Trade and the Environment: A Survey of the Literature*

Daniel M. Sturm
University of Munich and CEPR

Key words: Trade and Environment, Political Economy

Abstract: This survey examines the rapidly growing literature on the links between environmental policy and international trade. The paper reviews the main questions and results in the literature and tries to point out their relationship and significance. For the purpose of this survey the literature has been grouped into four main themes. The first two of these are optimal policy towards local and transboundary pollution respectively. The third theme is the impact of trade liberalisation on environmental quality and welfare. The final theme is the political economy of the trade and environment nexus.

1. INTRODUCTION

The links between international trade and environmental policy have been an extremely active field of research during the last years.[1] The literature in this field started with a few contributions in the 1970s. However, particularly during the last decade it has expanded rapidly and a diverse set

* This survey builds on the second chapter of my Ph.D. dissertation at the London School of Economics. I am indebted to Peter Neary, Tony Venables and in particular Alistair Ulph for comments on earlier drafts of this survey. The usual disclaimer applies. Financial support through a Marie Curie Fellowship from the European Union is gratefully acknowledged.

1 This is also reflected in the recent introduction of a separate JEL-Code for this field (F18).

[*Marsiliani, L., Rauscher, M. and Withagen, C.*] (*eds.*),
[*Environmental Policy in an International Perspective*], 119—149.

of questions and issues has been addressed. This rapid growth was fuelled by a number of prominent policy debates. One important issue was the concern that increasing economic integration could make governments reluctant to burden local firms with stringent environmental regulations. It was argued that governments might instead enter into a "race to the bottom" in environmental policies, which would result in inefficiently low environmental policies and deteriorating environmental quality. To counteract such tendencies there have been proposals to delegate environmental policy to a supranational institution and to harmonise environmental policy across countries.

A second source of contention has been the use of trade policy to reduce environmental degradation abroad. One important example is the use of trade bans or of labelling schemes for tropical woods to reduce tropical deforestation. Another prominent example was the tuna-dolphin dispute between the United States and Mexico, which revolved around a US import ban on Mexican tuna which had not been caught with fishing nets which minimise the risk of the accidental death of dolphins.

Finally, there have been a large number of trade disputes over new national environmental policies. The typical pattern is that a country implements a new product regulation, which it defends as being necessary for either consumer or environmental protection, while importers to that market challenge the regulation as a "disguised barrier to trade" or simply "green protectionism". The United States and the European Union have, for example battled fiercely over growth hormones found in US beef exports to Europe and also over the proper treatment of genetically modified food. Supra-national institutions, such as the WTO and the European Court of Justice, were frequently forced to rule on such trade disputes. As they have often struck down the contested national regulations as unnecessarily trade restrictive, they have been the subjects of severe criticism from environmental lobby groups.

The aim of this survey is to provide an outline of some of the main strands in the diverse and voluminous literature that has investigated the interactions between trade and the environment. The approach will be to illustrate the main ideas and arguments with some of the key contributions, but no attempt will be made to supply an exhaustive list of references. For the purpose of this survey the literature will be grouped under four main questions: What are the properties of optimal environmental and trade policies in open economies with local pollution? What are the properties of such policies in the case of transboundary pollution? What are the environmental and welfare consequences of trade liberalisation? How can we explain the political economy of the trade and environment nexus?

The characterisation of optimal environmental and trade policies in an open economy is of central importance for the trade and environment debate and has generated a large amount of literature. Optimal policies will clearly depend on the presence or absence of transboundary pollution and for the purpose of this survey the optimal policy literature will therefore be divided along this line. The main focus of the literature on optimal policy with local pollution is the question whether optimal environmental policies should deviate from the closed economy benchmark of equalising marginal abatement costs and marginal damage. A related question is whether competition between several jurisdictions can result in a "race to the bottom" in environmental policy. The main theme of the literature on optimal policy in the presence of transboundary pollution is the design of optimal domestic and trade policies to influence foreign pollution emissions. One important application of these ideas is the "carbon leakage" problem in the context of unilateral policy towards climate change.

The implications of trade liberalisation for environmental quality and welfare has not only been the focus of a lot of popular debates but has also attracted some of the most prominent contributions to the academic literature on trade and the environment. The main focus of this literature is the impact of trade liberalisation on polluting emissions in each country and the conditions under which countries will gain or lose from trade liberalisation. Finally, there is a small but growing body of literature, which departs from the assumption of welfare-maximising governments and turns to political economy models to explain the observed policy-making in the trade and environment field. This may be a more realistic description of how policies are selected as the trade and environment nexus has "an above average risk of being exploited by special interest groups" according to Anderson and Blackhurst (1992).

Inevitably every survey needs to draw borderlines and exclude interesting topics. This survey excludes at least three interesting strands in the literature. The first omission is the literature on resources and trade. This survey will concentrate on the implications of polluting emissions in open economies and exclude the case where renewable and non-renewable natural resources are one input into production. The early literature on the implications of natural resources for international trade is surveyed in Kemp and van Long (1984) and some very interesting recent contributions are Brander and Taylor (1997a, 1997b, 1998) and Chichilnisky (1994). Secondly, there is a small body of literature, which deals with the implications of trade in hazardous waste, which will not be covered in this survey. See Rauscher (1997, ch.4) for an introduction and references to the literature and Levinson (1999) for an interesting recent contribution. Finally, there is a large amount of empirical literature, which investigates whether and to what extent

stringent environmental policy results in the relocation of firms and production. An excellent recent survey of this literature is contained in Jeppesen et al. (2002).

Some of the literature that will be discussed here has already been covered by other surveys. Some examples are Siebert et. al. (1980), Dean (1992), Wilson (1996) and Ulph (1997a), Schulze and Ursprung (2001) and Sturm and Ulph (2002). References to particularly useful earlier surveys are included in the relevant subsections of this survey.

The remainder of this survey is structured as follows. The following section considers optimal trade and environmental policies in an economy with local pollution. The third section looks at optimal policy in the case of transboundary pollution. The fourth section turns to the literature on the effects of trade liberalisation on environmental quality and welfare. The fifth section surveys the political economy literature and the final section concludes.

2. OPTIMAL POLICY WITH LOCAL POLLUTION

This section will survey the large body of literature, which assumes a benevolent government and analyses the properties of welfare-maximising policies for the case of purely local pollution damage. It is well understood that in a closed economy with perfect competition optimality requires that marginal abatement costs are equal to marginal damage. The first main theme of the literature surveyed below is the question whether the optimal policy in a trading economy should deviate from this benchmark. If the optimal policy is laxer than this benchmark, then the country is usually said to engage in "environmental dumping".[2]

The second main theme of this literature, which builds on the first, are the implications of decentralised environmental policy-making by two or more regions or countries. The key question is whether competition in environmental policies can result in a "race to the bottom", where environmental standards are lowered in an attempt to attract mobile firms or capital. This question has generated a large volume of literature and a number of

[2] This is the most frequently used definition of "environmental dumping" in the literature, but there are at least two alternative definitions. Firstly, the literature on competition for mobile firms usually identifies "environmental dumping" as a situation in which the non-cooperative environmental policies are laxer than the environmental policy that countries would set if they cooperated. See also section 2.4 and footnote 3. Secondly, Rauscher (1994) defines "environmental dumping" as a situation in which environmental policy is laxer in the tradables than in the non-tradables sector of the economy.

mechanisms have been identified that can potentially explain a "race to the bottom".

The next four subsections cover four different approaches to modelling optimal policy-making in the presence of local production externalities. One aspect, which will reappear in the discussion of all four of these arguments, is the sensitivity of results to the number of available policy instruments. Countries will only compete in environmental policies if the set of available policy instruments is sufficiently restricted. The final subsection looks at the case of optimal policy towards a local consumption externality. To date this question has attracted very few contributions.

2.1 Perfect Competition and the Terms of Trade

The first theoretical contributions to the trade and environment literature used the perfectly competitive models of classical trade theory. Some of the numerous contributions that fall into this category are Asako (1979), Baumol (1971), Copeland (1994), Krutilla (1991), McGuire (1982), Merrifield (1988), Neary (2000), Pethig (1976), Rauscher (1991a, 1994) and Siebert (1974, 1977, 1979). Siebert et al. (1980) survey the early literature and Ulph (1997a) contains an excellent recent survey of this literature.

This literature has employed a variety of models, which introduce pollution emissions into a Heckscher-Ohlin or Ricardian framework. A typical example is a standard Heckscher-Ohlin model with several goods and factors in which pollution is modelled as an additional factor of production. The benchmark result in such a model is that in a small open economy, which is undistorted apart from the pollution externality, optimal environmental policy will equate marginal damage to marginal abatement costs. This is not too surprising as there is only one distortion. Note also that environmental policy will (and should) influence the pattern of trade in line with comparative advantage.

For a large open economy the situation is slightly more complicated. If the government has access to a full set of policy instruments, then two policy instruments will be used. Environmental policy will still internalise the externality so that marginal damage is equal to marginal abatement costs. At the same time trade policy or an equivalent combination of domestic policy instruments will be used to exploit the country's market power on international markets. If, however, the government only has access to environmental policy, then we are in a classic second-best situation. The optimal environmental policy will now deviate from the benchmark of equalising marginal damage and marginal abatement costs in order to indirectly exploit the market power of the large country in international markets. To gain more intuition into this case consider a Heckscher-Ohlin

model with two goods and two factors, one of which is pollution emissions. If the country exports the pollution intensive good, then optimality requires that environmental policy is tightened relative to the point where marginal damage is equal to marginal abatement costs. This will increase the production costs in the export sector relative to the import sector and drive up the world market price of the export good, which is an improvement of the country's terms of trade.

One important implication of this analysis is that terms of trade motives cannot justify a "race to the bottom" in environmental policy. If governments used environmental policy to manipulate the terms of trade, then we would observe overly strict standards in countries that export pollution intensive goods and relatively lax standards in countries that import these goods.

The literature has extended these basic results in a number of directions. Copeland (1994) considers partial reforms of environmental and trade policy in an economy with multiple distortions. Rauscher (1994) introduces a non-tradables sector into the economy. He analyses whether and how the optimal environmental policy will differ between the traded and non-traded sector, if only environmental policy is available.

2.2 Strategic Environmental Policy

During the early 1990s the famous strategic trade policy analysis of Brander and Spencer (1985) entered the trade and environment debate. The basic argument was developed by Barrett (1994), Conrad (1993) and Kennedy (1994). A very good technical survey of this literature is contained in Ulph (1997a).

The basic setting is a third-country oligopoly model. Two countries with one firm each export their entire production to a third country, where the two firms are Cournot competitors. In contrast to the original analysis by Brander and Spencer (1985) the production activities of the two firms generate pollution emissions, which cause purely local damage. The government in each of the two exporting countries has access to an environmental policy instrument, which is either an emissions tax or an emission standard. Other policy instruments are assumed to be absent. The main result is that the unilaterally optimal policy is "environmental dumping", in the sense that it is laxer than the policy that would equate marginal damage and marginal abatement costs. An immediate implication of this result is that in the Nash equilibrium between the governments of the two exporting countries both governments will use environmental policy to subsidise their local firms and enter a "race to the bottom" in environmental policy. The two exporting countries could therefore achieve a strict Pareto improvement if they

cooperated to set stricter environmental policy. This would both reduce emissions and increase the world market price, which is a terms of trade improvement for the two exporting countries.

The intuition for this result is straightforward. The government is in a second-best situation, in which it needs to address two goals with just one policy instrument. On the one hand environmental policy has to internalise the pollution externality. On the other hand the government also wants to subsidise its local firm with the help of lax environmental policy for standard strategic trade policy reasons. A laxer environmental policy reduces the marginal production costs of the local firm and allows it to commit to a more aggressive strategy on the world market. Environmental policy is therefore used both for environmental purposes and as an indirect trade policy.

This analysis is open to a number of important criticisms and extensions. Barrett (1994) points out that the predictions of the model change if one assumes Bertrand rather than Cournot competition. In this case, the optimal environmental policy is stricter than a policy which would equate marginal damage and marginal costs. The outcome would therefore be a "race to the top" rather than a "race to the bottom". The intuition is that under Bertrand competition the governments want to commit their local firms to a less aggressive price-cutting strategy on the world market and in the absence of export taxes use strict environmental policy to do so. Althammer and Buchholz (1995) show that as the number of domestic firms increases the optimal environmental policy of the domestic government becomes stricter. The reason is that improving the terms of trade of the domestic firms becomes more important relative to the strategic trade policy incentive as the number of domestic firms increases.

Ulph (1996a) adds the possibility that firms can invest in R&D to the basic model. In his model environmental policy affects the marginal production costs of the local firm not only directly but also indirectly through its impact on R&D spending by the firm. He shows that allowing for this additional channel reduces the incentives to relax environmental policy. This line of research is extended further by Ulph and Ulph (1996), who use general functional forms and the possibility of both marginal cost and abatement cost reducing R&D to show that in this case the optimal policy can be either stricter or laxer than the closed economy benchmark.

Two further extensions of the basic model are pursued by Walz and Wellisch (1997), Sturm (2000) and Ulph (1997b, 2000). Barrett (1994) points out in a footnote that the incentive to use environmental policy as an indirect trade policy disappears if one introduces trade taxes as an additional instrument into the model. Walz and Wellisch (1997) return to this result and ask whether eliminating trade policy and restricting the set of available instruments to just environmental policy actually increases welfare in the

two exporting countries. They use a model with specific functional forms and find that welfare does indeed increase in their model if trade policy is eliminated. However, Sturm (2000) shows that this optimistic conclusion is not robust to small changes in their model.

Ulph (1997b, 2000) introduces a federal government into the model and asks whether delegation of policy-making from the state governments to the federal government can increase welfare. The key assumption is that only the state governments know the true marginal damage of pollution in their state. It is shown that the federal government will set more equal environmental policies in the two states compared to the full information case, but the equilibrium will not involve harmonisation of environmental policies. Furthermore a policy of harmonisation at the federal level could easily reduce welfare below the welfare level that is obtained with non-cooperative policy-making by the two states. Some further extensions of the strategic environmental policy literature are surveyed in Ulph (1997a).

2.3 Mobile Factors and Tax Competition

In the previous section environmental policy was used to shift profits between domestic and foreign firms. This section will turn to the possibility that environmental policy could be used to influence capital flows between regions or countries. The classic contribution to this literature is Oates and Schwab (1988). An excellent discussion of the literature surveyed in this and the following subsection is contained in Wilson (1996).

In Oates and Schwab (1988) a large number of jurisdictions each have a labour endowment and compete for mobile capital, which is in fixed supply. Each jurisdiction produces the same homogenous good with the help of a constant returns to scale technology, which uses labour, capital and pollution emissions. It is assumed that an increase in emissions increases the marginal product of capital and causes disutility to the local residents of the jurisdiction. Governments have access to a capital tax or subsidy and to an emission standard. The most important result of this approach is that the welfare-maximising policy involves setting the capital tax equal to zero and the environmental policy at the Pigouvian level. Governments should therefore use neither the capital tax nor environmental policy to try and attract more capital into the jurisdiction. The intuition for this result is similar to the case of perfect competition and no capital mobility. The environmental externality is the only distortion in the economy and therefore only the most efficient instrument, which is the environmental policy, will be used to correct this distortion. A direct implication of this result is that competition between jurisdictions will result in efficiency.

This benchmark result can be modified in a number of ways. Oates and Schwab (1988) first consider an exogenous tax on capital, which is not equal to zero. In this case optimal environmental policy will deviate from the Pigouvian level to indirectly compensate for the distortion introduced by the non-zero capital tax. In a second step they try to endogenise the non-zero capital tax through a political economy analysis. One approach that they explore is a government objective function, which includes both the residents' utility and tax revenue as arguments.

Kim and Wilson (1997) present another approach to overturn the efficiency result in the Oates and Schwab model. They assume that the jurisdictions have to raise tax revenue to finance a local public good. Furthermore they assume that the governments also have access to a distortionary labour income tax in addition to the capital tax and the environmental policy. They show that the optimal policy is to set the capital tax equal to zero and to use the tax on labour to finance the public good. More importantly they demonstrate that the optimal environmental policy is below the Pigouvian level. The intuition for this result is that relaxing the environmental policy increases capital inflow, which reduces the distortion associated with the labour tax and increases tax revenue. Further possibilities that could justify the use of environmental policy to influence the allocation of capital are discussed in Wilson (1996).

2.4 Firm Location and Environmental Policy

In the same way that jurisdictions may compete for mobile factors they may compete for mobile firms. The basic setting is again one in which environmental policy is the only policy instrument. In these models changes in the emission tax or standard change the marginal cost of production of the mobile firm and hence influence its location decision. An increase in the domestic emission tax rate can potentially affect domestic welfare through a number of channels if there is a plant in the domestic market. Firstly, higher emission taxes will imply less pollution. Secondly, there is an increase in tax revenue. Thirdly, through its impact on marginal costs the tax will lower consumer surplus. Finally, the tax will reduce the profits of the firm, which may or may not enter the domestic welfare function. In the absence of other policy instruments, the optimal environmental policy will therefore take all of these effects into account and in general does not equate marginal damage to marginal abatement costs.

A good illustration of the literature is Hoel (1997), which is very similar to Rauscher (1995). In this model two countries are possible locations for a single firm. Production generates emissions, which cause local damage. Emissions can be avoided with the help of an abatement technology, which

increases marginal costs. There are no trade barriers or transport costs between the two countries. The timing is such that the two governments first choose their emission tax rate and then the firm decides where to locate and how much to produce. The main result of the paper is that, depending on the parameter values, the emission tax rate can be either lower or higher than the tax rate, which would be chosen if the two countries cooperated and maximised their joint welfare. It is shown that the emission tax could be so high that the firm does not produce at all, a situation which is referred to as the "not in my backyard" scenario. In other parameter ranges the two countries will engage in "environmental dumping" and enter a "race to the bottom" in an attempt to attract the firm.[3]

There are several modifications to this approach, which have been investigated in the literature. Markusen, Morey and Olewiler (1993, 1995) introduce transport costs and the possibility that firms operate separate plants in the two countries, which considerably complicates the analysis. Ulph (1994) analyses the implications of rebating pollution tax revenues to the polluting firms and also considers transboundary pollution. Motta and Thisse (1994) assume that firms have already incurred some sunk costs before pollution taxes are introduced. Wellisch (1995) and Krumm and Wellisch (1995) introduce differences in damage costs across jurisdictions and consider the efficiency of polluting firms' location choices under various environmental policy instruments. Finally, Levinson (1997) compares the model with capital mobility in Oates and Schwab (1988) to the analysis in Markusen, Morey and Olewiler (1993, 1995).

Two further papers, which take a somewhat different approach, are Markusen (1997) and Venables (1999). Markusen (1997) introduces environmental policy into the model of foreign direct investment developed in Markusen and Venables (1998). He analyses how firm location changes as environmental policy is tightened. Interestingly he finds that the relocation effect is weaker in the presence of multinational firms and that national firms are likely to displace multinational firms if environmental policy is tightened. Venables (1999) uses an economic geography model with two regions to simulate the location response of firms, if one region tightens its environmental policy. He finds that environmental policy can result in hysteresis in location, as removing the environmental policy may not restore the initial equilibrium. This result is driven by agglomeration forces, which make an agglomeration of all the firms in either of the two regions or a symmetric distribution of the firms a stable equilibrium over certain parameter

[3] The cooperative environmental tax rate will not be equal to marginal damage due to the distortion caused by the firm's market power. "Environmental dumping" is here defined as a non-cooperative tax rate that is below the cooperative tax rate. See also the discussion in footnote 2.

ranges of the model. If the environmental policy therefore moves all the firms to the other region, then this relocation cannot be reversed by simply eliminating the environmental policy. The model also illustrates that the impact of a marginal change in environmental policy will critically depend on the parameters of the model. To quantify the likely effects of environmental policy on location the model is calibrated to data from the chemical industry.

2.5 Consumption Externalities and Product Standards

The design of optimal policies towards consumption externalities in an open economy has so far attracted relatively little attention. Copeland and Taylor (1995b) consider a competitive model with two countries and two goods, one of which creates local pollution during consumption. They show that the optimal policy will be a consumption tax equal to the marginal damage caused by consumption of the polluting good, if the regulator ignores the impact of this policy on the terms of trade.

Haupt (2000) develops a two-country monopolistic competition model with differentiated products. Consumption causes environmental damage, which is the same in both countries. The environmental impact of consumption can be reduced with the help of environmental R&D, which increases the fixed costs of production but leaves marginal costs unaffected. A stricter environmental policy will therefore reduce the number of varieties available to local consumers through two channels. Domestic firms increase in size to cover their increased fixed costs. Foreign firms either do the same or stop supplying the domestic market altogether. The two governments non-cooperatively choose a product standard to regulate the emissions from consumption of the goods. This game has a number of both symmetric and asymmetric Nash equilibria. One of these equilibria is the product standard that would maximise joint welfare. In this equilibrium both governments receive a payoff, which is at least as large as their payoff in any other Nash equilibrium.

Fischer and Serra (2000) present a model in which a domestic and a foreign firm both produce a homogenous good and are Cournot competitors in the domestic market. The foreign firm also supplies the foreign market, but the domestic firm does not export. Consumption of the good causes local damage. The domestic government specifies a product standard, which reduces the damage by increasing marginal production costs of both the domestic and the foreign firms' production for the domestic market. The foreign firm has the choice between either producing its entire output at the domestic standard, or to incur some fixed costs to produce its output for the foreign market at the lower foreign standard. The paper shows that for a

range of parameters it may be welfare-maximising for the government to set a standard at which the foreign firm will no longer supply the domestic market. Furthermore the paper argues that the domestic standard will always be protectionist, because it is stricter than the standard that would be chosen, if all the firms were domestic. The reason is that some of the costs of the stricter domestic standard are absorbed by the foreign firm. Finally, the paper also analyses how the optimal domestic policy of the home country changes as the size of the foreign country changes relative to the home country.

3. OPTIMAL POLICY WITH TRANSBOUNDARY POLLUTION

We now turn to the case of optimal trade and environmental policy-making in the presence of pollution spillovers. This issue has received considerable attention in both the academic literature and policy circles. With transboundary pollution non-cooperative environmental policies will be inefficient due to standard free-rider problems. The first-best approach would therefore be an international agreement. To enforce compliance with such an agreement it could be optimal to include trade measures as a punishment device in the agreements. One example for this approach is the Montreal Protocol, which regulates emissions of FCKWs. In the absence of an international agreement countries are faced with the choice of optimal unilateral trade and environmental policies. The properties of such optimal unilateral policies have been studied extensively in the literature.

The following two subsections deal with optimal unilateral policy. The first subsection deals with the question of how a country can use trade policy to combat foreign pollution spillovers. The second subsection turns to the case where trade policy is not available or cannot be adjusted. Optimal environmental policy now has to take into account that changes in domestic environmental policy will have effects on foreign emissions. This problem has received a lot of attention in the literature on the economics of climate change and is in that context often referred to as the “carbon leakage” problem. The final subsection discusses how trade policy can be used as a punishment device to stabilise international environmental agreements.

3.1 Trade Policy to Reduce Transboundary Pollution

In a seminal paper Markusen (1975) analyses the optimal choice of trade and environmental policy in the presence of transboundary pollution. In his model two countries, home and foreign, trade two goods. The production of

one of the two goods generates pollution emissions in a fixed proportion to output of the good. All the markets are perfectly competitive.

The foreign government is assumed to remain passive and the home country faces the following policy problem. It would like to influence emissions from both the domestic and also the foreign polluting industry. It is assumed that the home government has access to a full set of instruments and is a net importer of the polluting good. The key result of the paper is that the optimal policy involves both a domestic production tax (which in this setting is equivalent to an emission tax) and a tariff on imports of the polluting good. The optimal production tax is equal to the marginal damage that domestic production of the polluting good causes in the home country. In other words this is a Pigouvian tax on the domestic polluting industry, which only takes into account damage in the home country. The expression for the optimal tariff contains two terms. The first term reflects the standard terms of trade motive for a tariff. As the home country is large, it wants to manipulate the terms of trade in its favour. The second term is also positive and reflects the environmental objective. An increase in the tariff reduces demand for foreign output of the polluting good and hence its output. As this lowers foreign pollution and therefore domestic environmental damage, home has an additional incentive to levy a positive tariff. Baumol and Oates (1988) demonstrate this results with the help of a graph.

This important result has been extended in several ways. Copeland (1996) allows for the possibility of pollution abatement. In this case the optimal policy of the home country towards foreign pollution is a tariff on the pollution content of imports. This policy is equivalent to a normal import tariff combined with a process standard on foreign pollution. He also shows that the presence of a foreign pollution control policy generates an extra incentive for the home government to tighten its process standards on imports as this is a way of shifting some of the rents of the foreign pollution policy to the home country.

Ludema and Wooton (1994) not only consider optimal unilateral policies towards transboundary pollution but also the strategic interaction between two governments. In their set-up, foreign production, which is exported to the home country, generates emissions that only cause damage in the home country. From Markusen (1975) we know that, in this situation, the home country will impose an import tariff to both improve its terms of trade and reduce foreign pollution. Ludema and Wooton (1994) show that the foreign country's reply to this policy will be a combination of an environmental policy and an export tax. The foreign government implements the environmental policy even though the foreign country does not suffer any damage as this reduces the home government's incentive to impose an import tariff. Furthermore they show that even in the presence of a free trade

agreement the foreign country has an incentive to implement some environmental policy, as this is an indirect way of improving its terms of trade. In Ludema and Wooton (1997) the analysis is extended further. They introduce asymmetric information between the home and the foreign country about the foreign country's abatement costs and consider the possibility that the two countries enter into an international agreement about their trade and environment policies. In the absence of such an agreement countries choose trade and environmental policies non-cooperatively, which yields similar results as in Ludema and Wooton (1994). The main result of the paper is that restricting the availability of trade policy in the non-cooperative equilibrium influences the terms and efficiency of the international agreement and could be beneficial.

One important application of the idea that trade policy could be used to achieve environmental objectives is the case of tropical deforestation. Some of the recent contributions that have addressed this problem are Barbier and Rauscher (1994), Barbier and Schulz (1997), Dean (1995), Dean and Gangopadhyay (1997), Maestad (2001), Pestemon (2000) and Schulz (1996). This literature extends the ideas presented so far in at least two ways. One important modification is the addition of an intertemporal dimension to the economic environment. In the short-run an import tariff on tropical woods would reduce demand for tropical woods and hence deforestation. However, the drop in demand and the associated price reduction would also reduce the return from future harvests of the forest and therefore reduces the value of the remaining forest. The drop in the value of the forest in turn provides incentives to eliminate the forest and convert the land to alternative uses. A second important extension is the introduction of incomplete or missing property rights over forests, which further complicates the impact of trade restrictions on the rate of deforestation.

3.2 Optimal Environmental Policy

The last section has investigated to what extent trade policy can be used to influence transboundary pollution. This section will turn to the case where trade policies are constrained and environmental policy is the only policy instrument to deal both with domestic emissions and pollution spillovers from abroad. If environmental policy has to address both domestic and foreign pollution, then it will usually be optimal to have a policy, which is laxer than the policy that equates the marginal damage of domestic emissions to marginal abatement costs. The reason for this is that a domestic emission reduction through tighter environmental policy is likely to be partly offset by an endogenous increase in foreign emissions. One important practical application of this analysis is energy taxation, where the link

between domestic and foreign emissions is referred to as "carbon leakage", which is usually defined as the change in foreign emissions in response to a one unit reduction in domestic emissions.

The literature has analysed several mechanisms, which link domestic environmental policy to foreign emissions. Firstly, tighter environmental policy in home reduces home's comparative advantage in pollution intensive goods and encourages foreign production of these goods. The associated changes in the terms of trade and hence real income abroad can also influence foreign emissions. Furthermore Ulph (1994) shows that the impact of unilateral policy on the location of polluting firms can both be discontinuous and large in the case of imperfect competition. Secondly, in the case of energy taxation, higher energy taxes in the home country will tend to depress the world price of oil and other fossil fuels. This will increase the energy intensity of foreign production and also encourage a substitution towards fossil fuels in foreign energy generation. Welsch (1994) shows that this need not be the case, if fossil fuel markets are not competitive. Thirdly, there could be market structure effects if firms are imperfectly competitive as demonstrated in Gürtzgen and Rauscher (2000). Finally, foreign governments may react to stricter environmental policy in the home country with laxer environmental policy, as the tighter domestic policy improves environmental quality abroad.

A number of multi-country computable general equilibrium models have been used to quantify the effects of unilateral energy taxation. Some examples are Felder and Rutherford (1993), Manne and Rutherford (1994), Oliveira-Martins, Burniaux and Martin (1992), Perroni and Rutherford (1993) and Pezzey (1992). The estimated size of the carbon leakage varies greatly across models and scenarios and ranges from around five percent for some scenarios in Oliveira-Martins, Burniaux and Martin (1992) to leakage rates well beyond fifty percent in Pezzey (1992). Rutherford (1996) contains a good non-technical introduction to this literature.

A further extension of the theoretical literature is motivated by the observation that almost all countries which have unilaterally introduced increased energy taxation during the past decade have exempted the manufacturing sector or at least the energy intensive manufacturing industry from the tax increases. Hoel (1996) investigates the implications of such exemptions in a competitive two-country model with several sectors where energy is both consumed directly and used as an intermediate input. He first replicates the results in Markusen (1975) and shows that with a full set of policy instruments trade policy will be used to influence foreign emissions and the energy tax is uniform across all sectors. If energy taxes alone are available, then the tax should be differentiated across sectors. He does not,

however, find any simple relationship between the optimal tax rate and the energy intensity of the product.

3.3 Trade Measures in International Environmental Agreements

Informal discussions as for example in Subramanian (1992) have frequently argued that trade measures may be a useful tool in the context of international environmental agreements to stabilise cooperation and deter free-riding. The first formal analysis of this problem is Barrett (1997). In his model a large number of symmetric countries have one firm each. The firms produce a homogenous good and are Cournot competitors on the output market in each country. The markets are assumed to be segmented and there are no transport costs. Production generates transboundary emissions, which can be reduced with the help of an abatement technology. Governments are welfare-maximising and have two policy instruments, an emission standard and a trade ban. The trade ban can be used to reduce the bilateral trade flow with any number of a country's trading partners to zero.

The timing of the game is such that the governments first decide whether or not to join an international environmental agreement. Then governments choose their emission standard and finally firms compete. The participants in the international environmental agreement are assumed to maximise their joint welfare. In line with the literature on international environmental agreements the paper shows that only a small number of countries will join the agreement if it does not include trade measures. If the agreement, however, specifies that the participants in the international environmental agreement will impose a trade ban on all non-participating countries, then full cooperation becomes one possible Nash equilibrium. The intuition is that the benefits of free-riding on the cooperating countries are now offset by the loss of the pro-competitive effect of trade, if more than half of all the countries join the agreement. Barrett (1998) presents some extensions and robustness checks of this analysis.

4. ENVIRONMENTAL AND WELFARE EFFECTS OF TRADE LIBERALISATION

The previous two sections have dealt with the properties of welfare-maximising policies. The literature that will be surveyed in this section adopts an entirely different perspective. Now the key question is how trade liberalisation affects the emissions and the welfare of different countries. The focus is therefore not on optimal policies, but on the environmental and

welfare implications of a reduction in trade barriers. This question has been addressed by a diverse set of papers, which contains some of the most prominent contributions to the trade and environment literature.

4.1 Exogenous Environmental Policy

A first approach to analysing the effects of a reduction in trade barriers on environmental quality and welfare is to assume that environmental policy remains unchanged during trade liberalisation. Early contributions, which have taken this approach, are Pethig (1976) and Siebert (1977). Anderson (1992) provides a graph-based analysis.

The basic model is straightforward. The economy is competitive and there are two goods. The production of one of the goods generates some pollution emissions, which cause local damage, while the production of the other good is clean. Furthermore it is assumed for simplicity that no environmental policy is undertaken at all. If the country opens up to trade and specialises in the production of the clean good, then both environmental quality and welfare will increase. The welfare increase is due to the standard gains from trade, which are in this case reinforced by the decline in emissions from the production of the polluting good. If the country, however, specialises in the production of the polluting good, then the standard gains from trade are accompanied by a reduction in environmental quality and the net welfare impact of trade could well be negative. While clearly very simple, this analysis probably captures some of the reasoning behind public discussions about the links between environmental quality and international trade.

An interesting recent extension of this literature, which also assumes that no environmental policy at all is undertaken, is Copeland and Taylor (1999). They consider an economy with two goods, agriculture and manufacturing, and competitive markets. Production in the manufacturing sector generates emissions as a by-product. The key innovation of the paper is that these emissions do not cause any disutility to consumers, which is the standard assumption in the literature, but harm the local natural capital stock, which is used in the production of the agricultural sector. The implications of this assumption to some extent resemble the results of Ricardian models with external economies to scale. If the share of world income spent on the agricultural good is small, then opening two symmetric countries to trade can increase welfare in both countries by allowing the two incompatible industries to separate geographically. However, if the share of spending on the agricultural good is very large, then the country that attracts the manufacturing sector loses from trade as both its environmental quality and terms of trade deteriorate.

4.2 Endogenous Environmental Policy

A more plausible approach to modelling the environmental and welfare consequences of trade liberalisation - certainly in the long-run - is to endogenise the level of environmental policy. This line of research has generated several prominent contributions.

Two early contributions are Rauscher (1991b, 1992). Rauscher (1991b) develops a two-country model in which a single homogenous good is produced with the help of emissions and capital. The production function has constant returns to scale and all the markets are competitive. Both countries have an initial allocation of capital, which can be moved between the two countries at an exogenous mobility cost. Pollution emissions cause damage in both countries. The welfare-maximising governments in the two countries non-cooperatively choose environmental policy. The paper shows that a reduction in the mobility cost of capital will reduce emissions from at least one of the two countries, but the effect on overall emissions is ambiguous. The welfare effects of increased economic integration are also ambiguous. Both countries could gain or lose depending on the strength of the transboundary pollution spillovers and the effect of the environmental policy on the return of capital. Rauscher (1992) extends the analysis to a three-country model, where two countries form a free trade area.

Copeland and Taylor (1994) build on the informal discussions in Grossman and Krueger (1993) and divide the effect of a change in trade policy on environmental quality into a scale, technique and composition effect. They develop a modified Ricardian model with a continuum of goods. The goods are produced with the help of a Cobb-Douglas technology, which uses both labour and emissions as inputs, and different goods use the two inputs in different proportions. Emissions cause purely local damage, which is a disutility to consumers. There are two countries, North and South, which only differ in their endowment of effective labour, with the North having the larger endowment. The governments regulate pollution with the help of an emission tax and are assumed to be welfare-maximising. A straightforward implication of this assumption together with the absence of pollution spillovers, is that the usual gains from trade theorem applies and trade liberalisation always increases welfare.

The first contribution of the paper is to show how the environmental impact of trade liberalisation can be broken up into a scale, technique and composition effect in the model. The scale effect is the increase in pollution due to an increase in economic activity, holding constant both the technique of production and the composition of goods that are produced in a country. The technique effect is the change in aggregate pollution from a substitution to cleaner production techniques, holding constant both the scale and

composition of output. Finally, there is the composition effect, which is the change in aggregate pollution due to a change in the range of goods produced in a country. The main result of the paper is that trade liberalisation will increase pollution in the South, lower pollution in the North and increase world-wide pollution, if factor prices are not equalised by free trade.

In Copeland and Taylor (1995a) the model developed in Copeland and Taylor (1994) is extended to the case of transboundary pollution. They generalise the model to a large number of countries, which are again identical with the exception of differences in the endowment of effective labour. Each country non-cooperatively chooses its environmental policy, which is implemented with the help of pollution permits. They show that, also in this case, a move to free trade will increase world pollution if trade does not equalise factor prices. Furthermore they show that countries which are abundantly endowed with effective labour will lose from free trade, if the countries are not too different. Finally, they demonstrate that whenever free trade in goods increases world pollution, then free trade in pollution permits will reduce world pollution, even though each country can issue as many pollution permits as it wishes.

Two further extensions of this approach are contained in Copeland and Taylor (1997) and Antweiler, Copeland and Taylor (2001). The latter paper extends the models used in Copeland and Taylor (1994, 1995a) to include differences in factor endowments across countries. The two industries now use capital and labour as inputs and have different factor intensities. The capital-intensive sector produces emissions as a by-product, which can in turn be reduced with the help of an abatement technology, which uses the output of that sector as an input. The main new theoretical insight of the paper is that differences in endowments can dominate the influence of differences in environmental policy on comparative advantage. The intuition for this result is that the capital-intensive good will be exported by capital abundant countries even if their environmental policies are stricter than those of their trading partners if there are large differences in the capital to labour endowments across countries. The main contribution of the paper is to take this model to the data and carefully estimates the scale, technique and composition effect on data for sulphur dioxide emissions across a panel of countries from 1971 to 1996. They find that the combined impact of the three effects on environmental quality, while small in absolute magnitude, is positive and statistically significant for their dataset.

The model developed in Copeland and Taylor (1997) has some similarities with Copeland and Taylor (1999). There is a polluting industry that produces emissions as a by-product and a clean industry. In contrast to their other paper, emissions not only damage the natural capital stock which is used in the production of the clean industry, but also causes disutility to

consumers. The key assumption of the paper is that the government implements a pollution policy which only internalises the damage to consumers but ignores the potentially long-run implications of emissions for the natural capital stock. It is shown that for certain parameter values the diversified equilibrium, which prevails under autarky, will become unstable if the country starts to trade at fixed world prices. If the country specialises in the production of the polluting good, then the short-run gains from trade will be dominated by long-run losses due to the deterioration of the natural capital stock for sufficiently small discount rates.

5. THE POLITICAL ECONOMY APPROACH

This section will review the still small but growing body of literature that applies political economy models to trade and environment interactions. This literature has already addressed a diverse set of questions. This section will focus on four main questions in the literature: How much environmental policy will be undertaken in the political equilibrium and which instruments will be used? How will environmental policy change in response to trade liberalisation? How will political considerations influence the choice between assigning policy responsibility to the state or federal level? How do elections influence environmental policy? The following four subsections will deal with each of these questions in turn.

The most widely used theoretical model in this literature is the menu-auction model, which was used for the first time by Grossman and Helpman (1994) to explain political lobbying in the context of trade policy. In this model the government maximises a weighted sum of social welfare and contributions by lobby groups. Lobby group membership is usually assumed to be exogenous and only a subset of the population is organised. Apart from the menu-auction model the literature has also used other lobbying models and models that explicitly account for the role of elections in the political process. A more detailed survey of the literature in this section can be found in Sturm and Ulph (2002).

5.1 Politics and Environmental Policy

The first contribution, which applied the menu-auction approach to the political determination of environmental policy in an open economy, was Fredriksson (1997). He looks at a small open economy that has one numeraire sector, which only uses labour, and one further industry, which uses labour and a specific capital stock. Production in this sector generates emissions, which are proportional to output. These emissions cause disutility

to a subset of the population, which are labelled as "environmentalists". The government is lobbied both by the environmentalists and the industrialists, who are the owners of the specific capital stock, while consumers remain unorganised. The only policy instrument available to the government is a pollution tax. The paper shows that the environmental tax that emerges in the political equilibrium could be both higher or lower than the Pigouvian tax. The equilibrium tax rate depends on the size of both the green and industry lobby groups, the weight that the government attaches to social welfare and the parameters of the economic environment.

Schleich (1999) extends the model of Fredriksson (1997) by introducing both trade taxes and an environmental policy. The paper compares the situation where both instruments are endogenously determined with the situation in which one of the instruments is absent. The paper assumes that there are several sectors, all of which use a specific capital stock and labour as inputs. One of these sectors generates pollution in fixed proportion to output. A subset of the owners of the specific capital stocks lobby the government, while all other interests remain unorganised.

The main results of the paper are firstly, that in the case of a production externality only the environmental policy, which in this case is a production tax or subsidy, will be used in the political equilibrium. The reason for this is that the government also values social welfare and therefore uses the most efficient instrument to subsidise lobbying industries and to internalise the externality. Similarly with a consumption externality, the political equilibrium involves a consumption tax on the polluting good, which is at the Pigouvian level, and trade taxes, which are used to redistribute income between the industries that lobby and those that do not.[4] The second main result is that in the case of a production externality environmental quality could be higher under a regime in which only trade taxes are available compared to a situation where the environmental policy instrument is also available. The intuition for this result is that the additional distortions caused by a tariff will dampen the governments' incentive to redistribute income. Very similar results are derived in Aidt (1998), who looks at the political determination of an output tax and a tax on the polluting input.

A further extension of this literature is contained in Schleich and Orden (2000) and Conconi (2002), who look at the case of two large countries and also allow for transboundary pollution. They show how the political

[4] This result stands in contrast to a largely informal argument in Hoekman and Leidy (1992) and Leidy and Hoekman (1994) that industrialists will lobby for inefficient environmental policies in an open economy. The reason is that output and employment reductions induced by these environmental regulations could be (ab-) used to argue that the industry is experiencing "injury due to rising imports", which increases its chances of gaining protection under the existing system of anti-dumping rules.

equilibrium depends on whether the two governments choose their policies non-cooperatively or cooperatively. Finally, Rauscher (1997, ch. 7) presents a very general political support function model, which is not based on the menu-auction approach, in which the domestic politician has access to consumption taxes on domestic and foreign goods, emission taxes and product standards on domestic and foreign goods. He investigates to what extent the interests of industrialists and environmentalists will coincide in this set-up.

5.2 Trade Liberalisation and Environmental Policy

Bommer (1996), Bommer and Schulze (1999) and Fredriksson (1999) also analyse the political determination of environmental policy, but focus on a more specific question. They assume that there is an exogenous trade liberalisation and analyse how this affects environmental policy choices and environmental quality. Fredriksson (1999) uses the lobby model developed in Fredriksson (1997) and adds an abatement technology and a tariff on imports of the polluting good, which is exogenously determined. He shows that a reduction in the tariff has ambiguous effects on the pollution tax. The reason is that trade liberalisation reduces output in the polluting sector and therefore reduces the marginal incentives for both environmentalists and the owners of the specific capital stock to exert political influence. Furthermore the paper also shows that environmental quality could both increase or decrease as a consequence of trade liberalisation once the political economy effects have been taken into account.

The approach of Bommer and Schulze (1999) to this question is somewhat different. They consider an economy with two sectors. Both sectors use labour and a specific factor as inputs and one sector also uses emissions as an additional input, which increases the productivity of the other two factors. The only policy instrument available to the government is an emission limit for the polluting sector. In contrast to Fredriksson (1999) the political process is modelled with the help of a reduced form political support function. The government is assumed to maximise a strictly concave function, which has the wage rate, environmental quality and the returns to the two specific factors as arguments.

The paper now considers an exogenous trade liberalisation, which is modelled as an increase in the relative price of the pollution-intensive sector. The paper argues that this is a good description of the US after NAFTA came into force and presents some data to support this claim. This change in the price of goods clearly changes factor incomes and environmental quality. The main result of the paper is that the government will tighten the environmental standard in response to trade liberalisation. The intuition is

that this essentially reverses the distributional consequences of trade liberalisation, which must increase the government's payoff with a strictly concave political support function. Bommer (1996) uses the same mechanism as in Bommer and Schulze (1999) and derives some further extensions to the results described above.

An interesting recent addition to the literature, which is indirectly related to the question of the effects of trade liberalisation on environmental policy, is Eliste and Fredriksson (2002). Their paper is motivated by the difficulty to empirically measuring the impact of environmental regulations on location decisions and trade flows. They use a model, which is similar to Fredriksson (1997, 1999) and contains two policy instruments, a production subsidy for the polluting sector and a pollution tax. They analyse the effects of an exogenous increase in the pollution tax and show that this results in an endogenous increase in the subsidy to the polluting industry. They interpret this result as evidence that an endogenous increase in the subsidy will offset the true effect of environmental regulations on output and trade flows. To support this conclusion they run some cross-country regressions on data for the agricultural sector. Their results show that, even after the inclusion of several control variables, more stringent environmental policies are associated with larger direct transfers to the agricultural sector.

5.3 State versus Federal Policy-Making

In a series of papers, Johal and Ulph (2001, 2002a,b,c) have investigated the choice between having environmental policy determined at the state or federal level in various political economy settings. In Johal and Ulph (2002a,b) state government policy-making suffers from environmental dumping and transboundary pollution respectively. They consider a number of ways in which environmental and industrial lobby groups can influence the political process. Their main finding is that it is always better to have policies coordinated at the supra-national level relative to non-cooperative behaviour between the state governments. This finding is robust to a number of possible asymmetries in lobbying behaviour such as differences in the influence of the environmental lobby and the industrial lobby or differences in the influence of lobbies at the state and federal level.

Johal and Ulph (2001, 2002c) pursue this question further in a similar model, which also includes asymmetric information. Environmental damage in each state now depends on the realisation of a random variable, which is private knowledge to the government in power. At the same time governments continue to be lobbied by environmental and industrial lobby groups and can be captured by these interest groups. One possible way in which voters can try to limit the influence of special interest groups in this

model is to limit politicians' discretion. Since the information available to voters at the outset is solely expected damage costs, which are assumed to be the same in all states, limiting politicians' discretion will imply harmonisation. It turns out that it will pay to limit policy discretion if the potential gain in information is smaller than the potential distortion in policies by special interest groups. The main result of Johal and Ulph (2001, 2002c) is that it never pays to restrict political influence if policy is set at the federal level if it does not pay to restrict it when policy is set at the state level.

5.4 The Role of Elections

Two early contributions, which have explicitly modelled the role of elections, are Hillman and Ursprung (1992, 1994). They introduce an environmental lobby into an interest-group-cum-electoral-competition model in which trade policy is the only available policy instrument. In this model a liberal and a protectionist party collect campaign contributions from environmentalists and industrialists, which in turn influence the probability with which each party wins the election. The two papers show that the environmentalists will support the liberal party if they only care about local environmental damage and damage is caused by production. However, this leaves the two environmental lobbies in a conflict of interest. If they were able to coordinate their lobbying, they would then maximise their joint utility by supporting the protectionist party in both countries.

McAusland (2003) develops a median voter model to explain environmental policy choices in open economies. The economy is modelled as a small open economy with a clean and a polluting goods sector and heterogeneous consumers. The paper first analyses the incentives of different consumers to vote for strict environmental policy when the economy is closed and finds that contrary to conventional wisdom richer voters may prefer a laxer environmental policy than poorer voters. The second main result is that opening up the country to trade at world prices, which are equal to domestic prices, can potentially change the environmental policy chosen in the political equilibrium. This change in policy can in turn induce trade flows. The reason is that opening trade isolates goods prices from changes in environmental policy and therefore potentially changes voters' preferences with respect to environmental policy.

Sturm (2001) uses a political agency model and turns to the problem of trade disputes over national product standards. The usual pattern of such disputes is that a country introduces a new product standard for all sales of a good in its local market, which is justified as being necessary for consumer or environmental protection. Importers into the local market, however, chal-

lenge the standard as a "disguised barrier to trade" or "green protectionism". This issue had previously been addressed by a number of informal contributions such as Esty (1994), Laplante and Garbutt (1992), Runge (1990), Sorsa (1995) and Vaugham (1995). Engel (2000) and Ames (1998) provide detailed case studies of several prominent trade disputes, in which environmental standards were challenged as disguised trade barriers.

The contribution of Sturm (2001) is to develop a formal two-country political economy model to explain such disputes. Policy-making is modelled in the spirit of the political agency literature, which views the political process as a principal-agent relationship in which voters have to provide incentives for their politicians. Politicians are assumed to have an informational advantage in evaluating the probability with which imported consumption goods cause health or environmental damage. It is shown how a political equilibrium can emerge in which domestic politicians claim that the expected damage is high while their foreign counterparts claim that it is low. This divergence can either be due to an excessively strict environmental policy in the importing country or a too lax environmental policy in the exporting country. Furthermore the paper investigates the effects of two frequent proposals, those of mutual recognition of standards and harmonisation, to avoid such disputes. The principal finding is that both proposals may not improve welfare relative to decentralised environmental policy-making.

6. CONCLUSION

This paper has surveyed the voluminous literature on the links between environmental policy and international trade. The literature included in this survey has been grouped under four main questions: What are the properties of optimal environment and trade policies in open economies with local pollution? What are the properties of these policies in the case of transboundary pollution? What are the environmental and welfare consequences of trade liberalisation? How can we explain the political economy of the trade and environment nexus?

To summarise it is probably fair to say that while we know some of the answers to these questions there remains much scope for further research. While we know a good deal about the properties of optimal policies towards local and transboundary pollution, there remain many open issues, particularly in the area of the political economy of environmental policy and in the analysis of the effects of trade liberalisation on environmental quality and welfare. As in many other areas of economics careful empirical work would be invaluable. A good example of such work is Antweiler, Copeland

and Taylor (2001), which combines interesting theoretical work with important new empirical insights.

REFERENCES

Aidt, T. (1998), Political Internalisation of Economic Externalities and Environmental Policy, *Journal of Public Economics*, 69, 1-16.

Althammer, W., and Buchholz, W. (1995), Strategic Trade Incentives in Environmental Policy, *Finanzarchiv*, 52, 293-305.

Ames, G. (1998), The U.S.-Russian Poultry Trade Dispute: Whose Chicken Is in Your Soup?, *Journal of East West Business*, 4, 69-87.

Anderson, K. (1992), The Standard Welfare Economics of Policies Affecting Trade and the Environment, in: Kym Anderson and Richard Blackhurst (eds.), *The Greening of World Trade Issues*, Ann Arbor: University of Michigan Press.

Anderson, K., and Blackhurst, R. (1992), *The Greening of World Trade Issues*, Ann Arbor: University of Michigan Press.

Antweiler, W., Copeland, B., and Taylor, S. (2001), Is Free Trade Good for the Environment?, *American Economic Review*, 91, 877-908.

Asako, K. (1979), Environmental Pollution in an Open Economy, *Economic Record*, 55, 359-67.

Barbier, E., and Rauscher, M. (1994), Trade, Tropical Deforestation and Policy Interventions, *Environmental and Resource Economics*, 4, 75-90.

Barbier, E., and Schulz, C. E. (1997), Wildlife, Biodiversity and Trade, *Environment and Development Economics*, 2, 145-72.

Barrett, S. (1994), Strategic Environmental Policy and International Trade, *Journal of Public Economics*, 54, 325-38.

Barrett, S. (1997), The Strategy of Trade Sanctions in International Environmental Agreements, *Resource and Energy Economics*, 19, 345-61.

Barrett, S. (1998), The Credibility of Trade Sanctions in International Environmental Agreements, in: Per G. Fredriksson (ed.), *Trade, Global Policy, and the Environment*, World Bank Discussion Paper No. 402.

Baumol, W. (1971), *Environmental Protection, International Spillovers, and Trade*, Stockholm: Almkvist & Wicksell.

Baumol, W., and Oates, W. (1988), *The Theory of Environmental Policy*, Second Edition, Cambridge: Cambridge University Press.

Bommer, R. (1996), Environmental Regulation of Production Processes in the European Union: A Political-Economy Approach, *Aussenwirtschaft*, 51, 559-82.

Bommer, R., and Schulze, G. (1999), Environmental Improvement with Trade Liberalization, *European Journal of Political Economy*, 15, 639-61.

Brander, J., and Spencer, B. (1985), Export Subsidies and International Market Share Rivalry, *Journal of International Economics*, 18, 83-100.

Brander, J., and Taylor, S. (1997a), International Trade between Consumer and Conservationist Countries, *Resource and Energy Economics*, 19, 267-97.

Brander, J., and Taylor, S. (1997b), International Trade and Open-Access Renewable Resources: The Small Open Economy Case, *Canadian Journal of Economics*, 30, 526-52.

Brander, J., and Taylor, S. (1998), Open Access Renewable Resources: Trade and Trade Policy in a Two-Country Model, *Journal of International Economics*, 44, 181-209.

Chichilnisky, G. (1994), North-South Trade and the Global Environment, *American Economic Review*, 84, 851-74.

Conconi, P. (2002), Green Lobbies and Transboundary Pollution in Large Open Economies, *Journal of International Economics*, (forthcoming)

Conrad, K. (1993), Taxes and Subsidies for Pollution-Intensive Industries as Trade Policy, *Journal of Environmental Economics and Management*, 25, 121-35.

Copeland, B. (1990), Strategic Interaction Among Nations: Negotiable and Non-negotiable Trade Barriers, *Canadian Journal of Economics*, 23, 84-108.

Copeland, B. (1994), International Trade and the Environment: Policy Reform in a Polluted Small Open Economy, *Journal of Environmental Economics and Management*, 26, 44-65.

Copeland, B. (1996), Pollution Content Tariffs, Environmental Rent Shifting, and the Control of Cross-Border Pollution, *Journal of International Economics*, 40, 459-76.

Copeland, B., and Talyor, S. (1994), North-South Trade and the Environment, *Quarterly Journal of Economics*, 109, 755-87.

Copeland, B., and Taylor, S. (1995a), Trade and Transboundary Pollution, *American Economic Review*, 85, 716-37.

Copeland, B., and Taylor, S. (1995b), Trade and the Environment: A Partial Synthesis, *American Journal of Agricultural Economics*, 77, 765-71.

Copeland, B., and Taylor, S. (1997), The Trade-Induced Degradation Hypothesis, *Resource and Energy Economics*, 19, 321-44.

Copeland, B., and Taylor, S. (1999), Trade, Spatial Separation, and the Environment, *Journal of International Economics*, 47, 137-68.

Dean, J. (1992), Trade and the Environment: A Survey of the Literature, in: Patrick Low (ed.), *International Trade and the Environment*, Worldbank Discussion Paper 159.

Dean, J. (1995), Export Bans, Environment, and Developing Country Welfare, *Review of International Economics*, 3, 319-29.

Dean, J., and Gangopadhyay, S. (1997), Export Bans, Environmental Protection, and Unemployment, *Review of Development Economics*, 1, 324-36.

Eliste, P., and Fredriksson, P. (2002), Environmental Regulations, Transfers and Trade: Theory and Evidence, *Journal of Environmental Economics and Management*, 43, 234-50.

Engel, E. (2000), Poisoned Grapes, Mad Cows and Protectionism, *Journal of Policy Reform*, 4, 91-111.

Esty, D. (1994), *Greening the GATT: Trade, Environment, and the Future*, Washington: Institute of International Economics.

Felder, S., and Rutherford, T. (1993), Unilateral CO_2 Reductions and Carbon Leakage: The Consequences of International Trade in Oil and Basic Materials, *Journal of Environmental Economics and Management*, 25, 162-76.

Fischer, R., and Serra, P. (2000), Standards and Protection, *Journal of International Economics*, 52, 377-400.

Fredriksson, P. (1997), The Political Economy of Pollution Taxes in a Small Open Economy, *Journal of Environmental Economics and Management*, 33, 44-58.

Fredriksson, P. (1999), The Political Economy of Trade Liberalization and Environmental Policy, *Southern Economic Journal*, 65, 513-25.

Grossman, G., and Helpman, E. (1994), Protection for Sale, *American Economic Review*, 84, 833-50.

Grossman, G., and Krueger, A. (1993), Environmental Impacts of a North American Free Trade Agreement, in: Peter M. Garber (ed.), *The Mexico U.S. Free Trade Agreement*, Cambridge and London: MIT Press.

Gürtzgen, N., and Rauscher, M. (2000), Environmental Policy, Intra-industry Trade and Transfrontier Pollution, *Environmental and Resource Economics*, 17, 59-71.

Haupt, A. (2000), Environmental Product Standards, International Trade and Monopolistic Competition, *International Tax and Public Finance*, 7, 585-608.

Hillman, A., and Ursprung, H. (1992), The Influence of Environmental Concerns on the Political Determination of Trade Policy, in: Kym Anderson and Richard Blackhurst (eds.), *The Greening of World Trade Issues*, Ann Arbor: University of Michigan Press.

Hillman, A., and Ursprung, H. (1994), Greens, Supergreens, and International Trade Policy: Environmental Concerns and Protectionism, in: Carlo Carraro (ed.), *Trade, Innovation, Environment*, Dordrecht, Boston and London: Kluwer Academic Publishers.

Hoekman, B., and Leidy, M. (1992), Environmental Policy Formation in a Trading Economy: A Public Choice Perspective, in: Kym Anderson and Richard Blackhurst (eds.), *The Greening of World Trade Issues*, Ann Arbor: University of Michigan Press.

Hoel, M. (1996), Should a Carbon Tax be Differentiated Across Sectors?, *Journal of Public Economics*, 59, 17-32.

Hoel, M. (1997), Environmental Policy with Endogenous Plant Locations, *Scandinavian Journal of Economics*, 99, 241-59.

Jeppesen, T., List, J., and Folmer, H. (2002), Environmental Regulations and New Plant Loca-tion Decisions: Evidence from a Meta-analysis, *Journal of Regional Science*, 42, 19-49.

Johal, S., and Ulph, A. (2002a), Globalization, Lobbying and International Environmental Governance, *Review of International Economics*, 10, 387-403.

Johal, S., and Ulph, A. (2002b), Global Environmental Governance, Political Lobbying and Transboundary Pollution, in: John List and Aart de Zeeuw (eds.) *Recent Advances in Environmental Economics*, Edward Elgar Publishing (forthcoming).

Johal, S., and Ulph, A. (2002c), Limiting Political Discretion and International Environmental Policy Coordination with Active Lobbying, in: Laura Marsiliani, Michael Rauscher and Cees Withagen (eds.) *Environmental Policy in an International Perspective*, Dordrecht, Boston and London: Kluwer Academic Publishers.

Johal, S., and Ulph, A. (2001), International Environmental Policy Coordination, Harmonisation, and Limiting Political Discretion, University of Southampton mimeo.

Kemp, M., and van Long, N. (1984), The Role of Natural Resources in Trade Models, in: Ronald Jones and Peter Kenen (eds.), *Handbook of International Economics*, Vol. 1, Elsevier Science Publishers.

Kennedy, P. (1994), Equilibrium Pollution Taxes in Open Economies with Imperfect Competition, *Journal of Environmental Economics and Management*, 27, 49-63.

Kim, J., and Wilson, J. (1997), Capital Mobility and Environmental Standards: Racing to the Bottom with Multiple Tax Instruments, *Japan and the World Economy*, 9, 537-51.

Krumm, R., and Wellisch, D. (1995), On the Efficiency of Environmental Instruments in a Spatial Economy, *Environmental and Resource Economics*, 6, 87-98.

Krutilla, K. (1991), Environmental Regulation in an Open Economy, *Journal of Environmental Economics and Management*, 20, 127-42.

Laplante, B., and Garbutt, J. (1992), Environmental Protectionism, *Land Economics*, 68, 116-19.

Leidy, M., and Hoekman, B. (1994), 'Cleaning Up' while Cleaning Up? Pollution Abatement, Interest Groups and Contingent Trade Policies, *Public Choice*, 78, 241-58.

Levinson, A. (1997), A Note on Environmental Federalism: Interpreting Some Contradictory Results, *Journal of Environmental Economics and Management*, 33, 359-66.

Levinson, A. (1999), State Taxes and Interstate Hazardous Waste Shipments, *American Economic Review*, 89, 666-77.

Ludema, R., and Wooton, I. (1994), Cross-Border Externalities and Trade Liberalization: The Strategic Control of Pollution, *Canadian Journal of Economics*, 27, 950-66.

Ludema, R., and Wooton, I. (1997), International Trade Rules and Environmental Cooperation under Asymmetric Information, *International Economic Review*, 38, 605-25.

Maestad, O. (2001), Timber Trade Restrictions and Tropical Deforestation: A Forest Mining Approach, *Resource and Energy Economics*, 23, 111-32.

Manne, A., and Rutherford, T. (1994), International Trade in Oil, Gas and Carbon Emission Rights: An Intertemporal General Equilibrium Model, *Energy Journal*, 15, 57-76.

Markusen, J. (1975), International Externalities and Optimal Tax Structures, *Journal of International Economics*, 5, 15-29.

Markusen, J. (1997), Costly Pollution Abatement, Competitiveness and Plant Location Decisions, *Resource and Energy Economics*, 19, 299-320.

Markusen, J., Morey, E., and Olewiler, N. (1993), Environmental Policy when Market Structure and Plant Locations are Endogenous, *Journal of Environmental Economics and Management*, 24, 68-86.

Markusen, J., Morey, E., and Olewiler, N. (1995), Competition in Regional Environmental Policies when Plant Locations are Endogenous, *Journal of Public Economics*, 56, 55-77.

Markusen, J., and Venables, A. (1998), Multinational Firms and the New Trade Theory, *Journal of International Economics*, 46, 183-203.

McAusland, C. (2003), Voting for Pollution Policy: The Importance of Income Inequality and Trade, *Journal of International Economics* (forthcoming).

McGuire, M. (1982), Regulation, Factor Rewards, and International Trade, *Journal of Public Economics*, 17, 335-54.

Merrifield, J. D. (1988), The Impact of Selected Abatement Strategies on Transnational Pollution, the Terms of Trade, and Factor Rewards: A General Equilibrium Approach, *Journal of Environmental Economics and Management*, 15, 259-84.

Motta, M., and Thisse, J. F. (1994), Does Environmental Dumping Lead to Delocation?, *European Economic Review*, 38, 563-76.

Neary, P. (2000), *Trade and the Environment: Theoretical and Policy Linkages*, University College Dublin mimeo.

Oates, W., and Schwab, R. (1988), Economic Competition among Jurisdictions: Efficiency Enhancing or Distortion Inducing?, *Journal of Public Economics*, 35, 333-54.

Oliveira-Martins, J. Burniaux, J.-M., and Martin, J. (1992), Trade and the Effectiveness of Unilateral CO_2-Abatement Policies: Evidence from Green, *OECD Economic Studies*, No. 19, 123-40.

Perroni, C., and Rutherford, T. (1993), International Trade in Carbon Emission Rights and Basic Materials: General Equilibrium Calculations for 2020, *Scandinavian Journal of Economics*, 95, 257-78.

Pestemon, J. (2000), Public Open Access and Private Timber Harvests: Theory and Application to the Effects of Trade Liberalization in Mexico, *Environmental and Resource Economics*, 17, 311-34.

Pethig, R. (1976), Pollution, Welfare and Environmental Policy in the Theory of Comparative Advantage, *Journal of Environmental Economics and Management*, 2, 160-69.

Pezzey, J., (1992), Analysis of Unilateral CO_2 Control in the European Community and OECD, *Energy Journal*, 13, 159-71.

Rauscher, M. (1991a), Foreign Trade and the Environment, in: Horst Siebert (ed.), *Environmental Scarcity: The International Dimension*, Tübingen: Mohr.

Rauscher, M. (1991b), National Environmental Policies and the Effects of Economic Integration, *European Journal of Political Economy*, 7, 313-29.

Rauscher, M. (1992), Economic Integration and the Environment: Effects on Members and Non-members, *Environmental and Resource Economics*, 2, 221-36.

Rauscher, M. (1994), On Ecological Dumping, *Oxford Economic Papers*, 46, 822-40.

Rauscher, M. (1995), Environmental Regulation and the Location of Polluting Industries, *International Tax and Public Finance*, 2, 229-44.

Rauscher, M. (1997), *International Trade, Factor Movements, and the Environment*, Oxford and New York: Oxford University Press.

Runge, F. (1990), Trade Protectionism and Environmental Regulations: The New Nontariff Barriers, *Northwestern Journal of International Law and Business*, 11, 47-61.

Rutherford, T. (1996), Carbon Dioxide Emission Restrictions in the Global Economy: Leakage, Competitiveness, and the Implications for Policy Design, in: Charls Walker, Mark Bloomfield and Margo Thorning (eds.), *An Economic Perspective on Climate Change Policies*, Washington: American Council of Capital Formation.

Schleich, J. (1999), Environmental Quality with Endogenous Domestic and Trade Policies, *European Journal of Political Economy*, 15, 53-71.

Schleich, J., and Orden, D. (2000), Environmental Quality and Industry Protection with Noncooperative Versus Cooperative Domestic and Trade Policies, *Review of International Economics*, 8, 681-97.

Schulz, C. E. (1996), Trade Policy and Ecology, *Environmental and Resource Economics*, 8, 15-38.

Schulze, G., and Ursprung, H. (eds.) (2001), *International Environmental Economics: A Survey of the Issues*, Oxford: Oxford University Press.

Siebert, H. (1974), Environmental Protection and International Specialization, *Weltwirtschaftliches Archiv*, 110, 494-508.

Siebert, H. (1977), Environmental Quality and the Gains from Trade, *Kyklos*, 30, 657-73.

Siebert, H. (1979), Environmental Policy in the Two-Country-Case, *Zeitschrift für Nationalökonomie*, 39, 259-74.

Siebert, H., Eichenberger, J., Gronych, R., and Pethig, R. (1980), *Trade and Environment: A Theoretical Enquiry*, Amsterdam and Oxford: Elsevier Science Publishers.

Sorsa, P. (1995), Environmental Protectionism, North-South Trade, and the Uruguay Round, International Monetary Fund Working Paper, Nr. 95/6.

Subramanian, A. (1992), Trade Measures for the Environment: A Nearly Empty Box?, *The World Economy*, 15, 135-52.

Sturm, D. (2000), Choosing How to Compete: Is Environmental Policy the Optimal Instrument?, University of Munich mimeo.

Sturm, D. (2001), Product Standards, Trade Disputes, and Protectionism, CEP Discussion Paper No. 486.

Sturm, D., and Ulph, A. (2002) Environment and Trade: The Implications of Imperfect Information and Political Economy, *World Trade Review* (forthcoming).

Ulph, A. (1994), Environmental Policy, Plant Location and Government Protection, in: Carlo Carraro (ed.), *Trade, Innovation, Environment*, Dordrecht, Boston and London: Kluwer Academic Publishers.

Ulph, A. (1996a), Environmental Policy and International Trade When Governments and Producers Act Strategically, *Journal of Environmental Economics and Management*, 30, 265-81.

Ulph, A. (1997a), International Trade and the Environment: A Survey of Recent Economic Analysis, in: Henk Folmer and Tom Tietenberg (eds.), *The International Yearbook of Environmental and Resource Economics 1997/1998*, Edward Elgar Publishing.

Ulph, A. (1997b), International Environmental Regulation When National Governments Act Strategically, in: John Braden and Stef Proost (eds.), *The Economic Theory of Environmental Policy in a Federal System*, Edward Elgar Publishing.

Ulph, A. (2000), Harmonization and Optimal Environmental Policy in a Federal System with Asymmetric Information, *Journal of Environmental Economics and Management*, 39, 224-241.

Ulph, A., and Ulph, D. (1996), Trade, Strategic Innovation and Strategic Environmental Policy: A General Analysis, in: Carlo Carraro, Yiannis Katsoulacos and Anastasios Xepapadeas (eds.), *Environmental Policy and Market Structure*, Dordrecht, Boston and London: Kluwer Academic Publishers.

Vaughan, S. (1995), Green Protectionism: Environmental Policies are Worrying the Trade Community, *New Economy*, 2, 147-51.

Venables, A. (1999), Economic Policy and the Manufacturing Base: Hysteresis in Location, in: Richard Baldwin and Joseph Francois (eds.), *Dynamic Issues in Applied Commercial Analysis*, CEPR and Cambridge University Press.

Walz, U., and Wellisch, D. (1997), Is Free Trade in the Interest of Exporting Countries When There Is Ecological Dumping?, *Journal of Public Economics*, 66, 275-91.

Wellisch, D. (1995), Locational Choices of Firms and Decentralized Environmental Policy with Various Instruments, *Journal of Urban Economics*, 37, 290-310.

Welsch, H. (1994), Incomplete International Cooperation to Reduce CO_2 Emissions: The Case of Price Discrimination, *Journal of Environmental Economics and Management*, 27, 254-58.

Wilson, J. (1996), Capital Mobility and Environmental Standards: Is there a Theoretical Basis for a Race to the Bottom?, in: Jagdish Bhagwati and Robert Hudec (eds.), *Fair Trade and Harmonisation: Prerequisites for Free Trade?*, Vol. 1, Cambridge and Washington: MIT Press in cooperation with the American Society for International Law.