiom that if a person by choice reveals a preference for x over y, then he must not also reveal a preference for y over x (Weak Axiom of Revealed Preference). At first glance, this axiom appears as nothing but a requirement of consistency. As Sen has emphasized, though, the axiom loses its appeal unless we add the assumption that choice reflects preference. It is inconsistent to prefer x to y, and at the same time prefer y to x. But if choice does not reflect preference, it would not necessarily be inconsistent to choose x before y in one case and then choose y before x in another case.[2]

The preference ordering is used as the foundation for normative economics as well. To be sure, the assumption that preference has a certain normative force is by no means peculiar to economics. This idea has solid roots in philosophical traditions. John Stuart Mill, by way of illustration, wrote in his *Utilitarianism*:

> The only proof capable of being given that an object is visible, is that people actually see it. The only proof that a sound is audible, is that people hear it: and so of the other sources of our experience. In like manner, I apprehend, the sole evidence it is possible to produce that anything is desirable, is that people do actually desire it.[3]

The assumed normative significance of the preference ordering thus stems from the intuition that things desired must also be, in some sense, desirable.[4] In normative economics, this idea has usually been taken to imply that what a person desires is desirable for *himself*, i.e., that the preference ordering reflects *personal* welfare.

It is perfectly possible, of course, to *define* the concept of preference to represent either choice, welfare, personal interests, or judgements of what ought to be done. And in some cases, we might, perhaps, reasonably assume that the preference ordering reflects all these things at the same time. But to rely on the "multi-purpose" preference ordering in general, however, seems a bit ambitious, to say the least of it. This becomes particularly evident in choices and evaluations involving ethical dilemmas.

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[1]Samuelson (1938, 1948).
[2]Sen (1973).
[3]Mill (1987, p. 307).
[4]Note that to appeal from desire to desirability is to appeal from facts to values; a procedure that, following Hume and others, is philosophically unacceptable.

A characteristic feature of human beings is our ability once in a while to take a step back from our daily pursuits and ask ourselves questions like "do I really want to lead the life that I am currently leading?" Once St. Paul was pondering on this question, he exclaimed: "I fail to do the good I want to do, and I practice the bad that I do not want to practice". Two things can be inferred from this statement. First, there is no perfect overlap between St. Paul's choices and what he thinks is good (whatever that might be). Hence, actual behaviour is not a good indicator of his moral judgements. Secondly, St. Paul has a desire to change his way of life to reflect more closely his moral judgements. This casts doubt on the normative status of preferences revealed by choice, and it suggests that ethical reasoning may play a role in the process of changing such preferences.

The inclination to evaluate own behaviour in the light of ethical principles is surely not peculiar to St. Paul. The idea that actual behaviour may differ from morally good behaviour seems quite familiar to most people. We may, for example, realize that our behaviour towards others is less responsible and less considerate than it should be; "I really should have been more modest in my consumption of environmental resources, thus leaving more for the poor people in the world and for the future generations." Frustrated by the gap between our actual lives and the ideals we want to be faithful to, we may wish to develop a stronger desire to live in accordance with the values we cherish. Ethical reflection may thus initiate a process that will lead to a change in our motives for acting.

Similarly, our actual behaviour may be at odds with what we believe to serve our own true good. This may happen when our conception of a good life is, *inter alia*, a matter of good personal character.[5] If our actual character (which may be defined in terms of our preferences) differs from the ideal one, some of our preferences are likely to be regarded as inferior or unworthy of fulfilment. This phenomenon is familiar to many of those who are addicted. They may assert that their immediate desires (and the acts that are inspired by these desires) do not reflect anything at all about value or desirability. Even though the drug addict, by way of illustration, attempts to satisfy his desire for drugs, he may at the same time claim that it would be even better for him if the desire for drugs disappeared altogether. In this case, moral judgements about what would be a good life *for him* make the addict disapprove of the normative status of (some of) his desires.

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[5]The relationship between the good life and personal character has been stressed by the virtue theorists, as represented by philosophers in the ancient Greek tradition (Socrates, Plato and Aristotle), by T. Aquinas, and more recently by G. E. M. Anscombe and A. MacIntyre. See Pence (1991) for an overview. For a discussion of the relationship between utilitarianism and the virtues, see Taylor (1982).

It is not unreasonable to assume that similar judgements might be of some importance for environmental decisions as well. In the wake of more serious environmental problems, the standard Western conception of a good life has been under considerable attack from environmental movements, among others. More and more people seem to acknowledge that the desire to obtain an ever increasing level of consumption of commodities has too weak foundations in considerations about desirability. Hyde has described this desire as follows:

> The desire to consume is a kind of lust. We long to have the world flow through us like air or food. We are thirsty and hungry for something that can only be carried inside bodies. But consumer goods merely bait this lust, they do not satisfy it. The consumer of commodities is invited to a meal without passion, a consumption that leads to neither satiation nor fire. He is a stranger seduced into feeding on the drippings of someone else's capital without benefit of his inner nourishment, and he is hungry at the end of the meal, depressed and weary as we all feel when lust has dragged us from the house and led us to nothing.[6]

However, to really change one's way of life (by changing one's own desires), is more difficult than to admit that such a change would be desirable. Even the pure egoist, therefore, may act otherwise than he thinks would be desirable for himself.

This discussion raises several interesting questions for normative economics in general, and for environmental economics in particular. Two issues will be addressed in the following. The first concerns the question of how ethical judgements of the kind described above should be incorporated into normative analysis. Secondly, I shall discuss how the presence of ethical judgements in people's lives should affect the way we think about revelation and aggregation of preferences.

Normative economics has traditionally been concerned with the question of how to improve welfare in society. The meaning of "welfare" in this context is *satisfaction of people's preferences*. However, it is not altogether clear how we should think about preference satisfaction if there is a conflict within each of us between our immediate desires and what we consider to be desirable for ourselves at a more fundamental level. How should the desires of the drug addict enter his welfare function? Can his welfare be improved by satisfying his desire for something that he thinks is basically undesirable? Or should such preferences be censored by reference to the person's own basic value judgements?

Related to the fundamental problem of defining individual welfare functions, is the problem of how to reveal those preferences. The main problem is that we cannot be sure what actual

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[6]Hyde (1983, p. 10).

behaviour reflects about the value judgements of individuals once the "multi-purpose" preference ordering has been abandoned. Therefore, it would seem arbitrary to base public decisions solely on preferences revealed by choice. Other sources of information will be required as well.

After having established well-defined individual welfare functions that take appropriate account of people's conception of a good life, it remains to be discussed which role such welfare functions ought to play in the normative analysis. Should normative conclusions be based *exclusively* on individual welfare functions, or are there other relevant considerations to take into account? The answer to this question will depend partly on which ethical doctrine we advocate. A utilitarian would maintain that individual welfare functions will do the job. As shown in the second part of this paper, though, other ethical theories would deny that our environmental responsibilities can be reduced to a matter of preference satisfaction. If these theories are accepted by well-informed and rational moral agents, we need to find ways to take these ethical judgements into account in the normative analysis. The question of how this might be done is, indeed, a challenging one, because there are so many competing ethical views on this issue. A comprehensive normative analysis will have to find ways to settle this conflict between ethical views. I shall argue in the following that it is far from obvious that such conflicts should be settled by those methods that we usually apply in normative economics to settle conflicts of interests. But before turning to a more comprehensive discussion of these issues, I shall be somewhat more precise about how we might think of the structure of preferences if we want to take the role of moral judgements in people's lives more seriously.

3. The structure of preference

Several authors have emphasized the need to elaborate the structure of individual preferences in greater detail in order to get a better idea of how ethical considerations affect the relationship between choice, private interests, welfare, and judgements. Harsanyi has suggested to distinguish between a person's "ethical" preferences and his "subjective" preferences, "the former must express what this individual prefers (or, rather would prefer), on the basis of social considerations alone, and the latter must express what he actually prefers, whether on the basis of his personal interests or on any other basis".[7] In Harsanyi's framework, individual welfare functions are represented by the subjective preference orderings. The definition just cited shows that he thus allows for the possibility that individual welfare might differ from narrow self-interest; my welfare might, for instance, increase when the lives of others, with whom I have sympathy, go well. A more fundamental difference between Harsanyi's formulation and the traditional economic approach is the distinction between individual welfare

[7]Harsanyi (1955, p. 315).

functions and the judgements people make on the basis of an impartial ethic, and the claim that choices can be motivated by both these motivational forces.

A similar way of incorporating ethical motivations into the structure of preference is suggested by Sen's distinction between the *agency*-aspect and the *well-being*-aspect of individual choice.[8] The well-being-aspect includes the same motivations as are captured by Harsanyi's subjective preferences. But sometimes, according to Sen, our reasons for acting cannot be reduced to this kind of enlightened self-interest in a meaningful way. In these cases, the motivation behind our choices must rather be described as some kind of commitment to deeper held values. Such motivations are captured by the agency-aspect. The agency-aspect is thus similar to Harsanyi's ethical preferences. But whereas Harsanyi assumes that the ethical preferences have (or, rather should have) a particular form, namely a utilitarian welfare function based on people's subjective preferences, Sen does not place any such restrictions on the format of the agency-aspect. The values that people actually are committed to, may fall considerably short of the broad conception of value in utilitarianism and other major ethical theories.

The frameworks of Sen and Harsanyi focus on one particular, and important, kind of ethical reflection, namely the question of how I should live in my dealings with *other* people. It is more difficult, though, to see how reflection on the question of what is a good life *for me* might be incorporated into these models. Presumably, Sen and Harsanyi assume that the good life for the individual is reflected by the well-being-aspect (or the subjective preferences), and, hence, that individual motivations (and choices) can be seen as a compromise between considerations about the good life for the person himself and considerations about how he ought to treat others. However, there are desires that cannot be captured by this structure. The addict's disapproval of his own desires illustrates that the individual, upon reflection, may want to reduce the intensity of some of his own desires in order to be able to live what he holds to be a good life for himself.

To better capture those desires that are based neither on the individual's conception of a good life, nor on his judgements of how he ought to treat others, we need to add more structure. For instance, Sen's model might be further developed by adding a third source of motivation for choice; the *addiction*-aspect.[9] The presence of addictions, like agency, drives a potential wedge

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[8]Sen (1985) and (1987, pp. 40-41).

[9]It seems to be a *sufficient* condition for the presence of addiction that the individual disapproves of (the intensity of) the desires that motivate him in choices that affect his own well-being only. I leave it open to debate whether this is a *necessary* condition as well. (The question is; are there happy addictions? This problem is similar to the question of whether the fish that has swallowed a fishhook is *caught* if the fish afterwards prefers to swim in the direction of the fishline, so that the line remains slack.) For an attempt to explain addiction as a rational phenomenon, see Becker and Murphy (1988).

between choice and welfare and thus undermines the normative status of preferences revealed by choice.

The structure of preferences that has been worked out so far, based on an examination of the role of ethical reflection in people's lives, attempts to explain a person's actual behaviour by a set of complex, but settled, motivations (*well-being*, *agency*, and *addictions*). Choice is seen as a compromise between different and possibly conflicting sources of motivation. One important aspect that has been left out, is the role of ethical reasoning in balancing the different motivations against each other. For ethics is not neutral with respect to which motivations that win out. For example, ethical reflection may lead a person to morally condemn his addiction-motivations, or to realize that agency-motivations are morally superior to motivations rooted in considerations about own well-being. Given this ranking of different motivations, the person might morally prefer to have some preference orderings rather than others.

In order to make sense of these phenomena, it will be helpful to invoke the device of higher-order preferences, or *meta-preferences*. If X denotes the set of all possible outcomes, and Y denotes all possible orderings of the elements of X, a meta-ordering is defined as an ordering of the elements of Y.[10] This approach seems well suited for ethical theories that attach some intrinsic importance to people's motivations.[11] At first glance, however, the description of moral views in terms of meta-preferences appears to be at odds with major ethical theories (e.g., utilitarianism) which focus on *outcomes* or *actions* as the central object of moral concern. This is not a real problem, though. As Sen has pointed out, the meta-ordering may include, *inter alia*, a specification of a particular action-ranking as the "most moral".[12] (In addition, the meta-ordering may specify the relative moral goodness of the action-rankings that are *not* "most moral".) Moreover, if the individual is able to change his behaviour by revising his motives for acting, preference orderings will of course not be irrelevant from a utilitarian perspective either.

One great advantage of invoking the concept of meta-preferences is that it makes sense of the role of ethics in the process of preference change. This subject has received very little attention from economists, despite its obvious relevance for the discipline. Those rare occasions when preference change is discussed, it is most often referred to as a change in "tastes".[13] The word "tastes" draws the attention to minor preference changes, like the change from preferring apples before oranges to preferring oranges before apples. However, by abandoning the multi-

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[10]The idea that moral judgements can be represented by such meta-orderings was originally set forth by Sen (1974, 1977).

[11]Virtue theory is one such theory where motivation (or personal character) has intrinsic importance. (See footnote 4). Moreover, Kant would claim, in a similar vein, that it is only when individuals do their duty, *because that is their duty*, that their actions have moral worth. See Regan (1983, p. 176).

[12]Sen (1977).

[13]See Hirschman (1986).

purpose preference ordering and invoking the concept of meta-preferences, we more easily see how people may take a step back and call themselves to account for their whole preference structure: "In light of the values I cherish, are these the preferences I want to have?" This question may change people's entire way of life, not only their tastes.

The difficulty economists have had in dealing with big changes in preferences thus seems to stem, at least partially, from the defective way of dealing with moral judgements in economic theory. With only one, fixed preference ordering, there has simply been no room for ethical conflicts *within* a person; they have been regarded as interpersonal phenomena merely. By enriching the structure of individual preferences, we have been able to see how moral judgements can play a key role in the process of preference change. There may be a struggle going on within each person because the preference ordering that he reveals by his choices does not have high merit according to his own meta-preferences.

Even though it is possible to change preferences, nobody is entirely free to choose his preference ordering. This implies that the conflict between meta-preferences and preferences revealed by choice is likely to be enduring. The psychological stress of living with such a conflict may make us suppress the claims of our meta-preferences in our daily lives. (To preach otherwise than one lives is not held in high esteem.) Therefore, our basic judgements about right and wrong and our conception of a good life may live a rather anonymous life in our consciousness. But once in a while, when we face questions of a deep ethical character, we feel a need to dig out these judgements, searching at the bottom of our hearts for what we believe to be good and bad. If, after brushing the dust off our meta-preferences, we discover inconsistencies between these preferences and our actual choices, we will quite likely try to redirect the motivational forces behind our choices, i.e., we will re-balance the current compromise between the various motivations that affect our choices (although this process may be strongly restrained by the desire to have our "less ethical" preferences satisfied). It does not seem unreasonable to assume that the urgent ethical dilemmas involved in environmental decision-making may initiate processes of this kind.

4. Revelation and aggregation of preferences

Preliminaries

Since economic theory identifies social achievement with preference satisfaction, a fundamental issue in applied welfare economics is to reveal people's preferences. As long as we stick to the single, multi-purpose preference ordering, preference revelation is merely a technical problem, i.e., a matter of mechanism design. When we impose a more complicated structure on the

preference map, however, we need to consider *which aspect* of the preference structure we should be interested in as policy-advisors as well. Should we look for meta-preferences or preferences revealed by choice? And how should we deal with the presence of addictions and agency in addition to the well-being-aspect of individual preferences? Finally, after these questions have been addressed, we need to ask whether the extended preference structure has any implications for the choice of procedure when individual preferences shall be aggregated to arrive at a social choice.

I shall not attempt to give general answers to these questions. My project here is to discuss how these problems could (or should) be handled in normative environmental economics. I will argue that the traditional methods that economists have been using to reveal environmental preferences have been rather insensitive to the deep ethical nature of environmental decisions. Furthermore, I shall question whether the standard procedures used to aggregate individual preferences in applied welfare economics are appropriate in environmental decision-making.

Which aspect of the extended preference structure is relevant for social choice? Harsanyi's answer would be that social choice should be based on an aggregation of "true" or "informed" subjective preferences.[14] In short, this implies that it is the well-being-aspect of individual preferences that counts. Irrational preferences should be excluded.[15] Hence, addiction-preferences are likely to be somehow censored (note, however, that the desire to have one's addiction-preferences satisfied is not necessarily an irrational one even though the addiction-preferences themselves are). Furthermore, the fact that people sometimes may be motivated to act on their ethical preferences rather than their subjective preferences does not matter for social choice (although it will surely affect the need for government intervention). The agency-aspect should therefore be excluded as well.

Harsanyi does not discuss the status of meta-preferences explicitly. We can infer from his general argument, though, that meta-preferences are relevant for social choice only insofar as these preferences can reveal something about the true well-being of individuals. In other words, if my preferences for having other preferences than I actually have are based on the belief that the change in preferences will make me more able to live a life that is good *for me*, this would be relevant for social choice. (This is why addiction-preferences may be censored).

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[14]Harsanyi (1955, 1982). Harsanyi defines "true" preferences as the preferences a person would have if he had all the factual information, always reasoned with the greatest possible care, and were in a state of mind most conducive to rational choice (1982, p. 55).

[15]This notion of rationality (or irrationality), defined at the level of preferences, is a more comprehensive notion than the one that usually is invoked in economic theory; the latter being merely a requirement of consistent behaviour, assuming that preferences are well-defined. Elster (1983) uses the terms "thin" and "broad" rationality to distinguish between these different notions of rationality.

On the other hand, if my desire to have other preferences were based on the belief that this would create a better world for others, it would be irrelevant.

Harsanyi's recommendations are founded on a *welfarist* view, saying that states of affairs should be judged entirely in terms of preference information related to the respective states.[16] Welfarism is not an uncontroversial ethical view, despite its widespread acceptance in normative economics. Some of the major problems with welfarism are that it does not attach any intrinsic importance to liberty and rights, and that it does not involve any censoring of well-being derived from the satisfaction of antisocial preferences, such as sadism and envy.[17] The case for welfarism will be further weakened after an examination from the perspective of environmental ethics. Considerations about our moral responsibility towards future generations, towards animals, and towards other living creatures will show that the welfarist approach might be highly defective. (This is the topic of the second part of this paper.)

Insofar as there are good reasons to question the adequacy of welfarism, there are good reasons to reject Harsanyi's treatment of the extended preference structure (along with other welfare-based normative criteria, such as the Pareto principle and the Kaldor-Hicks criterion). Harsanyi's point of departure is that if some people are motivated by something else than their personal well-being, that would be (or, rather should be) by the well-being of others. To exclude moral concerns of this kind from the social welfare function seems quite appropriate; to do otherwise might lead to double-counting. But by acknowledging that people may be justified in their moral concern for other things than human preference-satisfaction, we will have to concede that individual moral judgements probably should play a far more vigorous part in social choice than Harsanyi allows for. As a first step, we will, of course, need to know the exact contents of these judgements. A central task when revealing environmental preferences is therefore to uncover people's moral judgements (or meta-preferences) on these issues.

Revealing environmental preferences

In applied environmental economics, individual preferences have traditionally been expressed by the individual willingness to pay for the various options involved. Willingness to pay has been revealed either by observing choices in actual markets or by using contingent valuation in hypothetical markets.

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[16]This is Sen's definition of welfarism, see Sen (1982a, p. 28).

[17]For a criticism of welfarism along these lines, see Sen (1970a, 1976, 1979, 1982b), among other contributions.

Consider first the revealing of willingness to pay by observing market behaviour. When a market is in equilibrium, marginal willingness to pay will be reflected by the price (provided there is no monopsony power). The equilibrium price is a function of consumer choices, among other factors. But since the normative status of preferences revealed by choice is uncertain, we need to ask some further questions before accepting market prices as parameters in social choice. Is the market price of heroin a good indicator of its marginal value for the addicts? And which normative status does the market price of more ordinary consumer goods have if the consumption of these goods is motivated partly by addiction? My point is the following; in order to take appropriate account of the moral judgements of individuals, observation of consumer choices may need to be supplemented by introspection and communication. The willingness to pay for consumer goods, as revealed by market prices, may need some adjustment if, upon reflection, the marginal consumer realizes that his willingness to pay *should* have been either higher or lower than those prices.

Since many environmental goods are public goods and therefore not traded in markets, contingent valuation is commonly applied in environmental decision-making.[18] With contingent valuation, willingness to pay is revealed by direct questioning. One problem with this method is that it often gives the respondents an incentive to behave strategically. If people have to pay in correspondence with stated willingness to pay, they have incentives to understate their benefits. Since a public good is available to everyone once it is produced, people may be tempted to take a free ride on the contributions of others. On the other hand, if the respondents do not have to pay, they will have incentives to overstate the benefits from goods that they want. Since economists tend to assume that people will not tell the truth unless they have economic incentives to do so, several contributions have focused on the design of mechanisms that will give people perfect incentives to be honest about their willingness to pay.[19]

However, the main problem with revealing preferences for environmental goods by contingent valuation is probably not technical; it is conceptual.[20] Since contingent valuation usually is hypothetical (no payment is collected), this method is likely to give more room for the expression of meta-preferences than the observation of actual behaviour. What people state as their willingness to pay is not necessarily what they actually would pay if they were to make a choice. Rather, it may reflect what they think they *ought* to pay, based on some higher-order

[18]For general discussions of contingent valuation, see Hausman (1983), Cummings *et.al* (1986), Mitchell and Carson (1989), and Freeman III (1993). (I owe these references to Angelsen *et.al* (1994)). For a critical contribution, see Vatn and Bromley (1994).

[19]Groves and Ledyard (1977) and Green and Laffont (1977).

[20]Studies have shown that the problem of strategic behaviour is less prominent in practice than what has been expected based on theoretical contributions. See Bishop and Heberlein (1990) and Marwell and Ames (1981).

preferences.[21] At this point, however, it is important to bear in mind that meta-preferences are not expressions of private interests in the same way as are ordinary preferences. Meta-preferences reflect what we believe is a good life, what we think is a good society, and what we believe to be right or wrong. These are judgements, views, and convictions; not desires, as we usually interpret the term.[22]

When people declare something as good or bad, right or wrong, it is appropriate to ask them to give reasons to support their judgements (as opposed to when they express their private tastes). The weight we attach to judgements depends on their cogency, not on how much people are willing to pay for them. The most celebrated moral leaders of our world have been poor people, unable to pay much to have their views accepted. Nor would anyone ask them to do so, because the significance of their moral judgements cannot be captured by the concept of willingness to pay; they belong to a different conceptual category.

Environmental preferences should be expressed as judgements and convictions, not as mere personal interests. It is therefore impossible to do justice to the nature of environmental preferences by measuring them in money terms. Rather, they must be revealed in such a format that they can be heard, understood, considered, and criticized. The contingent valuation approach deprives people of their role as citizens with something to say about good or bad, right or wrong in society at large. Assume, by way of illustration, that I am asked to state my willingness to pay for avoiding that a wilderness area is converted into an amusement park. What shall I then answer if I think that such conversion is simply wrong? I might state a very high amount of money, just to express that I think I have good reasons for my view. In the contingent valuation literature, such bids are known as "protest bids". Protest bids arise because "the contingent valuation method, ... , insofar as it tries to make respondents express preferences rather than deliberate about ideas, denies their status as thinking political beings."[23] Protest bids are the only way, and surely a very inaccurate way, to express value judgements when environmental decision-making is based on people's willingness to pay for environmental goods, rather than on their basic value judgements.[24]

To express environmental preferences by willingness to pay may raise some additional problems if there is incommensurability in the realm of values. (To illustrate what incommensurability involves, consider the following example. Assume that a person faces the

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[21]It would be worth studying whether this phenomenon explains some of the puzzles identified in the application of contingent valuation methods. See Angelsen *et.al* (1994) for an overview.
[22]See Sagoff (1988) for a discussion along these lines.
[23]Sagoff (1988, p. 88).
[24]In this context, it is interesting to note that those who state a high willingness to pay for environmental goods, tend to be less confident than others with their own response. See Schkade and Payne (1994).

choice between having a wilderness area converted into an amusement park or having his income reduced by 100 dollars, and that he is unable to state a strict preference for one alternative over the other. This shows that either is he indifferent, or he is facing a choice between incommensurable alternatives. Assume that the dollar amount is increased to 101, and that he still is unable to state a strict preference. Then there is incommensurability.[25]) Environmentalists sometimes claim that environmental values cannot be measured in money terms. Economists tend to reject this argument: environmental decisions are decisions about allocation of scarce resources, and we cannot therefore escape the problem of measuring environmental values against other values! This argument is not convincing, though. The fact that we are forced to make environmental decisions does not imply that the values involved are commensurable. There might be a fundamental reason for incompleteness in the realm of values, possibly implying that some environmental values (e.g., the value of walking in a wilderness area) belong to a value dimension that cannot be meaningfully compared with, and weighed against, those other values that are at stake. In that case, no single metric will be able to capture the values involved in environmental decision-making.[26]

By asking people to state their willingness to pay for environmental goods, or by inferring willingness to pay from actual behaviour, the possibility of incommensurability may easily be overlooked. The fact that a choice has been made, should not lead anyone to conclude that the choice is based on a rational decision-procedure, at least if it is doubtful whether such a procedure really exists. Such conclusions can only be drawn after introspection into the decision-procedure itself. Hence, if the realm of values cannot be represented by a single metric, the use of money values to express the rationale behind environmental decisions may conceal the fundamental structure of the decision problem.[27]

I have stressed the following weaknesses of the traditional approach to revealing environmental preferences; 1) it does not acknowledge that preferences revealed by choice may have a rather weak normative status (in the view of the agent himself), 2) it fails to uncover the different nature of moral judgements and private interests, and 3) it fails to give an appropriate representation of the structure of the decision problem when incommensurable values are involved. But if the revealing of environmental preferences by observing market behaviour or

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[25]The difficulty of stating a strict preference may also be due to genuine uncertainty about the alternatives. With genuine uncertainty (as opposed to risk), subjective probabilities are unavailable, and expected utility theory is therefore useless. It is far from obvious what it would entail to make rational decisions under such circumstances. My criticism against the concept of willingness to pay would be applicable to that case as well.

[26]Vatn and Bromley (1994) discuss this problem in an environmental context. Taylor (1982) argues, in a similar vein, that a complete ranking of the different values in a human life is impossible to really achieve. See also the discussion of incompleteness in Sen (1992, p. 49).

[27]It has been documented that some contingent valuation methods (e.g., bidding games) involve a *starting point bias*, i.e., the respondents final valuation is biased against the initial offer (see Angelsen *et.al* (1994)). Incommensurability of values might make this phenomenon more easy to understand.

by contingent valuation is inappropriate, how should we then go about? Should we simply ask people to state and to justify their moral judgements, or are there other methods available to inquire about meta-preferences? In the following, I shall present two arguments suggesting that to observe people in public discussions and political processes may be quite useful for this purpose.

The first argument says that by influencing public decisions, people may be able to commit to a way of life that is more in accordance with their meta-preferences (thus overcoming some of their own weaknesses of will). I have argued that preferences revealed by choice may express goals and aspirations that do not pass the test of moral judgement. The reason why the "wrong" goals nevertheless win out in actual behaviour must be that these motivations are in some sense stronger – not stronger as reasons, but as sheer psychic turbulence.[28] In this situation, it might be rational for a person to find ways of coping with his tendency to pursue the wrong goals. For example, he could vote for more stringent environmental regulations, knowing that without such regulations he would not be able to resist the temptation to pollute more than he should. (Similar strategies might be used in other areas of public policy as well, such as in regulations against tobacco and alcohol, or in the design of a tax system that makes redistribution obligatory). Choices on the political arena may thus be a way of exercising self-command; by restricting future opportunities, actual behaviour may change, without actually changing the preferences that guide the final choice.[29] By supporting laws that increase the costs of pollution, people might be able to deal more rationally with their weaknesses of will and act more in accordance with what they consider to be right (as represented by their meta-preferences).[30]

The second argument says that when people appear in public discussions, they perform a different role than when acting as consumers in ordinary markets. In political processes, people's frame of reference is determined by their image of a good life and a good society, rather than by the self-interested motives that guide their market choices, suggesting that the public arena is better suited to reveal meta-preferences. Several authors have argued along these lines.[31] The question that has been asked in the literature is whether the individual reveals a *different* preference ordering in his role as consumer than in his role as a citizen (i.e., as a

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[28]Elster (1989, p. 36).

[29]See Schelling (1984) for an illuminating discussion of various ways of exercising self-command. Whereas Schelling describes the phenomenon of self-command as a struggle between two independent parts of the self, my approach assumes that there is an internal mediator (the meta-preferences) between the different selves, and that the individual thus is able to take sides with respect to which self that represents the "true", the "higher", or the more "authentic" preferences.

[30]The phenomenon I have described here is closely related to the problem of inconsistent time-preferences. Inconsistent time-preferences may be seen as a rationalization of the phenomenon that people have difficulty sticking to their plans as time goes by. See Strotz (1956) and Elster (1979, 1989).

[31]Colm (1955), Marglin (1963), Sagoff (1988).

participant in political processes). The view of those who think there is such a difference, has been summarized by Marglin:[32]

> The preferences that govern one's unilateral market actions no longer govern his actions when the frame of reference is shifted from the market to the political arena. The Economic Man and the Citizen are for all intents and purposes two different individuals. It is not a question, therefore, of rejecting individual ... preference maps; it is, rather that market and political preference maps are inconsistent.[33]

It is pretty much a hopeless task to evaluate this proposition. If a person in one situation prefers x to y, and in another situation prefers y to x, it does not follow that the person is revealing different preference orderings in different situations. The reason is simply that different situations are exactly that – different, and the apparent inconsistency may perhaps be explained by reference to this difference.[34]

However, it is arguable that the observation of judgements made in public discussions may be a better way of revealing meta-preferences than observation of ordinary consumer choices, even though there is no inconsistency in the preferences revealed in these different situations. The reason is that some arguments simply cannot be stated publicly in political discussions, for example the argument that something should be chosen merely because it improves one's own welfare.[35] Those who appear in the public lose their esteem if their views cannot be reasonably justified with reference to an idea of what is good for society at large. Therefore, open and public debate may be a way of purging selfish and addictive motivations which are more influential in other situations.[36] The institutionalized incentive structure on the public arena induces people to act *as if* they were following some higher-order preferences.[37]

Aggregation of environmental preferences

After individual (environmental) preferences have been revealed, we have to choose an aggregation procedure that takes us the final step towards a social choice. Much attention in social choice theory has been devoted to the possibility (or impossibility) of coming up with

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[32]See also the discussion of Colm's position in Musgrave (1959, pp. 87-88).
[33]Marglin (1963, p. 98).
[34]See Sen (1993) for an analysis of situation-dependent (or menu-dependent) choice.
[35]Elster (1983, p. 35).
[36]This effect of the public debate has been emphasized by Rousseau, Hegel, Habermas, and others. See Elster (1983).
[37]Yet another argument why meta-preferences are more likely to be revealed in political decisions is that people may be unwilling to do what is right unless others do the same. See Sugden (1984) for a discussion of preferences where such considerations about fairness are important for a person's willingness to pursue the common good.

any satisfactory such procedure.[38] One of the first problems we encounter in the design of aggregation procedure is that of interpersonal comparability of welfare.[39] I shall have nothing to add about that controversy here, except observing that economists quite frankly have been willing to ignore this theoretical problem in applied normative analysis.

In applied environmental economics, the standard aggregation procedure has been to add up the willingness to pay of all affected parties. There are several problems with his approach. First, given that a sum-ranking procedure is being used, willingness to pay may be regarded as an inappropriate object of aggregation. This problem, which is duly recognized in the literature, is due to the sensitivity of willingness to pay to individual budget constraints. Sum-ranking based on willingness to pay tends to give higher priority to the preferences of the rich, at the expense of those of the poor. This problem might in principle be overcome, though, by incorporating distributional weights in the aggregation procedure.[40]

Furthermore, there are some inherent problems with the sum-ranking procedure.[41] Sum-ranking implies, roughly speaking, that all affected parties count equally. To aggregate environmental preferences (which are assumed to reflect moral judgements) by this procedure would thus be to count all moral views as equally justifiable. Sum-ranking thus fails to respond to the cogency of the moral judgements underlying environmental preferences, and it is therefore a defective aggregation procedure. (Sum-ranking is, of course, only one among a large number of aggregation procedures that fail on this account. The same criticism attaches to these other aggregation procedures as well.)

Personal tastes, e.g. for vegetables or fruit, are preferences that a person may have or not, and if he does not have them, no criticism attaches to him for that reason. The same cannot be said about moral views, as represented by our meta-preferences. A person who believes in the validity of certain ethical principles rarely advocates those principles as valid for him alone. Rather, he believes in these principles as *valid for everyone* (which is very different, of course, from claiming to *know* that they are).[42] Meta-preferences therefore express – in the language of Kant – categorical imperatives, i.e., goals and aspirations that everyone *should* have, and which other persons therefore might be criticized for not having.[43]

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[38]Arrow (1951) and Sen (1970b, 1982), among many others.
[39]See, e.g., Robins (1935) and Sen (1982a).
[40]See Angelsen *et.al* (1994).
[41]Sum-ranking is the aggregation procedure that is recommended by classical utilitarian theory. See Sidgwick (1981), among others. For an axiomatic derivation of the utilitarian aggregation procedure, see Harsanyi (1955, 1982). For further discussions of the informational requirements in the derivation of aggregation procedures, see Strasnick (1976), d'Aspremont and Gevers (1977), Hammond (1976), and Sen (1977a).
[42]See Regan (1983, p. 139) for a discussion of these issues.
[43]Taylor (1982) argues convincingly along these lines.

Environmental decision-making must be sensitive to this character of moral judgements in general, and of environmental preferences in particular. Before aggregating moral judgements, we should make sure that they are based on sound arguments. Judgements that cannot be reasonably justified should not be melted together with justifiable judgements and averaged out to find a golden mean. In political processes, racist and sexist views are dismissed as such. Similarly, if someone denies that we have responsibilities towards future generations, his environmental preferences are likely to be censored.

But censoring of reprehensible moral judgements is not the only purpose of a critical examination of environmental preferences. Education may be another important aim. As Elster has underscored, the political system may be geared towards the task of changing preferences, rather than aggregating them.[44] This seems to be of some relevance in environmental decision-making, since many people appear to be somewhat confused as to what really should be the normative foundation for environmental decisions. Of course, since nobody can prove what is objectively good or bad, right or wrong, ethical judgements must ultimately be based on belief rather than logic. But people do not pick their beliefs in the dark; they want to believe what they have *good reasons* to believe. In their everyday lives, people seem to be prone to a very large number of unfounded judgements stemming from defects in their cognitive apparatus.[45] By realizing that it is difficult for any single person to arrive at well-founded moral judgements on his own, we will acknowledge that public discussion on the judgements behind environmental preferences is an important part of environmental decision-making. In this perspective, the uncritical aggregation of willingness to pay revealed by direct questioning or market choices appears to be a rather unsatisfactory procedure for making choices about environmental management.

Against this background, one may, perhaps, wonder what really is the appropriate role of normative economics in environmental decision-making. About the proper role of welfare economics, John Ruskin once claimed:

> The real science of political economy, which has yet to be distinguished from the bastard science, as medicine from witchcraft, and astronomy from astrology, is that which teaches nations to desire and labor for the things that lead to life: and which teaches them to scorn and destroy the things that lead to destruction.[46]

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[44]Elster (1983, p. 34).
[45]R. Nisbett and L. Ross, *Human Inference: Strategies and Shortcomings of Social Judgement*. See Elster (1983, p. 26).
[46]Quoted in Daly (1992, p. 168).

Ruskin was indeed quite immodest on behalf of the discipline. But his general point is well worth bearing in mind: economists need to be sensitive to the ethical foundations of desires or preferences. As consultants for environmental decisions-makers it is our job to search for, acknowledge, and communicate not only people's immediate desires, but also which values they cherish, as expressed by their meta-preferences. These value judgements are not to be accounted for in money terms, because they cannot be. Nor are they to be accepted unconditionally, as they are; that would be to ignore that judgements are in need of justification and to deny the educating effect of political deliberation. In order to regain the sensitivity to moral judgements in normative economics, we have to rely on procedures that do not reduce value judgements to a single metric. This will certainly lead to less precision in our policy recommendations. However, there is no reason indeed why we should strive for more precision than the structure of the underlying problem allows for.

II

5. The ethical challenge

Who should count, morally? And what *kind* of moral concern do we owe to those who have moral status? These are some of the difficult questions that any satisfactory ethical theory must address. Most contributions in moral philosophy focus on the substance of our moral responsibilities (the latter question). In environmental philosophy, on the other hand, it is the problem of who (or what) belongs to the moral community that occupies the centre stage. Throughout history, people's views about who has moral status have changed significantly. Many environmental philosophers believe that we are now facing yet another of those cross-roads where we have to revise our inherited beliefs on these issues.[47] Albert Schweitzer, by way of illustration, once exclaimed:

> It was once considered stupid to think that colored men were really human and must be treated humanely. This stupidity has become a truth. Today it is thought an exaggeration to state that a reasonable ethic demands constant consideration for all living things down to the lowliest manifestations of life. The time is coming, however, when people will be amazed that it took so long for mankind to recognize that thoughtless injury to life was incompatible with ethics.[48]

The fact that people have been terribly mistaken and have revised their ethical views throughout history does not imply, of course, that our current beliefs are wrong. But the expansion of the

[47]See Nash (1989), among others.
[48]Quoted in Nash (1988).

moral community in the past should perhaps make us adopt a humble attitude towards our own judgements on this issue.

The aim of the following discussion is to substantiate the assertion that the normative foundation of environmental economics currently is under attack from a number of different perspectives. This suggests that the informational basis of environmental decision-making should be extended beyond individual welfare functions. It is beyond the scope of this paper, though, to deal with the full range of alternative views on environmental ethics. I shall confine my attention to questions about our moral responsibility towards 1) future generations, 2) animals, and 3) living creatures other than animals, such as plants. The emphasis will be on the implications of the various views for environmental economics.

6. Future generations

Never before has one generation been able to change the future living conditions as dramatically as we have. This has made the question of intergenerational moral responsibilities more relevant than ever. The question is: does it make any difference to the moral status of future generations that they do not yet exist? Most people would say no. This conclusion can quite readily be reached based on either utilitarian or Kantian reasoning. Moral status, according to these theories, depends on the ability to experience pleasure and pain, or the ability to have preferences (utilitarianism), and the capacity to reason (Kantianism). The fact that future generations do not yet have these capacities is unlikely to be of moral relevance. I shall not debate the view that we owe something to future generations, but concentrate instead on the more difficult question of *what* we owe. In the following, I shall argue that the concept of meta-preference will be helpful in dealing with this problem.

Assuming that we accept utilitarianism (or, rather welfarism), the relevance of inquiring about our meta-preferences would seem rather limited. We should then, following Harsanyi, just aggregate the (true) subjective preferences (or well-being preferences) of people from all generations. However, this is not a straightforward procedure when intergenerational welfare is involved, because the preferences of future generations are yet unknown. How should we approach this problem?

One possibility is to assume that the preferences of future generations are identical to the preferences of current generations. But is this really our best guess? Krieger argues in his article "What is wrong with plastic trees?" that environmental preferences are learned and that people learn to use and want the environment that is available at a reasonable cost.[49] If we leave

[49]Referred to by Seligman (1989).

future generations with amusement parks instead of wilderness areas, the preference for wilderness areas may be weakened or disappear, for instance because future people will have difficulty conceiving what they are missing, or because of a general tendency to reduce the distance between aspirations and possibilities.[50] If we instead preserve the wilderness, future people may place a much higher value on this resource.

The fact that we are shaping the preferences of future generations by what we pass on to them poses some deep problems for welfare economics. In the choice between wilderness preservation and the building of an amusement park, it might be the case that whatever we do, our choice will be unanimously approved of by future generations. We then have a circularity problem; there is no unambiguous ranking of alternatives.[51]

Parfit has argued that such circularity problems may, in fact, be inevitable in decisions affecting future generations.[52] His point is that our choices affect the identities of future people. Even small policy changes are likely to affect the timing of conception, and hence which sperm/egg combinations that will be conceived. When future people realize that they would not have existed unless their ancestors acted exactly as they did, they will not complain about past policies (provided their lives are worth living). Hence, whatever policy we implement, it will be unanimously approved of by future generations.

Besides the problem of circularity, the fact that our policies may affect the preferences of future people undermines the very rationale for making social choices based on those preferences. This point has been stressed by Elster:

> Why should individual want satisfaction be the criterion of justice and social choice when individual wants themselves may be shaped by the process that preempts choice? And, in particular, why should the choice between feasible options only take account of individual preferences if people tend to adjust their aspirations to their possibilities?[53]

But if the preferences of future generations constitute an unsatisfactory basis for intergenerational social choice, is there then a better alternative? At this point, I think the notion of ethical preferences (or the meta-preferences, if you prefer) will be helpful. I have argued that

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[50]Cowen (1993), Elster (1983). See also Sagoff (1988) and Sen (1987, pp. 45-46).

[51]The problem of circularity is well-known from cost-benefit analysis. Since different projects affect the income distribution differently, the *ex post* ranking may differ from the *ex ante* ranking of alternatives. (This is known as Scitovsky double-switching, see Scitovsky (1941)). In the present example, circularity arises without changes in the income distribution, because policy affects preferences directly. Note that circularity might as well arise if future preferences were *negatively* correlated with the options available (this is the *the-grass-is-always-greener-on-the-other-side* phenomenon).

[52]Parfit (1984).

[53]Elster (1983, p. 219).

present generations, upon reflection, may realize that they should have other preferences than they actually have. It would be morally incoherent of these people to exercise the inevitable paternalism with respect to the preferences of future generations without an eye to their own conviction that some preference orderings are morally superior to others. Hence, the meta-preferences of current generations will be of central importance in environmental decisions affecting generations to come.

This implies that when deciding what to pass on to future generations, we have to be explicit with our conception of a good life and a good society. Since we are shaping the character of future individuals by our choices, we should not only be concerned with what is good *for* future people; we should attempt to foster *good people* as well. This is a responsibility not necessarily to future generations, but to the ideals and the moral convictions we want to be faithful to. In the words of Sagoff, "our obligation to provide future individuals with an environment consistent with ideals we know to be good is an obligation not necessarily to those individuals but to the ideals themselves."[54]

7. Animals

"If you felt like snapping your fingers, perhaps to the beat of some music, and you knew that by some strange causal connection your snapping fingers would cause 10,000 contended, unowned cows to die after great pain and suffering, or even painlessly and instantaneously, would it then be perfectly all right to snap your fingers?"[55]

Yes, Descartes would have answered. Animals, in his view, are "thoughtless brutes"; they are machines. Despite appearance to the contrary, they are not conscious. They simply act according to the physical laws of their bodily organs, like an advanced clock. Humans, on the other hand, are spiritual beings, equipped with an immortal soul, and thus able to make sense of the world. Based on this world-view, Descartes concludes that the moral community is confined to the species *Homo Sapiens*.[56]

The normative approach to applied economic analysis seems to be heavily influenced by Cartesian dualism; only human welfare counts. In our laws, however, there is some protection of animals. But this does not show that our society has acknowledged the moral status of animals. Our duty not to be cruel to animals, some people claim, is a duty not to those animals, but to other people. Kant, for instance, advocated a such indirect duty view; "so far as animals

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[54]Sagoff (1988, p. 63).
[55]Nozick (1974, p. 36).
[56]See Regan (1983) for a discussion of Descartes's position.

are concerned, we have no direct duties. Animals are not self-conscious and are there merely as a means to an end. That end is man." Nevertheless, "we have duties towards the animals because thus we cultivate the corresponding duties towards human beings."[57] Kant's condemnation of the snapping of fingers relies on the premise that such acts would make people more inhumane. If, on the contrary, cruelty to animals were a substitute for aggressiveness against humans, such acts would be perfectly justified.[58]

The recent contributions by philosophers Singer and Regan have spurred a renewed interest in the question of the moral status of animals. I shall give a brief presentation of their views, emphasizing the implications for environmental decision-making.

Singer and animal liberation

The view that *all* humans, and humans *only*, count morally is very difficult to defend. The only observable characteristic that clearly separates humans from non-humans is *species*. But "species" is a criterion that seems to belong to the same category as "race" and "sex"; criteria that are used to classify individuals according to characteristics that are presumably not of any moral significance. Singer maintains that if racism and sexism are wrong, *speciesism* is morally unacceptable as well (speciesism is defined as the view that humans have moral status merely because they are humans). If Singer is right, a coherent moral theory must sacrifice either the "only humans" or the "all humans" clause.

The latter seems repugnant since those whose interests we would probably first deny would be mentally retarded people – people who we feel deserve a special concern. Singer argues that we should reject the "only humans" clause, and he supports this view by reference to the utilitarian theory. In fact, the possibility that animals might have moral status was recognized already by Bentham, the father of the utilitarian doctrine:

> The day *may* come when the rest of the animal creation may acquire those rights which never could have been withholden them but by the hand of tyranny. The French have already discovered that the blackness of the skin is no reason why a human being should be abandoned without redress to the caprice of a tormentor. It may come one day to be recognized, that the number of the legs, the villosity of the skin, or the termination of the os sacrum, are reasons equally insufficient for abandoning a sensitive being to the same fate. What else is it that should trace the insuperable line? Is it the faculty of reason, or the faculty of discourse? But a full grown horse or dog is beyond comparison a more rational, as well as a more conversable animal, than an infant of a day

[57]Kant (1963, p. 239).
[58]See Nozick (1974) and Regan (1983) for a criticism of indirect duty views.

> or a week, or even a month, old. But suppose they were otherwise, what would it avail? The question is not, Can they reason? nor Can they *talk*? but, *Can they suffer*?[59]

Despite Descartes's denial, most people believe that animals can suffer. It is difficult to *prove* this (as it is difficult to prove that (other) humans can suffer). But if we accept that they can, utilitarianism implies that animals deserve *some* moral concern. How much will depend on the complexity of animal awareness. Singer argues that some animals are self-conscious and have preferences for continued existence.[60] If this much is accepted, it will be *prima facie* wrong to kill those animals, even by giving them a painless death (i.e., killing is in need of moral justification). Animals that are conscious, but not self-conscious (and thus do not have any preference for continued existence), will have a weaker moral status; it would not be wrong in itself to kill them painlessly, but it would be *prima facie* wrong to make them suffer (or fail to alleviate their suffering).

The inclusion of animals in the utilitarian calculus raises few methodological problems for environmental economics. Of course, interpersonal (or interanimal) comparison of well-being will become considerably more difficult, due to the uncertainty about the degree of animal awareness. But this issue aside, it is straightforward to extend welfare economics to include animal welfare.

To apply the extended utilitarian ethic in practice, however, would have drastic implications for environmental policy, in particular for our treatment of wild animals. Nature is full of intense suffering. Much pain could be relieved by ensuring that no animal is killed by predators, and by preventing animal starvation. But given our limited capability to accomplish these goals, the best thing to do would perhaps be to reduce the number of animals substantially by giving them a painless death. Moral intuition would deem these implications reprehensible, though.

Regan and animal rights

Regan does not believe that utilitarianism tells the whole truth about our moral responsibility towards humans, nor towards animals. His objection is a very standard one and relates to the aggregation procedure; by assuming that the ultimate end is to maximize the sum of "utilities", utilitarianism treats individuals as mere receptacles of objects that have intrinsic value (happiness or desire fulfilment).[61] It would be wrong, according to Regan, to make one person suffer intensely, even though his suffering would be compensated in aggregate by a small

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[59]Bentham (1948, p. 311n).
[60]Singer (1980).
[61]Nozick (1974) argues along these lines as well.

increase in the well-being of a thousand other persons.[62] To make sense of this moral intuition, Regan claims that we have to assume that humans have inherent value, and that morality demands that their inherent value be respected.

Regan's argument for animal rights starts from the intuition that we have direct duties towards all humans, including "marginal cases", such as infants and severely mentally retarded who lack the capability to act morally. (He thus rejects Kant's view that to be a moral agent is a necessary condition for having moral status.) Furthermore, he assumes that a morally relevant similarity between all humans, including the marginal cases, is that they are "subjects-of-a-life". To be a subject-of-a-life involves, *inter alia*, to be self-conscious and have the capacity to believe, desire, conceive the future, entertain goals, and act deliberately.[63] Finally, Regan assumes that (at least) all normal mammals aged one year or more are subjects-of-a-life. By the formal principle that equal cases should be treated equally, he then draws the conclusion that it would be arbitrary to deny that (some) animals have moral status. In the same way as humans, these animals therefore have a basic moral right to respectful treatment, and a *prima facie* right not to be harmed.

If we accept Regan's view, we should include the welfare of all subjects-of-a-life in the social welfare function. Note, however, that Regan does not claim that the subject-of-a-life criterion is a necessary condition for ascribing inherent value to animals, it is only a sufficient one. Contrary to Singer, therefore, Regan does not indicate where the moral community ends. His project is to argue that at least *some* animals are included.

The issue of moral status aside, the most important implication of Regan's theory for environmental decision-making is that it rejects the basic aggregation principles of cost-benefit analysis. "...when we must decide to override the rights of the many or the rights of the few..., and when the harm faced by the few would make them worse-off than any of the many would be if any other option were chosen, then we ought to override the rights of the many".[64] In choosing between a wilderness area and an amusement park, we should let the individual that is harmed most severely in either of the alternatives have the final word. If one bear (or one person) must die to build the amusement park, and if the maximal harm done to any individual if the amusement park is not built is the lack of some trivial pleasure, then the amusement park should not be built, regardless of the number of individuals that would suffer the trivial harm.[65]

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[62]For a criticism of the utilitarian aggregation procedure, see Taurek (1977).
[63]Regan (1983, p. 243).
[64]Regan (1983, p. 308).
[65]This principle (the Worse-Off Principle) has some basic similarities with Rawls's Difference Principle (see Rawls (1971)). But whereas Rawls is concerned with *levels* (of primary goods), Regan seems to worry more

8. Respect for life

Even if we reject Regan's argument for animal rights, we may agree with him that a subject-of-a-life has inherent value and therefore is a proper object of moral concern. But, as Regan himself carefully points out, there is nothing in his argument saying that inherent value and moral considerability do not extend beyond the community of subjects-of-a-life. In his discussion of what makes a being morally considerable, Goodpaster rejects both Regan's subject-of-a-life criterion and Singer's sentience criterion and claims that "nothing short of the condition of being alive seems to me to be a plausible and non-arbitrary criterion".[66]

Claims about inherent value are claims about ultimate ends, and as such they are not susceptible of proof. Even if it were a universal human experience that life has inherent value, this would not show it to be so; it would only show that inherent value in life constitutes a universal feature of human experience. With this qualification in mind, I shall, in the following, pursue some *reasons* for perceiving of inherent value in all living things, suggesting that all living creatures have moral status.

The inherent value of *human* life has been quite unanimously accepted in moral theory. Philosophers such as Kant and Nietzsche argued that the inherent value of human life was based on the capacity to reason and the possession of a valuing consciousness. Nietzsche wrote, for instance, that the value of life made itself manifest through the activity of valuing:

> For the philosopher to see a problem in the *value* of life ... constitutes an objection to him, a question-mark to his wisdom, a piece of unwisdom. ... *The value of life cannot be estimated.* ... Not by a living man, because he is party to the dispute, indeed its object, and not the judge of it; not by a dead one, for another reason. ... When we speak of values we do so under the inspiration and from the perspective of life: life itself evaluates through us *when* we establish values.[67]

The assumption that the capacity to reason and the possession of a valuing consciousness are the only sources of inherent value is a controversial one, because it contradicts our moral intuition that infants and severely mentally retarded should be valued for their own sake. Alternative hypotheses might therefore be worth pursuing.

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about *changes* (in well-being) from a given decision. This difference in focus probably stems from the fact that Regan's theory is concerned with well-being rather than primary goods, and that it deals with individuals that are radically different from one another in their ability to experience well-being. If animals have a weaker sensation of well-being than humans, and therefore have a lower level of well-being, it seems greatly unreasonable that animals, for this reason alone, always should be decisive in social choices.

[66]Goodpaster (1978, p. 310).

[67]Quoted in Kleinig (1991, pp. 136-137).

In the neo-Kantian Voluntarist ethical tradition, *reason* has been replaced by *conation* (the "will-to-live") as the essence of the self.[68] The most famous philosopher in this tradition is Albert Schweitzer with his *Reverence for Life* ethic. He wrote:

> If we ask, "What is the immediate fact of my consciousness?" ... we find the simple fact of consciousness is this, I will to live. Through every stage of life, this is the one thing that I know about myself. I do not say, "I am life"; for life continues to be a mystery too great to understand. I only know that I cling to it. I fear its cessation – death. I dread its diminution – pain. I seek its enlargement – joy.[69]

Although Schweitzer discovers his "will-to-live" through his consciousness, he claims that "will-to-live" is a universal attribute in all living creatures, conscious or not. But in what sense has a plant a "will-to-live"? Can the human experience of "will-to-live" really be translated into non-sentient beings? Schweitzer has been accused of appealing too much to a mystical fellow-feeling in making this transition. However, it is possible to form an intelligible conception of the "will-to-live" in non-conscious beings by interpreting this attribute not as a matter of experience, but rather as an inherent biological urge in all living creatures to maintain their identity and realize their *telos* in tension with the threatening forces of their surroundings.

In his theory of *Respect for Nature*, Paul Taylor adopts this perspective to substantiate his claim that all living creatures have inherent value. Plants as well as animals, sentient beings as well as non-sentient, are all teleological centres of life; their internal functionings and external activities are goal oriented, searching to maintain and heal the organism so that biological operations are successfully performed.[70] All living beings thus have *a good of their own* that can be furthered or restrained.[71] Taylor concedes that it is possible to accept that a being has a good of its own and still reject that it has moral status. Nevertheless, he argues that when rational agents recognize this basic similarity between all living creatures, they will conceive of life as inherently valuable.

It might be objected that since plants do not *care* whether their interests are violated ("interests" should here be interpreted broadly to include also unconscious drives, urges, and goals), there is no reason why human beings should ever restrict their actions towards such creatures.[72]

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[68]See Callicott (1989, p. 144).
[69]Quoted in Kleinig (1991, p. 48).
[70]Taylor (1986, p. 121). These characteristics are central in Goodpaster's (1978) theory of respect of self-sustaining organizations as well.
[71]See Attfield (1994, ch. 12) for further arguments supporting this conclusion. For a more sceptical view, see Feinberg (1974).
[72]Johnson (1984), among others.

This objection should be understood in light of the fact that imaginative projection, (i.e., the ability to identify oneself with a fellow creature), traditionally has served as "the primary form of moral argument".[73] And, as Singer has pointed out, to imagine oneself in the position of a non-conscious being "yields a perfect blank".[74] Consequently, such beings do not qualify as moral patients. Irrespective of our position towards mental state theories (e.g., utilitarianism), sentience must therefore represent the ultimate limit of the moral community.

Against this view, Goodpaster replies: "biologically it appears that sentience is an adaptive characteristic of living organisms that provides them with a better capacity to anticipate, and so to avoid threats to life. This at least suggests, though of course it does not prove, that the capacities to suffer and to enjoy are ancillary to something more important rather than tickets to considerability in their own right."[75] For what reason should a flower or a tree be able to feel pleasure or pain? They are perfectly able to fulfil their *telos* without such capabilities. This does not seem to be the case for more advanced creatures, though. For instance, children who lack the sensation of pain are likely to hurt their own bodies severely through careless behaviour. And the human reproductive capacity would probably be substantially reduced without the ability to feel pleasure. Sentience may thus be seen as only instrumentally important in the sense that it is necessary in order to "guide" sophisticated creatures away from bad things and attract them to good ones.

Since plants lack consciousness, we cannot do any harm to *them*. However, thoughtless injury of life may be wrong even though it is not wrong towards the bearer of that life. To abuse or exploit a person in a dreamless coma, from which he or she will never awaken, may not be wrong *towards that person*, since the person has no conscious interests. But if we perceive of inherent value in life, such actions will be wrong because they show lack of respect for an inherently valuable thing. Although unnecessarily destroying a tree is not wrong towards that particular tree, it may nevertheless be wrong because such an act is an offence against something we perceive of as inherently valuable; it represents inappropriate behaviour towards *value*. (Note the parallel between this argument and the way I argued for our moral responsibility towards future generations. I claimed that our responsibility extends beyond the satisfaction of future preferences, because of an obligation *to those values* saying that some preferences are morally superior to others.)[76]

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[73]T. Nagel in *The Possibility of Altruism*. Quoted in Johnson (1984, pp. 356-357).
[74]P. Singer in *The Expanding Circle*. Quoted in Johnson (1984, p. 356).
[75]Goodpaster (1978). Quoted in Kneese and Schulze (1985, p. 199).
[76]Yet another objection against the view that life has inherent value is that it would lead to unacceptable prescriptions for our treatment of vermins (Regan (1986)). Why should we have respect for such poor living things that cause nothing but big trouble? This objection fails, I think, because it does not recognize that inherent value is not the only source of value. Our dislike of vermins is due to their negative *instrumental* value, not necessarily to their lack of inherent value. It is, of course, possible to recognize both negative instrumental value and positive inherent value in one creature. If the negative instrumental value of vermins is big enough,

What then would be the implications for economic theory of accepting that there is inherent value in life? It would, of course, be meaningless to talk about weighing human preferences against the preferences of trees, because trees do not have preferences. What a tree does have, though, is a good of its own, and we might therefore ask whether social choice should include weighing of the good of trees against the good of humans. I cannot see that such a procedure is possible in practice. Interpersonal comparability has been regarded as somewhat problematic when only humans are involved. If the moral community is enlarged to encompass all living creatures, this problem would seem virtually insurmountable.

A somewhat less ambitious approach would be to claim that the inherent value of life implies that the satisfaction of human preferences will require some kind of moral justification, where this justification must be compatible with the principle of respect for life. Both Schweitzer and Taylor follow this course. Schweitzer argues that when the satisfaction of human preferences requires that other lives are sacrificed, the preferences must be justified with reference to the *principle of necessity*. Therefore, "the farmer who has mowed down a thousand flowers in his meadow in order to feed his cows must be careful on his way home not to strike the head off a single flower by the side of the road in idle amusement, for he thereby infringes the law of life without being under the pressure of necessity."[77] Taylor develops a more comprehensive classification of preferences than Schweitzer does, but a distinction between basic and non-basic human interests is a central element in his theory as well.

The framework of economic theory does not distinguish conceptually between basic and non-basic interests. This may be both a strength and a weakness. It is a strength if basic interests differ between societies, as might well be the case. On the other hand, such a distinction seems to be of some significance in a number of normative questions, e.g., in discussions about poverty and the distribution of income. To accept the distinction between basic and non-basic interests as a relevant one in environmental ethics, would imply that information beyond (fully comparable) individual welfare functions is needed in environmental decision-making as well.

Even though we endorse the view that inherent value in life implies that human preference satisfaction should be justified by reference to *necessity* or *basic interests*, the most difficult question still remains unanswered; *what* qualifies as a necessity? Without some further clarification on this point, the theory does not seem to offer much guidance for practical choice. It is beyond the scope of this paper to pursue this issue in great detail.[78] But I would like to

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killing them might be justified, even though their possession of a life makes them morally considerable in their own right.

[77]Quoted in Nash (1989, p. 61).

[78]For a discussion of the distinction between "needs" and "wants", see Braybrooke (1987) and Thomson (1987).

make some general remarks on how the question might be approached. As it appears to me, the framework that was used to substantiate the claim about inherent value in life, offers a perspective that might be worth pursuing on this issue as well. If we acknowledge that life has inherent value because of its teleological character, it seems plausible to assume that the *fulfilment* or *realization* of telos is morally important as well. By recognizing the moral significance of telos-realization, we see how it is possible to justify killing while at the same time acknowledging the moral status of all living creatures. Similarly, it could be argued that encroachment upon other living beings is unjustified if it does *not* contribute to telos-realization.

The historical roots of the telos-realization principle can be traced back at least to Aristotle who claimed that the good life of a living organism turns on the fulfilment of its nature.[79] The difference between the principle of telos-realization and the traditional principle of preference satisfaction is that the former emphasizes that human beings are creatures who develop towards a goal. This is not merely a biological goal, like the goal of plants; the goal of humans is defined in terms of intellectual and moral developments as well. The presence of the moral dimension implies that it is meaningful to talk about *good* people, as opposed to *bad* people. The focus of the telos-realization principle is thus not (only) on what is good *for* people, but on what creates *good people*. Surely, preference satisfaction may not always be what produces good people. The telos-realization principle can thus be used to introduce a distinction between legitimate and illegitimate preferences. In making this distinction, meta-preferences will be of crucial importance, because they reflect our ideas of what it involves to be a good person, i.e., they reflect something about what it is for a human being to fulfil its telos in the moral dimension.[80]

9. Final remarks

These are but a few of the perspectives from which environmental ethics challenge the normative framework of environmental economics. I have confined my attention to ethical theories that ascribe moral status to individuals only. But there are theories that adopt holistic perspectives as well and ask whether we have responsibilities towards species-populations and ecosystems.[81] In addition, there are religious views, saying that our environmental responsibility ultimately is a responsibility to God. The cumulative significance of these

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[79]See Attfield (1994).

[80]For a more comprehensive treatment of the moral significance of *having a good life* versus *being a good person*, see Nozick (1981, pp. 411-413).

[81]See Leopold (1949), Callicott (1989), and Næss (1993) for holistic approaches. For general reviews, see Nash (1989), Johnson (1984), and Ariansen and Wetlesen (1994).

different views is to indicate that the normative foundation for environmental economics is a rather fragile one.

Environmental decision-making is a challenging task for a number of reasons. It involves the management of vital resources under great uncertainty about causes and consequences in complex ecological systems. Moreover, environmental decisions involve the balancing of interests of various affected parties; future generations versus present generations, developing countries versus developed countries, to mention but a few examples. To take adequate account of all these factors is extremely demanding by itself. At least as penetrating and exacting, however, is the challenge to develop an environmental ethic that will constitute a well-founded basis for normative environmental analysis and decision-making. The search for such a normative platform is currently proceeding. Economists should be aware of this process and design their methods to capture its significance for environmental management. In particular, they should be careful to observe that people's environmental preferences may not only reflect personal interests, but value judgements of a substantially more profound moral character.

I have argued that in order to accomplish these goals, the revelation of environmental preferences should proceed by introspection and communication of basic value judgements. Furthermore, the aggregation of environmental preferences should be made sensitive to the cogency of the arguments supporting these judgements. Finally, it has been argued that public discussions on environmental value judgements may be a useful device both for the revelation, the aggregation, and the formation of well-founded environmental preferences.

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-6-

Trade, Morality, and the Environment*

1. Introduction

The question whether trade is harmful to the environment has recently spurred considerable interest. This interest is due to an increasing awareness of environmental problems in our time and the attempt to explore those factors that may explain why this planet is no longer as healthy as we want it to be. Economists have generally been somewhat sceptical to the relevance of this focus on trade as an explanation for environmental distress. Trade is, after all, only the exchange of property rights; an institution that allows individuals and nations to consume what they do not produce, and to produce what others are going to consume. Trade *as such* can therefore hardly be any threat to the environment. Consumption and production may destroy the environment, that is true, but not trade itself. Environmental regulations should therefore concentrate on the core problem: to reduce environmentally harmful consumption and production. There is no need to interfere with trade.[1]

This conclusion hinges on two crucial assumptions: 1) there is a central authority with the necessary will and power to regulate consumption and production; 2) to regulate consumption and production directly will always be more efficient than to use other, more indirect measures. The significance of the first assumption has been demonstrated elsewhere[2]; once it is assumed that some governments are unwilling or unable to internalize environmental values, regulations of the pattern of trade may be an efficient policy instrument. For, although trade *as such* is an environmentally neutral activity, trade may, of course, influence the environment *indirectly* through its effect on relative prices (and thus on production and consumption).

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*For their valuable comments and suggestions, I am indebted to Jan I. Haaland, Ingunn Lønning, Stephen Marglin, Agnar Sandmo, Bertil Tungodden, Anthony J. Venables, and Svein Aage Aanes.

[1]The fact that trade usually involves some kind of environmentally harmful transportation does not affect the validity of this argument. Transportation is just another kind of production or consumption activity that can be regulated directly, rather than indirectly through trade measures.

[2]Mæstad (1994, 1995) [Essays 2 and 3 of this thesis].

In this paper, I explore whether trade can affect the extent of environmentally harmful consumption and production activities through other channels than relative prices. I pursue three different hypotheses, each originating from the idea that social morality may influence the extent of environmental degradation. The exercise aims at improving our understanding of how trade may have contributed to the extent of our current environmental problems. Note, however, that the existence of a causal relationship between trade and environmental degradation does not have any immediate policy implications. To regulate consumption and production directly may, of course, be more efficient than to focus the attention on the more or less subtle mechanisms that make people consume and produce as they actually do. Standard economic analysis suggests that when trade affects the environment through relative prices, the most efficient policy, conventionally measured, is to regulate production and consumption directly, and to let free trade prevail.[3] This may certainly also be the preferable strategy with regard to the causal relations I am going to explore in this paper. Nevertheless, I think the following discussion will demonstrate that other policy alternatives might be worth considering as well.

In analysing the relationship between trade and the environment, existing literature employs the standard Walrasian model of exchange. This approach has several obvious weaknesses. First, in the Walrasian model, trade is seen as merely an impersonal exchange of things (or property rights). In practice, however, trade almost invariably involves interaction between persons. Therefore, trade should be seen as a social act with potential impacts on social relations. In other words, trade may have a *social* outcome, in addition to the economic one. This is an interesting observation from an environmental perspective, because the nature of social relations has direct implications for how people treat each other, including how much environmental harm they are inclined to impose upon each other.

Section 2 of this paper is a discussion of how trade may affect the nature of social relations. The key to a deeper understanding of the social outcome of trade, I presume, is to illuminate the social significance of human interaction during the exchange process. Much of my discussion is therefore devoted to an exploration of how the exchange process may cause either social integration or social disintegration. Moreover, I try to elucidate and explain some trends in the development of exchange practices over time, with particular emphasis on the change in the significance of social morality in economic life that has taken place in our society after the Reformation.

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[3]Mæstad (1994).

A further weakness of the Walrasian model is the assumption that the agents possess all relevant information. This is, of course, a controversial assumption, and many economists have elaborated on the importance of uncertainty and information asymmetries for individual behaviour. In Section 3, I discuss how trade may affect the structure of relevant information available to decision makers who are morally commitment to take into account the environmental consequences of their actions. In particular, I will evaluate the assertion that trade, by increasing the geographical distance between consumers and producers and by increasing the complexity of economic systems, may reduce the ability of consumers to exercise environmental responsibility through their market transactions and, thereby, increase the extent of environmental problems.

In the Walrasian exchange model, the agents adjust their supply and demand to prices that they accept as given from outside. This description of market behaviour is usually claimed to be appropriate in a situation with large numbers of buyers and sellers. It is not uncommon to assume that trade liberalization will increase the numbers of buyers and sellers in each market and thus change the market structure to resemble more closely the competitive markets of the Walrasian model. Such changes in market structure will normally have environmental consequences through changes in aggregate output. In addition, tougher competition may increase the firms' costs of taking voluntary steps towards environmental protection. In Section 4, I evaluate the assertion that trade liberalizations, through their pro-competitive effects, might drive out voluntary environmental responsibility in businesses and thus contribute to an exacerbation of environmental problems.

Although the emphasis of this study is more on understanding the origins of environmental problems than on prescribing their solutions, the analysis will provide insights that might be relevant for environmental policy as well. The policy implications are summarized in Section 5.

2. The exchange process, social relations, and environmental problems

Neo-classical analysis of the trade-environment nexus assumes that the motivations that explain individual behaviour are unaffected by human interaction in the marketplace. The following discussion represents a departure from this tradition by the assumption that not only do agents make exchanges, but exchanges also make agents. More specifically, I will argue that the interpersonal (or social) relations in a society are determined partly by how people interact in exchange situations.

While economists in the neo-classical tradition have showed little interest in the endogeneity of preferences, this phenomenon has inspired considerable intellectual efforts by more radical

economists. One of Marx's central tenets was that economic processes exert a significant influence on the human character.[4] He writes, for instance, that "by acting on the external world and changing it, [the worker] at the same time changes his own nature".[5] Much of Marxist theory has developed around the idea that people's preferences are shaped by their work. Considerably less attention has been devoted to the effect on preferences and norms of exchange processes more generally, but some recent work in this tradition has emphasized the significance of exchange processes for the development of norms that ensure compliance with contracts.[6]

But economists were concerned with the impact of trade on human nature long before Marx wrote *Das Kapital*. Economists of the seventeenth and the eighteenth centuries claimed that trade did not only bring material prosperity, it also made people adopt a more calculating frame of mind and thus created people who were less passionate, more trustworthy, and more prudent.[7] For various reasons, however, such ideas almost disappeared from the agenda of economics during the nineteenth century, despite the influence of Marx. One explanation of this change is that nineteenth century economists were quite eager to make their discipline resemble the physico-mathematical sciences. Leon Walras was perhaps the prime proponent of this orientation in economic theory. In *Elements of Pure Economics*, he proposed to represent interactions between people as if they were relations between inputs and outputs.[8] Economic processes thus came to be viewed more as relations between *things*, rather than relations between people. Such a framework hardly encourages thinking on the connections between economic processes and social relations.

The aim of this section is to take some preliminary steps towards a deeper understanding of the social dimensions of exchange. First, I try to motivate the analysis of the social dimension of exchange by elucidating the importance of social relations for the extent of environmental problems. I then present the main views of the social effects of exchange prevalent in economic literature. Thereafter, I elaborate on how the social outcome of exchange is affected by the mode of exchange, and I close the discussion by commenting on the development of exchange practices in a historical perspective.

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[4]The effect of what we do on who we are is strongly emphasized by Aristotle as well: "Only an utterly senseless person can fail to know that our characters are the result of our conduct." (From *The Nicomachean Ethics*; quoted in Elster (1978, p. 46).)
[5]Marx (1906, pp. 197-198); quoted in Gintis (1974, p. 415).
[6]Bowles and Gintis (1990, 1993).
[7]See Hirschman (1977).
[8]Walras (1873). See also Bowles and Gintis (1993, p. 84).

2.1 Social relations and environmental problems

A common assertion in the literature of environmental economics is that an unrestricted market equilibrium will entail environmental problems. To refer to something as an environmental *problem* is a normative assertion, saying that the state of affairs would in some sense be improved if the strain on environmental resources were reduced. The underlying normative position in environmental economics is usually defined by the Pareto efficiency criterion, implying that an environmental problem exists if the use of environmental resources is too large to be compatible with Pareto efficiency (i.e., a state of affairs where nobody can be made better off without making someone else worse off).

Conventionally, the conclusion that there are environmental problems in an unrestricted market equilibrium is obtained by assuming that agents are selfish and that there are negative externalities in the use of environmental resources. To alleviate environmental problems, economists typically recommend to implement environmental taxes (or other equivalent measures), whereby external costs become internalized.

Social relations are an alternative mechanism by which environmental externalities might be internalized. I shall substantiate this claim shortly, but let me first be more precise about my use of the concept social relations. Social relations might be characterized along a number of dimensions. Our present concern will be with the nature of those *motivations* that guide people in their interpersonal relations. Social relations in a society will therefore be described here by the relative strength of such motivations as selfishness, sympathy, and various other kinds of other-regarding preferences. The interpretation of sympathy is straightforward; sympathy involves a direct care with the well-being of other people, possibly inspired by a personal, emotional involvement. Other-regarding preferences are not always a matter of personal sentiment, though. Such motivations may quite possibly originate in a more abstract conception of right or wrong, e.g., inspired by some general moral theory. I shall use "moral commitments" to denote social relations of this kind. Sympathy and moral commitments are, of course, not mutually exclusive; both kinds of motivation may be needed in order to describe the social relation between, e.g., friends, neighbours, colleagues, and trading partners.[9]

It is not difficult to see that if people were motivated more by sympathy and less by selfishness, the over-use of environmental resources in an unrestricted market equilibrium could be reduced. The theory of externalities may be interpreted to say that the source of environmental

[9]Sen (1977) invokes the concepts of sympathy and commitment to denote different ways in which other-regarding preferences may be related to personal welfare. That issue is not an important one in this context.

problems is an insufficient concern with the well-being of other people.[10] Sympathy directly involves such a concern and will therefore counteract our inclination to disregard the (environmental) costs and benefits that we impose upon each other. Sympathy may thus be seen as an alternative way of internalizing environmental externalities. Furthermore, sympathy (or the identification with other people in general) may make people adopt a more collective perspective on their individual actions. With a collective perspective, each person considers what *we* should do and what the consequences will be for *us*. It has been argued that the collective perspective is essential to the very notion of social interaction.[11] Its potential importance in solving the cooperation problems involved in environmental management is quite obvious.[12]

To show that moral commitments are likely to have a similar dampening effect on the over-use of environmental resources, I will briefly discuss what some important ethical theories have to say about moral behaviour in such cases. I do not claim that moral commitments regarding the use of resources necessarily originate in any of these theories; nor do I claim that people who are inspired by these theories will adopt moral commitments that correspond perfectly to the obligations that follow from the theories. But I do think that the underlying ideas in, respectively, *utilitarianism*, *Kantianism*, and *liberalism*, capture moral insights of a fairly universal character, appearing in a wide range of different normative foundations for interpersonal obligations.

Consider first the utilitarian position. According to one formulation of the utilitarian principle, an act is right if it produces a greater aggregate amount of well-being (or happiness) than any other feasible alternative. In calculating the aggregate well-being, all affected parties are to count equally. As a source of moral motivation, utilitarianism thus provides a strong invitation to take into account how the use of environmental resources influences the well-being of others. Taken literally, it requires a full internalization of all external costs (and benefits).[13]

Next, consider Kant's categorical imperative. Among the different formulations of this ethical principle, it is perhaps the so-called humanistic one that most clearly displays the moral relevance of the use of resources; "act in such a way that you always treat humanity, whether in your own person or in the person of any other, never simply as a means, but always at the

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[10]Based on this line of reasoning, Dasgupta (1990) suggests that environmental problems might be described as a norm failure rather than a market failure.

[11]See Hausman and McPherson (1993), and the references therein.

[12]Note that with a collective perspective, cooperation is possible even in a one-shot Prisoners Dilemma.

[13]This version of utilitarianism is usually called act-utilitarianism. Other versions, such as rule-utilitarianism, would also provide strong moral reasons for taking account of the well-being of other people in environmental decision-making. For an early discussion of rule-utilitarianism, see Mill's essay in Ryan (1987, pp. 272-238).

same time as an end".[14] To exploit environmental resources without taking into account the negative consequences for other people seems to qualify as a violation of this norm. To treat people as ends in themselves would thus imply that environmental degradation were reduced to a level below the "market solution".

But this formulation of the categorical imperative does not seem to offer much guidance with regard to the extent of our obligations to take environmental responsibility. Does the requirement of "never simply as a means" imply that the interests of all affected parties should count equally (as in utilitarianism), or is it morally legitimate to give others a smaller weight than yourself? Kant has provided another formulation of the categorical imperative which might shed somewhat more light on this issue; "act only on the maxim through which you can at the same time will that it be a universal law". To accept a maxim as a universal law implies that the maxim that I act on as a polluter must be accepted by me also when I am the victim of pollution.[15] This seems to indicate that I will choose a maxim which prescribes to pay much attention to the interests of others, although there is no guarantee that the interests of others will count as much as my own interests. Against this background, I conclude that Kantianism may give rise to moral commitments that might reduce environmental problems significantly.

The vague character of Kantian ethics has inspired much discussion about what it really involves to treat other people as ends in themselves. Liberalism can be seen as one of the contributions in this debate. According to libertarian ethics, there ought to be a protected sphere around each person, into which any intentional interference cannot be made without the person's voluntary consent. Libertarians may disagree somewhat on what belongs to the private sphere, but it is usually assumed that a person's life, his property, and his voluntary exchanges with other people should be included. A number of environmental problems are due to acts that hurt other people's life and/or property. Such acts seem irreconcilable with libertarian ethics, and some libertarians therefore claim that pollution is simply wrong, irrespective of the possible benefits that may be brought about by polluting activities.[16] This seems like a too extreme claim, though, and other libertarians have argued in favour of a traditional cost-benefit analysis of environmental problems, at least when only property is affected.[17] Anyway, we can conclude that libertarianism may give rise to moral commitments in the environmental field which are at least as dampening on the use of resources as the commitments arising out of the other normative frameworks we have been considering.[18]

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[14]Kant (1964, p. 96).
[15]See Johansen (1994, p. 135).
[16]M. Rothbard, *The Great Ecology Issue*; quoted in Wenz (1988, p. 65). See also Machan (1984).
[17]Nozick (1974, pp. 79-81).
[18]An ethical rule which might be defended within a libertarian framework, and which allows for polluting activities to take place, would be to say that pollution is legitimate if all victims of pollution are compensated

This brief discussion has demonstrated that there is a strong basis in various normative theories for moral commitments which would alleviate those environmental problems that arise in an unrestricted market economy with selfish agents. In the following, a society where the social relations have a strong element of moral commitments of this kind, or where sympathy is a significant motivation, will be characterised as a *strong social community*, as opposed to an *individualistic* society where such motivations are less important relative to pure selfishness.

A growing body of literature suggests that strong social communities are of great practical significance for sustainable resource management. Evidence of successful management of common property resources has been provided from a number of societies[19], questioning some of Hardin's predictions in his famous essay on *The Tragedy of the Commons*.[20] There is probably no single explanation why available evidence does not conform with Hardin's prophecies, but one explanation, which seems to be gaining increasing support in the literature, is Hardin's total neglect of social relations and their consequences for the exercise of social responsibility.[21]

I have tried to argue that the quality of social relations (sympathies and moral commitments) is important for the extent of environmental problems. I shall close this discussion by two examples where the strength of social communities obviously will affect our ability to deal with environmental challenges. Consider first the problem of sustainable resource management over generations. Without sympathies or moral commitments that compel us to share environmental resources with future generations, it is not easy to see how we might be able to limit our extraction of resources to sustainable levels. The second example concerns the case of international pollution. Since there is no central authority that can force the nations to reduce their emissions, these problems can only be solved through some kind of international agreement. Both in the negotiations of such agreements and when the agreements shall be carried out into practice, sympathies and moral commitments that make each country pay some attention to the world community as a whole, will be immensely important.

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for their welfare losses. A libertarian would be able to defend this rule because pollution then is transformed into a voluntary transaction.

[19]Berkes (1989), Bromley (1992), among others.

[20]Hardin (1968).

[21]In addition to Berkes (1989) and Bromley (1992), see brief discussions in Dasgupta (1990), Perrings (1985, 1989), Sahlins (1972), Bird-David (1992), and *The Ecologist* (1992, vol. 22).

2.2 The exchange process and social relations

Social communities come into existence through human interaction, but human interaction may also cause communities to dissolve. As our economy has developed from being largely a household economy to become a market economy, trade has become an increasingly important arena for human interaction. It therefore seems to be of some interest to reflect upon the impact of human interaction in trade on the building of social communities, and on their breaking apart. In the following, I will argue that trade may involve both forces that tend to weaken social relations, and forces that may give them further strength. Moreover, I shall argue that some forces that are not particularly conducive to the development of strong social communities play a predominant role in the exchange practices of our society.

When the effects of trade on society have been under debate, most attention has been devoted to political and economic consequences. Comparatively little effort has been put into systematic inquiries of the impact of trade on social communities. Although both economists, sociologists, anthropologists, historians, and political philosophers at various times have been struggling with this issue, no well-defined body of literature has emerged. It seems like rather different lines of thought have been pursued quite independently of each other at different points of time, and within different disciplines. Despite the fragmented nature of this literature, I shall suggest to classify the contributions in two categories: 1) those who insist that trade creates bonds of "friendship" between individuals (and nations), and 2) those who claim that trade in some way or the other promotes a more individualistic society.[22]

Jaques Savary, a seventeenth century thinker, maintained that "[Divine Providence] has dispersed its gifts so that men would trade together and so that the mutual need which they have to help one another would establish ties of friendship among them".[23] A similar, but perhaps somewhat weaker, claim about the socializing effect of trade was set forth by Samuel Ricard early in the eighteenth century: "Commerce attaches [men] one to another through mutual utility".[24] Both these statements seem to contain a claim that trade creates interpersonal dependency. Savary asserts, in addition, that such dependency brings about friendship between people. This is perhaps Ricards' position as well, provided "attachment" is to be interpreted as some kind of social bond between individuals, and not merely as a dependency relation.

Be this as it may, the assertions of Savary and Ricards present us with two vital questions. Is it true that trade makes people more dependent upon each other? And will economic dependency

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[22]The most important sources for the following discussion are the excellent works by Hirschman (1977, 1986a).
[23]Savary, *Le parfait négociant*; quoted in Hirschman (1977, pp. 59-60).
[24]Ricard (1704), *Traité général du commerce*; quoted in Hirschman (1986a, p. 108).

through trade lead to "friendship"? There is no easy answer to any of these questions. With regard to the first one, it seems that the relation between trade and interpersonal dependency must depend on the structure of the market. When a household economy starts to specialize, people will have to rely on their neighbour for what was earlier produced within the household. Neighbours may thus become more dependent upon each other. However, as the market system expands and people can choose among a large number of suppliers, the dependency on any particular neighbour is obviously reduced. There is still dependency, but it is now dispersed on a much larger group of people. In a competitive economy, there may be dependency on "the market", but there is indeed no dependency on any particular supplier (or buyer). But since no one interacts with "the market", but rather with particular persons in the market, it is not at all clear what the market dependency in a competitive economy is worth in terms of personal relations.[25]

In those cases where trade actually creates personal dependency, what will be the consequences for social relations? It seems quite obvious that dependency cannot be a sufficient condition for the strengthening of social relations. Sympathy and moral commitment may be absent even in the strongest dependency relation.[26] But even though the causal link between dependency and social relations may be rather weak, there might certainly be other aspects of the trade relation which create social bonds between people. Aristotle, whose general attitude towards commercial trade was rather sceptical, insists in the *Nicomachean Ethics* that "[i]t is by exchange that men hold together".[27] Reading the sentence in its full context reveals, however, that Aristotle here may have in mind another kind of exchange than what we usually refer to as trade: "It is by exchange that men hold together. That is why they give a prominent place to the temple of the Graces – to promote the requital of services, for this is characteristic of grace[28] – we would serve in return one who has shown grace to us, and should another time take initiative in showing it." What Aristotle seems to be talking about is the exchange of *gifts*; it is the exchange of gifts that holds a society together.

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[25]This may perhaps explain why the dependency argument often has been applied to the relation between nations, rather than to personal relations. Montesquieu, along with many other thinkers in the early era of capitalism, was an eager proponent of the view that trade is conducive to peace because it makes nations dependent upon each other. The reason why this argument may have more force on the national level than on the personal level is that there are fewer actors at the national level. In international trade, the number of trading partners is in some sense limited to the number of countries involved, since governments have the authority to act on behalf of all individual buyers and sellers in their country. Note, however, that as the world economy becomes more integrated, making it more easy for a country to switch between different buyers and sellers, international trade may lose some of its previous ability to create bilateral dependency between nations.

[26]To be sure, dependency will often have a disciplinary impact on people's behaviour, inducing them perhaps to "cooperate" more willingly. In that case, it is the threat of trade sanctions that make people change their behaviour. Such sanction mechanisms may surely be important in an environmental context as well (cf. the use of trade restrictions in international environmental agreements). Interesting though as this subject is, it is somewhat beyond the scope of the present analysis.

[27]Aristotle, *Nicomachean Ethics, 1133a*; quoted in Brockway (1991).

[28]Grace can also mean "kindness" or "favour".

Indeed, the power of gifts to bring about and maintain social bonds seems difficult to deny.[29] But have these assertions about the socializing effect of gift exchange anything to do with trade?[30] They may have. The central element in both kinds of transactions appears to be the reciprocation of favours. So, if gifts may bring about and maintain social bonds, cannot trade have some of the same effect? This question will be addressed after having presented the second major view of the effects of trade on social relations, to wit that trade brings about a more individualistic society.

It is interesting to observe that the idea that trade promotes individualism has been maintained both by those who have opposed the market system and by those who have strongly supported it. Starting with the sceptics, we should not be very surprised to find that Marx and Engels were eager to emphasize the corrosive effects of capitalism on communal values. In the *Communist Manifesto*, they claim that when everything passes into trade and commerce, all social bonds dissolve through money. More surprising, perhaps, is the fact that Montesquieu expressed exactly the same concern. In general, Montesquieu is full of praise for commerce. He saw in the market society a system with great political advantages. Trade would lead to peace between nations, and it would produce people with more gentle manners. "Commerce ... polishes and softens barbaric ways as we can see every day."[31] However, when it comes to the effects of trade on social bonds, he regrets that trade causes a monetization of all human relations and a loss of hospitality and other moral virtues.[32]

Both Marx/Engels and Montesquiue relate the impoverishment of human relations to the use of money. I presume that what they are concerned about is not money as a means of payment, but rather that money may become the overriding end and purpose of human interaction. In other words, when trade takes a more prominent place in human lives, the focus on economic values may reduce fellow human beings to mere means.[33]

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[29]"That friendship last longest ... in which friends both give and receive gifts." This passage from the poems of *Hávamál* illustrates, I think, a very general understanding of the socializing effect of gift exchange.

[30]Some readers may have difficulties with my use of the term gift exchange. Are not gifts something unilateral; something that is given without receiving anything in return? True, some gifts are of this kind. As Cheal (1988) has documented, however, most gift relations are characterized by some kind of reciprocity (cf. the tradition of gift exchange at Christmas time).

[31]Montesquieu, *Des l'esprit des lois*; quoted in Hirschman (1986a, p. 107).

[32]See Hirschman (1977, p. 80).

[33]It is possible to argue that the means of payment might as well have effects on social communities. Goods that are handed over to other people may carry with them something of the identity of the giver. Mauss, among others, has stressed the point that goods that are exchanged may tie person to person if the good is conceived of as inalienable: ".. to give something is to give part of yourself" (Mauss (1954, p. 10). See also Cheal (1988)). The problem with money in this respect is that it is difficult to attach personal identity to a piece of money. This problem is well known for those who give Christmas presents; to give present in the form of cash is not the same as giving presents in kind, not to speak about presents that are self-made.

The concern that such instrumental attitudes towards other people will penetrate the market society is also prevalent in the writings of Adam Ferguson, a member of the Scottish Enlightenment in the eighteenth century. He too was optimistic about the political effects of trade, but regretted its social implications. He contrasted the spirit of community in traditional societies with the "spirit that reigns in a commercial state where ... man is sometimes found a detached and a solitary being", where "he deals with his fellow creatures as he does with his cattle and soil, for the sake of profits they bring", and where "the bands of affection are broken."[34]

To treat other human beings merely as means, and not as ends in themselves, may be a *consequence* of individualism, as I have defined the term. But can the instrumental treatment of others *bring about* more individualistic people? Those who have commented on this topic seem to presume that the answer is yes: trade does not only give vent to a more or less constant individualistic attitude in human beings; through trade this attitude is cultivated and made a more dominating feature of human nature.

This line of reasoning is prominent in Hirsch's retrospective analysis of the impact of trade and commerce on social communities over the last few centuries. Hirsch goes rather far in emphasizing the eroding effect of the market system on the moral foundations of society. He claims that our moral legacy from preceding socio-economic regimes "has diminished with time and with the corrosive contact of the active capitalist values – and more generally with the greater anonymity and the greater mobility of industrial society. ... *As individual behavior has been increasingly directed to individual advantage, habits and instincts based on communal attitudes and objectives have lost out.*"[35]

Even Adam Smith, in fact, seems to have been somewhat concerned with some of the social effects of trade. Admittedly, he is most famous for his emphasis on the improvements that commerce would bring about in human nature. But at the same time, he was concerned that the commercial spirit would make people's minds more "contracted, and ... incapable of elevation".[36] Smith's idea is not very different from that of Hirsch; commerce will change human nature to become more directed towards individual economic gain. Although this change, in the view of Smith, may have several advantages, it may cause some problems when it comes to matters beyond individual advantage, such as the willingness to make sacrifices for the benefit of other people in the community.

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[34]Ferguson, *Essay on the History of Civilized Society*; quoted in Hirschman (1977, p. 120).
[35]Hirsch (1976, pp. 117-118). Emphasis added.
[36]From Smith's *Lectures*; quoted in Hirschman (1977, p. 106).

The idea that trade promotes individualism has been illustrated by a few selected references.[37] But I would like to underscore that this view has by no means been a minor one in the debate about the social effects of trade. The idea was perhaps most popular at the threshold of this century, after the revolutionary forces of the nineteenth century had made their imprint on people's minds. At that time, according to Hirschman, the view was widely held that "within the boundaries of the nation, the expansion of industry and commerce was ... contributing to the breakdown of traditional communities, and to the loosening and disintegration of social and affective ties, rather than to their consolidation".[38]

In the following, I will provide some explanations why trade does not have any unambiguous impact on the strength of social communities. Based on an investigation of the exchange process, emphasizing both its economic and its social dimension, it will be argued that trade entails elements that may breed both social integration and social disintegration.

Explanations

Trade may affect social relations through a number of mechanisms. Some people would emphasize the effect on social relations of trade-induced changes in social and geographical mobility. Others might focus on the relation between trade, competition, and social rivalry. These aspects, important though as they might be, will not be addressed in the following. This discussion is confined to the social aspect of the exchange process itself, emphasizing how different modes of exchange may give rise to different social outcomes.

There are several reasons why trade (or, the exchange process) may have an integrative effect on social communities. First, it is not difficult to conceive that trade may be conducive to the development of sympathy. Normally, people need to get into some direct contact with each other in order to develop strong social bonds of this kind.[39] Trade may establish such contact, make it easier to identify with other people, and may thus promote a direct care for the well-being of others. In order to obtain such social integration through trade, it would of course be necessary to abandon the Walrasian ideal of anonymous exchange; trade would have to involve a personal dimension. Moreover, enduring trade relations might be preferable to transitory ones if people need to be around each other for a certain period of time in order to develop social bonds.

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[37]On the relation between market society and individualism, see also Schumpeter (1919, 1942) and Hyde (1979), among others.

[38]Hirschman (1986a, p. 118).

[39]Elster (1989, p. 285) argues, in a similar vein, that people need to be around each other for a certain period of time in order to develop bonds of altruism and solidarity.

Furthermore, I will argue that trade in some cases might contribute towards a strengthening (or maintenance) of moral commitments. My argument derives from a particular view of the properties of moral resources, on which I shall briefly elaborate before proceeding.

Many resources are scarce because they are subject to depletion when they are used. Some authors have found it appropriate to use the scarce-resource-model to characterize moral resources as well.[40] They have argued that since the availability of moral resources is limited, we need to economize with them by creating institutions that reduce our reliance upon these resources. Although this argument has a certain appeal, it does not seem to capture the whole truth about how we should understand moral resources. Surely, the "supply" of moral resources is limited in the sense that we cannot rely solely upon the good will of people for a well-functioning society. This does not imply, however, that moral resources will become depleted when they are used. The very opposite does in fact seem more plausible; that moral resources are enhanced by frequent use. Hirschman has argued convincingly along these lines by characterizing moral resources as a skill that is acquired in a learning-by-doing fashion.[41] And Mill once exclaimed, in a similar vein, that "the only mode in which any active principle in human nature can be effectually cultivated is by habitual exercise".[42]

Granted that the availability of moral resources is positively linked to their use, it should not be difficult to conceive that trade in some cases may contribute towards a strengthening of the moral resource base. By way of illustration, a person who is going to sell his used car may on moral grounds desist from taking advantage of the buyer's ignorance of some hidden defects; and exchange parties may choose to comply with verbal agreements even though it would not be in their (narrow) self-interest to do so. These examples illustrate how the presence of asymmetric information and unformalized contracts may invite the agents to act on moral motivations during the exchange process. Insofar as the moral course of action is followed, trade has contributed to a cultivation of the moral resources of society.

This suggests that asymmetric information and unformalized contracts, which in conventional economic theory are regarded as impediments to efficient exchange, should not be seen as unqualified problems once the social dimension of the exchange process is acknowledged. In fact, a low degree of formalization of exchange may in some cases be a requirement for a positive social outcome of the exchange process. This is perhaps most clearly demonstrated in

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[40]Robertson (1956), Arrow (1972). Adam Smith argued along similar lines when he celebrated the ability of society to do without "benevolence", as long as individual "interests" were given free play.

[41]Hirschman (1986b). See Dasgupta (1988, pp. 64-66) for a somewhat different explanation of how moral resources (and trust in particular) may grow through their use. He argues, for instance, that by placing trust in each other, people will create a sense of obligation not to betray that trust.

[42]Mill, *Collected Works, X*. Toronto: University of Toronto Press (1969, p. 423); quoted in Hirsch (1976, p. 95).

the exchange of gifts. Imagine the family, which members sign a written contract about what to give each other for Christmas, including penalty rules in case someone does not comply with the agreement. It is questionable, to put it mildly, whether the integrative power of gift exchange is compatible with such extreme formalization of the exchange process.[43]

Even in the absence of any formalization, however, the practice of gift exchange occasionally degenerates to a non-integrating activity. This may happen if the practice is sustained by implicit incentive mechanisms that make gift giving a matter of (narrow) self-interest. A crucial factor for the integrative potential of gift exchange thus seems to be whether or not any appeal is made to motivations beyond that of (narrow) self-interest. But this is exactly what was argued to enhance the potential for a positive social outcome in ordinary trade. This shows why trade may have some of the same integrative potential as gift exchange.

The fact that the agents are invited to act on moral principles during the exchange process does not ensure, of course, that the moral course of action will be followed. When a seller gives the buyer credit without any formal contract, the buyer may be tempted to betray the trust that has been placed in him. But if he deceits, the social outcome of the exchange process will probably turn out rather unfavourable. An exchange process that appeals to moral behaviour is thus a double-edged sword; it may breed both social integration and social disintegration.

This leads to the second main view of the social effects of trade, to wit that trade may cause social communities to dissolve. I shall present three arguments that may support this view. The first argument concerns the social consequences of economic conflicts involved in exchange. Since the economic gain from exchange is finite, in the sense that neither party can enhance his own payoff except at the expense of the other party, exchange will always entail an element of conflict. It was this conflict that tempted the buyer to deceit in the example above; he saw an opportunity to make a large economic gain. By exploiting this opportunity, he would fail to produce a beneficial social outcome of the exchange process.

The fact that there are economic conflicts in exchange does not imply, of course, that there must be social conflicts as well. Different ways of settling the economic conflict may give rise to exchange processes with both positive and negative social consequences. One way of distributing the economic gain would be through acts of mutual generosity. Imagine a seller who offers a favourable price to the buyer, where-upon the buyer responds by paying a little more than he was asked. It is difficult to see how this way of settling the economic conflict can

[43]Boulding (1973, p. 26) has made the same point in his discussion of grants economics: "Once reciprocity is contractually formalized, there is [trade], and the integrative aspects of reciprocity disappears."

be a threat to social relations. Quite the contrary, such behaviour might be seen as a case where trust is displayed and reciprocated, facilitating a strengthening of the social community.

Those who maintain that the economic conflicts in exchange are a threat to social relations might object that such conflicts are not normally settled through mutual generosity, but rather through (mutual) greed. Greed can be expressed in a number of ways in exchange; from explicit deceit (as in the example above) to the relatively innocuous practice of always opting for the cheapest alternative. The social significance of greed derives from the fact that greed goes together with an instrumental attitude towards the other exchange party (by way of illustration, the greedy person does not bother whether his exchange party is affluent or needy). Greedy behaviour in exchange thus qualifies as a violation of Kant's categorical imperative that nobody should be treated as a means merely. It should be rather obvious that such instrumental attitudes might constitute a threat to the maintenance of strong social communities.

The next argument for the disintegrative effect of trade on social communities was originally set forth by Schumpeter.[44] He claimed that by devoting more time and energy to commerce, people would adopt a more calculating and instrumental attitude towards life in general. Such attitudes can undermine social morality, because people will no longer follow moral rules simply because that is what they ought to do. Instead, they will to an increasing extent start to ask what is in it for them. Norms that are not sustained by a well developed system of sanctions, will then easily disappear. (Note that a system of sanctions may itself be vulnerable to a more calculating attitude: "why should I punish the one who failed to punish the one who failed to punish the person who broke the norm?") The calculating spirit of commerce may thus do away with some of the bonds that hold a society together.[45]

The third, and final, argument may be seen as the mirror image of the previous argument that social communities may be strengthened by the appeal to, and the use of, moral resources in exchange. In short, I shall argue that if moral resources are *not* routinely appealed to and used in economic life, that may lead to a *depletion* of those resources. The argument proceeds in two steps; I first explain why moral resources may need to be used to remain intact, thereafter I explain why the moral dimension actually may be playing a less vigorous part than it could in many trade relations.

Along with his argument that moral resources are acquired in a learning-by-doing fashion, Hirschman sets forth the claim that moral resources – like the ability to speak a foreign

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[44]See Schumpeter (1942).

[45]In fact, Schumpeter went as far as to claim that the critical frame of mind that was cultivated through commerce eventually would destroy the moral foundations of the capitalist system itself.

language or to play the piano – are likely to become depleted and to atrophy if not used.[46] But what exactly is it with moral resources that gives them these properties? Hirschman does not address this question, but let me suggest the following. The moral resources of society can be described along (at least) two dimensions: 1) which moral principles people follow when they choose to act morally, and 2) under which circumstances people act morally. The use of moral resources will probably have some effect in both these dimensions, but my concern here is only with the latter. People's choice of whether or not to follow a moral course of action will of course depend on whether the choice in question is perceived as a moral issue. But if society is so organized that some problems, which ultimately are moral problems, are handled without appealing to moral motivations, these problems may eventually cease to be perceived as moral problems. The moral dimension of the problem might simply get out of sight if people are not used to interpret the situation from a moral perspective. It this way, the scanty use of moral resources may lead to a depletion of those resources.[47]

Of course, in those cases where society really might be so organized that the reliance on morality can be safely disposed of, such depletion of the moral resources would not pose any big problems. Trade is not such a case, though. Environmental externalities, asymmetric information, and uncertainty are phenomena that will continue to be of great significance in economic life. To dispose of moral resources in this situation might lead to considerable economic inefficiency.

From this perspective, it is somewhat paradoxical to observe how our society over the last few centuries has embraced the idea that self-interested behaviour in trade is fully legitimate. The historical background of this precarious idea will be illuminated shortly. For the moment, it suffices to note that some time in the latter half of this millennium, the claims of morality came to be regarded as far less relevant in economic life than in other fields of human interaction. The reasoning above suggests, however, that if individual behaviour in trade is directed increasingly by self-interest pure and simple, the moral dimension of the exchange process is likely to recede into the background of people's consciousness. Eventually, exchange practices organized around the principle of self-interest may reduce people's ability to perceive of the exchange process as involving moral choices. The moral resource base has then been depleted, and the social community has been weakened. The relevance of such effects for environmental degradation is quite obvious: if most people do not perceive of production and consumption

[46]Hirschman (1986b, p. 155). See also Hirsch (1976).

[47]Titmuss (1970) argues that there is evidence of such effects in the market for blood donations. He shows that the quality of blood donations is lower in countries that use the price mechanism to create blood supply than in countries that rely on appeals to social morality. Titmuss takes this to imply that the moral dimension involved in the supply of blood tends to lose ground once moral motivations are not appealed to.

activities as moral choices, that is probably part of the explanation of the extent of our current environmental problems.

This completes my discussion of why trade may have both integrative and disintegrative effects on social communities. It would seem appropriate to proceed by trying to explain the actual mode of exchange in different situations as an equilibrium phenomenon. One issue that we then would need to pay careful attention to, is the structure of the game that is played by exchange parties. Some kind of cooperative behaviour will often be important for the achievement of a positive social outcome of exchange. By way of illustration, in the example with the seller who was considering to give credit without contract, the seller first had to take a chance and place his trust in the buyer – otherwise there would be no scope for moral behaviour; the buyer must then reciprocate by trustworthy behaviour. But with this sequence of events, the subgame perfect equilibrium may easily turn out to be that the seller does not offer credit without contract, and hence that the moral resources stay unused. This may happen even though both parties would rather prefer the outcome where trust is displayed and reciprocated.

At least as important as such strategic aspects, however, is probably the specification of which importance individual exchange parties attach to the social outcome of exchange (compared to its importance for society at large). I shall close this section by claiming that the social dimension of exchange probably is perceived as less important in our society than in many previous ones, implying – *ceteris paribus* – that a positive social outcome of exchange has become less probable over time.

A historical perspective on the social dimension of exchange

Inquiries into the way of life in archaic societies have shown that an important purpose of their economic transactions was to bring about and maintain social communities.[48] Several authors have argued that exchange in primitive societies in fact originated in the need to maintain social systems, rather than in the human "propensity to barter, truck and exchange one thing for another", which Adam Smith considered as the main reason for economic transactions.[49]

The significance of the social dimension of exchange in archaic societies found expression in, for instance, extensive speech-making and other social activities surrounding the act of exchange.[50] One effect of these rituals was to play down the economic conflicts in exchange by making the economic motive appear as subordinate to the social motive of exchange. Behaviour

[48]Mauss (1954), White (1959), Polanyi (1944, 1957), Herskovits (1960).
[49]Smith (1776, p. 13). See Polanyi (1944) and White (1959, p. 334).
[50]Mauss (1954), Miller (1991).

that quite explicitly de-emphasizes the economic dimension of exchange has been documented by Herskovits in his study of exchange between tribes in the area of the Huan Gulf in New Guinea: "The goods are handed over as though they were free gifts offered out of friendship. Discussion of values is avoided, and each person does his best to convey the impression that no thought of a counter gift has ever crossed his mind."[51] Polanyi has made similar observations: "The giver may simply drop the object on the ground and the receiver will pretend to pick it up accidentally, or even to leave it to one of his hangers-on to do so for him. Nothing could be more contrary to accepted behavior than to have a good look at the counterpart received."[52]

As indicated by the language of the preceding quotations, exchange in archaic societies is usually described as reciprocal *gifts*. The use of the term *gift exchange* instead of *trade* underscores how important exchange was considered to be for the establishment and maintenance of social bonds. In addition to the factors already mentioned, the integrative aspect of exchange in archaic societies was enhanced by extensive reliance on trust for the reciprocation of economic favours; by the establishment of multi-party exchange relations, where reciprocity was carried on through a gift circle[53]; and by a strong perception that exchange was always carried on by groups, and not by individuals.[54]

The description of exchange in archaic societies stands in stark contrast to how people seem to conceive of exchange in a market economy. In particular, the relative importance of the social dimension of exchange seems to have diminished over time.[55] Buchanan describes exchange practices in our society like this: "I do not know the fruit salesman personally, and I have no particular interest in his well-being. He reciprocates this attitude. I do not know, and have no need to know, whether he is in direst poverty, extremely wealthy, or somewhere in between... Yet the two of us are able to ... transact exchanges efficiently..."[56] If Buchanan's description is representative, we can conclude that market exchange is characterized by a high degree of anonymity and by a quite explicit instrumental attitude between exchange parties. Moreover, Buchanan's statement illustrates a complete disregard of the social outcome of the exchange process; otherwise he would not have invoked the concept of efficiency.

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[51]Herskovits (1960, p. 194).
[52]Polanyi (1944, p. 59).
[53]The *kula* ring on the Trobriand Islands is a fascinating example of such multi-party gift exchange. Hundreds of persons participated and thousands of commodities circulated in this chain of gifts. See Mauss (1954). On the integrative power of multi-party exchange, see also Boulding (1973).
[54]Mauss (1954, p. 3).
[55]Several authors have argued that during the last few centuries, the market mentality with its focus on individual advantage has replaced much of the previous emphasis on the social (or moral) aspects of exchange. See Polanyi (1944), Thompson (1971), Zelizer (1979), and Cheal (1988), among others.
[56]Buchanan (1975, p. 17); quoted in Bowles and Gintis (1993, p. 85).

Why is it that the social dimension of exchange over time seems to have lost ground relative to the economic dimension? *Structural* differences between modern and traditional societies probably explain part of the transition. Due to a higher degree of economic specialization, a closer integration of the world economy, and a higher population, the number of profitable exchange opportunities has increased quite dramatically over the centuries. Since modern society is so organized that new opportunities of profitable exchanges are discovered all the time, there tends to be a high turnover in exchange relations. Therefore, people spend less time with each exchange party, leading to greater anonymity and reduced opportunities for sympathies and other social bonds to develop. Other structural explanations might be worth pursuing as well. However, I will argue that the decline of the social dimension of exchange cannot be fully understood unless we also consider some of those *ideological* developments that have taken place during the last few centuries. I now turn to a discussion of this issue.

The ideological foundations of exchange have changed dramatically since the medieval ages. Before the Reformation, economics was a branch of ethics, and ethics of theology.[57] Society was interpreted, not as the expression of economic self-interest, but as held together by a system of mutual obligations.[58] Medieval thinkers maintained that economic interests needed repression, and not a clear field. Trade was legitimate: the uneven distribution of resources showed that this was the will of God. But trade was regarded as dangerous business. Every man's obligation was to make sure that his trade was carried on for the benefit of society as a whole.[59] This subordination of economic interests to social obligations was probably conducive to a positive social outcome of the exchange process.

The Reformators initiated a process which eventually made it a widely held view that economic activity could be regarded as separable from social life and moral obligations. Luther drew a sharp antithesis between the external order and the life of the spirit. True Christians are so rare, he claimed, that, for all practical purposes, grace, goodwill and gift cannot be the basis of civil society. Other reformers elaborated these ideas more than Luther did. In Calvinist teaching, there is a systematic recognition and applaud of the world of economic motives.[60] And in the later Puritan movement, we observe an unveiled idealization of the life of the trader, "as the service of God and the training-ground of the soul".[61] These attitudes can be explained, first, by a general tendency towards greater individualism in religion, emphasizing that each individual is responsible for his relation to God: nobody can save his brother! Such teaching seemed to have the consequence that social obligations were disparaged. Second, in Puritan

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[57]Tawney, (1969, p. 272).
[58]*Ibid.* p. 37.
[59]*Ibid.* p. 44.
[60]*Ibid.* p. 114.
[61]*Ibid.* p. 238. See also Weber (1930).

teaching, the unlimited acquisition of wealth, which in earlier times had been regarded as the root of all evil, was transformed into a moral duty; commercial success being the sign of moral superiority, or even salvation.

Parallel with the religious defence of the pursuit of economic self-interest, there was a more secular one. At first, the arguments concentrated on the moral benefits of directing human energies into the accumulation of wealth. A major concern for seventeenth and eighteenth century thinkers was how to tame the wild and furious human passions. One of their ideas was that the passions could only be cured by pitting them against each other.[62] For the purpose of taming the more dangerous and destructive passions, people's passionate attraction towards economic advantage appeared to be a promising candidate. In an age when the beginnings of economic growth made it possible for an increasing number of people to improve their economic conditions, this passion for economic gain could be expected to have significant influence on human conduct. Moreover, the pursuit of economic interests appeared to be a relatively innocuous activity, because it implied more reflection and calculation than other passion-driven activities. The pursuit of economic interests thus came to be viewed in a morally favourable light, not so much for what it represented in itself, but more because of the other evils that it prevented.

A complementary, and perhaps even more powerful, defence of the pursuit of private economic gain emerged with the idea, appearing in Mandeville's *Fable of the Bees* and later elaborated by Smith, that there is no conflict between the pursuit of narrow self-interest in economic life and the general social welfare. Mandeville pointed out that the behaviour that appeared to be morally dubious at the individual level had the most desirable social consequences in terms of a rapid accumulation of wealth in society. "Private vices" promoted the "publick benefits", he maintained.[63] But since it was not through morals that the social welfare was attained, the claim for morality in economic life was regarded as false.[64]

Smith took a further step towards legitimizing the pursuit of economic self-interest by maintaining that since self-interested behaviour promoted the public benefit, there was no reason why such behaviour should be regarded as vicious. Smith emphasized the virtuous characteristics of self-interested economic behaviour, e.g., prudence and frugality, discipline, and probity. Thus he equipped the unfettered pursuit of private economic gain with a special moral character of its own. For our purposes it is important to underscore, however, that Smith

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[62]Hobbes (1968) appealed to the idea of countervailing passions when explaining the purpose of founding the state. This idea is prevalent in the writings of Bacon and Hume as well. See Hirschman (1977).
[63]Mandeville (1924).
[64]Dumont (1977, p. 74).

reached the conclusion about the desirability of pursuing economic self-interest in an intellectual model of exchange where economic life was clearly separated from social life.[65]

What we observe, then, in the first centuries after the Reformation, is the emergence of a completely new attitude towards the economic aspects of life. Economic life, which earlier had been regarded as inseparable from religious and social life, became an independent activity, governed by laws that gave the pursuit of economic gain a free rein, and judged by standards that completely disregarded the role of exchange as a social process. These insights seem to be of utter importance for our understanding of why exchange in our society is so rarely practised with an eye to its effects on social communities.

To sum up; I started out this section by arguing that social relations (i.e., sympathies and moral commitments) are potentially important for the proper management of environmental resources. I then showed how the exchange process might contribute to either a strengthening or a weakening of social communities. It was emphasized that if society does not routinely make demands upon people's moral motivations in economic life, their perception of the moral dimension of exchange may become seriously weakened. Finally, I argued that the demands upon moral resources in exchange have declined during the last few centuries, due to the influential – but extremely precarious – idea that the claims of morality are irrelevant or superfluous in economic life. This idea has made possible the elevation of anonymous exchange to an ideal, and it has legitimized the unfettered pursuit of individual economic gain. The consequences for environmental problems have been twofold. First, the separation between economic life and general moral obligations has done away with much of the ability of such obligations to dampen the adverse welfare effects of environmental externalities. Second, the habitual pursuit of economic self-interest in trade may over time have caused a depletion rather than a replenishment of the moral resources of society, e.g., by weakening people's perception of environmental externalities as an issue of moral concern.

3. Trade, information and environmental commitment

In the rest of this paper, people's motivations will be taken as given. But I will assume, in line with the reasoning in the previous section, that there are some individuals who recognize a responsibility for the environmental consequences of their actions. Such responsibility may

[65]Teichgraeber (1986, p. 159). Smith did this, according to Teichgraeber, despite being fully aware that eighteenth century exchange was *not* disentangled from social relationships. I shall not speculate on his reasons for disregarding the social aspects of exchange, only point to the fact that Smith lived in a time, heavily influenced as it was by the progress of the natural sciences, where such intangible causes and consequences as social relations did not have a particularly strong academic appeal.

take a number of different forms; here I shall think of it just as a general commitment to environmental protection.

One of the consequences of a commitment to environmental protection may be that the pattern of demand becomes sensitive to information about production processes; consumers[66] may discard products made in highly polluting production processes and go for "green" products instead. It will then be possible to alleviate environmental problems by informing consumers about the environmental consequences of production. The question I shall address in this section is how trade may affect consumers' access to information about production processes and, thereby, their exercise of environmental responsibility. The discussion will proceed as follows: After being more precise about what kind of information that is important for the exercise of environmental responsibility, I go on to discuss how trade affects the structure of this information and how consumers are likely to respond to changes in the flow of information. Thereafter, some brief comments will be made on the incentives of producers to provide environmentally relevant information.

The kind of information that is needed in order to take environmental responsibility will of course vary with the kind of environmental commitment people have. By way of illustration, if some people are motivated by a concern for the well-being of those individuals who are hurt by polluting production processes, they will need more information than if their concern is only with the effects of pollution on the environment itself. Anyway, they will need information about *technology* (i.e., about the level of emissions of pollutants in various production processes) and about *ecology* (i.e., about the ecological effects of a given level of emissions). I shall confine my attention to these two issues.

The environmental effects of production are often uncertain. In particular, it is often difficult to state the precise effect of a given level of emission on ecological systems. I shall assume that trade has a negligible effect on the degree of such uncertainty, and this issue will therefore be ignored. The basic premise of the following discussion is that *some* information about the environmental effects of production is available at the site of production (and in the corresponding areas of environmental degradation).[67] My concern here is therefore not with the overall availability of environmental information, only with the transmission of available information to those people who are ready to act on it.

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[66]"Consumers" can in the following be interpreted either as final consumers or as firms in their role as buyers of intermediary goods.

[67]Even though environmental degradation may occur beyond the vicinity of the production site, valuable information about the ecological effects of pollution will often be available at the site of production as well.

Prices are the primary mechanism of information transmission in a market economy. Prices are supposed to tell economic actors throughout the economy when to economize on, and when to increase, their use of resources, and thus make them behave as if an omniscient planner were allocating the resources to the place where they are most valued.[68] However, in an economy with environmental problems, prices cannot be trusted to reflect resource scarcities appropriately. According to conventional theory, it is precisely their inability to do so that is the reason why environmental problems arise in the first place. Hence, other sources of information are definitely required in order to alleviate environmental problems through the environmental responsibility of consumers.

PROPOSITION 3.1

Trade tends to increase an individual consumer's costs of tracing the environmental consequences of his consumer choices.

A major virtue of trade, as seen from the perspective of economic theory, is that it facilitates a separation between consumption and production. This separation generates possibilities for economic specialization and exploitation of comparative advantages between countries and between regions. It follows straightforwardly that in a specialized economy, there are economic forces that tend to increase geographical distances between consumers and producers. Longer distances will tend to make it more time-consuming and expensive for individual consumers to seek out the environmental consequences of their purchases. (Note that I do not claim that each and every liberalization of trade increases geographical distances between producers and consumers; only that trade, on the whole, contributes in this direction.)

Furthermore, economic specialization and (international) trade imply that consumers will be buying products that originate from a lot of different places around the world. Trade thus increases the number of ecological systems affected by our consumer choices. This poses informational problems beyond those related to geographical distance, because there are substantial differences between ecological systems, e.g., in their ability to absorb pollutants. It goes without saying that it is incredibly demanding for any person to obtain but a vague idea about the properties of the various ecological systems influenced by his choices in an integrated world economy.

In addition to increasing the distances between consumers and producers and increasing the number of ecological systems affected by each consumer's choices, trade may enhance the

[68]This ability of the price system to diffuse essential information about resource scarcities quickly among the relevant decision makers has lead Hayek (1945) to claim that if the price system "were the result of deliberate human design, ...this mechanism would have been acclaimed as one of the greatest triumphs of the human mind".

complexity of economic structures quite considerably. In an economy based on extensive trade, the very complexity may in itself be an extremely costly obstacle to overcome in tracing the environmental effects of economic transactions. Trade may thus make green consumers morally disabled.

So far, I have taken for granted that consumers who are committed to environmental protection have a desire (or a commitment) to trace the environmental consequences of their actions. As is demonstrated by the following example, though, it is not obvious that a commitment to environmental protection necessarily will make people search for environmental information:

Mr Green is on his way to the supermarket in order to buy oranges. He knows that two brands are available; Jaffa and Florida. Before entering the supermarket, Mr Green has the opportunity to drop in at the office of an environmentalist group, where information about the relative environmental performance of the respective brands is available at zero cost. It is easy to show that even though the relative environmental performance matters for Mr Green's choice, it may be perfectly rational for him not to visit the environmentalist office:

Assume that Mr Green has the (von Neumann-Morgenstern) utility function $u = u(J,F,I)$, where J and F denote the number of Jaffa and Florida oranges and I is an information index reflecting what Mr Green knows about the relative environmental performances of the respective producers. This index takes on one of the three following values; I_J (Mr Green knows that Jaffa has the best environmental performance), I_F (Mr Green knows that Florida has the superior environmental performance), and 0 (Mr Green has no information about environmental performances, except, perhaps, some subjective probabilities over the respective states). Assume that Mr Green's preference structure can be represented as follows:

$$u(1,0,0) = 9 \qquad u(0,1,0) = 4$$
$$u(1,0,I_J) = 12 \qquad u(0,1,I_J) = 0$$
$$u(1,0,I_F) = 6 \qquad u(0,1,I_F) = 7$$

Consider now the implications for Mr Green's level of utility of visiting the environmentalist office. If Mr Green remains uninformed, he will choose Jaffa ($u(1,0,0) > u(0,1,0)$), and his level of utility will be 9. If he is informed that the production of Jaffa is friendly to the environment, he will continue to choose Jaffa ($u(1,0,I_J) > u(0,1,I_J)$). His utility will increase to 12 (e.g., because of a more quiet conscience). If he, on the other hand, is told that Florida is better to the environment, he gets troubled by bad conscience if he continues to consume Jaffa ($u(1,0,I_F) < u(1,0,0)$). By choosing Florida instead, he avoids the bad conscience, but the taste of Florida oranges is so poor compared to Jaffa that his level of utility will be no greater than 7.

Since more information possibly makes Mr Green worse off, he might prefer to remain uninformed. Exactly how he chooses to deal with the problem at hand will depend on how the uncertainty involved is handled. If there is genuine uncertainty (i.e., no subjective probabilities are available), expected utility theory will have no predictions to offer. If subjective probabilities are available, it will be rational, according to expected utility theory, to remain uninformed if the probability is less than 0.4 that Jaffa is the preferable brand in terms of environmental performance.[69]

The example demonstrates that even though a person would take environmental responsibility if he were exposed to environmentally relevant information, his efforts to obtain such information may be rather lukewarm.[70]

PROPOSITION 3.2

There may be only a weak link between a person's willingness to take environmental responsibility and his demand for environmentally relevant information. This link tends to be particularly weak, first, if the person has a strong a priori preferences for either of the alternatives and, second, if he is motivated to take environmental responsibility primarily by bad conscience for irresponsible behaviour, rather than a positive motivation for responsible behaviour and, third, if it does not bother him much to make uninformed choices.[71]

The example proves the first part of the proposition. The importance of *a priori* preferences is easily demonstrated by changing the figures of the example so that the two alternatives are treated symmetrically. For example, by raising the number 7 to 12, Mr Green will no longer have any incentive to avoid becoming informed, as he has in the original example. The significance of positive welfare effects of information for the demand of information is self-

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[69]If subjective probabilities are available, we would expect the utility levels in the uninformed state to be affected by these probabilities. The example might be accommodated to capture this case as well. Yet another plausible extension of the example would be to assume that there is uncertainty about the utility levels after information has been obtained.

[70]Nothing has been said in the example about the interpretation of the utility function. One possibility would be to interpret utility in terms of personal welfare. The example then illustrates how environmental responsibility can be modelled by letting individual welfare levels vary with environmentally relevant information. Alternatively, we might assume that Mr Green is motivated to take environmental responsibility by a pure commitment (in the language of Sen (1977)), and not by the welfare effects of behaving in a certain manner. In that case, Mr Green might have chosen Florida oranges (assuming that they are better for the environment) even though we reversed the numbers in the example so that $u(0,1,I_F) < u(1,0,I_F)$, implying that he would always had been better off with Jaffa oranges. But if there is such a weak link between Mr Green's motives to take environmental responsibility and his personal welfare, it becomes even more unclear whether he actually will search for information about the ecological consequences of his acts.

[71]In addition, the nature of the person's commitment to environmental protection will in itself be important. If Mr Green thinks that he ought to do what is possible in order to make sure that his purchases do not cause unnecessary environmental harm, his demand for information will clearly be greater than if he thinks that only presently available information needs to be taken into account.

evident and is easily demonstrated in the example by increasing the value of $u(1,0,I_j)$ to a number greater than 12. Finally, the importance of the attitude towards making uninformed choices can be seen by increasing the value of $u(1,0,0)$ to a number greater than 9. That would have a negative impact on the demand for information.

Some readers may have problems with my assumption that it is possible to live "happily ignorant". In support of my position on this issue, I would like to argue that in a modern economy, people may have difficulty in perceiving even what they are ignorant of. By way of illustration, they may not even know that alternative ways of producing oranges have significantly different environmental consequences (or do they?).With ignorance at this level, it does not seem unreasonable to assume that people are not much bothered by it.

Against this background, I conclude that the consumers' (unintentional) exposure to facts of environmental significance may be important for the exercise of environmental responsibility.

PROPOSITION 3.3

Trade is likely to reduce the probability that consumers will obtain environmental information unintentionally, unless the producers themselves provide this information.

Environmental information can be obtained unintentionally by the consumers through various channels; during shopping activities, in the middle of a conversation, while reading the newspapers, or otherwise in the middle of the daily doings. But if trade increases the costs of obtaining environmental information for each consumer (cf. Proposition 3.1), it will probably increase the costs of information for many of those alternative channels of information in the consumers' community as well. Assuming that these alternative information channels are sensitive to costs, trade reduces the probability that the consumers will be exposed to environmental information.

It might be objected that this argument does not pay sufficient attention to the existence of environmental organizations and their supply of environmental information. In order to assess this objection, we need to specify how environmental organizations operate when it comes to transmission of environmental information. One possibility would be to assume that environmental organizations are national organizations with only limited exchange of information across national borders (e.g., due to cultural differences). In that case, Proposition 3.3 would still carry through, at least as far as international trade is concerned. Such trade would tend to increase the costs of national organizations in their search for relevant information about production processes. (This is simply Proposition 3.1 applied at the national level.)

Alternatively, environmental organizations might be seen as a collection of people dispersed around the whole world and connected by highly developed information networks. This description (which may seem less realistic than the previous one) would suggest that the location pattern would only be of minor importance for the costs of obtaining environmental information. Surely, information transmission of this kind may be a future possibility. Its relevance for understanding the informational consequences of trade in the past seems rather limited, though.[72]

But even though trade tends to reduce the flow of information through a number of channels, would not this tendency be counteracted by increased supply of environmental information from the producers themselves? Trade does not increase the producers' cost of obtaining environmental information, does it? I shall close this section by a brief examination of the producers' incentives to provide environmental information.

Producers have the opportunity both to ease the consumers' search for environmental information and to expose consumers, who do not search for (but nevertheless may act on) such information, to facts of environmental significance. The latter can be achieved, for example, by ecolabelling of specific products. (With appropriate ecolabels on oranges, Mr Green will be exposed to the relevant environmental information whether he likes it or not.) We know that extensive ecolabelling currently takes place, and we may therefore be tempted to ask whether the present discussion about the informational problems of trade is nothing but a storm in a teacup. Will not producers, wherever they are located in the world, provide the required environmental information when there are consumers who are responsive to such signals?

PROPOSITION 3.4

Producers may have incentives to provide some environmental information. They also have incentives to obscure core environmental facts.

Clearly, if there are consumers who are ready to take environmental responsibility, the producers have an incentive to signal their own superiority with respect to environmental performance. Producers might therefore be expected to provide *some* environmental information.

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[72]Note as well that in order for such an information network to become effective, it would probably not suffice simply to make all information about production processes available; insofar as different production processes have different environmental consequences, an individual consumer would need to know exactly where *his* product originated as well. It goes without saying that it would be an extremely demanding task to provide such detailed information.

But the fact that producers have incentives to provide information does not necessarily imply that they have incentives to provide *accurate* information. A fundamental problem with relying on the producers for the provision of environmental information is that they lack incentives to provide unfavourable information about their own products. Therefore, ecolabelling will seldom refer to environmental *mis*management, only to sound environmental practices. Admittedly, information about proper management may have some value, but it does not necessarily bring up the core issues. For example, to label non-bleached disposable diapers "environment friendly" makes some sense by enabling us to discard the bleached ones. But it obscures the fact that diapers of cloth probably is better for the environment. Similarly, to paint petrol pumps containing lead-free petrol in green colours may induce people who are ready to take environmental responsibility to switch to that fuel. It does not, however, identify the core environmental problem related to car-use, to wit the extensive use of fossil fuels.

A further problem with the kind of environmental information that currently is provided by producers is the extremely vague character of most ecolabels, creating vast opportunities for abuse. Since environmental performance often can be characterized along a great number of dimensions, many producers will be able to find at least one dimension in which they perform relatively well. Even though Jaffa, by way of illustration, has a superior environmental performance in all relevant dimensions except one, Florida may still have some evidence in support of a claim to be "environment friendly", misleading though as it will be.[73]

This shows that producers may have a credibility problem in their provisions of environmental information. The credibility problem increases with the costs of controlling the validity of the messages that they pass on to the consumers. I have argued that trade is likely to make it more costly to obtain information about production processes. Hence, trade may also enhance the credibility problem of producers in their provision of environmental information. And if the consumers do not trust the producers, the impact of their information on consumer behaviour cannot be expected to be very significant.[74]

To sum up, I have argued that trade is likely to make it more costly to trace the environmental consequences of our consumer choices. If consumers are sensitive to such costs, trade will tend to reduce the amount of environmental information made available to consumers through their own efforts. Moreover, trade will reduce the probability that consumers are exposed to

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[73]Problems of this kind might be overcome if producers with a superior environmental performance provide a more comprehensive description of their production processes than their competitors. Detailed accounts would then become a sign of environmental superiority. However, this may be difficult to do if the consumers need to exposed to very conspicuous ecolabels in order to take environmental responsibility (see Proposition 3.2).

[74]Producers seem to try to alleviate their credibility problems through cooperation with environmental groups with a reputation for a true commitment to environmental protection. The reputation of WWF, for instance, is currently being used as a guarantee for the ecological safety of a number of products.

environmental information through other channels than the producers' own provision of information, because other information channels typically will have higher costs in obtaining information as well. And since the producers have an incentive to block all kinds of unfavourable mention of their own products, the information they provide is not necessarily particularly valuable for consumers who are committed to environmental protection. Trade may thus create information problems contributing to a reduction in the consumers' exercise of environmental responsibility and, thereby, to an exacerbation of environmental problems.[75]

4. Trade, competition and environmental voluntarism

The discussion in this section has its offspring in two common assertions which together imply that a more liberal trading system will make it more difficult for individual firms to make voluntary acts in order to protect the environment. The first assertion says that trade liberalizations will lead to increased competition, causing prices to fall and aggregate outputs to rise. The second one says that as competition becomes stronger, so does the pressure on each firm to maximize its profit. This latter assertion is the foundation for Baumol's claim that perfect competition (or perfect contestability) "precludes all genuine business voluntarism, including care for the environment beyond that imposed by law".[76] If these assertions are correct, therefore, there is reason to ask whether trade liberalizations might lead to further environmental degradation by reducing environmental voluntarism.[77] In other words; is there a Gresham's Law for voluntary environmental protection, saying that polluting firms drive out the clean ones?[78]

I will not have much to say here about the relationship between trade liberalization and the degree of competition. A number of studies have concluded that trade liberalization – through a reduction of trade barriers between countries and/or through market integration – most likely has a pro-competitive effect.[79] Reductions in trade costs create stronger competition by

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[75]My discussion has focused on the consequences of the structure of information for the extent of environmental degradation. It is possible to argue that the structure of information is important for other reasons as well. Machan (1990) argues, for instance, that it is important to design economic systems where individuals are able to exercise a high degree of moral autonomy. Within this line of reasoning, it may be regarded a problem in itself that economic specialization and trade cause a loss of morally relevant information. Moreover, against the background of the discussion in the previous section, there is reason to be concerned about a reduction in the flow of morally relevant information to the decision makers, because this is likely to reduce the active use of moral principles and moral reflection in human lives. Over time, this may lead to a deterioration of the moral resources of society.

[76]Baumol (1991, p. 3).

[77]Note that a positive relationship between the degree of competition and the level of aggregate output creates another reason to be concerned about the environmental effects of trade liberalizations, provided the extent of environmental problems is positively linked to the level of output. This issue will not be addressed here.

[78]The principle that "Bad money drives out the good" is usually called Gresham's Law after Sir Thomas Gresham (1519?-1579).

[79]Smith and Venables (1988), Gasiorek, Smith and Venables (1992), among others.

increasing import penetration in each market. Market integration implies that the monopoly power that a firm enjoys in a particular market (e.g., their home market) will be replaced by an average degree of market power corresponding to the firm's position in the total market. Both these effects are normally expected to yield lower prices and higher aggregate outputs.[80] In addition, it is possible that larger markets in the wake of trade liberalizations may lead to stronger competition through an increase in the number of firms in the market.[81]

The rest of this section is devoted to a discussion of whether strong competition may be expected to drive out environmental voluntarism (assuming that there is such a thing). There are several ways to approach this issue, depending on how we choose to define environmental voluntarism and how we go about modelling changes in competitive pressure. My first task will be to investigate the premises of Baumol's claim about a fundamental incompatibility between perfect competition and environmental voluntarism. I will then present an analytical framework facilitating a discussion of the effect on environmental voluntarism of various degrees of (less than perfect) competition. The analysis will show that it is by no means obvious that stronger competition reduces firms' voluntary actions to alleviate environmental problems.

Perfect competition and environmental voluntarism

A common assertion in textbooks in micro-economics is that in a competitive market "the pressures are such that firms have no viable alternative other than adopting profit maximization"[82] This insight is also known as the Waste-Preclusion Theorem.[83] If this theorem is correct, so is also Baumol's claim about the incompatibility between perfect competition and environmental voluntarism. I shall not question the validity of this theorem, but I think it will be instructive to elucidate some of its premises.

What the Waste-Preclusion Theorem really is saying is that a price-taking firm *whose factor-owners are themselves profit-maximizers* has no viable alternative other than adopting profit-maximization as its objective. But this raises the question whether it is meaningful to talk about the objective of a firm in complete isolation from the objectives of those people who make the firm possible through their supply of capital, labour, and other factors of production. Is it ever

[80]See, however, Haaland and Wooton (1992) who argue that market integration in some special cases may reduce competitive pressures and lead to higher prices and reduced outputs.
[81]Norman (1986, p. 229). The simulations in Smith and Venables (1988) indicate, however, that trade liberalizations in Europe are likely to reduce the number of firms in many industries.
[82]Crew (1975, p. 92). See also Gravelle and Rees (1981, p. 159).
[83]Baumol (1991, p. 12).

possible for a firm to rationally pursue other objectives than the (unanimous) objective of its factor-owners? If not, the theorem seems to close to a tautology.

Notice that the issue at hand is different from the well-known problem of separation between ownership and control. The group of factor-owners is not confined to the owners of the firm (the latter being defined as the residual claimants to the firm's profit[84]). Factor-owners are all those people who stand behind the various resources employed in the firm. Thus the managers are included among the factor-owners by their supply of managerial skills. A basic premise for the Waste-Preclusion Theorem is therefore that the managers are themselves profit-maximizers in their role as suppliers of managerial skills. But if they are pure profit-maximizers in their role as factor-owners, is it then reasonable to expect them to sacrifice profits voluntarily in their role as decision-makers of the firm?

To answer this question affirmatively, we have to assume that the managers are not willing to incur any personal costs in order to satisfy their preference for environmental protection. With such a preference structure, we will have to conclude that perfect competition drives out environmental voluntarism. The central point is this: with perfect competition, environmental voluntarism must be paid for by a factor-owner who is willing to accept a factor return below what he could achieve in the market by employing his factors differently. This will simply not occur if all factor-owners are profit-maximizers.

It does not seem unreasonable to assume, however, that if the decision makers of the firm are inclined to take environmental responsibility, they may be willing to incur some personal costs in order to achieve this objective. In that case, perfect competition will not preclude environmental voluntarism. In the long run, though, the exercise of environmental voluntarism is constrained by the fact that the factor return must be non-negative. Stronger competition may increase the probability that this constraint will bind.

Competition and the costs of environmental voluntarism

Even though perfect competition normally does not *preclude* voluntarism, does not competition make such behaviour more costly for the firm, thus contributing to *less* voluntarism? This argument seems intuitively appealing, and I think it captures some important insights. It is easy to show, however, that the opposite may in fact be the case. Assume that environmental problems are related to the quantity of production and that any environmental voluntarism therefore will show up as a reduction in output below the profit-maximizing quantity. It is not difficult to show that the costs of such a (non-marginal) output reduction for a monopolist may

[84]Grossman and Hart (1986) define ownership along these lines.

exceed the corresponding costs of a firm in a competitive market. Hence, the degree of competition has no straightforward implications for the costs of taking environmental responsibility.

In order to bring the discussion a step further, it will be helpful to impose some additional structure on the problem. In creating a framework for further analysis, careful attention should be paid to the following issues: How should the objectives of the firms be formalized? How should the costs of environmental voluntarism be modelled? And which changes in the market structure will give the most appropriate representation of the idea of increased competition?

With regard to the latter of these issues, I have chosen to start out by modelling increased competition by a change in the market structure from national monopoly in two markets to Cournot duopoly in two markets. This is a kind of change in market structure that may arise due to reduced trade costs between countries, since such cost savings typically lead to increased import penetration in each market. Later, I will let the competitive pressure change by variations in the total number of firms as well.

The objectives of firm i will be represented by a utility function $U^i = U^i(\pi^i, Q^i)$ defined over the firm's profit (π^i) and an indicator of the firm's environmental performance (Q^i). In the present formulation of the model, it seems most natural to interpret Q^i as a measure of the environmental standard of the firm's production processes and its input mix.[85] Marginal utilities are assumed to be positive with respect to profits and non-negative with respect to environmental performance. I will assume that only firm 1 has a positive marginal utility of environmental performance ($U^1_Q > 0$). Other firms are pure profit maximizers ($U^i_Q = 0,\ \forall i \neq 1$). Both π^i and Q^i will be treated as normal goods (provided, of course, that marginal utilities are positive).

In contrast to the example above, where environmental voluntarism was formulated as a reduction in output below the level of profit maximization, I will propose here that we should think of environmental voluntarism rather as affecting the cost function of the firm. Environmental improvements are often brought about through investments in new technology, through the use of other, more expensive inputs, and the like. These are the kinds of environmental improvements that will be captured by the following formulation.

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[85]In a more general formulation, Q^i might be used as an indicator of the overall effect of the firm's activity on the environment as well. For empirical purposes, the appropriate interpretation of Q^i will of course be determined by the characteristics of the firms' environmental preferences, which may vary from case to case.

For simplicity, I assume that marginal costs do not vary with the level of output. Marginal costs may change, however, when the firms environmental performance changes; this relationship is given by the function $c(Q^i)$. For instance, marginal costs may increase if environmental voluntarism entails the use of more expensive factors of production. But I also allow for the possibility that marginal costs may decrease when Q^i increases. This may happen, for instance, if the firm improves its environmental performance through investments in new technology. But if marginal costs may be reduced in this way, all firms will want to choose a positive level of Q^i, unless the costs of investing in new technology exceed the benefits that can be reaped through lower marginal costs. Let $f(Q^i)$ denote the fixed (i.e., the output-independent) costs related to improvements in environmental performance. I assume that these costs always are so high that profits are declining in Q^i. This implies that environmental voluntarism will be exercised by firm 1 only.[86]

(a) From two monopolies to Cournot duopoly in two markets

Assume at the outset that there are prohibitive trade costs between two identical countries (or regions). In each country, there is a national monopoly. Let us investigate what happens to the firms' choice of environmental performance if trade costs are reduced and the firms start competing against each other in the two markets.

Let x^i and x^j denote the total outputs of firm i and firm j. Furthermore, let α^i and α^j denote the shares of firm i's and firm j's output that are sold in their respective home markets. In its home market, firm i earns the revenue $R(\alpha^i x^i, (1-\alpha^j)x^j)$. The export revenue is $R((1-\alpha^i)x^i, \alpha^j x^j)$. As usual, marginal revenue is assumed to be decreasing in the firm's own output ($R_{ii} < 0$) and in the output of the competitors ($R_{ij} < 0$).[87]

For simplicity, the choice of α^i will not be modelled explicitly. We know from the concavity of the revenue function that when it is profitable to sell in both the home and the foreign markets, α^i will be chosen so that the marginal (net) revenue is equal in the two markets. Assuming that α^i has been chosen optimally, firm i's maximization problem can be formulated as[88]

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[86]It is not difficult to generalize the model to the case where firm i's profit is first increasing, then declining in Q^i. Our present concern, however, is with the range in which profits are declining in Q^i.

[87]To ensure stability of the Cournot equilibrium, it will be assumed that $R^i_{ii}R^j_{jj} > R^i_{ij}R^j_{ji}$.

[88]The treatment of Q^i as a continuous variable may be inappropriate in many situations, in particular when changes in technology are involved. Nevertheless, I think the present framework may capture essential aspects of a firm's choice of environmental performance.

$$\max_{x^i,Q^i} U^i(\pi^i,Q^i) \equiv U^i\left[R(\alpha^i x^i,(1-\alpha^j)x^j)+R((1-\alpha^i)x^i,\alpha^j x^j)-c(Q^i)x^i-f(Q^i),Q^i\right],\ i=1,2 \quad (1)$$

By invoking the standard Cournot assumption, the first order conditions are found to be

$$R_i(\alpha^i x^i,(1-\alpha^j)x^j)-c(Q^i)=0, \quad i=1,2. \quad (2a)$$

$$U^i_\pi(-c_Q x^i-f_Q)+U^i_Q=0, \quad i=1,2. \quad (2b)$$

Eq. (2a) is simply the condition of profit maximization and defines the optimal output of firm i, x^{i*}, as a function of its level of environmental performance and the output of the other firm; $x^{i*}=r^i(x^j,Q^i)$. By inserting the expression for the optimal output into Eq. (2b), we obtain the following general solution to the maximization problem:

$$-\frac{U^i_Q}{U^i_\pi}=-c_Q x^{i*}-f_Q, \quad i=1,2. \quad (3)$$

Eq. (3) says that in optimum, the marginal rate of substitution between environmental performance and profits shall equal the marginal costs of improved environmental performance, measured in profit terms. The optimal solution is illustrated in Fig. 1.

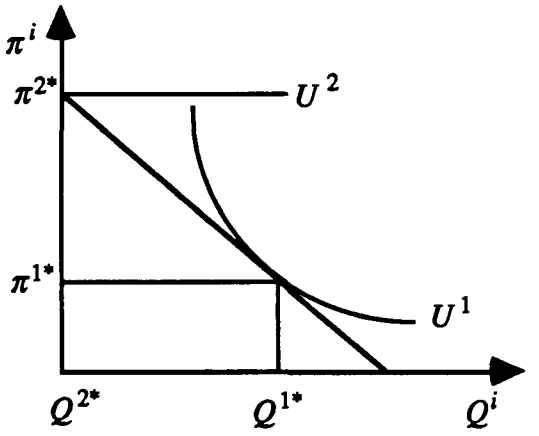

Fig. 1.

The slope of the transformation curve is negative by assumption. Its shape may be convex, linear, or concave, depending on the precise structure of the problem. The indifference curves of firm 2 are horizontal, due to the assumption that $U^2_Q=0$. Consequently, the optimal solution for firm 2 is the corner solution where the firm maximizes its profit and makes no voluntary effort to protect the environment. Firm 1, on the other hand, chooses a positive level of Q^1 due to its disposition to take environmental responsibility.

Changes in market structure will affect the location of the transformation curve. The removal of trade costs will make it profitable for each of the monopolists to penetrate the "foreign" markets. This will have implications for output levels and profits. For a given level of Q^i, total sales in each market will increase, and aggregate profits will decline. These effects follow from the stability requirement of the Cournot equilibrium, implying that import penetration will not be completely offset by reductions in the home market sales of the incumbent firm. In order to determine the changes in outputs and profits at the firm level, however, we need to impose more structure on the problem.

PROPOSITION 4.1
If $c_Q = 0$, the change in market structure from monopoly to Cournot duopoly will reduce the environmental performance of firm 1.

When $c_Q = 0$, the two firms will have identical marginal costs, and the Cournot equilibrium will therefore be symmetric. It follows straightforwardly that the change in market structure will reduce profits of both firms. This causes a downward shift in the transformation curve. Moreover, when $c_Q = 0$, the marginal rate of transformation will be unaffected by the transition from monopoly to duopoly; $MRT_M = MRT_D = -f_Q$ (see Eq. (3)). The proposition then follows directly from the normality assumption.

The picture becomes more complicated when marginal costs vary with the firm's environmental performance. Consider first the effect on the level of profits. Since only firm 1 is inclined to take voluntary environmental responsibility, the two firms will have different marginal costs and thus different market shares in the duopoly game. Although aggregate profits decline, it is then possible that one of the firms (the low cost firm) will obtain higher profits in duopoly than in the monopoly solution. In other words, when stronger competition is brought about through trade liberalizations, the gain from a larger market may outweigh the costs of increased competition for the most competitive firms.

PROPOSITION 4.2
If $c_Q < 0$, the change in market structure might shift the transformation curve upwards for firm 1. The income effect might thus pull towards more environmental voluntarism.

When marginal costs are declining in Q, firm 1 will enjoy a competitive advantage over firm 2.[89] The market share of firm 1 will then be higher than that of firm 2. Therefore, firm 1 may be able to increase its profit, even though tougher competition will reduce prices in both markets. It is firm 1's commitment to environmental protection that is the source of its competitive advantage. If the other firm were inclined to take environmental responsibility as well, this competitive advantage would vanish.

In the following, it will be assumed that the change in market structure reduces firm 1's profit. The income effect will thus contribute to a lower level of environmental performance. As will be demonstrated shortly, though, there may be substitution effects which pull in the opposite direction.

Substitution effects will arise if changes in market structure affect the marginal rate of transformation between π and Q. The general formula for the marginal rate of transformation is given by Eq. (3) as $MRT = -c_Q x^{i*} - f_Q$. The first term in this expression reflects that changes in marginal costs (from changes in the level of Q) will have the most significant effect on the profit of a firm with a high output level. I will refer to this term as *the scale effect.* If the scale effect becomes greater (less negative or more positive) after the change in market structure, firm 1 will substitute towards more environmental voluntarism (the slope of the transformation curve becomes less negative).

PROPOSITION 4.3

Firm 1 will substitute towards more environmental voluntarism after the transition from monopoly to duopoly if (a) $c_Q < 0$ *and* $x_D^{1*} > x_M^{1*}$, *or (b)* $c_Q > 0$ *and* $x_D^{1*} < x_M^{1*}$.

The result follows straightforwardly from the expression for the marginal rate of transformation between π and Q.

Our next task is to investigate whether any of the situations described in Proposition 4.3 are possible equilibrium outcomes. Since aggregate output will be greatest in the duopoly, we know that $x_D^{1*} > x_M^{1*}$ in a symmetric equilibrium. But then we must have $x_D^{1*} > x_M^{1*}$ in the case of $c_Q < 0$ as well, because firm 1 then will have lower marginal costs than firm 2 and therefore capture more than 50% of the total market.

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[89]Would not firm 2 offset this effect by strategic investments in Q? No; if such investments were profitable, they would be profitable for firm 1 as well. Firm 1 would therefore still enjoy a competitive advantage, due to its pure preference for environmental protection.

PROPOSITION 4.4
If $c_Q < 0$, stronger competition may lead to more or less environmental voluntarism, depending on the relative strengths of the income and substitution effects.

Since firm 1 produces more as a duopolist than as a monopolist, the gain from lower marginal costs will be greatest in duopoly. The marginal costs of environmental voluntarism will thus become lower in the duopoly situation, inducing substitution towards higher Q^1. With a negative income effect, the net effect on Q^{1*} is ambiguous.[90]

PROPOSITION 4.5
If $c_Q > 0$, the change in market structure may increase or reduce firm 1's marginal costs of environmental voluntarism.

Assuming that the marginal costs of production in firm 1 are not much higher than the marginal costs of firm 2 (i.e., Q^{1*} small), x_D^{1*} will be greater than x_M^{1*} when $c_Q > 0$ as well. (When $Q^{1*} \to 0$, we approach the symmetric equilibrium.) The change in market structure then leads to less voluntary environmental protection, since income and substitution effects pull in the same direction.

However, if the marginal costs of production in firm 1 are relatively large (i.e., Q^{1*} large), there is a possibility that $x_D^{1*} < x_M^{1*}$. In order to see this, assume that the change in market structure implies that firm 1 is indifferent between selling to the foreign market or not (i.e., there are some trade costs left). In this case, firm 2 will sell a positive amount in the home market of firm 1, since firm 2 has lower marginal costs than firm 1. Firm 1 will then reduce its output, implying that $x_D^{1*} < x_M^{1*}$. Hence, the marginal costs of voluntary environmental protection will be reduced (i.e., the slope of the transformation curve becomes less negative).

(b) More firms and strategic voluntarism

So far, the possibility that trade liberalizations may affect the number of firms in the market has been ignored. I will now allow for the possibility that competition may be further strengthened by the entry of one additional firm. This will lead to lower prices and higher aggregate outputs. But since the new firm captures one third of the market, market shares are likely to be reduced.

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[90]In this example, there is a kind of "scale economics" in environmental voluntarism (the scale being the level of output). Such effects might in the general model cause the transformation curve to become upward sloping (e.g., at low levels of Q^i). Hence, increased competition through trade liberalization might in fact induce pure profit maximizers to improve their environmental performance.

Thus the entry of an additional firm seems to increase the probability that the change in market structure will reduce the level of output of the incumbent firms.

This implies that the change in market structure may reduce the optimal output of firm 1, even though $c_Q < 0$. But if x^{1*} declines, the substitution effect will no longer counteract the negative income effect from increased competition. Consequently, the change in market structure will lead to an unambiguous reduction in environmental voluntarism in this case.

However, this conclusion may need to be modified if we assume that firm 1 can commit to a particular level of environmental performance before the Cournot output game is played.[91] The ability to credibly commit to a particular environmental performance becomes greater if it is costly to make instant adjustments in the level of Q, which, by way of illustration, probably will be the case if environmental voluntarism involves a change in technology. I will now demonstrate that a first-mover advantage may improve the strategic position of firm 1 and thus make environmental voluntarism less costly than it otherwise would be.

In finding the optimal level of Q^1, firm 1 will take into account the effect of Q^1 on equilibrium outputs at later points of time. If we assume, in order to simplify the presentation, that there are no trade costs, α^i will equal 1/2, and the optimal Q^1 can be found as the solution to the following problem:

$$\max_{Q^1} U^1(\pi^1, Q^1) \equiv U^1\left[2R^1\left(\frac{1}{2}x^{1*}, \frac{1}{2}x^{2*}, \frac{1}{2}x^{3*}\right) - c(Q^1)x^{1*} - f(Q^1), Q^1\right], \tag{4}$$

where (x^{1*}, x^{2*}, x^{3*}) is the Nash equilibrium output vector.[92] The first order condition can be written on the following form

$$-\frac{U^1_Q}{U^1_\pi} = \left(R^1_2 \frac{\partial x^{2*}}{\partial x^{1*}} + R^1_3 \frac{\partial x^{3*}}{\partial x^{1*}}\right)\frac{\partial x^{1*}}{\partial Q^1} - c_Q x^{1*} - f_Q. \tag{5}$$

PROPOSITION 4.6

If $c_Q < 0$, and firm 1 can credibly commit to a level of environmental performance, the change in market structure may lead to more environmental voluntarism even though the scale effect might pull in the opposite direction.

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[91] I assume that f_Q is so large that strategic investments in environmental performance never is profitable for firm 2 (i.e., the transformation curve is always downward sloping).

[92] The Nash equilibrium is defined as the output vector (x^{1*}, x^{2*}, x^{3*}) which satisfies $x^{i*} = r^i(x^{-i*}, Q^i)$ for $\forall i$ (where x^{-i*} denotes the vector of optimal outputs for all firms, except firm i).

Compared to the case with no precommitment, the marginal rate of transformation now contains two additional terms. These terms reflect the impact on firm 1's profit of a change in Q^1 via its effect on the structure of the output game. This strategic effect is positive; both R_j^i and $\partial x^{i*}/\partial x^{j*}$ are negative because of the assumption that $R_{ij}^i < 0$, and $\partial x^{i*}/\partial Q^i$ is positive when $c_Q < 0$ (cf. Eq. (2a)). Furthermore, since there is no strategic effect in the monopoly situation, the change in market structure will have a positive impact on the slope of the transformation curve through this effect. If the strategic effect is strong, it may outweigh a scale effect that pulls in the opposite direction (as will be the case when the entry of new firms causes a reduction in the output of firm 1). Hence, the change in market structure may create a substitution effect that favours more environmental voluntarism.

Proposition 4.6 reflects the more general result that in a Cournot oligopoly, the profit will increase for a firm that becomes a more aggressive competitor.[93] When $c_Q < 0$, firm 1 will become a tougher competitor when Q^1 increases. Such strategic effects will contribute towards lower marginal costs of environmental voluntarism. (In the terminology of Fudenberg and Tirole, the ability of firm 1 to commit to a particular level of Q^1 allows for a 'top dog' strategy.[94])

(c) Profit constraints

The discussion so far has not paid any attention to the possible division between ownership and control in a firm; the firm has been treated as a unit without internal conflicts of interest. I shall close this section by some brief comments on how the present framework might be adapted to a situation where the owners of the firm are less eager than the managers to take environmental responsibility.

Possible conflicts between managers and owners have been extensively discussed in the so-called managerial theories of the firm.[95] A common presumption in these theories is that managers have the opportunity to behave discretionary, because the owners have imperfect information about potential profits. This does not imply, however, that the managers are free to do whatever they prefer. The degree of information asymmetry imposes limits as to how far below the maximum profit the firm will be allowed to operate. The usual way of formalizing

[93]Tirole (1989).
[94]Fudenberg and Tirole (1984). With Bertrand competition, the strategic effect would have the opposite impact on the transformation curve. It would then be costly for firm 1 to commit to a more aggressive strategy.
[95]See Crew (1975) and Gravelle and Rees (1981) for an overview of such theories.

this information asymmetry is to specify a profit constraint which defines a limit to the managers' discretion.[96]

A similar approach might be useful in the present context as well. Managers who are more eager than the owners of the firm to take environmental responsibility, can be said to operate under a profit constraint (this profit constraint may of course reflect information asymmetries as well). By assuming that the profit constraint is independent of market structure, we obtain:

PROPOSITION 4.7

Unless firm 1 has a very strong competitive position, the change in market structure will lead to an unambiguous reduction in environmental voluntarism if the decision makers operate under a binding profit constraint.

If firm 1's competitive position is not very strong, the change in market structure will cause a reduction in its profit (cf. Proposition 4.2). Proposition 4.7 then follows straightforwardly from the assumption of a negative slope of the transformation curve.[97]

I conclude from the analysis in this section that the relationship between trade liberalizations and the exercise of environmental voluntarism may be quite complex. We have seen that strong competition does not necessarily preclude costly voluntary improvements in environmental performance. Moreover, I have demonstrated that increased competitive pressure in some cases may reduce the costs of voluntary environmental protection. We have also seen that when trying to determine the effect of trade liberalizations on environmental voluntarism, we need to pay careful attention to 1) how trade liberalizations affect the structure of the market, 2) how environmental voluntarism enters the utility function of the decision makers, 3) how environmental protection affects the firm's costs and strategic position in the market, and 4) whether the preferences of the owners impose any constraints on the decision makers opportunity to take environmental responsibility.

5. Some policy issues

In this paper, I have examined some of the mechanisms, other than prices, through which trade may affect the extent of environmental problems. This analysis has no immediate policy implications, because it will often be possible to regulate polluting activities more directly than

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[96]Such a constraint appears explicitly in Baumol's theory of revenue maximization (Baumol (1967)). It also appears in Williamson's 'expense preference theory' (Williamson (1967)), although it never binds, due to the decision makers' positive marginal utility of 'discretionary profits', i.e., profits in excess of the profit constraint.

[97]In a more general formulation, we might wish to allow the profit constraint to change as the market structure changes. I leave to future work to spell out these generalizations in more detail.

by focusing on the indirect mechanisms that have been identified here. In some cases, however, the indirect solutions may have some advantages.

For example, there are some obvious benefits from alleviating environmental problems through a change in individual motivations, compared to government regulations. If we were able to change people's preferences, we would save the costs of administration and the costs of control that need to be incurred when regulations are imposed by a government. Moreover, due to information problems, government regulations may be difficult to implement *before* an environmental problem already has been identified. With internalization through the preference structure, environmental problems are less likely to arise in the first place. This is especially important when environmental degradation is irreversible.

I have argued that trade may influence people's preferences and norms; trade can be an institution that cultivates individualistic motivations, or it can be turned into an event that maintains and strengthens social communities. We have seen how the final social outcome will be a function of the mode of exchange. In this context, regulations on the *volume* of trade will only be of secondary importance. Of course, if trade creates a more individualistic society, there may be reason to reduce trade volumes. But the central policy issue here is how to achieve a more integrative mode of exchange. Unfortunately, this is a kind of goal that seems difficult, if not impossible, to reach through government regulations. Governments may of course restrict, or avoid to support, the development of technology and infrastructure that undermine the social dimension of exchange. But to impose regulations that make people appeal to and act on general moral principles in exchange situations seems virtually impossible. A possible first step, however, might be to illuminate the precarious foundation for the idea that the pursuit of narrow self-interest is fully legitimate in economic life.

Another central topic in this paper has been the relationship between trade and the ability of consumers to trace the environmental consequences of their choices. In commenting on the policy implications of this discussion, let me start by quoting W. S. Vickrey: "... one of the greatest defects of our economic system is that its very complexity makes it difficult for the individual to see just when he is expected to look farther than his own self-interest, and that on those occasions when he is expected to do so the consequences of his actions have become so difficult to trace that in many cases the individual may still find it beyond his capacity to discover the ethical course of action. One of the chief aims of public policy, therefore, should be to so organize the economic system as to make it easier for individuals to see in what respects they should attempt to look beyond their own interests, and easier for them to trace the consequences of their behaviour in such cases."[98]

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[98]Vickrey (1973, pp. 60-61).

Unless direct environmental regulations have been imposed, the consumers will (according to a number of ethical theories) need to look beyond their (narrow) self-interest in a great number of their choices. In such cases, a reorganization of society, with the purpose to transmit more environmental information to environmentally responsible consumers, might reduce environmental problems.[99] One way of attaining this goal would be to rely more on local production. Such a policy will be costly, however, in terms of reduced exploitation of comparative advantages and scale economics. When trying to determine the optimal organization of society, these considerations need to be balanced against each other.

Alternatively, the flow of environmental information to the consumers might be improved through direct government involvement in the transmission of information. This will obviously be an expensive task as well. It is beyond the scope of this paper to discuss which policy alternative that ought to be pursued. All that is claimed here, is that the benefits of improving the consumers' access to environmental information probably should bring forth some kind of policy response.[100]

The last topic of this paper was the relationship between trade liberalizations and firms' exercise of environmental voluntarism. It was demonstrated that both trade liberalizations and trade restrictions may induce more environmental voluntarism. It is therefore impossible, at the present level of abstraction, to give any general policy recommendations with regard to this issue.

However, even if we were able to design policies that would promote more environmental voluntarism, such policies might still be regarded as inappropriate. Some people claim that firms ought to pursue no other objective than profits. In the words of Friedman, "the social responsibility of business is to increase its profits."[101] The central argument of Friedman is that the managers of a firm are the agents of those individuals who own the corporation, and since the objective of the owners generally is to make as much money as possible, the managers should be steered by profits, and not by what they think is good for society as a whole. But, as has been convincingly argued by Stone and Sen, it is highly unclear why managers ought

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[99]It may also be counted as a benefit that such a reorganization may increase people's opportunities to exercise moral autonomy. See Machan (1990).

[100]Note that the appropriate policy response will depend on how close a link there is between the consumers' commitment to environmental protection and their demand for environmental information. If this link is weak, it will probably become more costly to solve the information problem through government involvement in the transmission of information, because the consumers then must be *exposed* to information; it does not suffice simply to reduce their costs of obtaining environmental information.

[101]Friedman (1970). The scepticism against businesses that adopt broader social objectives has roots back to Adam Smith who claimed that "I have never known much good done by those who affected to trade for the public good". (Smith (1776, p. 423).)

morally to consider themselves more as agents for the shareholders than for the employees, the creditors, the customers, and the neighbours of the firm.[102] Furthermore, it does not seem reasonable to confine the discussion of the social responsibility of the firm to the behaviour of the managers. Should not the objectives (and the behaviour) of the owners be included as well? Or are they immune against the claims of morality? I cannot see any reason why they should be, and Friedman's argument therefore seems to be in trouble: why should the immorality of the owners exempt managers from behaving socially responsibly? Does irresponsible behaviour become acceptable simply because one has been hired to do it? To answer this question affirmatively seems inconsistent with widely held moral beliefs.

A somewhat different argument against the firms' exercise of environmental voluntarism has been maintained by Baumol: "The notion that firms should by themselves pursue the objectives of society is, in fact a rather frightening proposition. Corporate management holds in its hands enormous financial resources. Voluntarism suggests, or rather demands, that management use these resources – other people's money – to influence the social and political course of events. But who is to determine in what way these events ought to be influenced? Who is to select these goals? If it is management itself, the power of interference with our lives and the lives of others that management is asked to assume is surely intolerable. The threat to effective democracy should be clear enough."[103]

But isn't this to turn the problem upside down? What seems to be really frightening is not so much that powerful firms pursue the objectives of society as that they so seldom look beyond their narrow self-interest. And the threat to democracy does not seem to be so much that firms pursue social goals as that they are equipped with the power to pursue whatever interests they want to, also those who do *not* serve the social goals. Some might argue, in defence of Baumol's view, that as long as the firm maximizes its profits, it will only be responding to the demands of sovereign consumers, and does therefore not constitute any threat to the objectives of society. This is by no means a trivial position, though. As has been convincingly argued by Galbraith and others, the sovereignty of consumers seems to be heavily diluted.[104] Businesses, in their role as profit maximizers, have, for instance, enormous influence on what people regard as a good life. Firms are thus, according to this view, in the position of shaping the social goals also when they "only" pursue profits. Against this background, I conclude that the concern about the extent of environmental voluntarism is a legitimate concern for public policy.

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[102]Stone (1975), Sen (1993).
[103]Baumol (1991, p. 50).
[104]Galbraith (1958).

6. Final remarks

Mahatma Gandhi used to talk disparagingly of "dreaming of systems so perfect that no one will need to be good".[105] To say that our society has attempted to do away with our need for morality in economic life would be an exaggeration. But the idea seems to be widely accepted, that the pursuit of individual gain in some sense is more legitimate in economic affairs than in other areas of human conduct. The presence of environmental problems clearly demonstrates, however, the dangers of excluding economic life from the domain of social morality. If the imposition of environmental costs upon others were to a greater extent perceived as a moral issue, both by individuals and by corporations, the severity of many environmental problems would probably have been reduced.

Despite the obvious significance of social morality for the extent of environmental problems, this issue has received little attention in the economic literature. The chief aim of this paper has been to illuminate some ways in which trade may affect the supply of moral resources in society and the ability of economic agents to act on their moral beliefs. It has been argued that if the institutions of society, including its exchange practices, rely too heavily on self-interest for their functioning, it might be difficult to maintain and enhance the moral resources of that society. Moreover, it has been demonstrated that the economic organization of society might influence the ability of individuals and firms to behave responsibly from an environmental point of view. This suggests that the relationship between trade and the environment is more complex than previously thought.

Obviously, we cannot rely solely upon morality for a well-functioning society; the use of moral resources will not increase the supply of these resources infinitely, because we eventually will reach a point where the practice of these virtues will come in a too heavy conflict with our disposition for self-love and even self-preservation.[106] Notwithstanding, it might be appropriate to reconsider the role of morality in economic life. To press my point home; it is far from obvious that the economists' disregard of these fundamental values of society has made us able to make the right priorities.

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[105]Quoted in Schumacher (1973, p. 22).
[106]See Hirschman (1986b).

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