INFORMATION TO USERS

This manuscript has been reproduced from the microfilm master. UMI films the text directly from the original or copy submitted. Thus, some thesis and dissertation copies are in typewriter face, while others may be from any type of computer printer.

The quality of this reproduction is dependent upon the quality of the copy submitted. Broken or indistinct print, colored or poor quality illustrations and photographs, print bleedthrough, substandard margins, and improper alignment can adversely affect reproduction.

In the unlikely event that the author did not send UMI a complete manuscript and there are missing pages, these will be noted. Also, if unauthorized copyright material had to be removed, a note will indicate the deletion.

Oversize materials (e.g., maps, drawings, charts) are reproduced by sectioning the original, beginning at the upper left-hand corner and continuing from left to right in equal sections with small overlaps. Each original is also photographed in one exposure and is included in reduced form at the back of the book.

Photographs included in the original manuscript have been reproduced xerographically in this copy. Higher quality 6" x 9" black and white photographic prints are available for any photographs or illustrations appearing in this copy for an additional charge. Contact UMI directly to order.

UMI

A Bell & Howell Information Company
300 North Zeeb Road, Ann Arbor MI 48106-1346 USA
313/761-4700 800/521-0600

Université d'Ottawa · University of Ottawa

TRADE AND THE ENVIRONMENT: A GAME-THEORETIC ANALYSIS OF THE LINKAGES

A thesis presented to the School of Graduate Studies and Research of the University of Ottawa in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Economics.

by

Karim Eslamloueyan

January 1998

ABSTRACT

This thesis attempts to analyze some prominent linkages between trade and the environment. More specifically, the thesis seeks to elucidate the endogenous determination of environmental policies in the context of North-South and North-North relations when pollution generated in one country can cross the border and flow into another country. It also provides a theoretical framework to analyze the political influence of environmental lobbies on environmental policies, environmental damages, and the strategic behavior of domestic firms in making political contributions and investments in *environmental* R&D.

This thesis adopts the political-support approach formalized with the help of the game-theoretic framework of a first-price menu auction formulated by Bernheim and Whinston (1986). In the political process, environmental interest groups that seek to influence environmental and trade policies set by politicians will face other lobby groups. By contrast, domestic firms in imperfectly competitive industries will press for protectionist trade policies and laxer environmental regulations.

We find that an equilibrium emission tax depends on the cost and emission per unit of output, the weight that an incumbent government attaches to social welfare, the amount of pollution that countries transfer to each other, and the type of environmentalists. This thesis shows how interactions between different interest groups and their national governments may prevent the adoption of socially optimal levels of environmental policies. Moreover, it shows that environmentalists might be pressing for more stringent environmental policies if they care only about their own local environment and might have common cause with protectionist tendencies if they believe that liberalized trade will result in more pollution.

With some exceptions, it is found that the presence of environmental lobbies improves the quality of their local environments. The exceptions arise when environmentalists also care about the global environment and pollution spills over from one country to another. This thesis shows that the presence of environmental lobbies may raise *environmental* R&D investments in the North, lower the profits of domestic firms, and improve the quality of their home and the world environments by inducing their incumbent government to adopt more stringent environmental policies.

The thesis also finds that a more stringent environmental regulation, if properly set, may induce a domestic firm to undertake R&D investments, but it fails to confirm that this will raise the firm's profitability or competitiveness. Indeed, we show that an increase in a pollution tax causes the domestic firm to either cut back its output or raise its R&D expenditure. In either case, the profit of the domestic firm declines.

JEL Classification: D72, F13, Q28

Key Words: Political Economy, Interest Groups, North-South, North-North, Environmental and Trade Policies, Transboundary Pollution, Green and Supergreen, Environmental R&D, Imperfect Competition.

TABLE OF CONTENTS

Acknowledgments

Special thanks go to Professor Nguyen Van Quyen who was very generous with his advice and encouragement during the course of writing my thesis. I was very fortunate to work with him and benefit from his insights. I am always indebted for his teaching. I am also thankful to Professors Quentin Grafton, Philippe J. Crabbé, and Viveke H. Dehejia for their comments and insights.

I express my gratitude to Professor Scott Taylor, the external examiner of this thesis, for his valuable comments and suggestions. My thanks also go to Professors Chantale LaCasse and Zhiqi Chen for their comments on an earlier version of the present work, and to Professors Gilles Grenier, André Plourde, and Rose Anne Devlin for their encouragement.

I would like to acknowledge the scholarship from the Ministry of Culture and Higher Education of the Islamic Republic of Iran. I also extend my gratitude to Dr. Sayed Reza Hosseini, Higher Education Advisor of Iranian Students in Canada, for his support and encouragement.

Finally, I am very grateful to my wife, sons: Amin and Ali, and my parents for their forbearance and invaluable support.

1 INTRODUCTION

1.1 Background

The issue of trade and environmental linkages is currently one of the most hotly debated topics on the international scene. In the United States and Canada, organized labor and environmentalists launched a fierce opposition to the North American Free Trade Agreement (NAFTA). The difficult liaisons between trade and the environment are also the source of numerous bilateral tensions. The United States squabbled with Mexico over the latter's practice of tuna fishing that kills dolphins, with Norway over whaling, and with Brazil over the destruction of rain forests. Canada quarreled with Spain over the turbot stock on the Grand Banks off the coast of Newfoundland. The fish dispute almost escalated to a naval conflict between the two countries, and the European Union (EU), in its effort to

support Spain -- a member state -- threatened to impose trade sanctions against Canada. The list of conflicts involving trade and the environment can be lengthened almost indefinitely.[1]

Environmentalists have identified four core propositions involving the linkages between trade and the environment.[2] First, trade -- by promoting economic growth -- may damage the environment. More precisely, trade raises the scale of economic activities and, without environmental safeguards, this results in the unsustainable consumption of natural resources and waste generation. Second, trade rules and trade liberalization often entail market access agreements that can be used to override environmental regulations unless appropriate environmental protection measures are built into the structure of the trade system. Third, trade-based measures should be used to address global or transboundary environmental problems and to reinforce international environmental agreements. Fourth, if one considers environmental quality as a normal good, then developing nations will adopt relatively low environmental standards. Therefore, even if the pollution they cause does not spill over into other countries, nations with lax environmental standards provide their own domestic firms with a cost advantage in the global market place and put pressure on nations with high environmental standards to reduce the rigor of their environmental requirements. The end result -- environmentalists contend -- will be competitive environmental degradation.

Proponents of liberalized trade counter the arguments of environmentalists by claiming that liberalized trade induces economic growth, which, in turn, will yield more

---

[1] See, for example, Esty (1994) for a presentation and analysis of the linkages between trade and the environment from the perspective of a negotiator for the United States.

[2] For more discussion see Chapter 2, Section 1.

resources to fight environmental degradation. They consider environmental quality as a normal good and, therefore, the income gain from trade should create demand for tougher environmental regulations. The causality from trade to the environment is thus beneficial according to the viewpoint of those who advocate trade liberalization.[3] Proponents of trade liberalization also argue that environmental measures are often a thin disguise for protecting domestic industries against imports.

Some argue that there is no conflict between economy and the environment. Klepper (1992, p.257) remarks that in the European Union (EU), as long as there are trade surpluses, it is unlikely that there will be a credible demand for protection motivated by the fear of losing competitiveness through tough environmental regulations. This author points out, for example, that the German Federation of Trade Unions does not see any reason to suspect that environmental policy has been harmful for the international competitiveness of Germany as long as German industries in general -- and the chemical industry in particular -- experience high trade surpluses. Michael Porter (1991) claims that tougher environmental regulations may even induce more international competition. According to this viewpoint, strict environmental laws can be beneficial to both the environment and trade. Porter (op cit) introduces innovation into the picture and argues that there is no conflict between environmental protection and economic competitiveness on the international scene. He (op cit, p.168) points out that strict environmental codes may actually foster competitiveness and argues that nations with the strictest environmental

[3] For a discussion on the pros and cons of this argument, we refer the reader to the World Bank Discussion Paper 159 edited by Low (1992).

laws, such as Germany and Japan, have led those with laxer environmental regulations in terms of economic performance and competitiveness. For example, Japan has some of the toughest automotive emission standards and air pollution regulations in the world. Thus, it has made a considerable reduction in the amount of sulfur dioxide emission. Indeed, Japan is a world leader in the development of sulfur oxide control technologies (Vogel, 1990, p.266.) Porter's idea is that stricter environmental regulation at home may induce innovation and thus increase competitiveness on the international market through rising productivity. Thus, to enhance the long-run profitability of domestic industries, governments can adopt environmental policies that are tough enough to induce home industries to discover greener technologies ahead of their rivals.

The issue of trade and the environment interactions has received relatively little attention in the theoretical literature. The economic literature on trade-environment linkages is rather recent and contains several strands. One strand of the literature is mainly concerned with extending the results of standard trade theory to situations in which pollution is internalized within the production process.[4]

Another part of the literature focuses on market failure, namely the lack of environmental property rights[5], to analyze the linkages between trade and the environment. For example, Chichilnisky (1994), in a general equilibrium model, attempts to explain the

[4] For an exposition of this line of attack, see also Pethig (1976), McGuire (1982), Sibert et al. (1980), Baumol and Oates (1988), Copeland and Taylor (1994, 1995), and Bhagwati and Srinivasan (1996).

[5] For an exposition of this line of attack, we refer the reader to Anderson (1992a), Lloyed (1992), and Snape (1992). See also Anderson (1992b) for an empirical study of the effects of welfare and the environment induced by the liberalization of the world trade in food and coal. Devlin and Grafton (1998) also provide some case studies to demonstrate how the assignment of property rights can be used to solve certain environmental problems.

North-South pattern of trade through the pervasive lack of environmental property rights in developing countries.

Part of the literature attempts to extend the strategic-trade theory to include environmental quality as one of the variables manipulated by national governments to maximize national social welfare, assumed to depend on the profits made by domestic firms and the damages to the environment.[7]

In the three strands of research just discussed, environmental quality is determined by the maximization of social welfare pursued by national government. However, casual empiricism demonstrates that governments seldom set policies by maximizing national welfare. The idea that politicians behave as benevolent dictators with the single objective of maximizing social welfare is simply a myth. As a group, politicians have their own objectives -- for example, the desire to be elected and the pursuit of financial gains -- and must constantly respond to the pressures exerted by the electorate or special-interest groups. Environmental and trade policies, like any area of regulation and public choice, are the outcomes of the strategic behavior of politicians and special-interest groups. Lack of attention to the strategic behavior of special-interest groups and politicians limits most analyses of the issues linking trade and the environment. Esty (1994, p.74) makes the following remarks:

> *... many trade experts have become consumed with the theoretical opportunity to make trade and environment policies compatible by means of economically "appropriate" environmental policies that force polluters to pay for the damage they cause. Their relative disinterest in the real-world political difficulty of getting such measures adopted seems particularly ironic since the creation of the General Agreement on Tariffs and Trade*

[7] For an exposition of this line of attack, see Barrett (1994) or Ulph and Ulph (1994).

(GATT) was sparked by the inability of national governments to maintain appropriate trade policies in the face of political pressure.

When it comes to environmental and trade regulations, two pressure groups are prominent -- namely environmental and industry lobbies. Modeling confrontations between environmental and industry interests on one hand, and the selfish desires of politicians in setting regulations on the other hand, requires special treatment. More specifically, without a formal game-theoretic model to analyze the strategic behavior of the players embroiled in the formation of environmental and trade policies, "political failure" is often invoked to explain the difficulties encountered in this process. (Esty, op cit)

The above observations constitute the basis for the fourth strand in the literature known as the political economy of trade and environmental policies. This work has its roots in the seminal works of Olson (1965), Tullock (1967), and Stigler (1971). In this strand of research, the strategic behavior of special-interest groups and politicians are analyzed to explain policy outcomes. However, the analysis tends to be mostly discursive[7] and only few formal models are presented.[8]

Two different approaches are prominent in the literature on the political economy of environmental and trade policies. One approach stresses political competition between two opposing candidates. An interest group will contribute resources to the candidate that promises its members the greatest gains. The motivation for political contributions in this setting is clearly to influence the election outcome.[9] The second approach, sometimes called

---

[7] See, for example, Hoekman and Leidy (1992), VanGrasstek (1992), Klepper (1992), and Verbruggen (1991).

[8] See Chapter 2, Section 4.

[9] For an exposition of this approach, see Brock and Magee (1978), Magee et al (1989), and Hillman and Ursprung (1992, 1994).

the "political support" approach was advanced by Stigler (1971). This approach sees economic policies as being set by an incumbent government seeking to maximize political support. The political support function is assumed to depend on the welfare of the interest groups involved and the deadweight loss imposed on society at large.[10]

1.2 Contributions

The literature on the political economy of trade and the environment lacks a positive theory to explain the determination of environmental and trade policies in the context of North-South and North-North relations. Furthermore, no formal model exists to analyze the impact of the environmental lobby on environmental and trade policies and environmental quality simultaneously. No theoretical framework has investigated environmental and trade policies when environmentalists have both national and global environmental concerns and emissions can spillover from one country to another. The literature also lacks a formal model to investigate the impact of emission tax, resulted from lobby-government interactions, on the strategic behavior of a firm in choosing its output level and environmental R&D investments when it competes in an imperfect international market.

This thesis attempts to analyze some prominent linkages between trade and the environment and fill the above gaps in the literature. More specifically, this thesis seeks to elucidate the endogenous determination of environmental and trade policies in the context of North-South and North-North relations when pollution generated in one country can cross the border and flow into another country. It also provides a theoretical framework to

[10] For a survey of literature on political economy of trade and the environment we refer the reader to Chapter 2, Section 4.

analyze the political influence of environmental lobbies on environmental policies, environmental quality, and the strategic behavior of domestic firms in making political contributions and investment in *environmental* R&D. It also shows how interactions between different interest groups and national governments may prevent the adoption of socially optimum levels of environmental policies.

This thesis adopts the political-support approach formalized with the help of the game-theoretic framework of a first-price menu auction formulated by Bernheim and Whinston (1986). The political support approach is chosen to embody the belief that in selecting environmental and trade policies, an incumbent government is rarely guided by the objective to maximize social welfare but by its selfish desire to maximize political support. This approach is also particularly suited for analyzing the finer details of environmental and trade policies, such as emission taxes and tariffs. Moreover, the game-theoretic framework is adopted to capture the conflicting interactions among different interest groups and their incumbent governments. In the games in this thesis, each interest group offers political contributions to its own government contingent on the environmental and trade policies adopted by its government.

In the political process, environmental interest groups that seek to influence environmental and trade policies set by politicians will face other lobby groups. Domestic firms in imperfectly competitive industries will press for protectionist trade policies and laxer environmental regulations. Environmentalists might, in turn, press for more stringent environmental policies if they care only about their own local environment and might have common cause with protectionist tendencies if they believe that liberalized trade will result in

more pollution. The games formulated in this thesis are also intended to capture some salient aspects of these interactions. They also seek answers to the questions of whether environmentalists, through the pressure they exert on politicians, are successful in raising environmental standards and *environmental* R&D.

The analysis is positive, not normative. The players in these games consist of environmental and industry lobbies and their incumbent governments. The strategic behavior of these players is modeled explicitly and their joint actions determine endogenously the environmental and trade policies of each country.

The thesis consists of six chapters. In Chapter 2, the linkages between trade and the environment are discussed and a survey of the literature is presented. Chapter 3 is the centerpiece of this thesis. In this chapter, a game is formulated to explain how environmental and trade policies are endogenously determined in an industrialized country that engages in international trade with a developing country from the South. The implication of the North-South assumption is that there is a vocal environmental movement in the North that tries to influence its own government's policy on the environment and that only the government of the industrialized country actively pursues environmental and trade policies. The analysis is conducted in a partial equilibrium framework. Furthermore, it is assumed that the market in question is located in the industrialized country and served by only two firms -- one domestic firm and one foreign firm from the developing country. Pollution is a by-product of production. The policies chosen by the home government is a tariff on imports and an emission tax on the domestic firm.

This chapter shows that in the absence of transboundary pollution, the emergence of an environmental lobby that only cares about its local environment raises both the emission tax and the tariff. The end results are a better home environment and a decline in the profit of the both firms. When industry lobby doesn't offer any political contribution to the government and hence the game is played between the environmental lobby and an incumbent government, domestic firm's profit is at its lowest level, but the quality of the home environment is at its highest level. Moreover, it finds that in the absence of transboundary pollution, when the environmental lobby only cares about its local environment, the quality of its home environment deteriorates with free trade. Hence, environmentalists might have an incentive to join protectionist forces. In the presence of transboundary pollution, the impact of an environmental lobby on the profit of the domestic firm depends on the emission per unit of output and the amount of pollution that countries transfer to each other. Nevertheless, the quality of the environment in the North improves with the emergence of a green environmental lobby. In the case of transboundary pollution, when the domestic environmentalist also cares about the foreign environment, its impact on the firms' profit and the home environment depends on emission per unit of output and the amount transboundary pollution. However, this chapter shows that quality of the global environment improves with the emergence of a supergreen environmental lobby in the North.

In Chapter 4, environmental policies are analyzed from the perspectives of two industrialized countries of the North. The implication of the North-North assumption is that there are active environmental groups in both countries and that the incumbent national

governments in both countries will actively pursue environmental policies. Under liberalized trade, each national government behaves strategically in choosing emissions taxes to maximize its own payoffs while taking into account the political contributions of the domestic environmental interest group and the domestic firm. As in Chapter 3, the analysis is conducted in a partial equilibrium framework and under imperfectly competitive conditions. However, to concentrate on the strategic behavior of the two national governments, we assume that the market in question is located in a third country. The equilibrium of the game played between environmental and industry groups and their incumbent governments determines endogenously the levels of emission taxes in the Northern countries.

Chapter 4 finds that in the absence of transboundary pollution, if environmentalists' concerns are local, the emergence of environmental lobbies in the two countries of the North raises the emission taxes, lowers the profits of the firms and improves the quality of the environment. In the presence of transboundary pollution, the emergence of green environmentalists might increase or decrease the equilibrium emission tax and the firm's profit in each Northern country, depending on the amount of pollution transferred from one country to another and the emission per unit of output. In this case, the emergence of green environmentalists improve the quality of the environment in each industrialized country of the North. Moreover, when the home county does not transfer any pollution to the foreign country but receives emission from abroad, for a sufficiently high amount of transboundary pollution, the home government will adopt a laxer emission tax. In the presence of transboundary pollution, when the environmentalists' concerns are global, the chapter finds

that the emission tax, the domestic firm's profit, and the quality of the environment in each Northern country might improve or deteriorate with the emergence of supergreen environmental groups. However, the quality of the environment in the North improves with the presence of supergreens. This might provide insight for environmentalists lobbying to reduce or limit greenhouse gas emission in the industrialized countries.

Chapter 5 extends the North-South model to incorporate *environmental* R&D. It shows how the results obtained in Chapter 3 will be affected when the domestic firm located in the Northern country undertakes *environmental* R&D investments. Emission tax is the only policy instrument used by the government of the Northern country. The chapter contains a four-stage game. In the first stage, interest groups communicate a contingent political contribution schedule to their incumbent government. In the second stage, the home government chooses an environmental policy to maximize its objective function. In the third stage, the domestic firm chooses its level of environmental R&D. In the fourth stage, the domestic and foreign firms choose their output levels.

The chapter finds that when environmentalist's concern is local and pollution does not cross borders, the presence of an environmental lobby in the industrialized country induces its incumbent government to raise the emission tax on the domestic firm and hence improves the quality of the local and global environments. This asserts that the emergence of an environmental lobby increases the emission tax which, in turn, either causes the domestic firm to cutback its output or to invest in environmental R&D. In either case the quality of the environment improves. When transboundary pollution is allowed, for a sufficiently high level of emission tax, the emergence of an environmental lobby raises the

emission tax and lowers the damage to the home and world environments. This result is independent of the environmentalist's type. Hence, it is different from those obtained in the absence of an R&D program (in Chapter 3) in which the impacts of a supergreen environmental group on the emission tax and the quality of the home environment were ambiguous. This chapter also shows that a more stringent emission tax set by an incumbent government in the North can have three different impacts on its domestic firm: (i) if it is set too low, the domestic firm will not undertake any environmental R&D investment and it will cut back its output; (ii) if it is too high, the firm will shut down and foreign firms will capture the whole market; and (iii) if it is in a certain range, the domestic firm will implement environmental R&D programs and its market share will not be affected. While this chapter finds that a more stringent environmental regulation may induce a domestic firm to undertake R&D investment, it fails to confirm that this will raise the firm's profitability or competitiveness. Indeed, it is shown that an increase in pollution tax causes the domestic firm to either cut back its output or raise its R&D expenditure. In either case, the profit of the domestic firm declines. Chapter 6 contains some concluding remarks and offers some directions for future research.

2 TRADE-ENVIRONMENT LINKAGES

2.1 Trade and the Environment: The Difficult Liaisons

Because life depends on the proper functioning of the biosphere - the relatively narrow zone of air, water, soil, and rock in which all life on Earth exists - it is absolutely essential that the biosphere be maintained in a healthy operating condition. Today, with continued population growth, industrial expansion, and accelerating technological change, mankind, in its desire to live in greater numbers and at a standard considerably higher than previously enjoyed, is degrading the natural environment at an unprecedented rate.

Environmental degradation is caused by the mismanagement of natural resources and the pollution of the environment. The greatest single cause for the destruction of natural communities

and the extinction of wild species has been the desire to use land for more productive purposes. This has involved extensive clearing of forests and woodlands, burning of vegetation, and the cultivation of previously undisturbed land for crop production. Some of the lands that are cleared eventually prove to be poorly suited for the purposes for which they were intended and are ultimately abandoned; however, it is then no longer possible to protect the natural communities that previously existed in these areas. Because each wild plant and animal contains a storehouse of genetic and biochemical information, the loss of a single species might result in the loss of information that could ultimately have great value for mankind as a source of food or medicine. If, for example, all apparently worthless rosy periwinkle plants had been destroyed, an important drug used in treating leukemia would not have been discovered.

Although the importance of environmental protection may seem obvious, most of the world's people live too close to the margin of existence to show concern for anything other than their immediate survival. A view of the long run becomes difficult when the present itself is in doubt, and activities are carried out to satisfy the most immediate basic needs without any concern for the health of the natural environment.

The last three decades have witnessed a change in the public awareness of environmental issues. It is now recognized by many people that social and economic development in the long run depends on the availability and quality of natural resources as well as a healthy environment. This awareness has led to shifts in priorities[1]. Political parties in industrialized countries now cautiously

---

[1] For example, in the United States, "fully 89 percent of respondents in a recent poll stated that they considered themselves to be environmentalists (Environment Opinion Study, Inc., 1991); another poll found 80 percent of the public identifying themselves in this way (Hart-Teeter, 1991). The first poll also asked that respondents identify which one of five problems "will pose the greatest threat to the well-being of future generations of America; "more than twice as many respondents cited "environmental problems" (28 percent) as "foreign economic competitions" (12 percent). Pollsters routinely ask respondents to name the leading problems in the country; environmental concerns are almost

lean to the position that the environment should be put before income, and sustainable development is currently seen as a substantive goal for economic policy. Faced with serious environmental degradation and warned by biologists and ecologists that the damages to the environment might be catastrophic and irreversible, the challenge, in a nutshell, is how to economize within the ecological space available.

The rise of environmentalism reflects, in part, a wealth effect. Specifically, in affluent societies, the quality of life becomes more important and people, who enjoy a high-income level, feel that they can afford higher environmental standards. Perhaps the public now believes that it does not have to make the trade-off between growth and the environment. Although interest in the environment is greater in the richest countries, such as, the United States, Germany, the Netherlands, and the Scandinavian countries, the trends extend across the world.

2.1.1 Impacts of the Environment on Trade

In industrial countries, an environmental ethic has emerged and industries operating in those countries are subject to an array of environmental laws and regulations. The spillovers from environmental policies into international trade are numerous and varied. Sometimes, the linkages between trade and the environment are obvious; other times, they are deeper and more subtle.

The most recognizable form of spillover from the environment into trade is the desire of one country to impose its environmental standards upon other countries. Thus, several nations have proposed restrictions on imports of tropical timber as a way of preserving the rain forests. Austria's

---

always in the top-ten list (and are often high on it), but trade-related concerns are rarely on the list at all" (VanGrasstedk 1992, p.232).

tropical timber legislation, adopted in June 1992 and withdrawn in December 1992 in the face of a threatened boycott by the ASEAN nations, is the best example of this genre of trade action. The United States invoked the U.S. Marine Mammal Protection Act, enacted in 1972, to ban tuna import from Mexico, alleging that the latter country's method of tuna fishing killed dolphins. Mexico challenged the law and asked GATT to settle the dispute. In 1991, GATT ruled in favor of Mexico and concluded that the United States was in violation of its GATT obligations. Several American laws - among them one intended to protect whales - lay down that trade bans must be applied against countries that will not follow American environmental standards. The practice, by rich countries, of applying their environmental standards extraterritorially has caused much resentment in developing countries and is often denounced as a subtle form of protectionism designed to keep their products out of the markets of the industrialized countries.

A less obvious but economically significant spillover from the environment into trade involves an argument often known as "leveling the playing field." It is often alleged that foreign production processes fail to meet domestic environmental standards and products produced according to these processes enjoy an unfair cost advantage over domestic producers who have to adhere to much stricter national environmental regulations. This argument was used in the past by North American producers against Codelco, the Chilean government copper mining company which was accused of eco-dumping. U.S. producers argued that Codelco was operating under environmental standards less stringent than those in the United States and demanded the raising of trade barriers against Codelco in order to "level the playing field".

It is often asserted that different environmental standards will affect relative competitiveness. The argument is as follows. If polluters in one country have to carry the full costs of environmental

damages, its manufacturers will face higher costs than foreign competitors who do not. So they will lose sales, at home and abroad, and be tempted to move to countries with less rigorous standards. The common-sense view is that different environmental standards will affect relative competitiveness. However, economists have found little evidence to support this common-sense view. An OECD study (the Economist, February 27, 1993, p.26), published in 1985, found that pollution-control measures in France, Holland, and America might have reduced their total exports by 0.5 to 1%. Presumably, other factors, such as, labor and transport costs, access to markets, and political stability count much more. Those who deny the effect on competitiveness of compliance with environmental regulations also claim that expenditures on environmental compliance amount to less than 2% of value added for 85% of American industries (Low (1992), Chapter 7). Levinson (1996) provides a synthesis of the empirical literature on whether or not lower standards affect firms' locational and technological decisions and concludes that they do not. Moreover, he also points out that the perception that environmental regulations harm competitiveness cannot be supported due to the lack of economic evidence (p.453).

Esty (1994, p.22) suggests that the summary dismissal of environmental standards as a factor affecting competitiveness is premature. First, he argues that traditional economic analysis has largely focused on the overly narrow category of spending on pollution controls. When other aspects of environmental costs -- for example, energy pricing -- are factored in, serious competitive questions emerge. Second, some industries such as petrochemicals, refining, cement, and steel do have significant pollution control expenditures which potentially has serious implications for environmental competitiveness. Esty reminds the reader of the US experience of competition among various states for new investments during the 1940s, 50s, and 60s. Throughout this period, states practiced strategic-trade

policy by selling themselves as attractive sites for new industrial sites, at least in part, because they offered low costs, including lax pollution control requirements. This pattern of interstate competition contributed significantly to the drive for national standards in the United States in the 1960s and 1970s. The author suggests that with the globalization of the world economy, there is every reason to believe that a similar pattern of international competition will plague environmental policy making.

2.1.2 The Impact of Trade on the Environment

There are several ways trade can exert its impacts on the environment. First, trade can affect the environment through the international movement of products that directly harm ecosystems, such as, hazardous wastes, dangerous chemicals, and endangered species. In this case, trade controls are needed to restrict the export of toxic substances and wastes from industrialized countries to developing countries.

Second, trade can have significant impacts on the environment through the patterns of production and resource use that result from market failure or some government interventions. Here market failure reflects the lack of well-defined environmental property rights. The lack of well-defined property rights mean that in planning their production, firms do not include the environmental damages they cause in their cost calculations. This form of market failure results in a divergence between private and social costs often decried by environmentalists. Further subsidies, such as provided by the EU to its farmers under the Common Agricultural Policy (CAP) have encouraged farmers to increase their production often at the expense of the environment. The overproduction causes environmental degradation both at home and in developing countries. In order to produce the tremendous volume of agricultural products induced by the generous subsidies, European farmers have used an excessive

amount of chemical fertilizers, pesticides, herbicides, and other chemicals that pollute their own lands and waters. Furthermore, the agricultural surplus is dumped on the world market, depressing world prices. In order to compensate for the lower agricultural world prices they receive, farmers in the developing countries try to increase their own production and, in the process, further degrade their environment. In an empirical study, Anderson (1992b) suggests that trade liberalization on the world markets for coal and food might raise both welfare and environmental quality.

Third, through its effects on growth, trade can have a positive or negative impact on the environment. Proponents of trade liberalization argue that the economic growth induced by trade means higher incomes, specially for developing countries, and part of these incomes can be devoted to raising environmental quality. Environmentalists, on the other hand, oppose trade liberalization on the ground that the economic growth encouraged by trade means more production and consumption, which further damages the environment.[2]

2.1.3 Trade as a Tool to Further Environmental Quality

Environmentalists often advocate the use of trade measures to influence environmental policies outside a country's territory, especially when they involve transboundary and global issues. Lacking a global authority to deal with the issues concerning the global commons - the oceans and atmosphere, animal and plant species threatened with extinction - and short of going to war, it is tempting for powerful countries to unilaterally impose their environmental preferences over others through trade sanctions. After all, trade might be the only link existing between two countries, and the use of trade measures

[2] Grossman and Kruger (1995) investigate relationship between per capita income and several environmental indicators. They find little evidence that environmental quality declines steadily with increase in income. For most indicators, they observed that environmental degradation and GDP per capita have an inverted U-shaped relationship. Also see Grossman and Krueger (1993) for the environmental impacts of the North American Free Trade Agreement.

might be the only means available for bringing about the degree of multilateral cooperation needed in dealing with transborder environmental problems.

The use of trade measures by a country to influence environmental policies in other countries is often frowned upon by the World Trade Organization (WTO), which often rules that damage at home is mostly the business of the polluting country. A country cannot use trade sanctions against a product that is not harmful in itself but whose manufacturing process is damaging to the environment. That is, as long as a widget meets an important product standard, it is irrelevant that it was made using banned chemicals. However, when the pollution crosses nations boundaries or involves the global commons, the position of WTO becomes less tenable[3].

2.2 Innovation and Environmental Regulations

The prevailing view among many economists and other policy analysts is that there is a trade-off between economic competitiveness and environmental protection. This trade-off has emerged from the traditional cost-benefit approach used extensively by many economists to assess environmental and other regulatory programs. In this approach, the comparison is between social benefits - such as the reductions in premature mortality, the enhanced recreational opportunities, the enhanced vitality of aquatic ecosystem, and etc. -- that arise from tough environmental regulations and private costs for companies - costs that raise prices and reduce competitiveness.

Michael Porter (1991), and Porter and van der Linde (1995a,b) argue that the traditional cost-benefit approach to the analysis of environmental regulation is an artifact of a "static mindset". They point out that in a static world where technology, products, processes, and customer needs are taken

[3] For a summary of key trade and environmental disputes and multilateral agreements with trade provisions see Appendix C and Appendix D in Esty (1994).

fixed, environmental regulation inevitably will raise firms' costs and reduce the market share of regulated firms in the international market. In this world there is a conflict between ecology and the economy. These authors argue that the new paradigm of world competitiveness is a dynamic one, built on innovation. In such a dynamic world, there is no such fixed trade-off between the environment and the economy.

They claim that in a dynamic world in which innovation plays a crucial role, more stringent environmental regulations might not make an industry less competitive in international markets. The idea -- sometimes referred to as the Porter hypothesis -- is that tougher environmental regulations, if properly designed, may encourage firms to innovate greener technologies ahead of their rivals and hence increase their long-run profits.

Stimulated innovation may enhance international competitiveness through offsetting the cost of complying with new regulation. The reasoning is as follows. Porter and van der Linde (1995a, p.122) argue that pollution is equal to inefficiency. When resources are not used completely, or efficiently, harmful substances, or energy forms will be discharged into the environment as pollution. Thus, innovation can simultaneously reduce pollution and improve the productivity of resources.

Porter and van der Linde (1995a,b) categorize the innovation induced by environmental regulations into two types. One type minimizes the cost of dealing with pollution once it occurs. Thus, new technologies take the resources embodied in the pollution and convert them into some thing valuable. For example, they (1995a, p.125) point out that new de-inking technologies was developed by Thermo Electron Corporation to allow more extensive use of recycled paper.

The second type of innovation improves resource productivity and hence addresses the causes of pollution. For example, firms can improve the productivity of their resources by substituting for

more costly materials or by better utilizing of existing ones. More productive use of inputs -- raw materials and energy -- may offset the cost of improving environmental impact. This increase in resource productivity makes firms more competitive in international markets.

They present several case studies of sectors affected by environmental regulations to show the relationship between environmental improvement, innovation, and resource productivity. They find that when stimulated innovation brings other competitive benefits, the cost of compliance with environmental regulations can be minimized and in some cases eliminated. For example, they (op cit) present a case study of the chemical sector in which only one activity out of 181 waste prevention activities at 29 chemical plants resulted in a net cost increase. Of the 70 activities, 68 reported increases in product yields. To achieve these "innovation offsets", one-quarter of the 48 initiatives required no capital investment at all. About two-thirds of the 38 initiatives recouped their initial investments in six months or less. These show that innovation offsets for these chemical plants were achieved with very low investment and short payback time. This study also found that waste disposal and environmental regulation were the two main motivating causes for source reduction activities. All of the examples presented by Porter and van der Linde (1995a,b) show that certain polluting companies were able to reduce their emissions through innovations at relatively low cost[4].

2.3 The Environmental Movement

The rise of the environmental movement in the last three decades in industrialized nations is one of the main changes on the political scene of these countries. In the North, environmental groups have

[4] For a counter argument see Palmer et al. (1995).

been able to influence the behavior of their national governments and stand firm against strong industry lobbies.

The history of environmental movements in many industrialized countries can be traced to the nineteenth century.[5] The rise and decline of the environmental movement in industrialized countries has been responsible for many changes in their environmental regulations. We will present some historical examples here.

It was between 1965 and 1975 that the world heard widespread news about dramatic environmental disasters around the globe. This threatening environmental news, in addition to high levels of income and education among Northern citizens, boosted environmentalism throughout North America, Japan, and West Europe. Hence, this period witnessed an increase in both the number and size of environmental organizations. By the mid-1970s, the environmental movement in the industrialized world was influential enough to force the governments of Northern countries to respond to the public's demand for a healthier environment. Under political pressure exerted by the environmental movement on politicians, new environmental regulations were adopted by incumbent governments in the industrialized world.

For example, in the first half of the 1970s, the environmental movement was relatively strong in Japan. Hence, despite fierce opposition from industry, the Japanese government adopted the world toughest air pollution control and automotive emission standards. By 1975, Japanese industry spent 4.6 percent of its total investment on pollution control. (Vogel, op cit, p.262)

After 1975, environmentalism lost its steam and hence became less politically influential in Japan. As a result, the politicians -- mainly from the ruling conservative party, the LDP -- became more

[5] See Vogel, 1990.

friendly to industries. This had an impact on the behavior of firms in Japan. For example, in 1981 the expenditure of Japanese firms on pollution control was only one-third of what they had spent in 1975. (Vogel, op cit, pp.265-6)

In Canada, according to Macdonald (1991, p.31), the environmental movement has gone through four distinct phases. In the first phase, which started after the turn of the century and lasted until 1945, the primary job of environmentalist organizations such as the Federation of Ontario Naturalists was to serve nature without entering into politics. The second phase covers the first two decades after 1945 in which the environmental movement still was not very strong and public interest in the natural environment was mainly restricted to certain activities like camping trips and bird-watching. The third phase, which started in 1960 and lasted until the early 1970s, politicized the environmental movement in Canada. The modern era started in the early 1970s. Macdonald (op cit, p.32) argues that during this phase environmental politics moved to the center of Canadian political life. With these changes come the variation in politicians' positions.

Between the mid-1970s and the mid-1980s, the environmental movement in Britain was less influential compared to the business community. The British government was reluctant to put more pressure on polluting industries. Margaret Thatcher (the British prime minister at the time) once described environmentalists as "the enemy within."[6] The British government was in favor of the least restrictive limits on the production of CFCs, emissions of sulfur, and radiation in food. (Vogel, op cit, p.267)

In the late 1980s, Britain witnessed a change in the strength of the environmental movement. In 1980, only 50 percent of those polled considered protecting the environment to be more important than

---

[6] Vogel, 1990, p.266.

keeping prices down: by 1985 the number had risen to 60 percent: and in 1988 to 74 per cent.(Vogel, op cit, p 267) Hence, the position of the British government on environmental regulations changed dramatically in the late 1980s. Thatcher also changed her position and argued that the health of the economy and the environment were interdependent. The British government considered environmental problems such as acid rain and ozone layer depletion as important issues facing the world. The development in Britain's environmental politics and policies was partially brought about by pressures from more organized national and international environmental movements.

Environmental movements in other West European countries such as Germany (West Germany at the time), Sweden, France, and Austria also gained more strength during the second half of the 1980s. As a result, the incumbent governments in Europe became very active in fighting against water and air pollution.[7]

In the U.S., some environmental organizations such as the Audubon Society (1886) and the Sierra Club (1892) were established long ago. However, while they were active in resource conservation, wilderness and wildlife preservation, and even anti-pollution work, they were not interested in lobbying government. After the Second World War, some environmental problems, such as radioactive materials disseminated by nuclear bomb tests, attracted the attention of the environmental movement in North America. It was only in the 1960s, however, that the environmentalists' concerns turned into political actions. Old and newly formed green organizations tried to politicize environmental problems. In the early 1970s, pollution became an important issue for the public to the extent that it could not be ignored by the U.S. government.

[7] For more discussion we refer the reader to Vogel (1990).

2.4 Modeling Trade-Environment Linkages

The literature on trade and the environment is relatively new and adverse in nature. The next two sections present a survey of those parts of the literature which are more relevant to our analysis -- namely determination of environmental policy in open economies.[8]

2.4.1 The Conventional Approach

The conventional approach uses standard trade theories to study environmental issues. Dean (1992) provides a thematic review of previous works on trade and environmental issues and Ulph (1994) surveys recent analysis on environmental policy and international trade. Two main strands can be distinguished in this literature.

One strand of the literature uses the conventional neoclassical trade theories in which producers and consumers behave competitively and, depending on the size of economy, governments may be able to affect world prices. It extends the results of traditional trade theories, in which comparative advantage is the basis for international trade, to study environmental problems. Effects of environmental and trade policies on the pattern of trade have also been investigated.

Pethig (1976) introduces a simple pollution generating industry into a two-country, two-sector general equilibrium model. McGuire (1982) incorporates environmental regulation into the theory of production, distribution, and trade in a modified two-sector, two-country Heckscher-Ohlin model to study the effects on the environment of regulatory control under autarky and free trade.

---

[8] For a discussion on various trade and environmental issues, we refer the reader to the World Bank Discussion Paper 159 edited by Low (1992) and *The Greening of World Trade Issues* edited by Anderson and Blackhurst (1992). Bhagwati and Hudec (1996, vol. I, specially parts II and VI) also contains papers which treat some important issues such as the so called "race to the bottom" and the impact of environmental regulations on industry location.

Siebert et al. (1980) integrate pollution into production theory. They consider two possible ways for modeling the environment. First, they consider pollution as a joint product of production activities and separate abatement activities from production. Second, they integrate production and abatement into a single activity and consider environmental services as a factor of production to determine comparative advantage. They also analyze relationships among environmental quality, environmental policy, and international trade. Markets are assumed to be perfectly competitive. Siebert (1985) also uses traditional trade theory to see how environmental abundance or environmental scarcity affects the pattern of trade and studies the effect of environmental policy on comparative advantage and the impacts of trade flows and factor mobility on the environment. Baumol and Oates (1988) use the theory of externalities to analyze the problem of environmental policy design in general equilibrium. Rauscher (1992) focuses on the changes in environmental quality induced by the reduction in barriers to international capital mobility as well as the issue of competitive environmental degradation in which national governments strategically set environmental standards to maximize social welfare -- an index that depends on both national income and environmental quality. Bhagwati and Srinivasan (1996) show that differences in fundamentals can legitimate diversity of standards -- such as pollution charges -- among the countries. Hence, any change in the fundamentals resulted from policy changes, according to them, will influence the standards and may lead to harmonization or divergence.[9] They consider a sequence of models in which pollution is considered as a production externality that affects welfare. These models differ with respect to the nature of pollution, size of economies in question, abatement expenditure by countries, and policy objective.

[9] We refer the readers to Bhagwati and Hudec (1996) for further discussion on whether a move toward harmonization is a prerequisite for free trade.

Some researchers have attempted to introduce the environment into North-South trade. For example, Copeland and Taylor (1994) develop a simple static Ricardian general equilibrium model of North-South trade to analyze interactions between national income, pollution, and trade. They assume that a benevolent planning authority in each country sets pollution tax to offset the damage from emissions. Their paper shows that when the two countries produce a continuum of goods and differ in pollution intensity, the higher income country chooses tougher environmental regulation and specializes in relatively clean goods. They also find that free trade increases world pollution, while growth in the South may have the opposite effect. In their subsequent paper, Copland and Taylor (1995) address the issue of trade and transboundary pollution. They assume that all countries are equally exposed to a given unit of pollution. Their model, which is built on Copeland and Taylor (1994), allows them to examine how interaction between national income and trading opportunities determines the level and incidence of world pollution. They find that when income differ significantly across nations, free trade deteriorates the world environment. Furthermore, these researchers show that international trade in pollution permits can improve the global environment, but united income transfers may have no effect on world pollution. They also find that when pollution policy is used to manipulate the terms of trade it will not affect the global environment.

Chichilnisky (1994) formulates a general equilibrium model to analyze environmental problems in the context of North-South trade. The model developed is a modification of the Heckscher-Ohlin model in which the supplies of inputs are price dependent. The environment is considered as one factor of production and is treated as an unregulated common property in the South, but as a private property in the North. This paper shows that if the two regions (North and South) are identical in all respects but the South does not have well-defined property rights over environmental resources, the North and

South will engage in trade. In this case, the North overconsumes underpriced imported environment-intensive commodity produced in the South. The difference in property rights is thus the basis for trade among regions. In order to deal with the inefficient use of resources in the South, the author suggests that property-rights policies might be more effective than taxing the use of resources.

The second strand of the literature, and also the most recent, applies the framework of strategic trade theory to the analysis of environmental policy. This work stresses producers' strategic behavior in an imperfectly competitive industry. Most models developed in this literature consider the cases in which governments and producers act strategically. Governments behave strategically to shift rents from foreign producers to their domestic firms. The work of Brander and Spencer (1985) constitutes the basis for many of the models that link trade to strategic environmental policy. However, the results derived from these models are not robust. For an exposition of this approach, see Ulph and Ulph (1994) and Barrett (1994). Ulph (1994) also provides a survey of this line of research.

Barrett (op cit) develops a basic model in which two governments and their respective industries engage in a two-stage game. Governments act as Stackelberg leaders and choose environmental standards while firms follow by choosing either outputs or price levels. He shows that governments may have an incentive to impose lax environmental regulations on their own industries that compete in an imperfectly competitive international market. Furthermore, industrial policy is superior to environmental policy as a tool to improve competitiveness. Ulph and Ulph (op cit) provide a general analysis of trade, strategic innovation by producers, and strategic environmental policy and allow both governments and firms to behave strategically. However, their results are not robust due to the difficulties in signing certain terms in their comparative static exercises. They also point out how special and restrictive is the existing strategic trade analysis.

2.4.2 The Political-Economy Approach

In a representative democracy, voters elect politicians, who then, in principle, represent the interests of their constituents. In practice, however, a principal-agent problem arises because voters may not be able to monitor or control the decisions of their agents, the politicians. Because of the low expected benefit an individual voter might obtain from acquiring information of politician's position, the individual voter, according to Olson (1965), may rationally choose to be ignorant. In representative democracies, governments shape policies in response not only to the concerns of the general electorate, but also to the pressure applied by special-interest groups.

Interest groups participate in the political process to influence policy outcomes. They offer campaign contributions, endorse positions taken by candidates for political office, or put pressure on politicians. Politicians respond to the incentives they face, making tradeoffs between financial and other types of support that come from heeding the demands of interest groups, against the alienation of general voters that may result from the implementation of socially unpopular policies.

The games formulated in this thesis follow the research on the political economy of environmental policy that seeks to explain the equilibrium outcome of the above political process. The literature on the political economy of trade and the environment is vast. However, previous relevant contributions to the analysis of environmental policy are relatively few. Two different approaches are prominent in the literature on the political economy of environmental and trade policies.

One approach stresses political competition between two opposing candidates. Each candidate articulates his own policy proposal, and interest groups evaluate the prospects of their members under the alternatives proposed by the two opposing candidates. An interest group will contribute resources to

the candidate that promises its members the greatest gains. The two opposing candidates use the resources they receive from interest groups to sway voters who are presumed to be rationally ignorant about the candidates' positions. The motivation for political contributions in this setting is clearly to influence the election outcome. This approach is suited for explaining broader issues, such as whether trade will be liberalized or whether environmental concerns will be put before economic growth.[10]

Brock and Magee (1978) analyze the interactions of politicians and special-interest groups. In their model, interest groups gain economic return by contributing to political campaigns. These authors consider two different politicians who attempt to maximize their probability of election. Each politician calculates the response of campaign contributions and voters to different tariff levels and then announces his position. The politicians are assumed to play a Cournot-Nash game against each other.

Another example is found in Magee et al. (1989), who introduce the concept of politically efficient equilibrium. These researchers consider an action to be politically efficient if it increases the chance of election of one of the political parities. They combine economics and political science to create an approach called "endogenous policy theory." In the first part of their book, they analyze the behavior of rationally ignorant voters, two lobbies, and two political parties in the context of partial equilibrium. In the second part, they analyze the probabilistic voting model of endogenous policy theory from the general equilibrium perspective. It is shown how interactions between two lobbies, two political parties, and the rationally ignorant agents determine endogenous trade policy.

Mayer (1984) provides a short review of the process of tariff formation. He uses several models for studying the interactions of economic and political forces in determining a country's actual tariff. In the context of general equilibrium, Mayer (op cit) uses standard assumptions of the trade and public

[10] For an exposition of this approach, see Brock and Magee (1978), Magee et al. (1989), and Hillman and Ursprung (1992, 1994).

choice theories to determine the tariff rate. A two-by-two Heckscher-Ohline model and a many-commodity model are used to derive the results. The paper shows that tariff rates depend on factor-ownership distribution, voter eligibility and participation rules, the degree of factor mobility, and industry diversification in the economy. It also demonstrates when a small minority of factor owners can gain protection for their industry under majority voting.

With the exception of the works of Hillman and Ursprung (1992, 1994) none of these models deals with the issue of trade and the environment linkages. Hillman and Ursprung (1992) use the political competition approach to explain how the emergence of environmentalists as an interest group might influence the determination of trade policy when the production or consumption of a product has an adverse environmental effect. The political support, in this model, is the relative share of campaign contributions received for protecting a domestic industry. The contributions are made to influence candidates' election prospects before the outcome of political competition is known. The candidates choose trade policy to maximize their probability of being elected. In their 1994 paper, Hillman and Ursprung also develop a framework to investigate how environmental lobbies might influence the determination of trade policy. The issue facing the environmentalists is to decide which of the two candidates to support, one that is more protectionist or one which advocates more liberal trade policy. The model, however, only addresses trade policy and ignore, the determination of environmental policy.

The second approach, sometimes called the "political support" approach, was advanced by Stigler (1971) who wanted to show why regulation is demanded by industry and is set primarily for its benefit. This approach sees economic policies as being set by an incumbent government seeking to maximize political support. The political support function is assumed to depend on the welfare of the

interest groups involved and the deadweight loss imposed on society at large. According to this approach, campaign contributions do not enter the analysis directly although they may be implicit in the notion of support by interest groups. The incumbent government maximizes political support with the apparent goal of getting reelected. Neither the election itself nor the positions of potential rivals are explicitly considered.

The political-support approach is utilized by Hillman (1982) to study endogenous protection. This author studies the problem of protection for declining industries. The main concern is trade policy which, by assumption, is determined in accord with the authorities' political support. The paper shows how in the political-support framework, the politicians' perception of their own self-interest determines the help that a specific factor receives in a declining industry. However, Hillman (op cit) does not analyze the behavior of interest groups in detail, and is not concerned about the issue of trade and environment interactions.

The political support approach has been refined by Grossman and Helpman (1994), who derive the government's objective function from more primitive preferences defined over campaign contributions and voters' welfare. In their model, the trade policy adopted by an incumbent government is influenced by contributions of special-interest groups, which are basically different industries.[11]

This approach has been used very recently by Fredriksson (1997) and Aidt (1997) to study the determination of environmental policy. They develop two different versions of the model of Grossman and Helpman (1994) to include pollution tax. Fredriksson (op cit) considers a small open competitive economy with two sectors: a polluting sector and a non-polluting one. The economy is populated by N

[11] The literature on political economy of trade policy is vast and diverse. To see other strands of the literature, we refer the reader to Bhagwati (1982) and Feenstra et al. (1996). However, as we have already mentioned, the focus of our attention in this thesis is not trade policy.

heterogeneous citizens. All citizens have labor income, whereas only environmentalists have environmental concerns, and only industrialists have some factor income from production. Fredriksson (op cit) assumes that free trade prevails in both markets. Supply is a function of the producers price and the world market price is fixed. The author shows how the pollution tax is determined. He also introduces an abatement subsidy which is assumed to be exogenous in his model, whereas the tax rate is set by the government. The paper finds that the equilibrium pollution tax rate differs from the Pigouvian rate. He also shows that the equilibrium pollution tax rate may decrease in the pollution abatement subsidy. Aidt (op cit) develops a different version of Grossman and Helpman (op cit) by introducing an output externality in a small open economy model. Emission is assumed to be a by-product of production. There are k competitive sectors in the economy. Using constant return to scale technology, each sector employs labor and industry specific capital in production. The government sets the pollution tax to maximize its political support. The author finds that the politically optimal pollution tax is different from the set of Pigouvian tax. The paper argues that organized sectors get a tax discount.[12]

The assumption of a small open economy used by Fredriksson (op cit) and Aidt (op cit) is highly restrictive. As Bhagwati and Srinivasan (1996, p.203) point out, the problem with the assumption of a small open economy is that since the country is "small" it will behave as if its share of global outputs is negligible, hence it will consider that global pollution cannot be changed by its economic activity. Since a small country takes the world prices as constant, there is no channel by

[12] Hahn (1989, 1990) uses a simple game for a closed economy in which different groups compete to obtain their favorite results regarding the choice of environmental targets, the selection of environmental instruments, etc.. The government maximizes a welfare function that is a weighted average of utilities of different interest groups. The contribution schedules and behavior of interest groups are not modeled in details and the government is considered as a benevolent dictator.

which it can influence the goods prices in the rest of the world. In reality, many polluting firms competing in an international market enjoy some sort of market power and their activities may have significant domestic and transnational environmental impacts. Fredriksson (op cit) and Aidt (op cit) are also silent about the determination of environmental policies in the context of North-South and North-North relations. Firms in their models do not compete in an imperfect market and hence have no market power. This restricts them to consider the cases in which firms behave strategically to shift rents from foreign firms to themselves. The impact of environmental policies on lobby payoffs and environmental quality when firms undertake *environmental* R&D investment is not formulated. No transboundary pollution is taken into consideration in these models. The outcome of games might be very different when environmental lobbies care about both home and the foreign environment and the emission crosses the borders. However, no formal model has been developed to bring all these dimensions together. The next three chapters of this thesis formulate games to fill these gaps in the literature.

2.5 Classification of Pollution for Economic Analysis

Although pollution is usually classified under the headings air, water, and land, from the perspective of economic analysis, it is more useful to identify pollution as being local, transboundary, or global. The economic classification of pollution reflects the increasing complexity of the issue in terms of cost and benefit calculations as well as the shrinking number of instruments at the disposal of a national government for tackling environmental problems.[13]

The pollution is local if both its source and impact are confined to a single country. Because a national government has complete jurisdiction over its own territory, it can tackle local-pollution

[13] Polluters are also classified as mobile versus stationary; point versus non-point source; stock and flow. See Devliin and Grafton (1997, Chapter 2)

problems with a maximum degree of freedom. An array of policy instruments are at its disposal, such as, taxes, subsidies, emission standards, product standards, and process standards. The World Trade Organization (WTO) often maintains that a country has the right to choose whatever environmental standards it desires as long as the damage is contained within its own borders. In their opposition to uniform environmental standards across trading nations, economists from the World Bank often argue that the environments of different countries have different capacities to absorb pollutants and, therefore, a uniform standard across nations will not equalize marginal costs of pollution abatement. Furthermore, it is also argued that the preferences of a nation for a dirty or clean environment represents its tradeoff between income and environmental quality and should be respected.

Transboundary pollution is involved when the pollution generated in one country spills over into another. Because the jurisdiction of national governments stops at their border, problems involving transboundary pollution are particularly difficult to solve. A nation that suffers from the impact of pollution generated by another country has a legitimate interest in the environmental practices of the latter. However, the damaged country often has little recourse to redress its grievances. The primary effect of national borders is to limit the instruments available to national governments. Short of military action, the only recourse left for the affected country is to impose trade sanctions against the country that is the source of the transboundary problem.

Global pollution, such as, the greenhouse effect (caused by the burning of fossil fuels), depletion of the ozone layer (caused by the release into the atmosphere of chlorofluorocarbons contained in aerosols or refrigeration products), pollution of the oceans, etc., affects the entire planet. Problems associated with the global commons arouse passion among environmentalists and are extremely difficult, if not impossible, to solve. The large number of nations involved and the vast array

of issues to be negotiated mean that many years of negotiation are required and the international environmental agreements that result from this arduous process are far from being comprehensive. The single largest impediment is the "free rider" problem. Since all will benefit from the improvements brought by an agreement, individual nations have an incentive to abstain the agreement, hoping to reap its benefits without having to pay the costs. Frustration with the difficulty of negotiating international environmental agreements is one of the reasons for an upsurge of interest in the use of trade measures to achieve environmental objectives. If it is not possible to speedily arrive at effective and comprehensive treaties, then it becomes tempting for powerful countries to impose their preferences on others through trade sanctions.

In the next chapter, we adopt the political support approach and formulate a game to explain how environmental and trade policies are endogenously determined in an industrialized country that engages in international trade with a developing country from the South. The impacts of an environmental lobby on the quality of the environment and firms' payoffs are also examined.

3

TRADE AND ENVIRONMENTAL POLICIES: THE NORTH-SOUTH CASE

3.1 Introduction

North-South conflicts over the determination of environmental standards and the use of "trade measures" by the developed world against developing nations are among the most important issues on the international scene. The industrialized countries of the North argue that production processes in the South fail to meet advanced environmental standards practiced in the developed world. Not only does this give companies operating in the South cost advantages over their rivals in the North, but it also increases the degradation of the global environment. Thus, industrialized nations of the

North have a strong desire to impose their own environmental regulations upon the developing countries of the South in order to "level the playing field" and prevent further damage to the world environment.

Developing countries respond that many global environmental problems are a result of emissions accumulated over the last three centuries of economic activities by the industrialized nations. Thus, they argue that the financial burden of meeting global environmental goals should be borne by the developed world. Leaders in the South believe that unless their countries are compensated by those who bear moral responsibility for environmental damages, it is unfair to ask developing nations to forgo economic development or to bear additional costs to comply with the North's environmental requirements.

The countries of the South are also suspicious of the North's environmental interests. They fear that the North is putting pressure on them for upward harmonization to limit their access to markets in the developed world. Hence, they consider new environmental requirements as disguises for protectionism.

Given the above differences, the fact that the southern countries have other budget priorities than conservation programs or pollution controls, and that the North declines to compensate these countries for costs borne by them for meeting advanced environmental requirements, the conflicts spill over into the international trade scene. The rich industrialized countries use trade measures to reinforce their environmental priorities and to protect their domestic producers. The South sees unilaterally determined environmental policies of the North, supported by trade measures, as real threats to its sovereignty and economic development programs.

In this chapter, we formulate a game between an industrialized country of the North and a developing nation of the South. The implication of the North-South assumption is that there is a vocal environmental movement in the North that tries to influence its own government's policy on the environment and that only the government of the industrialized country actively pursues environmental and trade policies.

Environmentalists are classified either as greens, when their concerns are local, or supergreens, when their concerns are global. Only local environmental quality enters the utility function of greens. As for supergreens, they care about environmental quality both at home and abroad. In each game, special-interest groups announce schedules of political contributions -- financial contributions or blocks of votes -- to their own incumbent national government. For example, a domestic firm might say to its incumbent national government that if it adopts a particular tariff or environmental regulation, then the firm might be willing to offer a certain amount of campaign contributions, with the contributions varying according to the policies set by the national government. This incumbent national government considers the political contributions of the interest groups, with an eye on the possibility of future reelection, in setting policies. That is, an incumbent national government acts as a follower in a Stackelberg game in relation to its domestic special-interest groups. An equilibrium of such a game, played by various special-interest groups and the incumbent national government, then determines endogenously trade and environmental policies.

This chapter is organized as follows. In Section 2, the model is presented. The game formulated in this section follows the political economy approach advanced by Stigler (1971) using the game-theoretic framework of a first-price menu auction formulated by Bernheim and Whinston

(1986). Section 3 presents the model under some specific functional forms. This enables us to gain more insights into trade and environmental policies. In Section 4, the model is solved for the case in which the environmental lobby is a green and there is no transboundary pollution. Section 5 studies the example presented in the previous section in the context of trade liberalization. In Section 6, we solve the model under assumption of transboundary pollution. Section 7 analyzes the problem when the environmentalist interest group is a supergreen. Section 8 contains some concluding remarks.

3.2 The Model

Consider a commodity whose inverse demand curve is represented by $p: q \rightarrow p(q)$. The demand function $p(q)$ satisfies $p(0)>0$ and $p'(q)<0$. Suppose that the market for this commodity is located in a country -- called country 1-- and is served by only two firms, with firm 1 located in country 1 and firm 2 located in another country -- called country 2. In what follows, country 1 and country 2 will frequently be referred to as the home country and the foreign country, respectively.

The production activities of each firm generate a certain amount of pollution, part of which might cross the border and flow into the other country. For each $i=1,2$, let q_i be the output of firm i. The total cost of producing q_i and the pollution generated by q_i are denoted, respectively, by $c_i(q_i)$ and $e_i(q_i)$. We assume that the total cost function $c_i(q_i)$ satisfies $c_i(0)=0$, $c_i'(q_i)>0$, $c_i''(q_i) \geq 0$. Also, let $e_{ij}(q_i)$ be the transboundary pollution flowing from country i into country j, $i \neq j$, that arises from the production activities of firm i. The total pollution inflicted on country i is thus given by

$$x_i(q_1, q_2) = e_i(q_i) - e_{ij}(q_i) + e_{ji}(q_j), \quad i \neq j, \; i,j = 1,2.$$

For each $i=1,2$, the total pollution in country i is assumed to be a nonnegative increasing function of the output levels q_1, q_2 of the domestic and foreign firms. Let $d_i(x_i)$ be the damage suffered by

country i when the level of pollution in this country is given by x_i. In general, $d_i \neq d_j$ because different environments have different capacities for absorbing pollutants.

Suppose that in the home country there exists a group of environmentalists which actively seeks to improve the quality of the environment, while in the foreign country such a group is practically nonexistent. The existence of environmentalists as a special-interest group in the home country can be attributed to the high income enjoyed by its citizens and where the quality of the environment becomes more and more important when the country grows richer. In our model, the foreign country might be a developing nation, which is more preoccupied with raising the income of its population than improving the quality of its own environment.

As a special-interest group, environmentalists in the home country behave like a single agent that we call the representative environmentalist. The utility of the representative environmentalist is assumed to depend on the quality of the environment and the consumption of a numéraire good:

$$u(m, x_1, x_2) = m - \vartheta(x_1, x_2).$$

Here m is the amount of the numéraire good consumed and $\vartheta(x_1, x_2)$ is the disutility caused by the pollution at home and abroad. The disutility function $\vartheta(x_1, x_2)$ is assumed to be differentiable, convex, and a strictly increasing in each of its arguments. A possible specification of $\vartheta(x_1, x_2)$ is obtained by assuming that ϑ is additively separable in x_1 and x_2, say $\vartheta(x_1, x_2) = \eta_1 \vartheta_1(x_1) + \eta_2 \vartheta_2(x_2)$, where $\eta_1 > 0$, $\eta_2 \geq 0$ are two constants; $\vartheta_1(x_1)$ and $\vartheta_2(x_2)$ denote, respectively, the disutilities caused by the pollution at home and abroad. If $\eta_2 = 0$, the representative environmentalist cares only about

his own local environment and he will be classified as a green. On the other hand, when $\eta_2>0$, his concerns are more global, and he will be classified as a supergreen if η_2 is significantly positive.

If the representative environmentalist is a supergreen who considers pollution abroad to be the same as pollution at home, then his disutility depends only on the sum x_1+x_2. In this case, one can assume that $\mathcal{D}(x_1,x_2) = \tilde{D}(x_1+x_2)$, where $\tilde{D}$ is a continuously differentiable, strictly increasing, and strictly convex function of (x_1+x_2).

It is assumed that trade and environmental policies are actively pursued only by the home government, not the foreign government. Furthermore, the home government has two policy instruments: an emission tax and a tariff. We define an environmental and trade policy by an ordered pair (τ,θ), where τ is the tax per unit of emission that the home government imposes on the domestic firm, and θ is the tariff it imposes on the foreign firm. For two positive constants $\bar{\tau}$ and $\bar{\theta}$ the emission tax and the tariff are constrained to belong to the following intervals respectively, $\bar{\tau} \geq \tau \geq 0$ and $\bar{\theta} \geq \theta \geq 0$. The home government has a utility function that depends on the political contributions it receives and some measure of social welfare. Following conventional applied welfare economics, we assume that social welfare is given by the sum of consumer surplus, producer surplus, and tax revenues minus the pollution damage.

The model is a three-stage game and its extensive form is as follows. In the first stage, the domestic firm announces its political contribution schedule $f_1:(\tau,\theta) \rightarrow f_1(\tau,\theta)$ while the representative environmentalist announces his political contribution schedule $f_2:(\tau,\theta) \rightarrow f_2(\tau,\theta)$. Here $f_1(\tau,\theta)$ and $f_2(\tau,\theta)$ represent, respectively, the monetary payoffs that the domestic firm and the representative environmentalist promise to offer to the home government, conditioned on the chosen environmental and trade policies (τ,θ). For each $i=1,2$, the political contribution schedule

$f_i^{\#}(\tau,\theta) \rightarrow f_i(\tau,\theta)$ is assumed to be a nonnegative and continuous function of (τ,θ). In the second stage, taking (f_1, f_2) as given, the home government chooses (τ,θ) to maximize its objective function. We shall let $(\tau^{\#}(f_1, f_2), \theta^{\#}(f_1,f_2))$ denotes its best response. In the third stage, the home government receives the political contributions $f_1(\tau^{\#}(f_1,f_2),\theta^{\#}(f_1,f_2))$ and $f_2(\tau^{\#}(f_1,f_2),\theta^{\#}(f_1,f_2))$ promised by the domestic firm and the representative environmentalist, respectively. Also, the two firms, taking $(\tau^{\#}(f_1,f_2), \theta^{\#}(f_1,f_2))$ as given, choose their output levels to maximize profits. To analyze the game, we begin with the last stage then move backward to the first stage.

The third stage

Suppose that (τ,θ) represents the environmental and trade policies chosen by the home government. Taking (τ,θ) as given, the two firms choose their own output levels to maximize profits. If $(q_1^{\#}(\tau,\theta), q_2^{\#}(\tau,\theta))$ is the Cournot equilibrium, then

$$(1) \qquad q_1^{\#}(\tau,\theta) = \underset{q_1}{\operatorname{argmax}} [q_1 p(q_1 + q_2^{\#}(\tau,\theta)) - c_1(q_1) - \tau e_1(q_1)].$$

$$(2) \qquad q_2^{\#}(\tau,\theta) = \underset{q_2}{\operatorname{argmax}} [q_2 p(q_1^{\#}(\tau,\theta) + q_2) - c_2(q_2) - \theta q_2].^{1}$$

Let $q^{\#}(\tau,\theta) = q_1^{\#}(\tau,\theta) + q_2^{\#}(\tau,\theta)$ be the total output of the two firms under Cournot equilibrium. The profits of firm 1 and firm 2 are given, respectively, by

$$(3) \qquad \pi_1(\tau,\theta) = q_1^{\#}(\tau,\theta)\, p(q^{\#}(\tau,\theta)) - c_1(q_1^{\#}(\tau,\theta)) - \tau e_1(q_1^{\#}(\tau,\theta)),$$

$$(4) \qquad \pi_2(\tau,\theta) = q_2^{\#}(\tau,\theta)\, p(q^{\#}(\tau,\theta)) - c_2(q_2^{\#}(\tau,\theta)) - \theta q_2^{\#}(\tau,\theta).$$

---

[1] While the existence of imperfect competition in the industry in question can be explained by some additional sunk cost, it is excluded from our model because it does not play any role in our analysis.

We can interpret (3) as payoff of the domestic firm gross of its political contribution and denote it by φ_1. Also, let

(5) $$\varphi_2(\tau,0) = \bar{m} - \eta_1 \vartheta_1(x_1^{\#}(\tau,0)) - \eta_2 \vartheta_2(x_2^{\#}(\tau,0))$$

be the gross payoff of the representative environmentalist. Here $\bar{m}$ denotes the representative environmentalist's income -- expressed in the numéraire -- $x_1^{\#}(\tau,0) = x_1(q_1^{\#}(\tau,0), q_2^{\#}(\tau,0))$, and $x_2^{\#}(\tau,0) = x_2(q_1^{\#}(\tau,0), q_2^{\#}(\tau,0))$.

Under the Cournot equilibrium $(q_1^{\#}(\tau,0), q_2^{\#}(\tau,0))$ the consumer surplus, the producer surplus, the tax revenues, and the pollution damage suffered by the home country are given, respectively, by

(6) $$\omega_1(\tau,0) = \int_{\cdot}^{\cdot} p(q)dq - q^{\#}(\tau,0)\ p(q^{\#}(\tau,0)),$$

(7) $$\omega_2(\tau,0) = q_1^{\#}(\tau,0)\ p(q^{\#}(\tau,0)) - c_1(q_1^{\#}(\tau,0)) - \tau\, e_1(q_1^{\#}(\tau,0)),$$

(8) $$\omega_3(\tau,0) = \tau\, e_1(q_1^{\#}(\tau,0)) + 0\, q_2^{\#}(\tau,0),$$

(9) $$\omega_4(\tau,0) = d_1(x_1^{\#}(\tau,0)).$$

Hence, the total welfare, conditioned on the policy choices $(\tau,0)$, is given by

(10) $$\omega(\tau,0) = \omega_1(\tau,0) + \omega_2(\tau,0) + \omega_3(\tau,0) - \omega_4(\tau,0).$$

Assuming that the home government's objective function is a linear function of the political contributions and social welfare, we can write its utility, conditioned on $f_1, f_2, \tau, 0$, as follows

(11) $$\Gamma(f_1, f_2, \tau, 0) = [f_1(\tau,0) + f_2(\tau,0)] + [\alpha\omega(\tau,0)],$$

where α is a positive constant.

The second stage

In the second stage, taking (f_1,f_2) as given, the home government chooses (τ,θ) to maximize its objective function. If we let $\Re: (f_1,f_2) \rightarrow \Re(f_1,f_2)$ be the set of environmental and trade policies that are best responses to (f_1,f_2), then the home government's best response correspondence is defined by

$$\Re(f_1,f_2) = \underset{\tau,\theta}{\operatorname{argmax}}\, G(f_1,f_2,\tau,\theta). \tag{12}$$

The Nash Equilibrium

A combination of strategies $(f_1^*, f_2^*,\tau^*,\theta^*)$ is a Nash equilibrium if the following conditions are satisfied:

a) The chosen environmental and trade policies (τ^*,θ^*) represent the home government's best response to f_1^* and f_2^*, i.e., $(\tau^*,\theta^*)\in \Re(f_1^*, f_2^*)$.

b) For $j,j^*=1,2$, $j\neq j^*$, taking $f_{j^*}^*$ as given and the reaction of the home government into account, a best political contribution schedule that lobby j can announce is f_j^*. More precisely, the following inequality must hold for any possible contribution schedule f_j:

$$\sup_{(\tau,\theta)\in \Re(f_j,\, f_{j^*}^*)} [\varphi_j(\tau,\theta) - f_j(\tau,\theta)] \leq [\varphi_j(\tau^*,\theta^*) - f_j^*(\tau^*,\theta^*)].$$

We observe that the inequality in b) is sufficient for f_j^* to be lobby j's best political contribution schedule against $f_{j^*}^*$, the political contribution schedule of lobby j^*. This inequality is also necessary if f_j^* is best against $f_{j^*}^*$. Indeed, if this were not true, then one can find a feasible strategy f_j and an element (τ,θ), which is a best response for the home government against $f_j, f_{j^*}^*$, $j\neq j^*$, such that

$$[\varphi_i(\tau,0) - f_j(\tau,0)] > [\varphi_i(\tau^*,0^*) - f_j^*(\tau^*,0^*)].$$

If lobby j adjusts f_j by increasing its political contribution slightly at $(\tau,0)$, then it can certainly induce the home government to choose $(\tau,0)$ as the best response. In this manner, lobby j's net payoff is higher at $(\tau,0)$ than at $(\tau^*,0^*)$, which then implies that f_j^* is not a best response to f_j^* and the combination of strategies $(f_1^*, f_2^*, \tau^*, 0^*)$ cannot represent a Nash equilibrium.

The following proposition gives a characterization of the Nash equilibria. The proposition is a version of Bernheim and Whinston (1986, Lemma 2) that is modified to be used in the context of our model.

PROPOSITION 1: *A combination of strategies* $s = (f_1^*, f_2^*, \tau^*, 0^*)$ *is a Nash equilibrium if and only if the following conditions are satisfied:*

a) $(\tau^*, 0^*) \in \mathcal{R}(f_1^*, f_2^*)$.

i.e., the combination of environmental and trade policies $(\tau^*, 0^*)$ *is a best response to* (f_1^*, f_2^*) *for the home government.*

b) For each $j, j' = 1, 2, j \neq j'$,

$$(\tau^*, 0^*) \in \underset{\tau, 0}{\operatorname{argmax}} [\varphi_{j'}(\tau, 0) - f_{j'}^*(\tau, 0) + \alpha\omega(\tau, 0)].$$

i.e., given the political contribution schedule $f_{j'}^*$ *of lobby* j', *the combination of environmental and trade policies* $(\tau^*, 0^*)$ *maximizes the joint payoff of lobby* j *and the home government.*

c) For each $j=1,2$, *there exists a combination of environmental and trade policies, say* $(\tau_j^*, 0_j^*)$, *which is a best response to*(f_1^*, f_2^*) *such that* $f_j^*(\tau_j^*, 0_j^*) = 0$.

PROOF: To prove the necessary part, suppose that $\mathcal{S}^* = (f_1^*, f_2^*, \tau^*, \theta^*)$ is a Nash equilibrium. Then condition a) follows immediately because (τ^*, θ^*) must be a best response for the home government against (f_1^*, f_2^*). To establish b), let us first analyze how lobby j chooses a best response to f_j^*. Now if lobby j does not make any political contribution, then the home government will solve the following maximization problem:

$$(13) \qquad \max_{\tau,\theta} [f_j^*(\tau,\theta) + \alpha\omega(\tau,\theta)] = \gamma.$$

In general, for any feasible strategy $f_j \geq 0$, the home government solves the following maximization problem:

$$(14) \qquad \max_{\tau,\theta} [f_j(\tau,\theta) + f_j^*(\tau,\theta) + \alpha\omega(\tau,\theta)].$$

Because $f_j \geq 0$, the home government's payoff under problem (14) is always greater than or equal to γ. In designing a best response to f_j^*, lobby j -- the principal in this case -- should search for the environmental and trade policies that maximize the joint payoff of itself and the home government then offer to the government -- the agent -- just enough political contributions to induce the latter into adopting the environmental and trade policies most advantageous to itself. Hence, lobby j first must solve the following maximization problem:

$$(15) \qquad \max_{\tau,\theta} [\varphi_j(\tau,\theta) + f_j^*(\tau,\theta) + \alpha\omega(\tau,\theta)] = \gamma + v_j.$$

We shall let $(\hat{\tau}, \hat{\theta})$ be a solution of problem (15). To induce the home government into choosing environmental and trade policies such as $(\hat{\tau}, \hat{\theta})$, lobby j can announce the following political contribution schedule:

$$(16) \qquad \hat{f}_j(\tau,\theta) = \max[\varphi_j(\tau,\theta) - v_j, 0].$$

Bernheim and Whinston, op cit, called $\hat{f}_j$ a *truthful* strategy. If lobby j chooses $\hat{f}_j$, it only aims for a net payoff equal to v_j. More precisely, if the gross payoff $\varphi_j(\tau,\theta)$ falls short of the desired net payoff level v_j, this firm will not offer any political contributions, i.e., $\hat{f}_j(\tau,\theta) = 0$. On the other hand, when the gross payoff exceeds the desired net payoff level v_j, all the excess, namely $\varphi_j(\tau,\theta)$-v_j, will be offered to the home government. To show that $\hat{f}_j$ is best against f_j^* under the incentive compatibility constraint that the home government's payoff must be greater than or equal to γ we proceed as follows.

Let (τ,θ) be a best response for the home government against $(\hat{f}_j, f_j^*)$. If (τ,θ) is a solution of the maximization problem (15), the payoff for the home government is γ. If (τ,θ) is not a solution of the maximization problem (15), then $[\varphi_j(\tau,\theta) - f_j^*(\tau,\theta) - \alpha\omega(\tau,\theta)] < \gamma + v_j$. Furthermore, because the home government's payoff is always greater than or equal to γ, it must follow that $\varphi_j(\tau,\theta) < v_j$ in this case. Using the last result and (16), we assert that $\hat{f}_j(\tau,\theta) = 0$. Hence, the home government's payoff is equal to $f_j^*(\tau,\theta) - \alpha\omega(\tau,\theta)$, which must then be equal to γ. We have just shown that $(\hat{\tau},\hat{\theta})$ is a best response to $(\hat{f}_j, f_j^*)$ for the home government.

Next, we claim that using $\hat{f}_j$ in response to f_j^* will give lobby j a net payoff equal to v_j. Indeed, let (τ,θ) be a combination of environmental and trade policies the home government chooses in response to $(\hat{f}_j, f_j^*)$. If $\hat{f}_j(\tau,\theta) > 0$, then it follows directly from (16) that $\varphi_j(\tau,\theta) - \hat{f}_j(\tau,\theta) = v_j$ = the domestic firm's net payoff. On the other hand, if $\hat{f}_j(\tau,\theta) = 0$, then $\varphi_j(\tau,\theta) - v_j \leq 0$. Furthermore, if the strict inequality holds, namely $\varphi_j(\tau,\theta) - v_j < 0$, then the net payoff for the domestic firm in this case is $\varphi_j(\tau,\theta) > v_j$. Also, in this case the home government obtains the level

of payoff γ. Lobby j can certainly avoid this situation by raising its political contributions at $(\hat{\tau}, \hat{\theta})$ slightly from $\hat{f}_j(\hat{\tau}, \hat{\theta})$ to $\hat{f}_j(\hat{\tau}, \hat{\theta}) + \varepsilon$, where ε is positive but sufficiently small. Therefore, we can always assume that if the domestic firm chooses $\hat{f}_j$ against f_j^*, its net payoff will be v_j.

Having evaluated the payoff for lobby j if it plays $\hat{f}_j$ against f_j^*, we shall now show that $\hat{f}_j$ is best against f_j^*. To this end, let f_j be any feasible strategy for lobby j and (τ,θ) a combination of environmental and trade policies that are best against (f_j, f_j^*). Then we must have $\varphi_j(\tau,\theta) + f_j^*(\tau,\theta) - \alpha\omega(\tau,\theta) \leq \gamma + v_j$. Furthermore, using its best response always gives the home government a payoff level greater than or equal to γ. Hence, $\varphi_j(\tau,\theta) - f_j(\tau,\theta) \leq v_j$, showing that $\hat{f}_j$ is best against f_j^*.

Having proved that $\hat{f}_j$, as defined by (16), is a best strategy for lobby j to use against f_j^*, we now return to our general goal to prove b). Because $(f_1^*, f_2^*, \tau^*, \theta^*)$ is a Nash equilibrium, for each $j, j' = 1, 2, j \neq j'$, f_i^* must be best against $f_{j'}^*$. Hence both $\hat{f}_j$ and f_i^*, when played against $f_{j'}^*$, must give lobby j the same net payoff, i.e.,

(17) $$\varphi_j(\tau^*,\theta^*) - f_i^*(\tau^*,\theta^*) = v_j.$$

Furthermore, because the home government's payoff under the Nash equilibrium $(f_1^*, f_2^*, \tau^*, \theta^*)$ is greater than or equal to γ, we must have

(18) $$\varphi_j(\tau^*,\theta^*) + f_{j'}^*(\tau^*,\theta^*) - \alpha\omega(\tau^*,\theta^*) \geq \gamma + v_{j'}.$$

Together (18) and (15) imply that

(19) $$(\tau^*,\theta^*) \in \underset{\tau,\theta}{\operatorname{argmax}} [\varphi_j(\tau,\theta) + f_{j'}^*(\tau,\theta) - \alpha\omega(\tau,\theta)].$$

(20) $$f_i^*(\tau^*,\theta^*) + f_{j'}^*(\tau^*,\theta^*) + \alpha\omega(\tau^*,\theta^*) = \gamma.$$

The proof of b) is now complete.

To prove c) for each j,j' =1,2, j≠j', let (τ_j^*,θ_j^*) be a solution of the maximization problem (13). We claim that $f_j^*(\tau_j^*,\theta_j^*)=0$. Indeed, if $f_j^*(\tau_j^*,\theta_j^*)>0$, then the home government's payoff will be $\gamma + f_j^*(\tau_j^*,\theta_j^*) > \gamma$ if it chooses (τ_j^*,θ_j^*) instead of (τ^*,θ^*), contradicting the fact that (τ^*,θ^*) is best against (f_1^*,f_2^*). The proof of the necessary part is now complete.

To prove the sufficiency part, let $(f_1^*,f_2^*,\tau^*,\theta^*)$ be a combination of strategy that satisfies a), b), and c) of the proposition. Condition a) asserts that (τ^*,θ^*) is a best response of the home government against (f_1^*,f_2^*).

To show that f_j^* is a best response against $f_{j'}^*$, we proceed by reductio ad absurdum. To this end, suppose that lobby j has a feasible strategy, say $\tilde{f}$, which is strictly better than f_j^* against $f_{j'}^*$, i.e., for some $(\tilde{\tau},\tilde{\theta}) \in \mathcal{R}(\tilde{f},f_{j'}^*)$ the following strict inequality holds

(21) $$\varphi_i(\tilde{\tau},\tilde{\theta}) - \tilde{f}(\tilde{\tau},\tilde{\theta}) > \varphi_j(\tau^*,\theta^*) - f_i^*(\tau^*,\theta^*).$$

Next, using b) we can assert that

(22) $$\varphi_i(\tau^*,\theta^*) + f_{j'}^*(\tau^*,\theta^*) + \alpha\omega(\tau^*,\theta^*) \geq \varphi_i(\tilde{\tau},\tilde{\theta}) + f_{j'}^*(\tilde{\tau},\tilde{\theta}) + \alpha\omega(\tilde{\tau},\tilde{\theta}).$$

It follows from (22) and (21) that

(23) $$[f_{j'}^*(\tau^*,\theta^*) + \alpha\omega(\tau^*,\theta^*)] - [f_{j'}^*(\tilde{\tau},\tilde{\theta}) + \alpha\omega(\tilde{\tau},\tilde{\theta})] \geq$$
$$[\varphi_i(\tilde{\tau},\tilde{\theta}) - \varphi_i(\tau^*,\theta^*)] + [\tilde{f}(\tilde{\tau},\tilde{\theta}) - f_i^*(\tau^*,\theta^*)].$$

In the chain of inequalities (23), the strict inequality between the first expression and the last expression allows us to write

(24) $$[f_i^*(\tau^*,\theta^*) + f_{j'}^*(\tau^*,\theta^*) + \alpha\omega(\tau^*,\theta^*)] < [\tilde{f}(\tilde{\tau},\tilde{\theta}) + f_{j'}^*(\tilde{\tau},\tilde{\theta}) + \alpha\omega(\tilde{\tau},\tilde{\theta})].$$

Now by c) of the proposition there exists $(\tau_j^*, \theta_j^*) \in \mathcal{R}(f_1^*, f_2^*)$ such that for j=1,2, $f_i^*(\tau_j^*, \theta_j^*) = 0$, i.e.,

$$f_j^*(\tau_j^*, \theta_j^*) + \alpha\omega(\tau_j^*, \theta_j^*) = f_j^*(\tau^*, \theta^*) + f_j^*(\tau^*, \theta^*) + \alpha\omega(\tau^*, \theta^*). \tag{25}$$

Using (25) in (24), we obtain

$$f_j^*(\tau_j^*, \theta_j^*) + \alpha\omega(\tau_j^*, \theta_j^*) + \hat{f}(\tau, \theta) > f_j^*(\tilde{\tau}, \tilde{\theta}) + \alpha\omega(\tilde{\tau}, \tilde{\theta}). \tag{26}$$

Because $\hat{f}(\tau_j^*, \theta_j^*) \geq 0$, we use (26) to assert that

$$\hat{f}(\tau_j^*, \theta_j^*) + f_j^*(\tau_j^*, \theta_j^*) + \alpha\omega(\tau_j^*, \theta_j^*) + \hat{f}(\tilde{\tau}, \tilde{\theta}) > f_j^*(\tilde{\tau}, \tilde{\theta}) + \alpha\omega(\tilde{\tau}, \tilde{\theta}). \tag{27}$$

The left side of (27) is the payoff the home government obtains if it chooses (τ_j^*, θ_j^*) against $(\hat{f}, f_j^*)$ while the right side of the same strict inequality is the payoff it obtains under the best response to $(\hat{f}, f_j^*)$. This is clearly a contradiction. Therefore, f_i^* is best against f_j^*. The proof of the sufficiency part is now complete. Q.E.D.

Let us consider a Nash equilibrium $(f_1^\circ, f_2^\circ, \tau^\circ, \theta^\circ)$ with the following properties. First, $(\tau^\circ, \theta^\circ)$ belongs to the interior of the set of feasible trade and environmental policies. Second, the political-contribution schedules f_1° and f_2° are differentiable in a neighborhood of $(\tau^\circ, \theta^\circ)$. Under these assumptions, the following first-order condition characterizes $(\tau^\circ, \theta^\circ)$ as a best response to (f_1°, f_2°):

$$Df_1^\circ(\tau^\circ, \theta^\circ) + Df_2^\circ(\tau^\circ, \theta^\circ) + \alpha D\omega(\tau^\circ, \theta^\circ) = 0. \tag{28}$$

Here, Df_i is a vector of partial derivatives of f_i with respect to each of its arguments. Using Proposition 1b, we have the following first-order condition that characterizes $(\tau^\circ, \theta^\circ)$ as a combination of environmental and trade policies that maximizes the joint payoff of lobby j and the home government, given f_i°, $j \neq j^\circ$, the political-contribution schedule of lobby j°:

(29) $D\varphi_j(\tau^*, \theta^*) - Df_j^*(\tau^*, \theta^*) + \alpha D\omega(\tau^*, \theta^*) = 0, \quad j, j^* = 1, 2, \ j \neq j^*.$

It follows directly from (28) and (29) that

(30) $D\varphi_j(\tau^*, \theta^*) = Df_j^*(\tau^*, \theta^*).$

Equation (30) asserts that in a neighborhood of (τ^*, θ^*), any increase (decrease) in the gross payoff of lobby j is matched by an equal increase (decrease) in the political contributions that this lobby makes to the home government. Using (30) in (28), we obtain the following first-order condition that characterizes the environmental and trade policies under the Nash equilibrium

(31) $D\varphi_1(\tau^*, \theta^*) + D\varphi_2(\tau^*, \theta^*) + \alpha D\omega(\tau^*, \theta^*) = 0.$

If we are willing to make the assumptions that (τ^*, θ^*) belongs to the interior of the set of feasible environmental and trade policies and f_1^* as well as f_2^* are differentiable in a neighborhood of (τ^*, θ^*), then (31) can be used to determine (τ^*, θ^*).

To continue with the characterization of Nash equilibrium, let us define

(32) $v_0^{max} = \max_{\tau, \theta} [\alpha\omega(\tau, \theta)];$

(33) $v_j^{max} = \max_{\tau, \theta} [\varphi_j(\tau, \theta) + \alpha\omega(\tau, \theta)], \quad j = 1, 2;$

(34) $v_{12}^{max} = \max_{\tau, \theta} [\varphi_1(\tau, \theta) + \varphi_2(\tau, \theta) + \alpha\omega(\tau, \theta)].$

For any combination of strategies $\xi = (f_1, f_2, \tau, \theta)$, let

$$\phi_0(\xi) = f_1(\tau, \theta) + f_2(\tau, \theta) + \alpha\omega(\tau, \theta).$$

$$\phi_j(\xi) = \varphi_j(\tau, \theta) - f_j(\tau, \theta), \quad j = 1, 2$$

Having presented a general characterization of Nash equilibria, we now analyze the payoffs that the players obtain under equilibrium. To this end, let us consider a Nash equilibrium, say $\xi^* = (f_1^*, f_2^*, \tau^*, \theta^*)$. Under such an equilibrium, the home government's payoff is

$$(35) \qquad f_1^*(\tau^*, \theta^*) + f_2^*(\tau^*, \theta^*) - \alpha\omega(\tau^*, \theta^*) = \max_{\tau, \theta} [f_1^*(\tau, \theta) + f_2^*(\tau, \theta) - \alpha\omega(\tau, \theta)] \geq \max_{\tau, \theta} [\alpha\omega(\tau, \theta)] = v_0^{\max}.$$

In (35), $v_0^{\max}$ is the maximum level of payoff that the home government -- considered as player 0 -- can obtain if both the domestic firm -- considered as player 1 -- and the domestic environmentalist -- considered as player 2 -- decide to make no political contributions at all, no matter which environmental and trade policies are adopted.

By Proposition 1b, under the Nash equilibrium $(f_1^*, f_2^*, \tau^*, \theta^*)$ the joint payoff of lobby j and the home government is

$$(36) \qquad \varphi_j(\tau^*, \theta^*) + f_j^*(\tau^*, \theta^*) - \alpha\omega(\tau^*, \theta^*) = \max_{\tau, \theta} [\varphi_j(\tau, \theta) + f_j^*(\tau, \theta) - \alpha\omega(\tau, \theta)] \geq \max_{\tau, \theta} [\varphi_j(\tau, \theta) - \alpha\omega(\tau, \theta)] = v_{0j}^{\max}, \text{ for } j=1,2.$$

In (36), $v_{0j}^{\max}$ represents the maximum attainable level of joint payoff for lobby j and the home government if lobby j' decides to make no political contributions at all, regardless of the environmental and trade policies adopted by the home government.

The global payoff, i.e., the joint payoff of the domestic firm, the domestic environmentalist, and the home government is given by

$$(37) \qquad \varphi_1(\tau^*, \theta^*) + \varphi_2(\tau^*, \theta^*) - \alpha\omega(\tau^*, \theta^*) \leq \max_{\tau, \theta} [\varphi_1(\tau, \theta) + \varphi_2(\tau, \theta) - \alpha\omega(\tau, \theta)] = v_{012}^{\max}.$$

In (37), v_{012}^{max} represents the globally efficient payoff, i.e., the maximum joint payoff the three players, namely the home government, the domestic firm, and the domestic environmentalist, can obtain. We summarize the results just obtained in the following proposition.

PROPOSITION 2: *Let* $\xi^*=(f_1^*, f_2^*, \tau^*, \theta^*)$ *be a Nash equilibrium. Then the following conditions must hold:*

a) $\phi_0(\xi^*) = f_1^*(\tau^*, \theta^*) + f_2^*(\tau^*, \theta^*) + \alpha\omega(\tau^*, \theta^*) \geq v_0^{max}$;

b) $\phi_j(\xi^*) = \phi_j(\tau^*, \theta^*) - f_j^*(\tau^*, \theta^*) \leq v_{012}^{max} - v_{0j}^{max}$. $\quad j,j^*=1,2,\ j\neq j^*$.

c) $\phi_1(\xi^*) + \phi_2(\xi^*) \leq v_{012}^{max} - v_0^{max}$.

Now let

$$P' = \{(v_1, v_2) \mid 0 \leq v_1 \leq v_{012}^{max} - v_{02}^{max},\ 0 \leq v_2 \leq v_{012}^{max} - v_{01}^{max},\ v_1 + v_2 \leq v_{012}^{max} - v_0^{max}\}.$$

In view of conditions a), b), and c) of Proposition 2, the set P' which is obviously not empty, contains all the vector of net payoffs for the domestic firm and the domestic environmentalist under equilibrium.

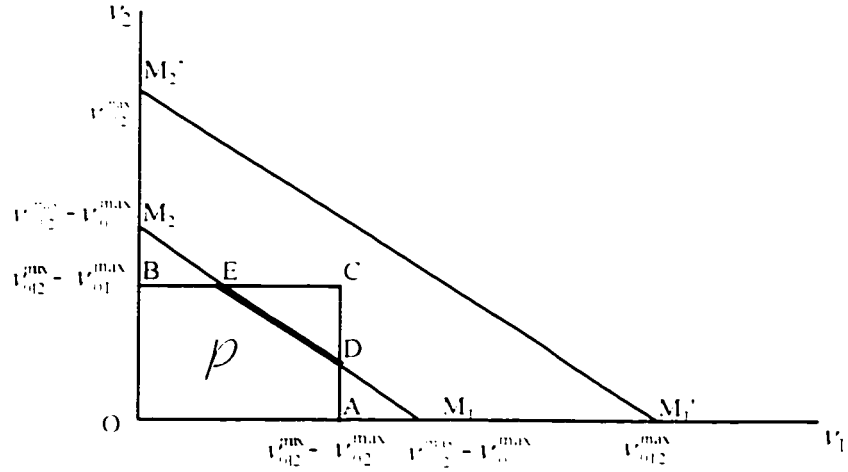


Figure 1 P' = the Pareto Efficient Frontier of P= ED

A possible depiction of P is represented by the area OADEB in Figure 1. Because $(v_{012}^{max} - v_{01}^{max}) - (v_{012}^{max} - v_{02}^{max}) \leq v_{012}^{max}$, the point C is always below $M_1'M_2'$. However, in general $(v_{012}^{max} - v_{01}^{max}) - (v_{012}^{max} - v_{02}^{max})$ might be greater or less than $v_{02}^{max} - v_{01}^{max}$, and therefore, the point C might lie above or below M_1M_2. In Figure 1, we have depicted the case C is above M_1M_2.

Now in the case $\alpha = 0$, i.e., the home government gives no weight to social welfare, then $v_{01}^{max} = 0$. In this case v_{012}^{max} is simply the maximum joint gross payoff attainable for the domestic firm and the domestic environmentalist

$$v_{012}^{max} = \max_{\tau, 0} [\varphi_1(\tau, 0) - \varphi_2(\tau, 0)];$$

The maximum gross payoff attainable for the domestic firm is

$$v_{01}^{max} = v_1^{max} = \max_{\tau, 0} \varphi_1(\tau, 0);$$

The maximum gross payoff attainable for the home environmentalist is

$$v_{02}^{max} = v_2^{max} = \max_{\tau, 0} \varphi_2(\tau, 0).$$

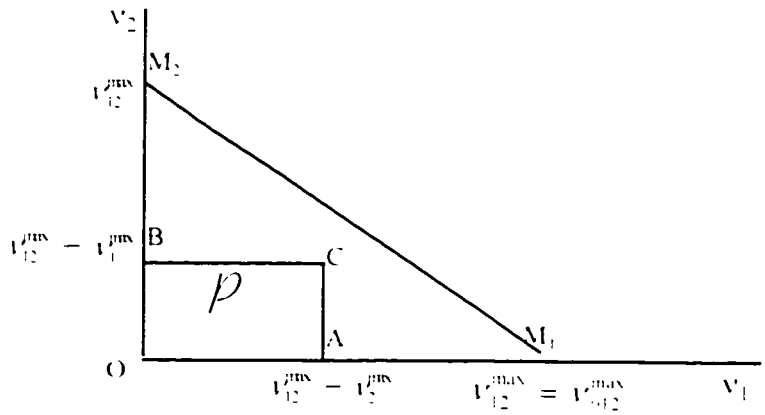


Figure 2 Pareto Efficient Frontier of $P = P' =$ the single point C.

In this particular case, $M_1'M_2'$ coincides with M_1M_2 and the point C now lies below M_1M_2. The set I' is represented by the rectangle OACB in Figure 2. In Figure 3, we depict for the case the point C is strictly below M_1M_2.

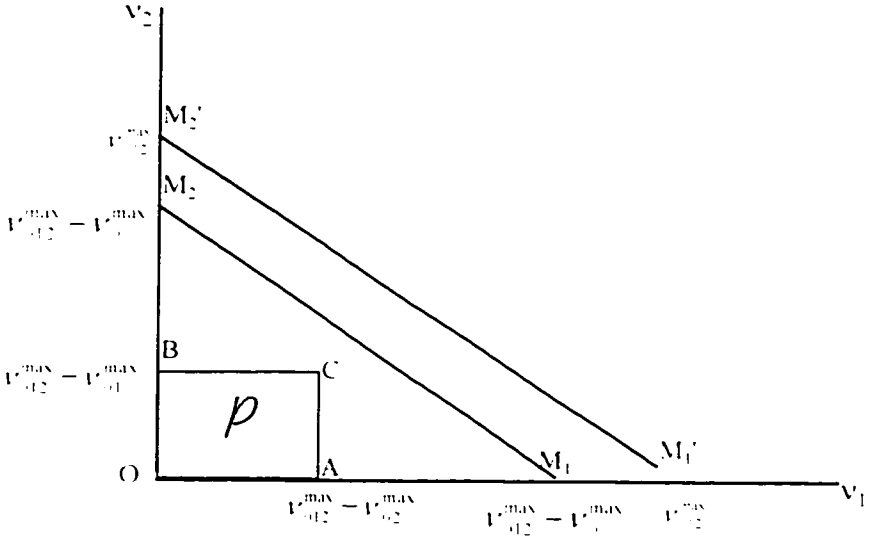


Figure 3 I' =Pareto Efficient Frontier of $I'=\{e\}$

Because I' contains all the vector of net payoffs for the domestic firm and the domestic environmentalist, its Pareto Frontier is of particular importance. We have just shown that this Pareto Frontier is either a line segment -- when C lies strictly above M_1M_2 -- or a single point -- when C lies on or below M_1M_2.

The following proposition gives a constructive proof for the existence of a special type of Nash Equilibria -- The truthful Nash equilibria. The proposition is a version of Bernheim and Whinston (1986, Theorem 2) which is modified to be used in the context of our model.

PROPOSITION 3: *Let (τ^*,θ^*) be a combination of environmental and trade policies that maximizes the joint payoff of the home government and the two lobbies, i.e., (τ^*,θ^*) is a solution of the following maximization problem:*

$$\max_{\tau,\theta} [\varphi_1(\tau,\theta) + \varphi_2(\tau,\theta) + \alpha\omega(\tau,\theta)] = v_{o12}^{\max}.$$

Next, pick any element, say (v_1^*,v_2^*), on the Pareto efficient frontier of P then define the following truthful strategies for lobby j:

$$f_j^*(\tau,\theta) = \max [\varphi_j(\tau,\theta) - v_j^*, 0], \quad j=1,2.$$

Then $(f_1^*, f_2^*,\tau^*,\theta^*)$ is a Nash equilibrium, which is called a truthful Nash equilibrium because the strategies used by the two lobbies are truthful. Furthermore, under this truthful Nash equilibrium, the net payoff for the domestic firm and the domestic environmentalist are v_1^* and v_2^*, respectively. That is, any vector of net payoffs on the Pareto efficient frontier of P can be supported by a truthful Nash equilibrium.

PROOF: First, we show that under the combination of strategies $(f_1^*, f_2^*,\tau^*,\theta^*)$, v_j^* is the net payoff obtained by lobby j. Indeed, because (v_1^*,v_2^*) is on the Pareto efficient frontier of P, we must have

$$v_j^* \le v_{o12}^{\max} - v_{oj}^{\max}, \text{ for j=1,2,}$$

i.e.,

$$v_j^* \le \varphi_j(\tau^*,\theta^*) + \varphi_{j'}(\tau^*,\theta^*) + \alpha\omega(\tau^*,\theta^*) - v_{oj'}^{\max},$$

or equivalently

$$\varphi_j(\tau^*,\theta^*) - v_j^* \ge v_{oj'}^{\max} - (\varphi_{j'}(\tau^*,\theta^*) + \alpha\omega(\tau^*,\theta^*)) \ge 0, \quad j,j'=1,2, \ j\neq j'. \tag{38}$$

Inequality (38) asserts that v_j^* is indeed the net payoff that lobby j obtains under $(f_1^*, f_2^*, \tau^*, \theta^*)$. Therefore, if $(f_1^*, f_2^*, \tau^*, \theta^*)$ is a Nash equilibrium, it does support the vector of net payoffs $(v_1^*, v_2^*) \in I^f$.

To show that $(f_1^*, f_2^*, \tau^*, \theta^*)$ is a Nash equilibrium, we shall establish that this combination of strategies satisfies conditions a), b), and c) of Proposition 1. To prove that (τ^*, θ^*) is a best response to (f_1^*, f_2^*), suppose that there exist a combination of environmental and trade policies, say $(\tilde{\tau}, \tilde{\theta})$, such that the home government's payoff is strictly higher at $(\tilde{\tau}, \tilde{\theta})$ than at (τ^*, θ^*), i.e.,

$$(39) \qquad [f_1^*(\tilde{\tau}, \tilde{\theta}) + f_2^*(\tilde{\tau}, \tilde{\theta}) + \alpha\omega(\tilde{\tau}, \tilde{\theta})] - [f_1^*(\tau^*, \theta^*) + f_2^*(\tau^*, \theta^*) + \alpha\omega(\tau^*, \theta^*)] =$$

$$\varphi_1(\tilde{\tau}, \tilde{\theta}) - v_1^* + \varphi_2(\tilde{\tau}, \tilde{\theta}) - v_2^* + \alpha\omega(\tilde{\tau}, \tilde{\theta}) = v_{12}^{max} - v_1^* - v_2^*$$

Observe that the equalities in (39) follow from the definition of (f_1^*, f_2^*) and the results $\varphi_1(\tau^*, \theta^*) - v_1^* \geq 0$, $\varphi_2(\tau^*, \theta^*) - v_2^* \geq 0$, just established.

We shall now show that the strict inequality (39) is not possible. There are three possibilities to consider:

(i) Both $f_1^*(\tilde{\tau}, \tilde{\theta})$ and $f_2^*(\tilde{\tau}, \tilde{\theta})$ are strictly positive. In this case (39) becomes

$$\varphi_1(\tilde{\tau}, \tilde{\theta}) - v_1^* + \varphi_2(\tilde{\tau}, \tilde{\theta}) - v_2^* + \alpha\omega(\tilde{\tau}, \tilde{\theta}) > v_{12}^{max} - v_1^* - v_2^*,$$

i.e.,

$$\varphi_1(\tilde{\tau}, \tilde{\theta}) + \varphi_2(\tilde{\tau}, \tilde{\theta}) + \alpha\omega(\tilde{\tau}, \tilde{\theta}) > v_{12}^{max},$$

which is obviously impossible.

(ii) For $j, j^* = 1, 2$, $j \neq j^*$, $f_j^*(\tilde{\tau}, \tilde{\theta}) > 0$ but $f_{j^*}^*(\tilde{\tau}, \tilde{\theta}) = 0$. In this case, (39) becomes

$$\varphi_j(\tilde{\tau}, \tilde{\theta}) - v_j^* + \alpha\omega(\tilde{\tau}, \tilde{\theta}) > v_{12}^{max} - v_j^* - v_{j^*}^*$$

i.e.,

$$v_i^* + v_{-i2}^{max} - [\varphi_i(\tilde{\tau},\tilde{\theta}) + \alpha\omega(\tilde{\tau},\tilde{\theta})] \geq v_{-i2}^{max} - v_{-i}^{max}.$$

contradicting the hypothesis that $(v_1^*, v_2^*) \in J^1$.

(iii) $f_1^*(\tilde{\tau},\tilde{\theta}) = f_2^*(\tilde{\tau},\tilde{\theta}) = 0$. In this case, (39) becomes

$$\alpha\omega(\tilde{\tau},\tilde{\theta}) \geq v_{-i2}^{max} - v_1^* - v_2^*.$$

i.e.,

(40) $$v_1^* + v_2^* + v_{-i2}^{max} - \alpha\omega(\tilde{\tau},\tilde{\theta}) \geq v_{-i2}^{max} - v_{-i}^{max}.$$

However, because (v_1^*, v_2^*) belongs to J^1, the Pareto frontier of J, we must also have $v_1^* + v_2^* = v_{-i2}^{max} - v_{-i}^{max}$, which is not consistent with (40). We have just proved that (τ^*,θ^*) is a best response that the home government may choose against (f_1^*, f_2^*).

Let us now show that $(f_1^*, f_2^*, \tau^*, \theta^*)$ satisfies condition b) of Proposition 1. It follows directly from the definition of f_i^* that for any (τ,θ),

$$f_i^*(\tau,\theta) \geq \varphi_i(\tau,\theta) - v_i^* = \varphi_i(\tau,\theta) - [\varphi_i(\tau^*,\theta^*) - f_i^*(\tau^*,\theta^*)].$$

i.e.,

(41) $$\varphi_i(\tau^*,\theta^*) - \varphi_i(\tau,\theta) \geq f_i^*(\tau^*,\theta^*) - f_i^*(\tau,\theta) \geq$$
$$[f_i^*(\tau^*,\theta^*) - f_i^*(\tau,\theta)] - [f_i^*(\tau,\theta) - f_{-i}^*(\tau,\theta) - \alpha\omega(\tau,\theta)] - [f_i^*(\tau^*,\theta^*) - f_{-i}^*(\tau^*,\theta^*) - \alpha\omega(\tau^*,\theta^*)].$$

In (41), the second inequality is due to the fact that (τ^*,θ^*) is a best response that the home government might choose against (f_1^*, f_2^*). Rearranging the inequality between the first and last expression in (41), we obtain

(42) $$\varphi_i(\tau^*,\theta^*) + f_{-i}^*(\tau^*,\theta^*) + \alpha\omega(\tau^*,\theta^*) \geq \varphi_i(\tau,\theta) + f_{-i}^*(\tau,\theta) + \alpha\omega(\tau,\theta).$$

The proof that the combination of strategies $(f_1^*, f_2^*, \tau^*, \theta^*)$ satisfies condition b) of Proposition 1 is now complete.

To show that $(f_1^*, f_2^*, \tau^*, \theta^*)$ also satisfies condition c) of Proposition 1, let (τ_0, θ_0) be a solution of the following maximization problem:

$$(43) \qquad \max_{\tau,\theta} [\alpha\omega(\tau,\theta)] = v_{012}^{\max} ;$$

(τ_{0j}, θ_{0j}) be a solution of the following maximization problem:

$$(44) \qquad \max_{\tau,\theta} [\varphi_j(\tau,\theta) - \alpha\omega(\tau,\theta)] = v_{0j}^{\max}, \text{ for } j=1,2.$$

Now because (v_1^*, v_2^*) belongs to P, at least one of the inequalities $v_1^* \le v_{012}^{\max} - v_{02}^{\max}$, $v_1^* + v_2^* \le v_{012}^{\max} - v_0^{\max}$ must be binding. Let us consider first the case $v_1^* = v_{012}^{\max} - v_{02}^{\max}$. In this case, we have

$$v_{012}^{\max} - v_{02}^{\max} = v_1^* = \varphi_1(\tau^*, \theta^*) - f_1^*(\tau^*, \theta^*).$$

Hence,

$$f_1^*(\tau^*, \theta^*) = -v_{012}^{\max} + \varphi_1(\tau^*, \theta^*) - v_{02}^{\max}.$$

If we add $f_1^*(\tau_{0j}, \theta_{0j})$, which is nonnegative, to the right side of the preceding equality, we obtain the following inequality

$$(45) \qquad f_1^*(\tau^*, \theta^*) \le -v_{012}^{\max} + \varphi_1(\tau^*, \theta^*) - v_{02}^{\max} + f_1^*(\tau_{0j}, \theta_{0j}).$$

We observe that (45) will be a strict inequality if $f_1^*(\tau_{0j}, \theta_{0j}) > 0$.

Next, using the definition of f_1^*, we obtain the following inequality

$$f_1^*(\tau_{0j}, \theta_{0j}) \ge \varphi_j(\tau_{0j}, \theta_{0j}) - v_{0j}^{\max} = \varphi_j(\tau_{0j}, \theta_{0j}) - \varphi_j(\tau^*, \theta^*) + f_1^*(\tau^*, \theta^*),$$

i.e.,

(46) $$f_i^*(\tau^*,\theta^*) \le \varphi_j(\tau^*,\theta^*) - \varphi_j(\tau_{0i},\theta_{0i}) + f_i^*(\tau_{0i},\theta_{0i}).$$

Summing (45) and (46), we obtain

(47) $$f_i^*(\tau^*,\theta^*) + f_i^*(\tau^*,\theta^*) \le [-v_{-i2}^{\max} - \varphi_i(\tau^*,\theta^*) - \varphi_i(\tau^*,\theta^*)] + [v_{-j}^{\max} - \varphi_j(\tau_{0j},\theta_{0j})] +$$

$$[f_i^*(\tau_{0i},\theta_{0i}) + f_i^*(\tau_{0i},\theta_{0i})] = -\alpha\omega(\tau^*,\theta^*) - [f_i^*(\tau_{0i},\theta_{0i}) + f_i^*(\tau_{0j},\theta_{0j}) + \alpha\omega(\tau_{0j},\theta_{0j})].$$

Again, we remark that the inequality in (47) will be strict if $f_i^*(\tau_{0i},\theta_{0i})>0$. The inequality (47) implies that the home government's payoff under (τ_{0i},θ_{0i}) is greater than or equal to that under (τ^*,θ^*). Because it has been established that (τ^*,θ^*) is best against (f_1^*, f_2^*), we must have

(48) $$f_i^*(\tau^*,\theta^*) + f_i^*(\tau^*,\theta^*) + \alpha\omega(\tau^*,\theta^*) = f_i^*(\tau_{0i},\theta_{0i}) + f_i^*(\tau_{0i},\theta_{0i}) + \alpha\omega(\tau_{0i},\theta_{0j})$$

and therefore, $f_i^*(\tau_{0i},\theta_{0i}) = 0$. We have just shown that if $v_i^* = v_{-i2}^{\max} - v_{-j}^{\max}$, then (τ_{0i},θ_{0i}) is a best response for the home government against (f_1^*, f_2^*) and $f_i^*(\tau_{0i},\theta_{0i}) = 0$.

Next, consider the case $v_1^* - v_2^* = v_{-i2}^{\max} - v_{-j}^{\max}$. In this case, we can write

$$v_1^* - v_2^* = \varphi_i(\tau^*,\theta^*) - f_i^*(\tau^*,\theta^*) - \varphi_i(\tau^*,\theta^*) - f_i^*(\tau^*,\theta^*) = v_{-i2}^{\max} - v_{-j}^{\max},$$

i.e.,

$$f_i^*(\tau^*,\theta^*) + f_i^*(\tau^*,\theta^*) = \varphi_i(\tau^*,\theta^*) - \varphi_i(\tau^*,\theta^*) - v_{-i2}^{\max} + v_{-j}^{\max} = -\alpha\omega(\tau^*,\theta^*) + v_{-j}^{\max}.$$

Hence,

(49) $$f_i^*(\tau^*,\theta^*) + f_i^*(\tau^*,\theta^*) + \alpha\omega(\tau^*,\theta^*) = v_{-j}^{\max}.$$

Now using the definition of (τ_0,θ_0) and the fact that $f_i^* \ge 0$, $f_i^* \ge 0$, we have

(50) $$v_{-j}^{\max} = \alpha\omega(\tau_0,\theta_0) \le f_i^*(\tau_0,\theta_0) + f_i^*(\tau_0,\theta_0) + \alpha\omega(\tau_0,\theta_0).$$

We remark that inequality (50) will be strict if either $f_i^*(\tau_0,\theta_0) > 0$ or $f_i^*(\tau_0,\theta_0)>0$. Combining (49) and (50), we obtain the following inequality

(51) $$f_i^*(\tau^*,\theta^*) + f_i^*(\tau^*,\theta^*) + \alpha\omega(\tau^*,\theta^*) \le f_i^*(\tau_0,\theta_0) + f_i^*(\tau_0,\theta_0) + \alpha\omega(\tau_0,\theta_0).$$

i.e., the home government's payoff at (τ_0,θ_0) is at least as high as that at (τ^*,θ^*). Therefore, (τ_0,θ_0) is also a best response that the government might use against (f_1^*, f_2^*). Furthermore, because strict inequality can never hold in (51), we must have $f_1^*(\tau_0,\theta_0) = f_2^*(\tau_0,\theta_0) = 0$. We have just shown that if $v_1^* - v_2^* = v_{12}^{max} - v_{21}^{max}$, then (τ_0,θ_0) is a best response against (f_1^*, f_2^*) and $f_j^*(\tau_0,\theta_0)$ $= f_2^*(\tau_0,\theta_0) = 0$. The proof that the combination of strategies $(f_1^*, f_2^*, \tau^*, \theta^*)$ satisfies c) of Proposition 1 is now complete and so is the proof of Proposition 3. Q.E.D.

DEFINITION: A Nash equilibrium $\mathfrak{S}$ is said to be Pareto efficient for the two domestic lobbies if there exist no Nash equilibrium $\mathfrak{S}''$ such that $\phi_j(\mathfrak{S}') \leq \phi_j(\mathfrak{S}'')$ for j=1,2, with at least one strict inequality holding.

We shall only accept as a solution of the game a Nash equilibrium that is Pareto efficient for the two lobbies.

PROPOSITION 4: *Let $\mathfrak{S} = (f_1^*, f_2^*, \tau^*, \theta^*)$ be a Nash equilibrium that is Pareto efficient for the domestic firm and the domestic environmentalist. Also, let v_1^* and v_2^* be the net payoffs for the domestic firm and the domestic environmentalist, respectively. Then the following results hold:*

$$a)\ (\tau^*,\theta^*) \in \underset{\tau,\theta}{argmax}[\varphi_1(\tau,\theta) + \varphi_2(\tau,\theta) + \omega(\tau,\theta)],$$

i.e., the combination of environmental and trade policies (τ^*,θ^*) is globally efficient in the sense that it maximizes the joint payoff of the home government, the domestic firm, and the domestic environmentalist.

b) The vector of net payoffs for the domestic firm and the domestic environmentalist, namely (v_1^*, v_2^*), *belongs to the Pareto efficient frontier of* I^2.

c) If $(v_{o12}^{max} - v_{o1}^{max}) + (v_{o12}^{max} - v_{o2}^{max}) \geq v_{o12}^{max} - v_o^{max}$, *then the net payoffs for the home government, the domestic firm, and the domestic environmentalist are unique and given, respectively, by*

(i) $\phi_0(\xi^*) = v_{o1}^{max} + v_{o2}^{max} - v_{o12}^{max}$.

(ii) $\phi_1(\xi^*) = v_{o12}^{max} - v_{o2}^{max}$.

(iii) $\phi_2(\xi^*) = v_{o12}^{max} - v_{o1}^{max}$.

d) If $(v_{o12}^{max} - v_{o1}^{max}) + (v_{o12}^{max} - v_{o2}^{max}) \geq v_{o12}^{max} - v_o^{max}$, *then the payoff for the home government is unique and given by*

(i) $\phi_0(\xi^*) = v_o^{max}$.

the same level of payoff it obtains by including only social welfare in its objective function. On the other hand, the net payoffs for the two domestic special-interest groups are not unique but constitute a line segment defined by the following conditions

(ii) $\phi_1(\xi^*) + \phi_2(\xi^*) = v_{o12}^{max} - v_o^{max}$.

(iii) $\phi_1(\xi^*) \leq v_{o12}^{max} - v_{o2}^{max}$.

(iv) $\phi_2(\xi^*) \leq v_{o12}^{max} - v_{o1}^{max}$.

Proof: By a) and b) of Proposition 2, (v_1^*, v_2^*) must belong to I^2. If $(v_1^*, v_2^*) \notin I^J$, then we can find $(\hat{v}_1, \hat{v}_2) \in I^J$ with $\hat{v}_1 \geq v_1^*$, $\hat{v}_2 \geq v_2^*$ and $\hat{v}_1 + \hat{v}_2 > v_1^* + v_2^*$. Invoking Proposition 3 we can then assert the existence of a truthful Nash equilibrium under which the net payoffs for the

domestic firm and the domestic environmentalist are given by $\hat{v}_1$ and $\hat{v}_2$, respectively, contradicting the hypothesis that α^* is Pareto efficient for these two players. Part b) of the proposition is now established.

To establish a) of the Proposition, let us first consider the case $v_1^* + v_2^* = v_{012}^{\max} - v_0^{\max}$. Because the home government's payoff is always greater than or equal to $v_0^{\max}$, in this case we must have

$$v_1^* + v_2^* + f_1^*(\tau^*,0^*) + f_2^*(\tau^*,0^*) + \alpha\omega(\tau^*,0^*) \geq v_1^* + v_2^* + v_0^{\max}.$$

Thus,

$$\varphi_1(\tau^*,0^*) + \varphi_2(\tau^*,0^*) + \alpha\omega(\tau^*,0^*) \geq v_{012}^{\max}.$$

Hence a) must be true in this case. Next, let us consider the case $v_1^* + v_2^* < v_{012}^{\max} - v_0^{\max}$. Because (v_1^*, v_2^*) has been shown to belong to the Pareto frontier of Γ, we must have $v_1^* = v_{012}^{\max} - v_{02}^{\max}$ and $v_2^* = v_{012}^{\max} - v_{01}^{\max}$. According to b) of Proposition 1 and (36), we have

$$\varphi_1(\tau^*,0^*) + f_2^*(\tau^*,0^*) + \alpha\omega(\tau^*,0^*) \geq v_{01}^{\max},$$

$$\varphi_2(\tau^*,0^*) + f_1^*(\tau^*,0^*) - f_1^*(\tau^*,0^*) + f_2^*(\tau^*,0^*) + \alpha\omega(\tau^*,0^*) \geq v_{01}^{\max},$$

$$v_1^* + f_1^*(\tau^*,0^*) + f_2^*(\tau^*,0^*) + \alpha\omega(\tau^*,0^*) \geq v_{01}^{\max},$$

$$v_1^* + f_1^*(\tau^*,0^*) + v_2^* + f_2^*(\tau^*,0^*) + \alpha\omega(\tau^*,0^*) \geq v_2^* + v_{01}^{\max}.$$

Thus,

$$\varphi_1(\tau^*,0^*) + \varphi_2(\tau^*,0^*) + \alpha\omega(\tau^*,0^*) \geq v_{012}^{\max}.$$

i.e., the combination of environmental and trade policies $(\tau^*,0^*)$ maximizes the joint payoff of the domestic firm, the domestic environmentalist, and the home government. The proof of a) is now complete.

To establish part c) of the Proposition we claim that if $(v_{012}^{max} - v_{01}^{max}) + (v_{012}^{max} - v_{02}^{max}) < v_{012}^{max} - v_0^{max}$, then $v_1^* + v_2^* = \phi_1(\xi^*) + \phi_2(\xi^*) = v_{012}^{max} - v_0^{max}$. Indeed, if this is not the case, then either $v_1^* + v_2^* < v_{012}^{max} - v_0^{max}$, which is not possible or $v_1^* + v_2^* = v_{012}^{max} - v_0^{max}$. In the latter case, since $(v_1^*, v_2^*) \in \Pi$, we must have $v_1^* \le v_{012}^{max} - v_{02}^{max}$ and $v_2^* \le v_{012}^{max} - v_{01}^{max}$. Hence, $(v_{012}^{max} - v_{01}^{max}) + (v_{012}^{max} - v_{02}^{max}) \ge (v_{012}^{max} - v_0^{max})$, which contradicts the hypothesis of c). Hence, $v_1^* + v_2^* < v_{012}^{max} - v_0^{max}$. In this case, since (v_1^*, v_2^*) belongs to the Pareto frontier of Π we must have $v_1^* = v_{012}^{max} - v_{02}^{max}$ and $v_2^* = v_{012}^{max} - v_{01}^{max}$. Hence, we can write

$$\varphi_1(\tau^*,0^*) + \varphi_2(\tau^*,0^*) + \alpha\omega(\tau^*,0^*) = v_{012}^{max},$$

$$\varphi_1(\tau^*,0^*) + \varphi_2(\tau^*,0^*) - v_1^* - v_2^* + \alpha\omega(\tau^*,0^*) = v_{012}^{max} - v_1^* - v_2^*,$$

$$f_1^*(\tau^*,0^*) + f_2^*(\tau^*,0^*) + \alpha\omega(\tau^*,0^*) = v_{012}^{max} - (v_{012}^{max} - v_{02}^{max}) - (v_{012}^{max} - v_{01}^{max}).$$

Thus,

$$\phi_0(\xi^*) = v_{01}^{max} + v_{02}^{max} - v_{012}^{max}.$$

Hence the proof for c-i) is complete.

To establish parts c-ii) and c-iii) from part c-i) we know that $v_1^* + v_2^* < v_{012}^{max} - v_0^{max}$. Thus, we must have $v_1^* = v_{012}^{max} - v_{02}^{max}$ and $v_2^* = v_{012}^{max} - v_{01}^{max}$ which are equivalent to $\phi_1(\xi^*) = v_{012}^{max} - v_{02}^{max}$ and $\phi_2(\xi^*) = v_{012}^{max} - v_{01}^{max}$. Therefore, the proof of part c) is complete.

To establish part d) of the proposition let us start with d-ii). We claim that if $(v_{012}^{max} - v_{01}^{max}) + (v_{012}^{max} - v_{02}^{max}) \geq v_{012}^{max} - v_{0}^{max}$, then $v_1^* + v_2^* = \phi_1(\xi^*) + \phi_2(\xi^*) = v_{012}^{max} - v_{0}^{max}$. Indeed, if this is not the case, then either $v_1^* + v_2^* > v_{012}^{max} - v_{0}^{max}$, which is not possible or $v_1^* + v_2^* < v_{012}^{max} - v_{0}^{max}$. In the latter case, since $(v_1^*, v_2^*) \in P'$, one must have $v_1^* = v_{012}^{max} - v_{02}^{max}$ and $v_2^* = v_{012}^{max} - v_{01}^{max}$. Hence, $(v_{012}^{max} - v_{1}^{max}) + (v_{012}^{max} - v_{02}^{max}) < (v_{012}^{max} - v_{0}^{max})$, which contradicts the hypothesis of d-ii).

Hence, $v_1^* + v_2^* = v_{012}^{max} - v_{0}^{max}$, as desired. Furthermore, since $(v_1^*, v_2^*) \in P'$, we must have $v_1^* \leq v_{012}^{max} - v_{02}^{max}$ and $v_2^* \leq v_{012}^{max} - v_{01}^{max}$. Thus, d-iii) and d-iv) are also established.

Finally, we prove d-i) of the proposition. From d-ii), we know that $v_1^* + v_2^* = v_{012}^{max} - v_{0}^{max}$. Moreover, since $\xi^* = (f_1^*, f_2^*, \tau^*, 0^*)$ is a Nash equilibrium and $(v_1^*, v_2^*) \in P'$, we can write

$$v_1^* + v_2^* = \phi_1(\tau^*, 0^*) - f_1^*(\tau^*, 0^*) + \phi_2(\tau^*, 0^*) - f_2^*(\tau^*, 0^*) = v_{012}^{max} - v_{0}^{max},$$

i.e.,

$$f_1^*(\tau^*, 0^*) + f_2^*(\tau^*, 0^*) = \phi_1(\tau^*, 0^*) + \phi_2(\tau^*, 0^*) - v_{012}^{max} - v_{0}^{max} = -\alpha\omega(\tau^*, 0^*) - v_{0}^{max}.$$

Hence,

$$f_1^*(\tau^*, 0^*) + f_2^*(\tau^*, 0^*) + \alpha\omega(\tau^*, 0^*) = v_{0}^{max}.$$

Part d) of the proposition is now established. Q.E.D.

According to Proposition 4b, the net payoffs received by the domestic firm and the representative environmentalist under a Nash equilibrium that is Pareto efficient for these two lobbies belong to the Pareto efficient frontier of P'. Furthermore, according to Proposition 3 any point on Pareto efficient frontier of P' can be supported by a truthful Nash equilibrium, which is obviously Pareto efficient for the two lobbies. Also, what matters for a lobby is its net payoff, not

how the net payoff is obtained. Therefore, one can concentrate on the truthful Nash equilibria in searching for a solution of the game.

To gain some understanding concerning the impact of the environmental lobby on environmental and trade policies, let us imagine a stage on which is found only the home government at the beginning. Without any special-interest group on the scene, the home government solves the welfare-maximizing problem (32) and obtain the payoff level v_0^{max}. Assuming that the problem has a unique solution, let us denote by (τ_0, θ_0) the combination of environmental and trade policies that maximizes social welfare.

Next, let us add the domestic firm to the scene. We now have a game consisting of two players, namely the home government and the domestic firm. The domestic firm -- the principal in this case -- will try to design a political contribution schedule that induces the home government -- the agent -- into adopting a combination of environmental and trade policies most advantageous to itself. In designing such a strategy, the domestic firm must take into account the incentive compatibility constraint that the political contribution schedule it announces must give the home government at least a payoff equal to v_0^{max}, the payoff level that the home government can guarantee itself by including only social welfare in its objective function and choosing the combination of environmental and trade policies (τ_0, θ_0). Hence the maximum net payoff that the domestic firm can obtain is $v_{01}^{max} - v_0^{max}$, where v_{01}^{max}, as defined by (33), is the maximum joint payoff for the domestic firm and the home government if the home government ignores completely the political contribution of the environmental lobby. Recall that (τ_{01}, θ_{01}) is the combination of environmental and trade policies, assumed to be unique, that maximizes this joint

payoff, i.e., (τ_{01}, θ_{01}) is the solution of the maximization problem in (33). An optimal strategy for the domestic firm in this principal-agent game is the following political-contribution schedule:

$$f_1(\tau,\theta) = max[\varphi_1(\tau,\theta) - (v_{01}^{max} - v_0^{max}),0].$$

As its best response to f_1, the home government will choose (τ_{01}, θ_{01}) and obtain the payoff $f_1(\tau_{01}, \theta_{01}) + \alpha\varphi(\tau_{01}, \theta_{01}) = v_0^{max}$. As for the domestic firm, its net payoff will be $v_{01}^{max} - v_0^{max}$.

Finally, let us bring the domestic environmentalist on the scene. Now if the environmental lobby refuses to join the domestic firm in making political contributions to the home government, then the principal-agent game played by the domestic firm and the home government will result in the combination of environmental and trade policies (τ_{01}, θ_{01}) being chosen. Under such a scenario, the net payoff for the environmentalist lobby is $\varphi_2(\tau_{01}, \theta_{01})$. On the other hand, if the environmental lobby decides to join the domestic firm in making political contribution to the home government, let $\xi^* = (f_1^*, f_2^*, \tau^*, \theta^*)$ be a Nash equilibrium under this scenario. It is obvious that the second scenario will only happen if the net payoff for the environmental lobby under the Nash equilibrium ξ^* exceeds $\varphi_2(\tau_{01}, \theta_{01})$, i.e., if

$$\varphi_2(\xi^*) \geq \varphi_2(\tau_{01}, \theta_{01}). \tag{52}$$

PROPOSITION 5: *Let $\xi^* = (f_1^*, f_2^*, \tau^*, \theta^*)$ be a Nash equilibrium under which the political contribution of the environmental lobby is positive and for which (52) holds. Then we have the following results*

a) If the environmental lobby cares only about its local environment, then

$$x_1^*(\tau^*, \theta^*) < x_1^*(\tau_{01}, \theta_{01}).$$

i.e., the quality of the home environment rises when the environmental lobby joins the domestic firm in making political contributions to the home government.

b) If the environmental lobby is a supergreen, which cares as much about the foreign environment as about the local environment, then

$$x_1(\tau^*, \theta^*) - x_2(\tau^*, \theta^*) > x_1(\tau_{01}, \theta_{01}) - x_2(\tau_{01}, \theta_{01}),$$

i.e., the quality of the global environment rises with the emergence of the environmental lobby.

PROOF: In a more explicit manner, inequality (52) can be written as follows

$$\bar{m} - f_2^*(\tau^*, \theta^*) - \vartheta(x_1(\tau^*, \theta^*), x_2(\tau^*, \theta^*)) \geq \bar{m} - \vartheta(x_1(\tau_{01}, \theta_{01}), x_2(\tau_{01}, \theta_{01})). \tag{53}$$

Now if the environmental lobby's political contribution under ξ^* is positive, i.e., if $f_2^*(\tau^*, \theta^*) > 0$, then it follows directly from (53) that

$$\vartheta(x_1(\tau^*, \theta^*), x_2(\tau^*, \theta^*)) < \vartheta(x_1(\tau_{01}, \theta_{01}), x_2(\tau_{01}, \theta_{01})). \tag{54}$$

If the environmental lobby only cares about its own local environment, then (54) implies that $x_1(\tau^*, \theta^*) < x_1(\tau_{01}, \theta_{01})$ and a) must hold.

If the environmental lobby is a supergreen which cares only about the sum of pollution at home and abroad, then (54) implies that $x_1(\tau^*, \theta^*) + x_2(\tau^*, \theta^*) < x_1(\tau_{01}, \theta_{01}) + x_2(\tau_{01}, \theta_{01})$ and b) must hold. Q.E.D.

Having shown how the emergence of the environmental lobby affects the local and global environments, let us now consider its impact on the net payoff of the domestic firm. There are two possibilities to consider.

First, if

(55) $(v_{o12}^{max} - v_{o1}^{max}) - (v_{o12}^{max} - v_{o2}^{max}) > v_{o12}^{max} - v_{o}^{max}$.

then by Proposition 4c, the net payoff for the domestic firm under the Nash equilibrium ξ^* is given by

(56) $v_{o12}^{max} - v_{o2}^{max} = \phi_1(\xi^*)$

Using (55) and (56), we obtain the following inequality

(57) $v_{o1}^{max} - v_{o}^{max} > \phi_1(\xi^*)$.

The expression on the left side of inequality (57) represents the domestic firm's net payoff before the emergence of the environmental lobby. We have just shown that if (55) holds, then the emergence of the environmental lobby has a negative impact on the net payoff of the domestic firm.

On the other hand, if

$$(v_{o12}^{max} - v_{o1}^{max}) - (v_{o12}^{max} - v_{o2}^{max}) \leq v_{o12}^{max} - v_{o}^{max}.$$

then by Proposition 4d, we have

(58) $v_{o12}^{max} - v_{o}^{max} = \phi_1(\xi^*) + \phi_2(\xi^*)$.

(59) $v_{o12}^{max} - v_{o1}^{max} \geq \phi_2(\xi^*)$.

Let us rewrite (58) as follows

(60) $\phi_1(\xi^*) = -\phi_2(\xi^*) + v_{o12}^{max} - v_{o}^{max}$.

Using (59) in (60), we obtain the following inequality

(61) $\phi_1(\xi^*) \geq v_{o1}^{max} - v_{o}^{max}$.

i.e., the emergence of the environmental lobby has a positive effect on the net payoff of the domestic firm. This result seems to be paradoxical. However, some reflection might be sufficient

to convince the reader that the result is quite plausible. Intuitively, one expects that the emergence of the environmental lobby will induce the home government to move away from (τ_{01}, θ_{01}) with ensuing deleterious effects on the profits of the domestic firm. However, because the home government's payoff remains the same after the emergence of the environmental lobby, it is possible, at least in theory, that the best response to the environmental lobby's strategy for the domestic firm is to reduce its political contribution. The end result might be an increase in the net payoff for the domestic firm. Another possibility is that the new environmental and trade policies (i.e., τ_{012} and θ_{012}) raise the firm's revenue to the extent that it compensates for the cost.[1] The end result might be an increase in the net payoff for the domestic firm. We summarize the results just obtained in the following proposition.

PROPOSITION 6: *The emergence of the environmental lobby will have a negative impact on the net payoff of the domestic firm if the following inequality holds:*

$$(V^{max}_{012} - V^{max}_{01}) < (V^{max}_{012} - V^{max}_{2}) + (V^{max}_{2} - V^{max}_{1}).$$

On the other hand, if the direction of this inequality is reversed, then the net payoff for the domestic firm will rise with the emergence of the environmental lobby.

When more explicit functional forms are introduced to the thesis, the above proposition will be used extensively to evaluate the changes in the net payoff of the domestic firm with the emergence of environmental group. Finally, let us consider the impact of the environmental lobby on the government.

---

[1] As we will see later in this chapter and the following chapter, in the case of transboundary pollution the emergence of a supergreen environmental lobby might increase a domestic firm's profit.

PROPOSITION 7: *Let* $\xi^* = (f_1^*, f_2^*, \tau^*, \theta^*)$ *be a Nash equilibrium the emergence of the environmental lobby either increases or has no impact on the payoff of the home government. More precisely, we have the following results:*

a) If $(V_{012}^{max} - V_{01}^{max}) - (V_{012}^{max} - V_{02}^{max}) \geq (V_{012}^{max} - V_{0}^{max})$, *then the government's payoff under the Nash equilibrium* ξ^* *is given by*

$$\phi_0(\xi^*) = V_0^{max},$$

where, we recall, V_0^{max} *is the payoff level it obtains by ignoring completely all the political contributions in the calculations of its utility or the payoff level it obtains in the principal-agent games it plays with the domestic firm. The home government gains no extra reward through its "cooperation with the two special-interest groups."*

b) If $(V_{012}^{max} - V_{01}^{max}) - (V_{012}^{max} - V_{02}^{max}) < (V_{012}^{max} - V_{0}^{max})$, *then the home government's payoff rises with the emergence of the environmental lobby. More specially the home government's payoff under the Nash equilibrium* ξ^* *is given by*

$$\phi_0(\xi^*) = V_{01}^{max} + V_{02}^{max} - V_{012}^{max} < V_0^{max}.$$

In the next section we will introduced some functional forms. This will enable us to obtain more explicit results and present some numerical examples.

3.3 The Model Under Some Special Functional Forms

To gain more insights about trade and environmental policies, we shall introduce some specific functional forms for demand and cost conditions as well as for pollution.

Consumers' Demand Curve

Following the literature on strategic trade (Brander and Spencer (1984) and Dixit (1988)), we assume the following inverse demand function for the good in question

(66) $$p(q) = a - q,$$

where q is the quantity demanded and $p(q)$ is the price corresponding to q.

Producers' profits

For the domestic firm –firm 1 – and the foreign firm – firm 2 – their cost function and emission function are assumed to be identical and have the following forms, respectively:

(67) $$c_i(q_i) = cq_i, \quad e(q_i) = \varepsilon q_i, \quad \text{for } i = 1,2.$$

where c and ε are positive constants. Given the output of firm 2, say q_2, the profit-maximizing output level of firm 1 is

$$q_1^{\pi} = (a - q_2 - c - \tau\varepsilon)/2.$$

Similarly, given the output of firm 1, say q_1, the profit-maximizing output level of firm 2 is

$$q_2^{\pi} = (a - q_1 - c - 0)/2.$$

If $(\tau,0)$ is the combination of environmental and trade policies chosen by the home government, then the Cournot equilibrium is represented by

(68a) $q_1^{\pi}(\tau,\theta) = (a - c + \theta - 2\tau\varepsilon)/3.$

(68b) $q_2^{\pi}(\tau,\theta) = (a - c - 2\theta + \tau\varepsilon)/3.$

We observe that the output of firm 1 (firm 2) is decreasing (increasing) in the emission tax and increasing (decreasing) in the tariff. Using (68), we obtain the following profits – in terms of the environmental and trade policies – for firm 1 and firm 2, respectively

(69a) $(a - c + \theta - 2\tau\varepsilon)^2/9.$

(69b) $(a - c - 2\theta + \tau\varepsilon)^2/9.$

Depending on the value of the parameters, the profit of each firm can be decreasing or increasing in emission tax and tariff.

Social Welfare

Let us begin with the damage function. For $i,j = 1,2$; $i \neq j$, let $e_{ij}(q_i) = \rho_{ij}\varepsilon q_i$ be the transboundary pollution flowing from country i into country j. The total pollution inflicted on country i is then given by

(70) $x_i(q_i,q_j) = (1 - \rho_{ij})\varepsilon q_i + \rho_{ji}\varepsilon q_j, \quad i \neq j, \; i,j = 1,2,$

where $0 \leq \rho_{ij},\rho_{ji} \leq 1$. The transboundary effects are captured by parameter ρ_{ij}. When $\rho_{ij}=0$, no pollution flows from country i into country j. Total pollution in each country can be obtained by substituting (68) into (70). Thus,

(71a) $x_1^{\pi}(\tau,\theta) = [\varepsilon(1-\rho_{12})(a-c+\theta-2\tau\varepsilon)+\rho_{21}(a-c-2\theta+\tau\varepsilon)]/3.$

(71b) $x_2^{\pi}(\tau,\theta) = [\varepsilon(1-\rho_{21})(a-c-2\theta+\tau\varepsilon)+\rho_{12}(a-c+\theta-2\tau\varepsilon)]/3.$

Bearing in mind that there is a positive relation between the environmental damage and the level of pollution, i.e., $d_i'(x_i)>0$ and, furthermore, assuming that $d_i''(x_i)>0$, the following functional form is suggested for $d_i(x_i)$

(72) $$d_i(x_i) = x_i^2.$$

Using (66) and (68), we obtain the following expression for consumer surplus

(73) $$\omega_1(\tau,\theta) = (1/18)(2a-2c-\tau\varepsilon-\theta)^2.$$

If a is sufficiently large, the above function is decreasing in (τ,θ).

Using (67) and (68), we obtain the following expression for tax revenue

(74) $$\omega_2(\tau,\theta) = \tau\varepsilon(a-c-2\theta-2\tau\varepsilon)/3 + \theta(a-c-2\theta)/3.$$

The welfare loss due to the damage made by polluting firms to the environment of the home country is given by

(75) $$\omega_3(\tau,\theta) = (\varepsilon^2/9)[(a-c)(1-\rho_{12}-\rho_{21})/(1-\rho_{12}\rho_{21})(2\tau\varepsilon-\theta) - \rho_{21}(\tau\varepsilon-2\theta)]^2.$$

Depending on the amount of pollution that the two countries transfer to each other -- captured by ρ_{12} and ρ_{21} -- ω_3 can be decreasing or increasing in (τ,θ). In the special case when there is no transboundary pollution (i.e., $\rho_{12}=\rho_{21}=0$), ω_3 is decreasing in τ and increasing in θ.

Social welfare also includes the following producer surplus

(76) $$\omega_4(\tau,\theta) = (a - c - \theta - 2\tau\varepsilon)^2/9,$$

which is basically the profit of the domestic firm in terms of trade and environmental policies.

While we follow the tradition by including both consumer surplus and producer surplus in the social welfare, one should note that since in our model the domestic firm operates in an imperfect competitive market it can take care of itself. Indeed, by including producer surplus in

the total welfare, the incumbent government attaches a higher weight to the payoff of the domestic firm. Thus, in this case, ω is not the welfare of ordinary voters but is a proxy for social welfare. The home government might put higher weight on the payoff of the domestic firm for different reasons: for example, they might consider "job" to be a big issue in the upcoming election.

After adding the various components of social welfare, we obtain the following expression for total welfare

(77) $$\omega(\tau,\theta) = (1/18)\{60(a-c+\tau\varepsilon-2\theta)+(2a-2c-\tau\varepsilon-\theta)^2-2(a-c+\theta-2\tau\varepsilon)(a-c+\tau\varepsilon+\theta)+ 2\varepsilon^2[(a-c-2\theta)/3-(\varepsilon^2/9)(a-c+\tau\varepsilon-2\theta)(1-\rho_{21})-\rho_{12}(a-c+\theta-2\tau\varepsilon)]^2\},$$

which can be increasing or decreasing in policy variables, depending on the values of the parameters.

The environmentalist's payoff

The utility of the representative environmentalist is assumed to be a function of the quality of the environment and the consumption of a numéraire good. The following form is proposed for the disutility function:

(78) $$\vartheta_i(x_i) = (x_i)^2$$

By substituting (71) into (78), we obtain the following expression for the gross welfare of the representative environmentalist

(79) $$\varphi_2(\tau,\theta) = \overline{m} - \eta_1[\varepsilon(1-\rho_{12})(a-c+\theta-2\tau\varepsilon)+\rho_{21}(a-c-2\theta+\tau\varepsilon)]/3]^2 - \eta_2[\varepsilon(1-\rho_{21})(a-c-2\theta+\tau\varepsilon)+\rho_{12}(a-c+\theta-2\tau\varepsilon)]/3]^2.$$

Now let (τ^*,θ^*) be a solution of the following maximization problem

(80) $$\max_{\tau,\theta}[\varphi_1(\tau,\theta)+\varphi_2(\tau,\theta)+\alpha\omega(\tau,\theta)]$$

and (v_1^*, v_2^*) be a point on the Pareto efficient frontier of V. Next, let f_1^* and f_2^* be two truthful political contribution schedules defined as follows

$$f_1^*(\tau,\theta) = \max[\varphi_1(\tau,\theta)-v_1^*,0],$$

$$f_2^*(\tau,\theta) = \max[\varphi_2(\tau,\theta)-v_2^*,0].$$

By Proposition 3, the list $\xi^* = (f_1^*, f_2^*, \tau^*, \theta^*)$ is a truthful Nash equilibrium. When we let (v_1^*, v_2^*) range over the Pareto efficient frontier of V and (τ^*, θ^*) range over the set of solutions of (81), we obtain all the truthful Nash equilibria of the game. If we assume that (80) has an interior solution, then (τ^*, θ^*) satisfies the following first-order condition

(81) $$D_1\varphi_1(\tau^*,\theta^*)+D_1\varphi_2(\tau^*,\theta^*)+\alpha D_1\omega(\tau^*,\theta^*)=0,$$

$$D_2\varphi_1(\tau^*,\theta^*)+D_2\varphi_2(\tau^*,\theta^*)+\alpha D_2\omega(\tau^*,\theta^*)=0.$$

Here, $D_i\varphi_j$ is the partial derivative of φ_j with respect to the ith argument, $i,j=1,2$. Under the functional forms we assume, (81) is a system of two linear equations in two unknowns τ^* and θ^*. This system can be solved to yield

(82)
$$\tau^* = \frac{(a-c)_i^1-3+\varepsilon^2(\rho_{12}+\rho_{21}-1)[2\varepsilon^2(1+\eta_1)\eta_2(\rho_{12}+\rho_{21}-1)-2-2\eta_1+3\eta_2+(1+\eta_1+\eta_2)(3\rho_{21}-2\rho_{12})]_i^1}{\varepsilon_i^1-2+\varepsilon^2(\rho_{12}+\rho_{21}-1)[2\varepsilon^2(1+\eta_1)\eta_2(\rho_{12}+\rho_{21}-1)-3-3\eta_1+\eta_2+(1+\eta_1+\eta_2)(\rho_{21}-3\rho_{12})]_i^1},$$

$$\theta^* = \frac{(a-c)_i^1-1+\varepsilon^2(\rho_{12}+\rho_{21}-1)[2\varepsilon^2(1+\eta_1)\eta_2(\rho_{12}+\rho_{21}-1)-1-\eta_1+2\eta_2+(1+\eta_1+\eta_2)(2\rho_{21}-\rho_{12})]_i^1}{\varepsilon_i^1-2+\varepsilon^2(\rho_{12}+\rho_{21}-1)[2\varepsilon^2(1+\eta_1)\eta_2(\rho_{12}+\rho_{21}-1)-3-3\eta_1-\eta_2+(1+\eta_1+\eta_2)(\rho_{21}-3\rho_{12})]_i^1}.$$

Because (82) is the only solution of (81), the environmental and trade policies under truthful Nash equilibrium are unique. Observe that if $\xi = (f_1, f_2, \tau, \theta)$ is a Nash equilibrium which is

not necessarily truthful and that $(\hat{\tau}, \hat{\theta})$ is an interior solution, then by (31), $(\hat{\tau}, \hat{\theta})$ also satisfies the first-order condition (81), i.e., $(\hat{\tau}, \hat{\theta}) = (\tau^*, \theta^*)$. However, (81) alone is not sufficient to determine $\hat{f}_1$ and $\hat{f}_2$. Therefore, to obtain a solution of the game, i.e., the environmental and trade policies as well as the political contribution schedules, one must look for a truthful Nash equilibrium.

Given α, (82) shows that in equilibrium the emission tax τ^* and tariff θ^* depend on the cost per unit of output, c; the emission per unit of output, ε; the weight that the incumbent government of the Northern country attaches to social welfare, α -- which for simplicity has been set equal to one in this exercise; the amount of the emission spillovers from one country to the other ρ_{ij} $(i \neq j)$, and the type of environmentalist captured by η_1 and η_2.

3.4 Green Model without Transboundary Pollution

Let us take a simple case in which there is no transboundary pollution (i.e., $\rho_{12}=\rho_{21}=0$) and the representative environmentalist is a green (i.e., $\eta_2=0$). For simplicity, we also assume that the weight attached to the social welfare by the home government, α, is one. Thus, by setting ρ_{12}, ρ_{21}, and η_2 equal to zero and η_1 and α equal to one in (82) we obtain

$$\tau^*_{012} = \frac{(a-c)(-3+4\varepsilon^2)}{\varepsilon(-2+6\varepsilon^2)}, \tag{83}$$

$$\theta^*_{012} = \frac{(a-c)(-1+2\varepsilon^2)}{-2+6\varepsilon^2}. \tag{84}$$

Given a, the environmental and trade policies depend on the cost and emission per unit of output. By substituting (83) and (84) into (69a) and (71a), the profit of the domestic firm and the damage to the home environment are, respectively,

(85) $$\varphi_1(\tau_{012}^{\bullet}, \theta_{012}^{\bullet}) = (a-c)^2 (2-6\varepsilon^2)^2.$$

(86) $$d_1(x_1^{\#}(\tau_{012}^{\bullet}, \theta_{012}^{\bullet})) = \varepsilon^2(a-c)^2 (2-6\varepsilon^2)^2.$$

Next, we eliminate the environmental lobby from the model. The equilibrium emission tax and tariff for the game consisting only of the home government and the domestic firm are given by

(87) $$\tau_{01}^{*} = \frac{(a-c)(-3+2\varepsilon^2)}{-2\varepsilon+3\varepsilon^3},$$

(88) $$\theta_{01}^{*} = \frac{(a-c)(-1+\varepsilon^2)}{-2+3\varepsilon^2}.$$

In this case, the profit of the domestic firm and the damage to the environment of the home country are, respectively,

(89) $$\varphi_1(\tau_{01}^{\bullet}, \theta_{01}^{\bullet}) = (a-c)^2 (2-3\varepsilon^2)^2.$$

(90) $$d_1(x_1^{\#}(\tau_{01}^{\bullet}, \theta_{01}^{\bullet})) = \varepsilon^2(a-c)^2 (2-3\varepsilon^2)^2.$$

In order for $(\tau_{01}^{\bullet}, \theta_{01}^{\bullet})$ to be an interior solution, we must have $\varepsilon>1.225$. If this inequality is satisfied, then (83), (84), (87), and (88) are all interior solutions. For remaining section we shall assume that $\varepsilon>1.225$.

A comparison of (83-84) and (87-88) allows us to assert that $\tau_{012}^{\bullet}>\tau_{01}^{\bullet}$ and $\theta_{012}^{\bullet}>\theta_{01}^{\bullet}$. One can also see that $\varphi_1(\tau_{01}^{\bullet}, \theta_{01}^{\bullet})$ is larger than $\varphi_1(\tau_{012}^{\bullet}, \theta_{012}^{\bullet})$. Hence, the emergence of the environmental lobby lowers the profit of the domestic firm. A comparison of (86) and (90) allows us to conclude that the presence of the environmental interest group improves the quality

of the home environment. The intuition is that in order to accommodate the environmental lobby, the home government raises the emission tax. To alleviate the impact of a higher emission tax on the domestic firm, it simultaneously raises the tariff. The end result is an improvement of the quality of the home environment at the expense of the firms' profits.

Now, suppose that the industry is not participating in this game and hence the game will be between the environmental lobby and the incumbent government in the Northern country. In this case the equilibrium environmental and trade policies are, respectively,

$$\tau_{02}^{*} = \frac{(a-c)(-1+4\varepsilon^2)}{\varepsilon+6\varepsilon^3}, \tag{91}$$

$$\theta_{02}^{*} = \frac{2(a-c)\varepsilon^2}{1+6\varepsilon^2}. \tag{92}$$

In this case, the profit of the domestic firm is

$$\varphi_1(\tau_{02}^{*}, \theta_{02}^{*}) = (a-c)^2(1-6\varepsilon^2)^2. \tag{93}$$

which is even lower than $\varphi_1(\tau_{012}^{*}, \theta_{012}^{*})$. Hence, the profit of the domestic firm is at its lowest possible level when the industry does not enter the game as a special-interest group.

Similarly, we can show that the quality of the home environment is at its highest level when the industry lobby is absent. In this case, the damage to the home environment is

$$d_1(x_1^{\#}(\tau_{02}^{*}, \theta_{02}^{*})) = \varepsilon^2(a-c)^2(1-6\varepsilon^2)^2. \tag{94}$$

Which is clearly smaller than $d_1(x_1^{\#}(\tau_{012}^{*}, \theta_{012}^{*}))$. Proposition 5 provides more general proof for this case. Moreover, we know that the disutility of the green environmentalist decreases as the quality of the home environment increases. Hence, the utility of the representative environmentalist is at its highest level in the presence of the environmental lobby.

Next, suppose the lobbies offer no political contribution to their government. In this case, the incumbent government chooses emission and trade taxes to maximizes social welfare, as defined by (77). The equilibrium emission tax and tariff are, respectively, given by

$$\tau_0^* = \frac{(a-c)(-1+2\varepsilon^2)}{\varepsilon(1+3\varepsilon^2)},$$

$$\theta_0^* = \frac{(a-c)\varepsilon^2}{1+3\varepsilon^2}.$$

In the traditional approach, τ_0^* and θ_0^* are called "socially optimal environmental and trade taxes" because they are obtained by maximizing social welfare. The above emission and trade taxes are clearly different from those obtained in the presence of interest groups. This shows that the political equilibrium may not be socially optimum. In the absence of lobbies, the profit of the domestic firm is given by

$$\pi_1(\tau_0^*, \theta_0^*) = (a-c)^2 (1+3\varepsilon^2)^2.$$

It is clear that the domestic firm's profit is lower than those obtained when all lobbies were present in the game.

When there is no interest group in the economy and hence the home government maximizes the social welfare, the damage to the home environment is given by

$$d_1(x_1^{\pi}(\tau_0^*, \theta_0^*)) = \varepsilon^2(a-c)^2 (1+3\varepsilon^2)^2,$$

which is clearly greater than $d_1(x_1^{\pi}(\tau_{02}^*, \theta_{02}^*))$ but smaller than $d_1(x_1^{\pi}(\tau_{012}^*, \theta_{012}^*))$. Hence, in this section we find out that the emergence of the green environmental group always improves the quality of the home environment.

To find the payoffs net of political contributions for the domestic firm and the representative environmentalist, one can apply Propositions 4c, 4d. This involves computing π_1^{max}, π_{01}^{max}, π_{02}^{max}, π_{012}^{max}. If the hypothesis of Proposition 4c is satisfied, then the net payoff of the domestic firm is uniquely determined and is given by $\pi_1^* = \pi_{012}^{max} - \pi_{02}^{max}$. More specifically, in this case we have

$$\pi_1^* = \frac{(a-c)^2}{(1-6\varepsilon^2)(-2-6\varepsilon^2)} \quad (95)$$

which is nonnegative for $\varepsilon \geq 1$. Hence, given $\varepsilon \geq 1$, $a \neq c$, no matter what the profit of the domestic firm is its net payoff is always positive.

The following table presents the results of a numerical example for the case $a=200$, $c=10$, $\varepsilon=1.4$, $\alpha=1$, and $\bar{m}=6500$.

Table 1 Green model without transboundary pollution

	τ	θ	d	d_1	ω_1	ω_2	*Joint payoff*
Social Welfare, ω	57.6	54.1	7237	1495	763	5005	7766
ω plus environmentalist group	72.8	58.4	7112	435	222	6065	13460
ω plus industrial group	32.2	47.0	9032	4700	2398	1800	9118
ω plus both lobbies	67.3	56.8	7076	743	379	5757	13750

τ = emission tax; θ = tariff; d_1 = the environmental damage in country 1; $d = d_1 + d_2$; ω_1 = profit of the domestic firm; ω_2 = gross payoff of the representative environmentalist.

As Table 1 shows, when only the industry lobby is present in the model the equilibrium level of emission tax and the tariff are, respectively, 32.2 and 47.0. After the environmental lobby comes to the scene the level of emission tax and tariff rise to 67.3 and 56.8, respectively. A comparison of the first and the second rows from the bottom shows that the profit of the domestic firm and the damage to the home environment decrease from 2398 to 379 and from 4700 to 743, respectively, with the emergence of the environmental group. Moreover, as the first row of

Table 1 shows when the incumbent government only maximizes the social welfare, the optimal emission tax and tariff and hence the home environmental damage are different from those obtained when the interest groups offer political contributions to their government.

From Table 2 we can see that $V_{012}^{max} - V_{0}^{max}$ =5984 is greater than $(V_{012}^{max} - V_{01}^{max}) + (V_{012}^{max} - V_{02}^{max})$ = 4921. Hence, according to Proposition 6, we know that the emergence of the environmental lobby should lower the net payoff of the domestic firm. In this example, the net payoff of the domestic firm decreases from 1352 to 290.

Moreover, since in this example $V_{012}^{max} - V_{0}^{max} > (V_{012}^{max} - V_{01}^{max}) + (V_{012}^{max} - V_{02}^{max})$, from Proposition 7 we expect the home government's payoff to rise with the emergence of the environmental lobby. Using Table 1 and Table 2, the government's net payoff in the presence of the environmental group is $\phi_0 = V_{01}^{max} + V_{02}^{max} - V_{0}^{max}$ = 9538, which is greater than V_{0}^{max} =7766, its net payoff in the absence of the green environmental lobby.

Table 2 Green model without transboundary pollution: Net payoffs

V_{0}^{max}	V_{012}^{max}	$V_{012}^{max} - V_{0}^{max}$	$V_{01}^{max} - V_{0}^{max}$	$V_{1}^{*} = V_{012}^{max} - V_{02}^{max}$	$V_{2}^{*} = V_{012}^{max} - V_{01}^{max}$	$(V_{012}^{max} - V_{01}^{max}) + (V_{012}^{max} - V_{02}^{max})$	$\phi_0 = V_{01}^{max} + V_{02}^{max} - V_{012}^{max}$
7766	13750	5984	1352	290	4632	4921	8828

For $\eta_1 = 1$, $\eta_2 = 0$, $a = 200$, $c = 10$, $\varepsilon = 1.4$, $\alpha = 1$, and $\overline{m} = 6500$.

The political contribution of the domestic firm and the environmentalist group are, respectively, 89 and 1126. As expected, the political contribution of the environmentalist is higher in this case due to the higher weight that the incumbent government attaches to the welfare of the domestic firm by including producer surplus as a component of social welfare. In this example, we can show that when the producer surplus is excluded from social welfare, both interest groups

contribute the same amount of money to the politicians. The results obtained in Table 2 are illustrated in Figure 4, which shows that we have a unique solution for this example.

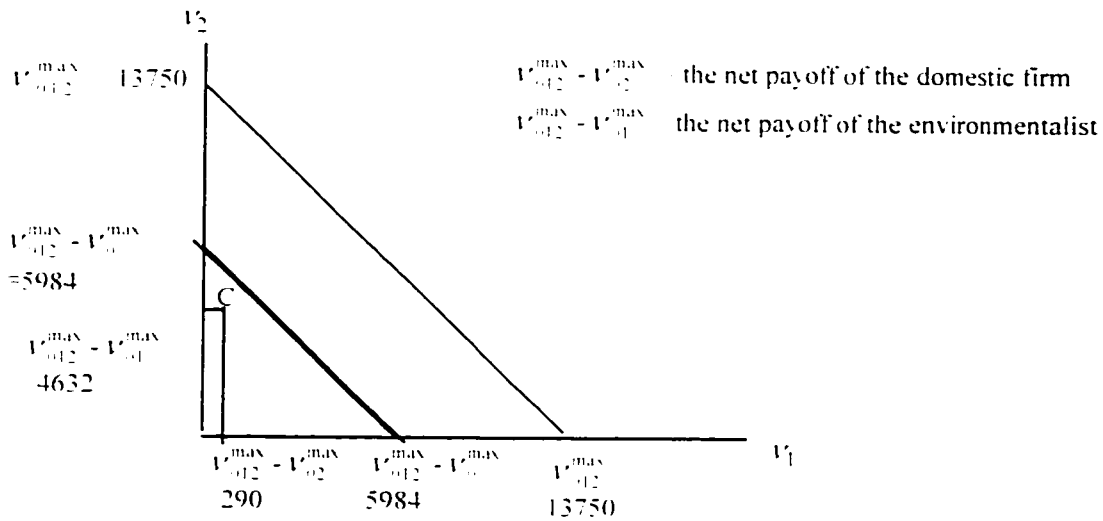


Figure 4 Green model without transboundary pollution

To sum up, the green environmental lobby has been able to increase the quality of the home environment and hence its utility by contributing to its incumbent government. In our example, the domestic firm is better off if it contributes to the incumbent government because its absence from the political scene will further deteriorate its payoff. This might provide additional incentive for an industry to form an interest group in this model.

3.5 Free Trade in the Green Model without Transboundary Pollution

In the model just discussed, we saw that the domestic firm will be pressing for protectionist policies. In this section, we will show that a representative environmentalist may have common cause with protectionist tendencies if he believes that liberalized trade will result in more pollution.

To examine this case let us assume that international agreements have ruled out the use of tariffs and that the only policy instrument available to the incumbent government in the Northern country is the emission tax.

We set $\theta=0$ in the model presented in Section 4 and solve for the equilibrium level of emission tax. First, consider the game between the industry lobby and the incumbent government. In the absence of the environmental group, the profit of the domestic firm and the damage to the home environment are, respectively.

(96) $$\varphi_1(\tau_{01}^{\bullet}) = 9(a-c)^2(5-8\varepsilon^2)^2.$$

(97) $$d_1(x_1^{\#}(\tau_{01}^{\bullet})) = 9\varepsilon^2(a-c)^2(5-8\varepsilon^2)^2.$$

When the environmental lobby enters the game the profit of the domestic firm and the damage to the home environment are, respectively.

(98) $$\varphi_1(\tau_{012}^{\bullet}) = 9(a-c)^2(5-16\varepsilon^2)^2.$$

(99) $$d_1(x_1^{\#}(\tau_{012}^{\bullet})) = 9\varepsilon^2(a-c)^2(5-16\varepsilon^2)^2.$$

From the above results it is clear that (96) is greater than (98) and (97) is greater than (99). Thus, the emergence of a green environmental lobby lowers the profit of the domestic firm and improves the quality of the home environment

We can also show that the damage to the home environment in the absence of the industrial lobby is

(100) $$d_1(x_1^{\#}(\tau_{02}^{\bullet})) = 9\varepsilon^2(a-c)^2(3-16\varepsilon^2)^2.$$

Thus, without the industry lobby the quality of the home environment and the utility of the green environmentalist are at their highest possible levels.

Moreover, by comparing the damage to the home environment under the assumption of free trade with the one derived in the absence of trade liberalization we find out that (99) is greater than (86) (i.e., $9\varepsilon^2(a-c)^2/(6-18\varepsilon^2)^2$). Hence, trade liberalization deteriorates the quality of the home environment. Thus, the green environmental lobby might have incentive to be against free trade and act as a protectionist. One explanation for this might be that since the home government cannot use tariff as a policy instrument, it cannot protect its domestic firm against foreign competition. To accommodate the domestic firm it has to relax the environmental standards.

Next, we turn to net payoff of the industry lobby. In this case, given Proposition 4c is satisfied the payoff of the domestic firm net of its political contribution -- i.e., $v_1^{\bullet}=v_{012}^{max}-v_{02}^{max}$ -- is

$$(101) \qquad v_1^{\bullet}=\frac{9(a-c)^2}{(-5+16\varepsilon^2)(3+16\varepsilon^2)},$$

which is nonnegative for $\varepsilon\geq 1$. Hence, given $\varepsilon\geq 1$, $a\neq c$, the domestic firm's net payoff is positive. If we compare (101) with (95), the net payoff of the industry lobby in non free trade case, we shall observe that trade liberalization increases the payoff, net of political contribution, of the domestic firm.

The following table presents the results of a numerical example for the case of free trade. It is the solution of the numerical example in Section 3.4 with the additional constraint $\theta = 0$.

Table 3 Green Model without Transboundary Pollution under Free trade

	τ	d	d_1	φ_1	φ_2	*joint payoff*
Social Welfare, ω	35.2	14288	1825	931	5675	6687
ω plus environmentalist group	50.1	8057	539	275	5961	12195
ω plus industrial group	10.7	14730	5583	2848	917	8315
ω plus both lobbies	44.7	14808	916	468	5583	12553

For a=200, c=10, z=1.4, α=1, and $\overline{m}$=6500. τ: emission tax; θ = tariff; d_1 = the environmental damage in country 1; d = d_1+d_2; φ_1: profit of the domestic firm; φ_2: gross payoff of the representative environmentalist.

Consider the last row of Table 3 for which both lobbies are active in the economy. In this case the emission tax and the profit of the domestic firm are equal to 44.7 and 468, respectively. As the second row from the bottom shows, in the absence of the environmental lobby the emission tax decreases to 10.7 and the profit of the domestic firm increases to 2848. In this case, the utility before political contribution of the green environmentalist also decreases from 5583 to 917 due to a higher level of damage to the home environment. As Table 3 shows, the optimal emission tax resulting from maximizing the social welfare is 35.2, which is different from those obtained when the lobbies offer political contributions to their incumbent government.

As Table 4 shows, in this example, $v_{012}^{max} - v_{01}^{max} = 5867$ is greater than $(v_{012}^{max} - v_{01}^{max}) - (v_{012}^{max} - v_{02}^{max}) = 4597$. Hence the emergence of the environmental lobby lowers the net payoff of the domestic firm from 1628 to 359. Also from Proposition 7, we know that the home government's payoff should rise with the emergence of the environmental lobby. In this case, the home government's payoff rises from $v_0^{max} = 6686$ to $\varphi_0 = v_{012}^{max} - v_{02}^{max} - v_{012}^{max} = 7956$.

Table 4 Free Trade in Green model without transboundary pollution: Net payoffs

V_1^{max}	V_{012}^{max}	$V_{012}^{max} - V_0^{max}$	$V_{01}^{max} - V_0^{max}$	$V_1^* = V_{012}^{max} - V_{02}^{max}$	$V_2^* = V_{012}^{max} - V_{01}^{max}$	$(V_{012}^{max} - V_{01}^{max}) - (V_{012}^{max} - V_{02}^{max})$	$\phi_0 = V_{01}^{max} + V_{02}^{max} - V_{012}^{max}$
6686	12553	5867	1628	359	4238	4597	7956

For $a=200$, $c=10$, $\varepsilon=1.4$, $\alpha=1$, and $\overline{m}=6500$.

The political contributions of the domestic firm and the home environmentalist are equal to 109 and 1346 respectively. The above results are also illustrated in figure 5, which shows Pareto efficient frontier is below MN. Hence we have a unique solution for the game.

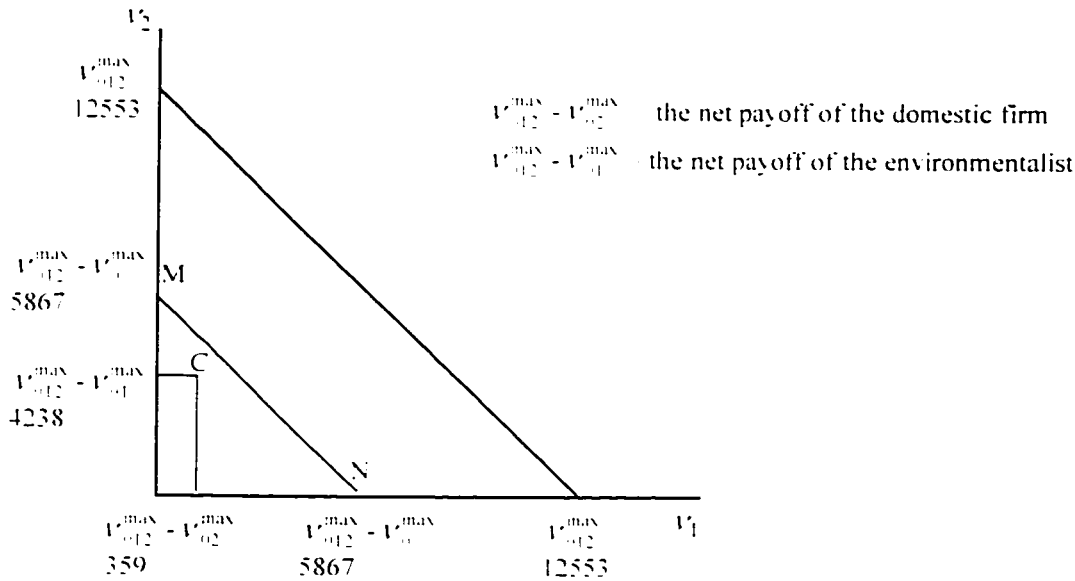


Figure 5 Free trade: Green model without transboundary pollution

Next section studies changes in the environmental quality and the payoffs when transboundary movement of pollution is allowed.

3.6 Green Model with Transboundary Pollution

In this section, the environmentalist is still a green but pollution can spillover from one country to another. For simplicity, it is assumed that the amount of pollution that spilling from country 1 into country 2 is negligible and that a considerable amount of pollutants is inflicted upon the Northern country by the Southern country. Thus, we set $\rho_{12}=0$ and $\rho_{21}>0$ then solve the model for the equilibrium emission tax and tariff in the presence of the two lobbies and the incumbent government in the game. We obtain the following results

$$\tau_{012}^{*} = \frac{(a-c)[3+\varepsilon^{2}(-4-2\rho_{21}+6\rho_{21}^{2})]}{2\varepsilon[1+\varepsilon^{2}(-3+2\rho_{21}+\rho_{21}^{2})]}. \tag{102}$$

$$\theta_{012}^{*} = \frac{(a-c)[1+\varepsilon^{2}(-2-2\rho_{21}+4\rho_{21}^{2})]}{2+2\varepsilon^{2}(-3+2\rho_{21}+\rho_{21}^{2})]}. \tag{103}$$

As (102) and (103) show, in addition to the cost and the emission per unit of output, the equilibrium emission tax and tariff also depend on the coefficient ρ_{21} that characterizes the pollution spillovers from the Southern country into the Northern country.

Using (102) and (103) we obtain the following expressions for the profit of the domestic firm and the damage to the home environment, respectively.

$$\varphi_{1}(\tau_{012}^{*}, \theta_{012}^{*}) = \frac{(a-c)^{2}[1-2\varepsilon^{2}(\rho_{21}-1)\rho_{21}]^{2}}{4[1-\varepsilon^{2}(2\rho_{21}-\rho_{21}^{2}-3)]^{2}} \tag{104}$$

and

(105) $$d_1(x_1^{\#}(\tau_{012}^{*}, \theta_{012}^{*})) = \frac{(a-c)^2\varepsilon^2(\rho_{21}-1)^2}{4[1-\varepsilon^2(2\rho_{21}-\rho_{21}^2-3)]^2}$$

Next, we eliminate the environmental group from the model and solve the system for the equilibrium emission tax and tariff. The profit of the domestic firm and the damage to the home environment in this game are given respectively, by

(106) $$\varphi_1(\tau_{01}^{*}, \theta_{01}^{*}) = \frac{(a-c)^2[1-\varepsilon^2(\rho_{21}-1)\rho_{21}]^2}{[2-\varepsilon^2(2\rho_{21}-\rho_{21}^2-3)]^2}$$

and

(107) $$d_1(x_1^{\#}(\tau_{01}^{*}, \theta_{01}^{*})) = \frac{(a-c)^2\varepsilon^2(\rho_{21}-1)^2}{[2-\varepsilon^2(2\rho_{21}-\rho_{21}^2-3)]^2}$$

Comparing (104) and (106) one can see that when the environmental lobby comes to the picture the profit of the domestic firm might increase, decrease, or remain unchanged, depending on the values of ε and ρ_{21}.

Indeed, it is not difficult to show that under certain circumstances the presence of the environmentalist has positive impact on the domestic firm's profit. This result should not be surprising when we allow transboundary pollution. One possible reason is that when the level of emission at home is low and the total amount of pollution received from the foreign country is high enough, a green environmental lobby might favor a combination of environmental and trade policies that reduces the amount of pollution it receives from foreign sources. This policy combination might increase the revenue of the domestic firm to the extend that it surpasses the

increase in its costs. Thus, the profit of the domestic firm can increase with the emergence of the environmental group.

In comparing the pollution damages represented by (105) and (107), we see that for $1>\rho_2\geq 0$ and $\varepsilon\geq 1$ the denominator of (107) is smaller than that of (105). Hence, the damage to the home environment is higher without the green environmental lobby. Thus, regardless of the changes in the profit of the domestic firm, the emergence of the environmental group improves the quality of the home environment.

The following table summarizes the results of a numerical example for the present model.

Table 5 Green model with transboundary pollution

	τ	θ	d	d_1	ω_1	ω_2	*joint payoff*
Social Welfare, ω	1.04	8.09	18.59	0.23	0.91	0.77	4.76
ω plus environmentalist lobby	1.05	8.11	18.52	0.10	0.94	0.90	5.61
ω plus industry lobby	1.06	7.55	30.95	0.17	1.57	0.83	5.95
ω plus both lobbies	1.07	7.56	31.14	0.07	1.62	0.92	6.84

For η_1 1, η_2 0, a=20, c=10, ε=10, α 2, $\overline{m}$ 1, and ρ_2 0.7, τ emission tax; θ = tariff, d_1= the environmental damage in country i; d= d_1+d_2; ω_1 profit of the domestic firm; ω_2 gross payoff of the representative environmentalist.

In Table 5, as shown on the second row from the bottom , in the absence of the environmental group the equilibrium emission tax and tariff are, respectively, 1.06 and 7.55. With the emergence of the green environmental lobby emission tax increases to 1.07 and tariff increases to 7.56. In this case, the profit of the domestic firm increases from 1.57 to 1.62, and the damage to the home environment decreases from 0.17 to 0.07. Higher environmental quality at home in turn increases the utility of the green environmentalist from 0.83 to 0.92. Moreover, as Table 5 shows the optimal environmental and trade taxes resulting from maximizing social welfare (which are, respectively, equal to 1.04 and 8.09) are not equal to those obtained in the political game played by the interest groups and the incumbent government in the North.

In this example, $v_{012}^{max} - v_{0}^{max} = 2.08$ is smaller than $(v_{012}^{max} - v_{01}^{max}) + (v_{012}^{max} - v_{02}^{max}) = .12$ and hence according to Proposition 4d the payoff for the home government is unique and given by $v_{0}^{max} = 4.76$. Using Proposition 6, we know that the emergence of the environmental lobby increases the net payoff of the domestic firm in this case.

Table 6 Green model with transboundary pollution: Payoffs

v_{0}^{max}	v_{012}^{max}	$v_{01}^{max} - v_{0}^{max}$	$v_{012}^{max} - v_{0}^{max}$	$v_{012}^{max} - v_{02}^{max}$	$v_{012}^{max} - v_{01}^{max}$	$(v_{012}^{max} - v_{01}^{max}) + (v_{012}^{max} - v_{02}^{max})$
4.76	6.84	1.19	2.08	1.23	0.89	2.12

For $\eta_1 = 1$, $\eta_2 = 0$, $a = 20$, $c = 10$, $\varepsilon = 10$, $\alpha = 2$, $\overline{m} = 1$, and $\rho_2 = 0.7$.

The results obtained in the above tables are also illustrated in Figure 6. Since $v_{012}^{max} - v_{0}^{max} < (v_{012}^{max} - v_{01}^{max}) + (v_{012}^{max} - v_{02}^{max})$ according to Proposition 4d the net payoffs for the two lobbies are not unique but constitute a line segment. As Figure 6 depicts, the point C is above MN and the Pareto efficient frontier is the line segment ED.

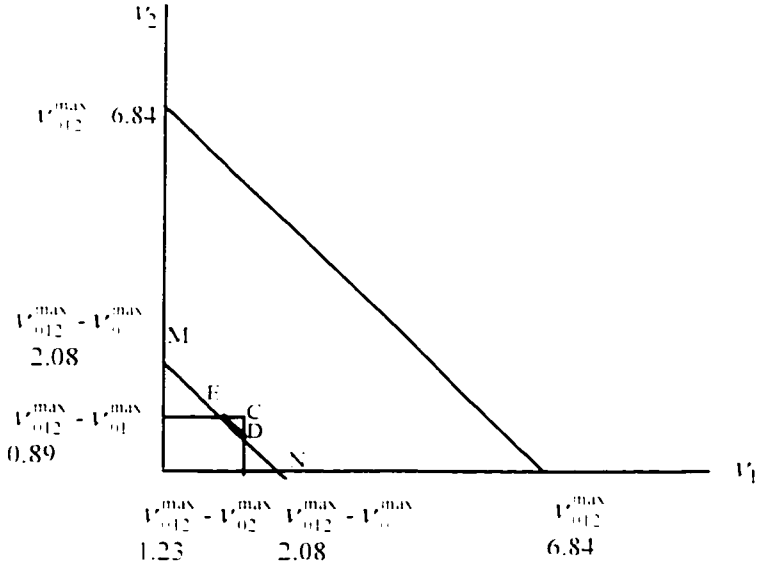


Figure 6 Green model with transboundary pollution

To sum up, the environmental lobby has been able to improve the quality of the home environment by contributing to the incumbent government. we showed that the emergence of the environmental lobby raises the payoff of the domestic firm. This exercise is also a good example for the case where an environmentalist group might be pressing for tougher environmental policy and also may have common cause with protectionist tendencies if it believes that laxer trade policy will result in more pollution.

3.7 Supergreen Model with Transboundary Pollution

In this section, the environmentalist is assumed to be a supergreen. Suppose that the representative environmentalist puts equal weight on the home and the foreign environment (i.e., $\eta_1=\eta_2=\eta$). As in the previous section, we assume that while the amount of pollution spillover from country 1 to country 2 is zero, there is a considerable amount of pollution flowing from the Southern to the Northern country.

Thus, after setting $\rho_{12}=0$, $\rho_{21}>0$, $\eta_1=\eta_2=\eta$, and solving the model for the equilibrium emission tax and tariff, we obtain

$$t^* = \frac{(a-c)\{-3+4\varepsilon^4(-1+\rho_{21})^2\eta-\varepsilon^2(-1+\rho_{21})[4-3\eta-3\rho_{21}(2+\eta)]\}}{\varepsilon\{-2+4\varepsilon^4(-1+\rho_{21})^2\eta-\varepsilon^2(-1+\rho_{21})[6-\eta-\rho_{21}(2+\eta)]\}}, \tag{108}$$

$$\theta^* = \frac{(a-c)\{-1+4\varepsilon^4(-1+\rho_{21})^2\eta-2\varepsilon^2(-1+\rho_{21})[1-\eta-\rho_{21}(2+\eta)]\}}{-2+4\varepsilon^4(-1+\rho_{21})^2\eta-\varepsilon^2(-1+\rho_{21})[6-\eta-\rho_{21}(2+\eta)]}. \tag{109}$$

Given a and c, (108) and (109) show that the equilibrium emission tax and tariff depend on the emission per unit of output, the coefficient that characterizes the pollution spillover from the Southern country to the Northern country, and the type of environmentalist captured by η_1, η_2.

Since in this section our environmentalist is assumed to be a supergreen, we set $\eta_1=\eta_2=\eta=1$ in (108) and (109). The profit of the domestic firm and the damage to the home environment in the presence of the two lobbies are, respectively, given by

$$(110) \qquad \varphi_1(\tau_{012}^{*}, \theta_{012}^{*}) = \frac{(a-c)^2[1-\varepsilon^2(1-4\rho_{21}+3\rho_{21}^2)]^2}{[-2+4\varepsilon^4(\rho_{21}-1)^2-\varepsilon^2(5-2\rho_{21}-3\rho_{21}^2)]^2}$$

$$(111) \qquad d_1(x_1^{\#}(\tau_{012}^{*}, \theta_{012}^{*})) = \frac{(a-c)^2\varepsilon^2(\rho_{21}-1)^2[\varepsilon^2(\rho_{21}-1)-1]^2}{[-2+4\varepsilon^4(\rho_{21}-1)^2-\varepsilon^2(5-2\rho_{21}-3\rho_{21}^2)]^2}$$

Next, we eliminate the environmental group from the model and solve the game for the equilibrium level of environmental and trade policies. In this case, the domestic firm's profit and the environmental damage at home are given, respectively, by

$$(112) \qquad \varphi_1(\tau_{01}^{*}, \theta_{01}^{*}) = \frac{(a-c)^2[1-\varepsilon^2(\rho_{21}-1)\rho_{21}]^2}{[2-2\varepsilon^2(-3-2\rho_{21}+\rho_{21}^2)]^2}$$

and

$$(113) \qquad d_1(x_1^{\#}(\tau_{01}^{*}, \theta_{01}^{*})) = \frac{(a-c)^2\varepsilon^2(\rho_{21}-1)^2}{[2-\varepsilon^2(-3-2\rho_{21}+\rho_{21}^2)]^2}$$

By comparing (110) with (112) and (111) with (113), one can see that with the emergence of the environmental lobby, the gross payoff of the domestic firm and the quality of the home environment might increase, decrease, or remain unchanged, depending on the values of ε and ρ_{21}.

By comparing the above case with the previous one in which the environmentalist is a green, we observe that in both cases the impact of the environmental lobby on the profit of the domestic firm is not known unless we specify the values of ε and ρ_{21}, but in the green model we

know that the emergence of a green environmentalist improves the quality of the home environment while the effect of a supergreen environmentalist on the home environment is not known. However, from Proposition 5b, we know that the damage to the global (i.e., North + South) environment is lower in the presence of a supergreen environmental lobby.

The following table provides the results of a numerical example for the present model. In this example, $\eta_1=1$, $\eta_2=1$, $a=100$, $c=10$, $\varepsilon=2$, $\alpha=.5$, $\bar{m}=420$, and $\rho_{21}=0.7$.

Table 7 Supergreen model with transboundary pollution

	τ	θ	d	d_1	φ_1	φ_2	*joint payoff*
Social Welfare, ω	38	65	418	370	2.4	2.2	294.23
ω plus environmentalist lobby	43	--	69	49	2.7	351	548.63
ω plus industry lobby	40	61	351	258	10	69	289.28
ω plus both lobbies	45	71	79	24	38	341	558.70

For $\eta_1=1$, $\eta_2=1$, $a=100$, $c=10$, $\varepsilon=2$, $\alpha=.5$, $\bar{m}=420$, and $\rho_{21}=0.7$, τ = emission tax; θ = tariff, d_1 = the environmental damage in country 1; $d=d_1+d_2$; φ_1 = profit of the domestic firm; φ_2 = gross payoff of the representative environmentalist.

In Table 7, as the second row from the bottom shows, in the absence of the environmental group, the equilibrium emission tax and tariff are, respectively, 40 and 61. With the emergence of the supergreen environmental lobby the emission tax increases to 45 and the tariff also rises to 71. A large increase in tariff might have been demanded by the supergreen environmental lobby to change the behavior of the foreign firm and hence to improve the quality of the environment. Table 7 shows that the emergence of the environmental lobby raises the profit of the domestic firm from 10 to 38. This result is not surprising because, as the example shows, the supergreen environmentalist group has common cause with the protectionist tendency of the domestic firm and hence is pressing for more stringent trade policy to lower the total amount of pollution. In this example, the presence of the supergreen environmentalist lobby also decreases the damage to the home environment, d_1 and the world environment, d (i.e., d_1+d_2). This in turn increases the

utility of the supergreen environmentalist from 69 to 341. As Table 7 shows, the socially optimal environmental and trade taxes resulting from maximizing social welfare (i.e., 38 and 65, respectively) are different from their corresponding political equilibrium taxes.

The payoffs are given in Table 8. As can be seen, $v_{012}^{max} - v_{0}^{max} = 264.47$ is smaller than $(v_{012}^{max} - v_{01}^{max}) + (v_{012}^{max} - v_{02}^{max}) = 279.48$ and hence, according to Proposition 4d, the payoff for the home government is unique and given by $v_{1}^{max} = 558.7$. Using Proposition 6, we know that the emergence of the environmental lobby increases the net payoff of the domestic firm in this case.

Table 8 Supergreen model with transboundary pollution: Payoffs

v_{0}^{max}	v_{012}^{max}	$v_{012}^{max} - v_{0}^{max}$	$v_{012}^{max} - v_{02}^{max}$	$v_{012}^{max} - v_{01}^{max}$	$v_{012}^{max} - v_{01}^{max} - v_{012}^{max} - v_{02}^{max}$
294.23	558.70	264.47	10.07	269.41	279.48

For $\eta_1 = 1$, $\eta_2 = 1$, $a = 100$, $c = 10$, $\varepsilon = 2$, $\alpha = .5$, $\overline{m} = 420$, and $\rho_2 = 0.7$.

3.8 Conclusion

In this chapter, we have formulated a game played by two special interest groups -- an industry lobby and an environmental lobby -- and their incumbent government in an industrial nation, to explain how environmental and trade policies are set in the context of North-South trade. In the game, the special-interest groups announce schedules of political contributions to their incumbent national government. The contributions vary according to the policies set by the national government. The incumbent government of the industrialized nation takes into account the political contributions of the interest groups in setting policies. An equilibrium of such a game then determines endogenously the trade and environmental policies adopted in this country.

The chapter sheds some lights on how the presence of an environmentalist interest group in the Northern country can affect the behavior of the incumbent government in choosing its trade and environmental policies.

In general, it is shown that equilibrium emission tax and tariff depend on the cost and emission per unit of output, the weight that an incumbent government in the Northern country attaches to social welfare, the amount of emission that flows from one country to another, and the type of environmentalists.

We find that in the absence of transboundary pollution, the emergence of the green environmental lobby lowers the profit of the domestic firm. Moreover, the chapter finds that trade liberalization can result in deterioration of the home environment. This might provide insight for the case in which environmentalists form an alliance with protectionist tendencies.

When transboundary pollution is allowed, the net payoff of the firm operating in the Northern country can be higher or lower, depending on the level of tariff and the emission tax set by its government. These in turn are mainly affected by the emission per unit of output and the amount of pollution that countries transfer to each other. However, in all cases, the presence of a green environmental interest group improves the quality of the environment in the North.

This chapter also shows that if the environmental lobby is a supergreen, then the quality of the home environment might be higher or lower with the emergence of the environmental group, depending on the emission per unit of output and the coefficient of the pollution spillover from one country to the other. However, the quality of the global environment rises with the emergence of a supergreen environmental lobby in the North. This might have particular insight for lobbying to limit GHG (greenhouse gas) emissions.

Finally, this chapter shows that the environmental and trade policies resulting from a political process may be above or below those obtained by maximizing social welfare. In another words, when various interest groups are present in the economy, the political equilibrium levels of emission tax and tariff are not necessarily socially optimum. Hence, the damage to the home environment might be higher or lower than its socially optimal level.

In the next chapter, we extend the model developed in this chapter and formulate a game between two rich countries of the North. The implication of the North-North assumption is that there are active environmental groups in both countries. Moreover, ordinary voters in the North are also concerned about the quality of their environment. Hence, the incumbent national governments in both countries will actively pursue environmental policies. The two firms are assumed to compete in a market located in a third country. The equilibrium of the game played between the special-interest groups and the incumbent governments determines endogenously the environmental policies in the Northern countries.

4

DETERMINATION OF ENVIRONMENTAL POLICY: THE NORTH-NORTH CASE

4.1 Introduction

In the previous chapter, we studied the formation of environmental and trade policies in the North-South model. No active environmental group was assumed to exist in the Southern nation and this was attributed to low level of income in the South. We assumed that only the incumbent government in the Northern country actively pursues trade and environmental policies.

In the last three decades, the world has witnessed a rapid increase of the environmental movement in Northern countries. Now, environmentalists have a strong presence on the political scene of their countries.[1] The Northern economies are now much more interconnected than they were thirty years ago. Moreover, the world trend is to remove barriers to free trade. Even if free

[1] See Chapter 2, Section 3.

trade prevails, however, as is our assumption in this chapter, environmental policy instruments are still at the disposal of governments in Northern countries. No matter what type of trade agreement is signed, air and water pollution do not respect national or political borders and flow easily from one territory to another. For example, Germany and Scandinavia can have very stringent environmental regulations, but could still suffer from acid rain resulting from loosely regulated power-plant emissions in Britain. All these make the linkages between trade and the environment in the Northern countries very complicated.

This chapter formulates a non-cooperative game between two countries of the North. Organized environmental movements are assumed to exist in both countries. As before, environmentalists are classified either as green or supergreen. One implication of the North-North assumption is that even ordinary voters are concerned with environmental quality. Hence, the incumbent government in each country has an incentive to actively pursue environmental policy. There are two firms, one in each country. These two firms are the only suppliers on a market for a certain commodity located in a third country. Firms and environmentalists in each country can influence the behavior of their incumbent national governments by offering them political contributions. The incumbent government in each country takes into account these political contributions in formulating environmental policies.

This chapter studies how environmental policies are determined endogenously in the Northern countries. We will also see how the presence of environmental interest groups in the North affects the quality of the environment and the payoffs of the domestic and foreign firms. To concentrate on this objective, we shall assume that international agreements preclude the use of tariff policies.

The chapter is organized as follows. The model is presented in Section 4.2. In Section 4.3, a characterization of the solution is given. Some functional forms are introduced in Section 4.4. This allows us to find the equilibrium level of the emission tax in each country under various assumptions. In Section 4.5, the model is solved for the case in which the environmental lobby is a green and there is no transboundary pollution. In Section 4.6, we solve the model under the assumption of transboundary pollution. Section 4.7 analyzes the problem when the environmental interest group is a supergreen. Section 4.8 contains some concluding remarks.

4.2 The Model

There are two firms, say a domestic firm and a foreign firm , with the domestic firm located in a country, called country 1, and the foreign firm located in another country, called country 2. These two firms are the only suppliers on a market for a certain commodity located in a third country, called country 3. In what follows, country 1 and country 2 will frequently be referred to as the home country and the foreign country, respectively. Let $p: q \rightarrow p(q)$ be the inverse demand curve for the commodity in question. Because the market is served by only two firms, we are dealing with a duopolistic industry. Furthermore, because the market is located in a third country, the consumer surplus associated with the consumption of this commodity does not enter the welfare calculus of country 1 and country 2.

The production activities of each firm generate a certain amount of pollution, part of which might cross the border and flow into the other country. For each i=1,2, the output of the firm operating in country i is denoted by q_i. The total cost of producing q_i and the pollution generated by q_i are denoted, respectively, by $c_i(q_i)$ and $e_i(q_i)$. It is assumed that $e_i(q_i)$ to be

increasing in q_i. Also, let $e_{ii'}(q_i)$ be the transboundary pollution flowing from country i into country i', $i \neq i'$, that arises from the production activities of the firm in country i. The total pollution inflicted on country i is thus given by

$$x_i(q_1, q_2) = e_i(q_i) - e_{ii}(q_i) - e_{i'i}(q_{i'}), \quad i \neq i', \; i, i' = 1, 2. \tag{1}$$

Let $d_i(x_i)$ be the damage suffered by country i when the level of pollution in this country is given by x_i.

Suppose both rival countries are rich nations of the North. We also assume that in each country, there exists a strong group of environmentalists who actively seeks to improve the quality of the environment.

As in the previous chapter, the utility of the representative environmentalist in country i is assumed to depend on the consumption of a numéraire good and the quality of the environment both at home and abroad:

$$u_i(m, x_1, x_2) = m - \sum_{j=1}^{2} \eta_{ij} \vartheta_{ij}(x_j), \quad i = 1, 2. \tag{2}$$

Here m is the amount of the numéraire good consumed; $\eta_{11} > 0$, $\eta_{12} \geq 0$, $\eta_{21} \geq 0$ and $\eta_{22} > 0$ are constants; $\vartheta_{11}(x_1)$ and $\vartheta_{12}(x_2)$ denote, respectively, the disutilities caused by the pollution at home and abroad for the home environmentalist while $\vartheta_{22}(x_2)$ and $\vartheta_{21}(x_1)$ denote, respectively, the disutilities caused by the pollution in his own environment and the environment of country 1 for the foreign environmentalist. If $\eta_{12} = \eta_{21} = 0$, the representative environmentalists care only about their own local environment and they will be classified as greens. However, when $\eta_{12} > 0$ and $\eta_{21} > 0$, their concerns are more global, and they will be classified as supergreens if η_{12} and η_{21} are significantly positive.

Suppose that the incumbent government in each country actively pursues environmental policy. The policy instrument for each governments is assumed to be an emission tax. Let τ_i be the tax per unit of emission that the incumbent government in country i imposes on its domestic firm. The incumbent governments have utility functions that depend on the political contributions they receive and some measure of social welfare. We assume that social welfare in each country is given by tax revenue plus producer surplus minus pollution damage to its own environment.

Following Grossman and Helpman (1995), we assume that special-interest groups do not openly announce their willingness to pay the incumbent government to conduct favorable policies. In another word, the "true" monetary arrangements between interest groups and their government are not known to the foreign interest groups and foreign politicians. Since the contribution schedules are unobservable abroad, a special-interest group cannot influence the behavior of the foreign government. The fact that there is no binding written contract specifying the political contributions of pressure groups to their incumbent governments also helps us to rule out the possibility of coalition among interest groups.

The model is a three-stage game and its extensive form is as follows. In the first stage, the representative environmentalists and the firms announce their political contribution schedules. The schedules announced by the domestic firm and the foreign firm are, respectively, $f_{11}:(\tau_1,\tau_2)\rightarrow f_{11}(\tau_1,\tau_2)$ and $f_{21}:(\tau_1,\tau_2)\rightarrow f_{21}(\tau_1,\tau_2)$. Here we interpret $f_{11}(\tau_1,\tau_2)$ as the contribution the firm in country 1 offers to its own national government if it chooses the policy τ_1, given that the foreign national government chooses the policy τ_2. As for $f_{21}(\tau_1,\tau_2)$, it represents the contribution that the firm in the foreign country promises his own national government if it

chooses the policy τ_2, given that the home government chooses the policy τ_1. The political contribution schedules to their own incumbent governments announced by the environmentalists at home and abroad are, respectively, $f_{12}:(\tau_1,\tau_2)\rightarrow f_{12}(\tau_1,\tau_2)$ and $f_{22}:(\tau_1,\tau_2)\rightarrow f_{22}(\tau_1,\tau_2)$. We interpret f_{12} and f_{22} in the same manner as f_{11} and f_{21}. In the second stage, taking the policy of the foreign government and (f_{11},f_{12}) as given, the home government chooses τ_1 to maximize its objective function. Similarly, the foreign government takes the policy of the home government and (f_{21},f_{22}) as given in maximizing its objective function . In the third stage, given the levels of emission taxes, the two firms choose their output levels to maximize profits. We use backward induction to find the subgame-perfect equilibrium for this game.

The third stage

Suppose that τ_i is the environmental policy chosen by the government in country i (=1,2). Taking τ_1 and τ_2 as given, the two firms choose their own output levels to maximize profits. If $(q_1^{\#}(\tau_1,\tau_2), q_2^{\#}(\tau_1,\tau_2))$ is the Cournot equilibrium, then

$$(3)\qquad q_i^{\#}(\tau_1,\tau_2)=\underset{q_i}{argmax}\,[q_i\,p(q_i+q_{i'}^{\#}(\tau_1,\tau_2))-c_i(q_i)-\tau_i e_i(q_i)],\qquad i,i'=1,2,\ i\neq i'.$$

Let $q^{\#}(\tau_1,\tau_2)=q_1^{\#}(\tau_1,\tau_2)+q_2^{\#}(\tau_1,\tau_2)$ be the total output of the two firms under Cournot equilibrium. The profit of the firm operating in country i is given by

$$(4)\qquad \varphi_{i1}(\tau_1,\tau_2)=q_i^{\#}(\tau_1,\tau_2)\,p(q^{\#}(\tau_1,\tau_2))-c_i\,(q_i^{\#}(\tau_1,\tau_2))-\tau_i\,e_i(q_i^{\#}(\tau_1,\tau_2)),$$

$i=1,2$.

The utility of the representative environmentalist in country i is given by

$$(5)\qquad \varphi_{i2}(\tau_1,\tau_2)=\overline{m}_i-\eta_{i1}\,\vartheta_{i1}(x_1^{\#}(\tau_1,\tau_2))-\eta_{i2}\vartheta_{i2}(x_2^{\#}(\tau_1,\tau_2)),\quad i=1,2.$$

Here $\bar{m}_i$ denotes the income of the representative environmentalist in country i and $x_i^{\#}(\tau_1,\tau_2) = x_i(q_1^{\#}(\tau_1,\tau_2), q_2^{\#}(\tau_1,\tau_2))$.

The total welfare (tax revenue plus producer surplus minus pollution damage) in country i conditioned on the policy choices is given by

(6) $$\omega_i(\tau_1,\tau_2) = \tau_i e_i(q_i^{\#}(\tau_1,\tau_2)) + \varphi_{i1}(\tau_1,\tau_2) - d_i(x_i(q_1^{\#}(\tau_1,\tau_2), q_2^{\#}(\tau_1,\tau_2))),\ i=1,2.$$

The second stage

The government's objective function in country i is assumed to be a linear function of the political contributions and social welfare, we can write its utility, conditioned on $f_{i1}, f_{i2}, \tau_1, \tau_2$, as follows

(7) $$\Gamma_i(f_{i1},f_{i2},\tau_1,\tau_2) = [f_{i1}(\tau_1,\tau_2) + f_{i2}(\tau_1,\tau_2)] + [\alpha_i\omega_i(\tau_1,\tau_2)],\ i=1,2,$$

where α_i is a positive constant.

In this stage, for $i,i'=1,2$, $i\neq i'$, taking (f_{i1},f_{i2}) and $\tau_{i'}$ as given, government i chooses τ_i to maximize its objective function. If we let $\Re_i(f_{i1},f_{i2},\tau_{i'})$ be the set of environmental policies that are best responses to $(f_{i1},f_{i2},\tau_{i'})$, then the best response correspondence of the government in country i is defined by

(8) $$\Re_i(f_{i1},f_{i2},\tau_{i'}) = \underset{\tau_i}{argmax}\ \Gamma_i(f_{i1},f_{i2},\tau_i,\tau_{i'}).$$

The Nash Equilibrium

A combination of strategies $(f_{11}^*, f_{12}^*, f_{21}^*, f_{22}^*, \tau_1^*, \tau_2^*)$ is a Nash equilibrium if the following conditions are satisfied:

a) For $i,i'=1,2$, $i\neq i'$, given $\tau_{i'}^*$, the chosen environmental policy τ_i^* represents a best response of the government in country i to $(f_{i1}^*, f_{i2}^*, \tau_{i'}^*)$.

b) For each $i=1,2$ and each $j=1,2$, if f_{ij} is any possible political contribution schedule for lobby j in country i, then the following inequality must hold

$$\sup_{\tau_i \in \Re_i(f_{ij}, f_{ij'}^*, \tau_{i'}^*)} [\varphi_{ij}(\tau_i, \tau_{i'}^*) - f_{ij}(\tau_i, \tau_{i'}^*)] \leq [\varphi_{ij}(\tau_1^*, \tau_2^*) - f_{ij}^*(\tau_1^*, \tau_2^*)],\ i,i'=1,2,\ i\neq i',\ j,j'=1,2,\ j\neq j'.$$

We observe that the inequality in b) is both necessary and sufficient for f_{ij}^*, $i,j=1,2$, to be a best response for lobby ij against $f_{ij'}^*$, $j'=1,2$, $j\neq j'$. The argument used to support this observation is the same as that given in Chapter 3.

Assumptions

The following assumptions are imposed upon the model

Assumption 1: *For each $i=1,2$, the emission tax in country i is constrained to belong to the interior $\bar{\tau}_i \geq \tau_i \geq 0$, where $\bar{\tau}_i$ is a be positive constant.*

Assumption 2: *For each $i,j=1,2$, the political contribution schedule $f_{ij}:(\tau_1, \tau_2) \rightarrow f_{ij}(\tau_1, \tau_2)$ is a nonnegative and continuous function defined in $\bar{\tau}_1 \geq \tau_1 \geq 0$, $\bar{\tau}_2 \geq \tau_2 \geq 0$.*

Assumption 3: *The demand function $p(q)$ satisfies $p'(q)<0$, $p(0)>0$.*

Assumption 4: *For $i=1,2$, the total cost function $c_i(q_i)$ satisfies $c_i(0)=0$, $c_i'(q_i)>0$, $c_i''(q_i)\geq 0$.*

Assumption 5: *For each $i=1,2$, the total pollution in country i, namely $x_i(q_1, q_2)$, is an increasing function of the output levels q_1, q_2 of the domestic and foreign firms.*

Assumption 6: *For each $i,j=1,2$, the disutility function $\vartheta_{ij}(x_j)$ is a strictly increasing and convex function of the pollution level in country j.*

4.3 Characterization of the Nash Equilibrium

Let $(f_{11}^*, f_{12}^*, f_{21}^*, f_{22}^*, \tau_1^*, \tau_2^*)$ be a Nash Equilibrium for the game just formulated. Then given τ_i^*, the list $(f_{i'1}^*, f_{i'2}^*, \tau_{i'}^*)$ is a Nash equilibrium in the component game played by the two lobbies in country i' and their home government, $i,i'=1,2$, $i \neq i'$. Assuming that $(f_{i'1}^*, f_{i'2}^*, \tau_{i'}^*)$ is Pareto efficient for the two lobbies $i'1$ and $i'2$, we can apply all propositions proved in Chapter 3 to this component game. In particular, one can assume that $(f_{i'1}^*, f_{i'2}^*, \tau_{i'}^*)$ is a truthful Nash equilibrium for this component game and invoke Proposition 4a of Chapter 3, to assume that

$$\tau_{i'}^* \in \underset{\tau_{i'}}{argmax} \{\varphi_{i'1}(\tau_i^*, \tau_{i'}) + \varphi_{i'2}(\tau_i^*, \tau_{i'}) + \alpha_{i'}\omega_{i'}(\tau_i^*, \tau_{i'})\}, \quad i,i'=1,2, \; i \neq i'.$$

We summarize the results just obtained in the following Proposition.

PROPOSITION 1: *Let $(f_{11}^*, f_{12}^*, f_{21}^*, f_{22}^*, \tau_1^*, \tau_2^*)$ be a Nash equilibrium for the game of endogenous environmental policy determination played by two industrialized countries of the North. Then the following result hold:*

$$(9) \qquad \tau_i^* \in \underset{\tau_i}{argmax} \{\varphi_{i1}(\tau_i, \tau_{i'}^*) + \varphi_{i2}(\tau_i, \tau_{i'}^*) + \alpha_i\omega_i(\tau_i, \tau_{i'}^*)\}, \quad i,i'=1,2, \; i \neq i'.$$

If the maximization problem in (9) has an interior solution, then the emission taxes chosen by the two industrialized countries in question satisfy the following first-order conditions:

$$(10) \qquad D_i\varphi_{i1}(\tau_1^*, \tau_2^*) + D_i\varphi_{i2}(\tau_1^*, \tau_2^*) + \alpha_i D_i\omega_i(\tau_1^*, \tau_2^*) = 0, \quad i=1,2.$$

Here, $D_i\varphi_{ij}$ is the partial derivative of φ_{ij} with respect to the ith argument, $i=1,2$. Once (τ_1^*, τ_2^*) has been found, it can be used to determine the solution of each of the two component games exactly as in Chapter 3 to arrive at the complete solution of the game formulated in Section 2.

To determine the net payoffs of the players in the game, let us define

(11) $$v_{i,i0}^{max} = \max_{\tau_i} [\alpha_i \omega_i(\tau_i, \tau_{i'}^*)], \quad i,i'=1,2,\ i \neq i';$$

(12) $$v_{i,0j}^{max} = \max_{\tau_i} [\varphi_{ij}(\tau_i, \tau_{i'}^*) + \alpha_i \omega_i(\tau_i, \tau_{i'}^*)], \quad i,i'=1,2,\ i \neq i',\ j=1,2;$$

(13) $$v_{i,012}^{max} = \max_{\tau_i} [\varphi_{i1}(\tau_i, \tau_{i'}^*) + \varphi_{i2}(\tau_i, \tau_{i'}^*) + \alpha_i \omega_i(\tau_i, \tau_{i'}^*)], \quad i,i'=1,2,\ i \neq i'.$$

For any combination of strategies $\xi = (f_{11}, f_{12}, f_{21}, f_{22}, \tau_1, \tau_2)$, let

$$\Phi_{i0}(\xi) = f_{i1}(\tau_1, \tau_2) + f_{i2}(\tau_1, \tau_2) + \alpha_i \omega_i(\tau_1, \tau_2), \quad i=1,2,$$

$$\Phi_{ij}(\xi) = \varphi_{ij}(\tau_1, \tau_2) - f_{ij}(\tau_1, \tau_2), \quad i,j=1,2$$

We have the following results:

PROPOSITION 2: *Let $\xi^*=(f_{11}^*, f_{12}^*, f_{21}^*, f_{22}^*, \tau_1^*, \tau_2^*)$ be a Nash equilibrium. Then the payoffs of the players in the game are as follows.*

a) If $(v_{i,012}^{max} - v_{i,01}^{max}) + (v_{i,012}^{max} - v_{i,02}^{max}) < v_{i,012}^{max} - v_{i,0}^{max}$, then the net payoffs for the players in the component game involving country i are unique. More precisely, the net payoffs for the incumbent government, the industry lobby, and the representative environmentalist – all in country i – are given, respectively, by

(i) $\Phi_{i0}(\xi^*) = v_{i,01}^{max} + v_{i,02}^{max} - v_{i,012}^{max}, \ i=1,2,$

(ii) $\Phi_{ij}(\xi^*) = v_{i,012}^{max} - v_{i,0j}^{max}, \quad i=1,2, \ i,j'=1,2, \ j \neq j'.$

a) b) On the other hand, if $(v_{i,012}^{max} - v_{i,01}^{max}) + (v_{i,012}^{max} - v_{i,02}^{max}) \geq v_{i,012}^{max} - v_{i,0}^{max}$, then the payoff for the incumbent government in country i is given by

(ii) $\phi_{i0}(\tilde{\tau}) = v_{i,0}^{max}$, $i=1,2$.

As for the net payoffs of the two lobbies in country i, they are not unique but constitute a line segment defined by the following conditions

(iii) $\phi_{i1}(\tilde{\tau}) - \phi_{i2}(\tilde{\tau}) = v_{i,012}^{max} - v_{i,0}^{max}$, $i=1,2$.

(iii) $\phi_{ij}(\tilde{\tau}) \leq v_{i,012}^{max} - v_{i,0ij}^{max}$, $i=1,2$, $j,j'=1,2$, $j \neq j'$.

Proposition 2 can be proved exactly in the same manner as Propositions 4c and 4d of Chapter 3.

4.4 The Model Under Some Special Functional Forms

Consumers' Demand

As in the preceding chapter, the inverse demand function is assumed to have the following form

(14) $p = a - q$.

where a is a positive constant.

Production technology

As before we assume that good in question is produced by two firms one in each country—with the same cost function and emission function

(15) $c_i(q_i) = cq_i$, $e(q_i) = \varepsilon q_i$, $i=1,2$.

where c and ε are marginal cost and emission per unit of output, respectively. If (τ_1,τ_2) is the vector of environmental policies chosen by the two governments, then the Cournot equilibrium output level of firm i is given by

(16) $q_i^{*}(\tau_1,\tau_2) = (a-c-2\tau_i\varepsilon+\tau_{i'}\varepsilon)/3, \quad i,i' = 1,2, \ i \neq i'.$

The profits – in term of (τ_1,τ_2) – of the two firms are given by

(17) $\pi_{ii}(\tau_1,\tau_2) = [(a-c)^2+2(a-c)(\tau_{i'}-2\tau_i)\varepsilon+(2\tau_i-\tau_{i'})^2\varepsilon^2]/9, \quad i,i' = 1,2, \ i \neq i'.$

Social Welfare

For $i,i' = 1,2, \ i \neq i'$, let $e_{ii'}(q_i) = \rho_{ii'}\varepsilon q_i$ be the transboundary pollution flowing from country i into country i'. The total pollution inflicted on country i is then given by

(18) $x_i(q_i,q_j) = (1-\rho_{ii'})\varepsilon q_i + \rho_{i'i}\varepsilon q_{i'}, \quad i,i' = 1,2; \ i \neq i'$,

where $0 \leq \rho_{ii'},\rho_{i'i} \leq 1$.

The following functional form is assumed for $d_i(x_i)$

(19) $d_i(x_i) = x_i^2$.

The tax revenues that the government of country i receives can be expressed in terms of emission taxes, i.e.,

$$\tau_i\varepsilon[a-c-\varepsilon(2\tau_i-\tau_{i'})]/3, \ i,i' = 1,2; \ i \neq i'.$$

The damage to the environment of country i in terms of policy variables is

$$(\varepsilon^2/9)[(a-c)(1-\rho_{ii'}+\rho_{i'i})+\varepsilon(1-\rho_{ii'})(-2\tau_i+\tau_{i'})+2\varepsilon\rho_{i'i}(2\tau_i-2\tau_{i'})]^2, \ i,i' = 1,2; \ i \neq i'.$$

Depending on the amount of pollution that countries transfer to each other -- captured by ρ_{12} and ρ_{21} -- the damage function can be decreasing or increasing in $(\tau_i,\tau_{i'})$. In a special case when there is no transboundary pollution (i.e., $\rho_{12}=\rho_{21}=0$), it is decreasing in τ_i and increasing in $\tau_{i'}$.

Social welfare in country i also includes producer surplus, which is given by

$$[a - c + \varepsilon(\tau_{i'}-2\tau_i)]^2/9.$$

The total social welfare – in terms of the policy variables – in country i is given by

$$\omega_i(\tau_1, \tau_2) = \tau_i\varepsilon[a-c+\varepsilon(-2\tau_i+\tau_{i'})]/3+[a-c+\varepsilon(\tau_i-2\tau_i)]^2/9-$$
$$(\varepsilon^2/9)[(a-c)(1-\rho_{ii}-\rho_{i'i})+\varepsilon(1-\rho_{ii})(-2\tau_i+\tau_{i'})-2\varepsilon\rho_{i'i}(2\tau_1-2\tau_{i'})]^2, \quad i=1,2.$$

The environmentalist's utility

The utility of the representative environmentalist in each country is assumed to be a function of the quality of the environment and the consumption of a numéraire good. The following form is proposed for the disutility function:

(20) $$\vartheta_{ij}(x_j) = (x_j)^2.$$

4.5 Green Model without Transboundary Pollution

Suppose there is no transboundary pollution and the representative environmentalist in each country is concerned only about the quality of his own local environment. For simplicity, we also assume that the weight attached to the social welfare by each government is one. Thus, by setting ρ_{12}, ρ_{21}, η_{12}, and η_{21} equal to zero and η_{11}, η_{22}, α_1 and α_2 equal to one in our model and solving the system expressed by (10) we obtain the equilibrium level of emission tax in country i

(21) $$\tau_{i,012}^* = (a-c)(8\varepsilon^2-5\gamma)/(\varepsilon^2-8\varepsilon^2), \quad i=1,2.$$

Given a, the environmental policies depend on the cost and emission per unit of output. Using (17) and (21), the profit of firm i in the presence of all special-interest groups in the economy is given by

(22) $$\varphi_{i1}(\tau_{1,012}^*, \tau_{2,012}^*) = 4(a-c)^2/(1-8\varepsilon^2)^2.$$

Now, we assume that the representative environmentalists are not active. Hence, we eliminate the environmental lobbies from the model and solve the system to find the environmental policies. In this case, the equilibrium emission tax for country i is given by

(23) $\tau_{1,01}^{*} = (a-c)(4\varepsilon^2-5)/(\varepsilon^2-4\varepsilon^4), \quad i=1,2.$

The profit of firm i is given by

(24) $\varphi_i(\tau_{1,01}^{*}, \tau_{2,01}^{*}) = 4(a-c)^2(1-4\varepsilon^2)^2, \quad i=1,2.$

which is clearly greater than (22). Hence, the emergence of the environmental lobbies in the model lowers the profits of the two firms.

In the absence of the industry lobbies, the equilibrium emission tax and the profit of the domestic firm in country i are, respectively, given by

(25) $\tau_{1,02}^{*} = (a-c)(8\varepsilon^2-1)/(5\varepsilon^2-8\varepsilon^4),$

(26) $\varphi_i(\tau_{1,02}^{*}, \tau_{2,02}^{*}) = 4(a-c)^2(5-8\varepsilon^2)^2, \quad i=1,2.$

It is clear that (26) is lower than (22). Hence, the profit of firm i is at its lowest possible level when only the environmental lobbies are present in the model.

Next, we will find the payoff of each firm net of its political contribution. For $\overline{m}=1$, if $(v_{i,012}^{\max} - v_{i,01}^{\max}) - (v_{i,012}^{\max} - v_{i,02}^{\max}) < v_{i,012}^{\max} - v_{i,0}^{\max}$, then the net payoff of each firm (i.e., $v_{i1}^{*} = v_{i,012}^{\max} - v_{i,02}^{\max}$) is given by

(27) $v_{i1}^{*} = 4(a-c)^2(64\varepsilon^4-13)(5-48\varepsilon^2+64\varepsilon^4)^2, \quad i=1,2.$

which is clearly positive for $\varepsilon \geq 1$. A positive net payoff gives industries an additional incentive to form interest groups and be more active on the political scene of their countries.

We can show that for $\varepsilon \geq 1$, the net payoff of the industry lobby in each country is decreasing in emission per unit of output. Thus, the higher is emission per unit of output, the lower is the industry lobby's net payoff in country i. This can be a result of the low level of the firm's profit and/or high level of its political contribution.

Next, we see how the emergence of environmental lobbies affects the quality of the environment in the Northern countries. When all lobbies are present in the model, the damage to the environment of country i is given by

(28) $$d_i(\tau_{1,012}^*, \tau_{2,012}^*) = 4\varepsilon^2(a-c)^2/(1-8\varepsilon^2)^2, \quad i=1,2.$$

Let $d(\tau_{1,012}^*, \tau_{2,012}^*)$ denotes the sum of environmental damages in the two countries (*i.e.*, $d_1(\tau_{1,012}^*, \tau_{2,012}^*) + d_2(\tau_{1,012}^*, \tau_{2,012}^*)$.) In this case, the total environmental damage is given by

(29) $$d(\tau_{1,012}^*, \tau_{2,012}^*) = 8\varepsilon^2(a-c)^2/(1-8\varepsilon^2)^2, \quad i=1,2.$$

Next, we eliminate the environmental lobbies from the model. The damage to the environment of country i is given by

(30) $$d_i(\tau_{1,01}^*, \tau_{2,01}^*) = 4\varepsilon^2(a-c)^2/(1-4\varepsilon^2)^2, \quad i=1,2.$$

which is clearly larger than (28). Hence, the sum of the environmental damage in the two countries is also lower when the environmental interest groups are present in the game.

When the industry lobbies are absent from the model, the damage to the environment of country i is given by

(31) $$d_i(\tau_{1,02}^*, \tau_{2,02}^*) = 4\varepsilon^2(a-c)^2/(5-8\varepsilon^2)^2, \quad i=1,2.$$

which is lower than (28) and (30). Hence, the quality of the environment in each country is at its highest level when the industry lobbies from the two countries are not present. Table 1 presents the results of a numerical example for this case.

Table 1 Green model without transboundary pollution

	τ_1	d_1	d	φ_{i1}	φ_{i2}	*Joint payoff*
Total Welfare, ω	8.867	19.753	39.506	.1975	80.247	19.8519
government - environmental lobby	8.933	4.988	9.976	.0499	95.012	110.025
government - industry lobby	8.865	20.149	40.298	.2015	79.85	20.0484
government - both lobbies	8.932	5.050	10.10	.0505	94.95	110.074

For $\eta_{ii}=1$, $\eta_{ij}=0$, $a=100$, $c=10$, $\varepsilon=10$, $\alpha_i=1$, and $\overline{m}=10^2$. τ_1 = emission tax; d_1 = the environmental damage in country i; $d=d_1+d_2$; φ_{i1} = profit of firm i; φ_{i2} = gross payoff of the representative environmentalist in country i.

Table 1 shows the equilibrium level of emission tax, the damage to the home and the foreign country environment, and the gross payoff of each lobby. Consider the last row of Table 1 for which all lobbies are active in the game. In this case, the emission tax and profit of the domestic firm in country i are, respectively, equal to 8.932 and 0.05. As the second row from the bottom shows, in the absence of the environmental lobbies the emission tax in each country decreases to 8.865 and the profit of the domestic firm operating in country i increases to 0.20. In this case, the utility of the green environmentalist in each country also decreases from 95 to 80 due to a higher level of damage to the home environment. Moreover, as the first row of Table 1 shows, the equilibrium emission tax resulting from maximizing total welfare (i.e., 8.867) is not equal to those obtained in the presence of lobbies in the model.

As Table 2 shows, in this example, $v_{i,012}^{max} - v_{i,0}^{max} = 90.223$ is greater than $(v_{i,012}^{max} - v_{i,1}^{max}) + (v_{i,012}^{max} - v_{i,02}^{max}) = 90.076$. From Proposition 2 we know that the net payoff of the firm operating in country i is $v_{i1}^{*} = v_{i,012}^{max} - v_{i,2}^{max}$. In this example, $v_{i1}^{*} = 0.05$. Hence, according to Proposition 6 of Chapter 3, we know that the emergence of the environmental lobbies lowers the net payoff of the domestic firm operating in country i. In this example, the net payoff of firm i decreases from 0.20 ($= v_{i,01}^{max} - v_{i,0}^{max}$) to 0.05. Also, from Proposition 7 of Chapter 3, we know that the government's payoff in each country should rise with the emergence of the environmental lobbies. From Table 2, the payoff of the incumbent government in country i can be computed. More specifically, $\phi_{i,0} = v_{i,01}^{max} + v_{i,02}^{max} - v_{i,012}^{max}$ is equal to 20, which is greater than $v_{i,0}^{max} = 19.8$.

Table 2 Green model without transboundary pollution: Net payoffs

$V_{i,\cdot\cdot}^{max}$	$V_{i,012}^{max}$	$V_{i,012}^{max} - V_{i,0}^{max}$	$V_{i,01}^{max} - V_{i,0}^{max}$	$V_{i,012}^{max} - V_{i,02}^{max}$	$V_{i,012}^{max} - V_{i,01}^{max}$	$V_{i,012}^{max} - V_{i,02}^{max} - V_{i,012}^{max} - V_{i,01}^{max}$	$V_{i,01}^{max} + V_{i,02}^{max} - V_{i,012}^{max}$
19.85	110.10	90.223	.1965	0.05025	90.02	90.0763	19.9981

For $\eta_{ii}=1$, $\eta_{ij}=0$, $a=100$, $c=10$, $\varepsilon=10$, $\alpha_i=1$, and $\overline{m}=10^2$.

The political contribution of the domestic firm and the environmental group in country *i* are, respectively, 0.0002518 and 4.92403. The above results are also illustrated in Figure 1, which shows Pareto efficient frontier is below MN. Hence we have a unique solution for the game.

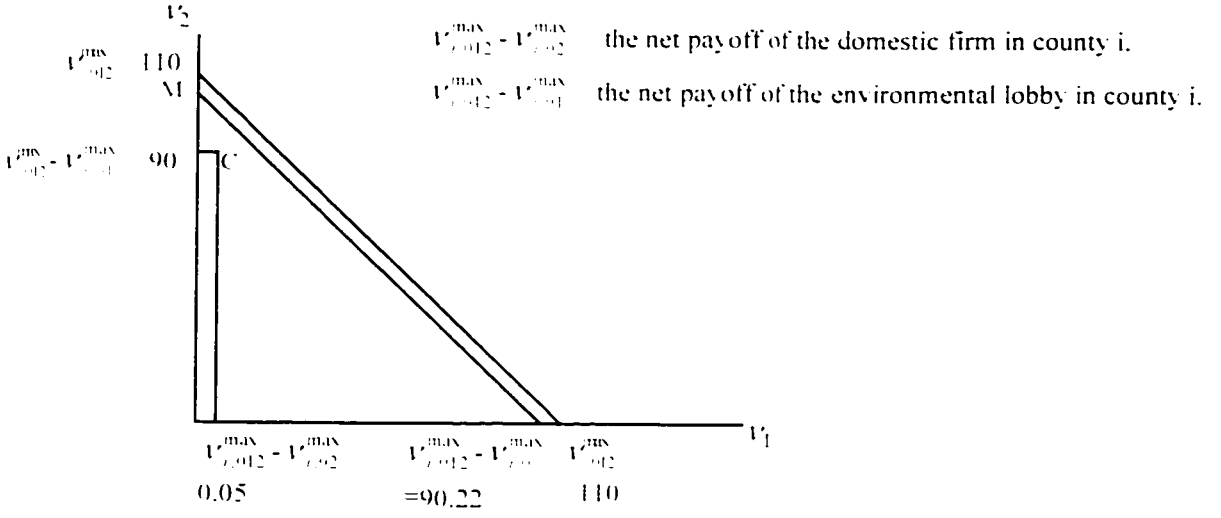


Figure 1 Green model without transboundary pollution

Next, we construct an example for the case in which the representative environmentalist and or the domestic firm in country 1 disappear from the game. However, we assume that all lobbies in the foreign country are active. In this case, taking $\tau_{2,012}^{*}$ as given, we find the emission tax, $\tau_{1,0j}^{*}$ that maximizes the joint payoff of the lobby j(=1,2) and the incumbent government in the home country. In other words,

(32) $$\tau_{1,0j}^{*} \in \underset{\tau_1}{argmax}\,[\varphi_{1j}(\tau_1, \tau_{2,012}^{*}) + \alpha_1 \omega_1(\tau_1, \tau_{2,012}^{*})],\quad j = 1,2.$$

The following tables present a numerical example for this case.

Table 3 Green model without transboundary pollution

country 1	τ_1	d_1	φ_{11}	φ_{12}	*Joint payoff*
Total Welfare, ω	8.900	19.753	.2000	80.247	19.9986
government - environmental lobby	8.933	5.000	.0500	95.000	110.024
government - industry lobby	8.899	20.30	.2030	79.70	20.1996
government - both lobbies	8.932	5.050	.0505	94.95	110.074

For η_{ij}=1, η_{ji}=0, a=100, c=10, z=10, α_i=1, and $\overline{m}$ =10^2. τ_1 = emission tax; d_1 = the environmental damage in country 1; φ_{11} = profit of firm 1; φ_{12} = gross payoff of the representative environmentalist in country 1.

Table 3 shows the equilibrium level of emission tax, the damage to the home and foreign country environments, and the gross payoffs of each lobby. Consider the last row of Table 3 for which all lobbies are active in the game. In this case, the emission tax and profit of the domestic firm in country 1 are, respectively, equal to 8.932 and 0.05. As the second row from the bottom shows, in the absence of the environmental lobby in the home country, the emission tax in country 1 decreases to 8.899 and the profit of the domestic firm increases to 0.20. In this case, the utility of the green environmentalist at home also decreases from 94 to 79.70 due to a higher level of damage to the home environment. As the table shows, the emission tax resulting from maximizing total welfare (i.e., 8.899) is not equal to one obtained when all lobbies are present in the model (i.e., 8.932).

By comparing Table 3 with Table 1, we see that when the foreign environmental lobby is always an active player in the game, the damage to the home environment is more than that when both environmental groups are absent from the model. The profits of the domestic firm in Table 3 are also higher than those shown in Table 1. The reason for this is the presence of an active

environmental lobby in the foreign country and the absence of a strong environmental interest group at home. While no environmental lobby is present in the home country, the foreign environmental interest group puts pressure on its national government to set a higher emission tax. This in turn will lower the profit of the foreign firm and improve the quality of the environment in the foreign country. Moreover, the absence of a domestic environmental lobby at home paves the way for the domestic firm to pollute more and hence to damage the home environment.

As Table 4 shows, in this example, $(v_{1,012}^{max} - v_{1,0}^{max} = 90.07)$ is greater than $(v_{1,012}^{max} - v_{1,01}^{max}) - (v_{1,012}^{max} - v_{1,02}^{max}) = 89.92$. Hence, according to Proposition 6 of Chapter 3, we know that the emergence of the environmental lobby at home lowers the net payoff of the domestic firm. In this example, the net payoff of firm 1 decreases from 0.20 to 0.05. Also, from Proposition 7 of Chapter 3, we know that the home government's payoff should rise with the emergence of the environmental lobby. From Table 4 the payoff of the incumbent government in country 1 can be computed. More specifically, $\phi_{1,0} = v_{1,01}^{max} - v_{1,02}^{max} - v_{1,012}^{max}$ is equal to 20.15, which is greater than $v_{1,0}^{max} = 19.99$.

Table 4 Green model without transboundary pollution: Net payoffs

$v_{1,0}^{max}$	$v_{1,01}^{max}$	$v_{1,012}^{max} - v_{1,0}^{max}$	$v_{1,01}^{max} - v_{1,0}^{max}$	$v_{1,02}^{max} - v_{1,0}^{max}$	$v_{1,012}^{max} - v_{1,02}^{max}$	$v_{1,012}^{max} - v_{1,01}^{max} - v_{1,02}^{max} + v_{1,0}^{max}$	$v_{1,01}^{max} + v_{1,02}^{max} - v_{1,012}^{max}$
19.99	110.10	90.076	.201	0.05025	89.875	89.9251	20.1493

For $\eta_{ii} = 1$, $\eta_{ij} = 0$, $a = 100$, $c = 10$, $\varepsilon = 10$, $\alpha_i = 1$, and $\overline{m} = 10^{-5}$.

By comparing Table 4 with Table 2, we see that the net payoff of the domestic firm is unchanged, but the net payoff of the environmental lobby in Table 4 is lower than that in Table 2

due to larger damage to the home environment in this case. In this example, the payoff of the home government is also higher than that obtained in the previous example.

The political contribution of the domestic firm and the environmental group in country 1 are, respectively, 0.000251864 and 5.07524. Hence, the political contribution of the home environmental lobby in this example is more than that obtained in the previous example.

The above results are also illustrated in Figure 2, which shows that the Pareto efficient frontier is below MN. Hence we have a unique solution for the game.

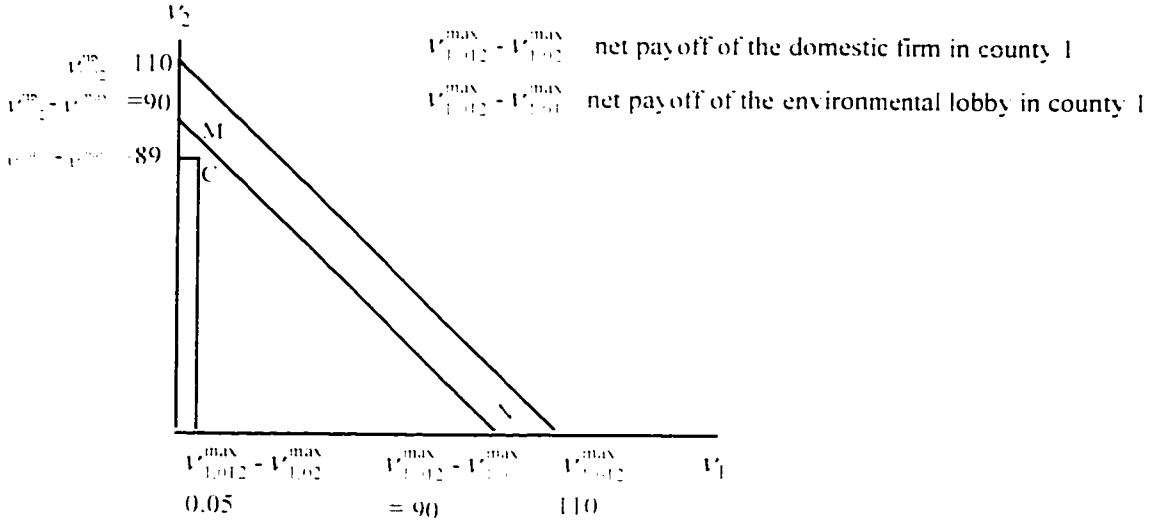


Figure 2 Green model without transboundary pollution

4.6 Green Model with Transboundary Pollution

In this section, the environmentalist is still a green, but pollution can spillover from one country to another. To avoid some complexities which are not central to our analysis, it is assumed that the amount of pollution spilling from country 1 (say, the home country) into country 2 (say, the foreign country) is negligible and that a considerable amount of pollutants is inflicted upon country 1 by country 2. Thus, we set ρ_{12}, η_{12}, and η_{21} equal to zero and η_{11}, η_{22}, and α equal to

one, then solve the model for the equilibrium emission taxes in the presence of all lobbies and the incumbent governments in the model. The equilibrium emission taxes for the home country and the foreign country are, respectively, given by

$$(33) \qquad \tau_{1,012}^{*} = \frac{(a-c)[-15+32\alpha^{3}(\rho_{21}-2)(\rho_{21}-1)^{2}+4\alpha^{2}(16-27\rho_{21}+12\rho_{21}^{2})]}{\alpha[3-4\alpha^{2}(\rho_{21}-4)+32\alpha^{3}(\rho_{21}-2)(\rho_{21}-1)^{2}]},$$

and

$$(34) \qquad \tau_{2,012}^{*} = \frac{(a-c)[-15+32\alpha^{3}(\rho_{21}-2)(\rho_{21}-1)^{2}+4\alpha^{2}(16-17\rho_{21}+6\rho_{21}^{2})]}{\alpha[3-4\alpha^{2}(\rho_{21}-4)+32\alpha^{3}(\rho_{21}-2)(\rho_{21}-1)^{2}]}.$$

Given $a>c$, (33) can be greater or smaller than (34), depending on the emission per unit of output and the amount of pollution that country 2 transfers to country 1. One can show that if the emission per unit of output is large and the amount of pollution inflicted upon the home country is small enough, the emission tax at home is larger than that in the foreign country. One reason can be that, while the home country receives a relatively small amount of pollution from the foreign country, it might generate a large amount of emission inside. Thus, the environmental lobby at home might put more pressure on its government to adopt a tougher environmental policy.

Using (33) and (34), the profits of the domestic firm and the foreign firm in the presence of all lobbies are, respectively, given by

$$(35) \qquad \varphi_{1}(\tau_{1,102}^{*}, \tau_{2,102}^{*}) = \frac{4(a-c)^{2}[3-4\alpha^{2}(2-6\rho_{21}+3\rho_{21}^{2})]^{2}}{[3-4\alpha^{2}(\rho_{21}-4)+32\alpha^{3}(\rho_{21}-2)(\rho_{21}-1)^{2}]^{2}},$$

$$(36) \qquad \varphi_{2}(\tau_{1,102}^{*}, \tau_{2,102}^{*}) = \frac{4(a-c)^{2}[3-4\alpha^{2}(\rho_{21}-2)]^{2}}{[3-4\alpha^{2}(\rho_{21}-4)+32\alpha^{3}(\rho_{21}-2)(\rho_{21}-1)^{2}]^{2}}.$$

The profit of the foreign firm is greater than that of the domestic firm if a numerator of (35) is smaller than that of (36) and this in turn depends on the amount of emission per unit of output

and the amount of pollution that spills over from the foreign country to the home country. One can show that if ε is large and the amount of pollution inflicted upon the home country is small enough, the profit of the domestic firm is lower than that of the foreign firm. This could be a result of a tougher environmental policy adopted by the home government in the presence of environmental lobbies.

Next, take a case where there are no active environmental lobbies in the two countries. Under this assumption, the equilibrium emission taxes in the home country and the foreign country are, respectively, given by

$$(37) \qquad \tau_{1.01}^{*} = \frac{(a-c)[-15+8\varepsilon^{4}(\rho_{21}-2)(\rho_{21}-1)^{2}+\varepsilon^{2}(32-54\rho_{21}+24\rho_{21}^{2})]}{\varepsilon[3-2\varepsilon^{2}(\rho_{21}-4)+8\varepsilon^{4}(\rho_{21}-2)(\rho_{21}-1)^{2}]},$$

$$(38) \qquad \tau_{2.01}^{*} = \frac{(a-c)[-15+8\varepsilon^{4}(\rho_{21}-2)(\rho_{21}-1)^{2}+\varepsilon^{2}(32-34\rho_{21}+12\rho_{21}^{2})]}{\varepsilon[3-2\varepsilon^{2}(\rho_{21}-4)+8\varepsilon^{4}(\rho_{21}-2)(\rho_{21}-1)^{2}]}.$$

The profits of the domestic firm and the foreign firm are, respectively, given by

$$(39) \qquad \pi_{1}(\tau_{1.10}^{*}, \tau_{2.10}^{*}) = \frac{4(a-c)^{2}[3-2\varepsilon^{2}(2-\rho_{21})(3-3\rho_{21}+\rho_{21}^{2})]^{2}}{[3-2\varepsilon^{2}(\rho_{21}-4)+8\varepsilon^{4}(\rho_{21}-2)(\rho_{21}-1)^{2}]^{2}},$$

$$(40) \qquad \pi_{2}(\tau_{1.10}^{*}, \tau_{2.10}^{*}) = \frac{4(a-c)^{2}[3-2\varepsilon^{2}(2-\rho_{21})]^{2}}{[3-2\varepsilon^{2}(\rho_{21}-4)+8\varepsilon^{4}(\rho_{21}-2)(\rho_{21}-1)^{2}]^{2}}.$$

As before, the profit of the foreign firm is greater than that of the domestic firm if the numerator of (39) is smaller than that of (40) and this in turn depends on ε and ρ_{21}.

In the presence of all lobbies in the model, the damage to the environment of the home and foreign countries are, respectively, given by

$$(41) \qquad d_{1}(\tau_{1.102}^{*}, \tau_{2.102}^{*}) = \frac{4(a-c)^{2}\varepsilon^{2}[8\varepsilon^{2}(\rho_{21}-1)^{2}-3(\rho_{21}-1)]^{2}}{[3-4\varepsilon^{2}(\rho_{21}-4)+32\varepsilon^{4}(\rho_{21}-2)(\rho_{21}-1)^{2}]^{2}},$$

(42) $$d_2(\tau_{1,102}^*, \tau_{2,102}^*) = \frac{4(a-c)^2\alpha^2[3-4\alpha^2(\rho_{21}-2)]^2(\rho_{21}-1)^2}{[3-4\alpha^2(\rho_{21}-4)-32\alpha^4(\rho_{21}-2)(\rho_{21}-1)^2]^2}.$$

As (41) and (42) show the quality of the home environment can be higher or lower than that of the foreign country, depending on the amount of pollution inflicted upon the home country and the emission level per unit of output.

When no environmental group is present in the model, the environmental damages in the home country and the foreign country are, respectively, given by

(43) $$d_1(\tau_{1,10}^*, \tau_{2,10}^*) = \frac{4(a-c)^2\alpha^2[4\alpha^2(\rho_{21}-1)^2-3(\rho_{21}-1)]^2}{[3-2\alpha^2(\rho_{21}-4)-8\alpha^4(\rho_{21}-2)(\rho_{21}-1)^2]^2},$$

(44) $$d_2(\tau_{1,10}^*, \tau_{2,10}^*) = \frac{4(a-c)^2\alpha^2[3-2\alpha^2(\rho_{21}-2)]^2(\rho_{21}-1)^2}{[3-2\alpha^2(\rho_{21}-4)-8\alpha^4(\rho_{21}-2)(\rho_{21}-1)^2]^2}.$$

As before, no comparison is possible between the two countries unless we know the values for ε and ρ_{21}. However, from Proposition 5a of Chapter 3, we can infer that the quality of the environment will improve with the emergence of a green environmental lobby in each country.

4.7 Supergreen Model with Transboundary Pollution

Borrowing the assumption of transboundary pollution from the previous section, let the environmental groups be supergreens (i.e., their concerns are global). For simplicity, suppose that the foreign country transfers part of its emission to the home country, but receives no pollution from outside. Furthermore, suppose that each environmental lobby assigns equal weight to his own environment and the foreign environment.

To see how the results obtained in the previous section are affected under this new assumption, let us first find the equilibrium level of emission taxes in the presence of all lobbies and the incumbent governments in the model. To do so, by setting ρ_{12} equal to zero and η_{11},

η_{12}, η_{21}, η_{22}, α_1 and α_2 equal to one in our model and solving the system expressed by (10), we obtain the equilibrium level of the environmental policies in the two countries of the North when the environmental lobbies are supergreen. Thus, the equilibrium level of emission taxes for the home country and the foreign country are, respectively,

$$\tau_{1,012}^{*} = \frac{(a-c)[-15+12\varepsilon^{4}(\rho_{21}-1)^{2}(2\rho_{21}-5)+2\varepsilon^{2}(34-63\rho_{21}+36\rho_{21}^{2})]}{\varepsilon[3+12\varepsilon^{4}(\rho_{21}-1)^{2}(2\rho_{21}-5)+2\varepsilon^{2}(5\rho_{21}-4)]}, \tag{45}$$

and

$$\tau_{2,012}^{*} = \frac{(a-c)[-15+12\varepsilon^{4}(\rho_{21}-1)^{2}(2\rho_{21}-5)+2\varepsilon^{2}(34-41\rho_{21}+18\rho_{21}^{2})]}{\varepsilon[3+12\varepsilon^{4}(\rho_{21}-1)^{2}(2\rho_{21}-5)+2\varepsilon^{2}(5\rho_{21}-4)]}. \tag{46}$$

Both (45) and (46) have the same denominator but different numerator. Given a and c, (45) can be greater or smaller than (46) depending on the level of emission per unit of output and the amount of pollution that country 2 transfers to country 1.

Using (45) and (46), the profits of the domestic firm and the foreign firm in the presence of all special-interest groups are given, respectively, by

$$\varphi_1(\tau_{1,102}^{*}, \tau_{2,102}^{*}) = \frac{4(a-c)^{2}[3-2\varepsilon^{2}(5-15\rho_{21}+9\rho_{21}^{2})]^{2}}{[3+12\varepsilon^{4}(\rho_{21}-1)^{2}(2\rho_{21}-5)+2\varepsilon^{2}(5\rho_{21}-4)]^{2}}, \tag{47}$$

and

$$\varphi_2(\tau_{1,102}^{*}, \tau_{2,102}^{*}) = \frac{4(a-c)^{2}[3+2\varepsilon^{2}(-5+4\rho_{21})]^{2}}{[3+12\varepsilon^{4}(\rho_{21}-1)^{2}(2\rho_{21}-5)+2\varepsilon^{2}(5\rho_{21}-4)]^{2}}. \tag{48}$$

As before, no comparison between (47) and (48) is possible unless we know ρ_{21} and ε.

Next, suppose there are no active environmental lobbies in the two countries of the North. Under this assumption we can solve the model to find a new equilibrium level of emission tax in each country. Thus, we obtain

(49) $$\tau_{1,01}^{*} = \frac{(a-c)[-15+8\alpha^{4}(\beta_{21}-2)(\beta_{21}-1)^{2}-\alpha^{2}(32-54\beta_{21}+24\beta_{21}^{2})]}{\alpha[3-2\alpha^{2}(\beta_{21}-4)+8\alpha^{4}(\beta_{21}-2)(\beta_{21}-1)^{2}]},$$

and

(50) $$\tau_{2,01}^{*} = \frac{(a-c)[-15+8\alpha^{4}(\beta_{21}-2)(\beta_{21}-1)^{2}-\alpha^{2}(32-34\beta_{21}+12\beta_{21}^{2})]}{\alpha[3-2\alpha^{2}(\beta_{21}-4)+8\alpha^{4}(\beta_{21}-2)(\beta_{21}-1)^{2}]}.$$

Since in this case there is no environmental group, in maximizing the joint payoffs the incumbent governments do no take into account the welfare of the environmentalists. Thus, regardless of whether the environmentalists are green or supergreen , the equilibrium levels of environmental policies in this case are equivalent to those obtained in the green model with transboundary pollution. The profits of the domestic firm and the foreign firm are given, respectively, by

(51) $$\varphi_{1}(\tau_{1,10}^{*}, \tau_{2,10}^{*}) = \frac{4(a-c)^{2}[3-2\alpha^{2}(2-6\beta_{21}+3\beta_{21}^{2})]^{2}}{[3-2\alpha^{2}(\beta_{21}-4)+8\alpha^{4}(\beta_{21}-2)(\beta_{21}-1)^{2}]^{2}},$$

(52) $$\varphi_{2}(\tau_{1,10}^{*}, \tau_{2,10}^{*}) = \frac{4(a-c)^{2}[3-2\alpha^{2}(2-\beta_{21})]^{2}}{[3-2\alpha^{2}(\beta_{21}-4)+8\alpha^{4}(\beta_{21}-2)(\beta_{21}-1)^{2}]^{2}},$$

which are identical to the profits of the firms in the green model when the environmental groups were absent. By comparing (47) with (51) and (48) with (52), we see that the profits of the domestic and foreign firms can increase or decrease with the emergence of the supergreen environmental lobby. An increase in the firm's payoff, in the presence of environmentalists, should not be surprising, specially when a tougher environment regulation can create oligopoly profits for the firms in the industry. For example, Melnnis (1992) shows that CFC producers supported the Montreal Protocol to secure such profits.

The damage to the environments of the home and foreign countries in the presence of all lobbies are given, respectively, by

(53) $$d_{1}(\tau_{1,102}^{*}, \tau_{2,102}^{*}) = \frac{4(a-c)^{2}\alpha^{2}[10\alpha^{2}(\beta_{21}-1)^{2}-3(\beta_{21}-1)]^{2}}{[3-2\alpha^{2}(5\beta_{21}-4)+12\alpha^{4}(\beta_{21}-1)^{2}(2\beta_{21}-5)]^{2}},$$

(54) $$d_2(\tau_{1,102}^{*}, \tau_{2,102}^{*}) = \frac{4(a-c)^2\alpha^2(\rho_2-1)^2[3-2\alpha^2(4\rho_2-5)]^2}{[3-2\alpha^2(5\rho_2-4)-12\alpha^4(\rho_2-1)^2(2\rho_2-5)]^2}.$$

As is clear, the quality of the home environment can be higher or lower than that of the foreign country, depending on the amount of pollution inflicted on country 1 and the level of emission per unit of output. The damage to the environment of the home country and the foreign country in the absence of the environmentalist groups are given, respectively, by

(55) $$d_1(\tau_{1,10}^{*}, \tau_{2,10}^{*}) = \frac{4(a-c)^2\alpha^2[4\alpha^2(\rho_2-1)^2-3(\rho_2-1)]^2}{[3-2\alpha^2(5\rho_2-4)-8\alpha^4(\rho_2-2)(\rho_2-1)^2]^2},$$

(56) $$d_2(\tau_{1,10}^{*}, \tau_{2,10}^{*}) = \frac{4(a-c)^2\alpha^2[3-2\alpha^2(\rho_2-2)]^2(\rho_2-1)^2}{[3-2\alpha^2(5\rho_2-4)-8\alpha^4(\rho_2-2)(\rho_2-1)^2]^2}.$$

Obviously, these are identical to those obtained in the green model when no environmentalist was present in the economy. As before, no comparison between the two countries is possible unless we know the amount of emission per unit of output and the transboundary pollution. However, from Proposition 5b of Chapter 3 we can infer that the presence of supergreen environmental interest groups in the industrialized countries will improve the quality of the environment in the North.

4.8 Conclusion

In this chapter, we formulate a non-cooperative game between two countries of the North. Organized environmental movements are assumed to exist in both rich countries. There are also two firms each located in different country. The firms compete in a market located in a third country. The game is played between different special-interest groups -- namely, environmentalists and industries -- and the incumbent governments in the North.

This chapter studies how environmental policies are determined endogenously in the Northern countries. We see how the presence of environmental interest groups in the North affects the quality of the home environment and the payoffs of the domestic and foreign firms.

In general, it is shown that the equilibrium emission tax in each Northern country depends on the cost and emission per unit of output, the weight that each incumbent government attaches to its social welfare, the amount of emission that flows from one country to another, and the type of environmentalists.

This chapter finds that when the environmental groups are greens and there is an absence of transboundary pollution, the emergence of environmental lobbies lowers the profits of the domestic and foreign firms and improves the quality of the environment in each country. Furthermore, we find that the net payoffs of the industry lobbies are always positive in political equilibrium. This might provide additional incentive for firms to be active on the political scene of their countries.

In the presence of the green environmentalists, when we allow transboundary pollution, we find that the equilibrium emission tax and the firm's profit in each country are very sensitive to the amount of pollution transferred from one country to another and the amount of emission per unit of output (i.e., ρ_{ij} and ε_i.) Hence, the impacts of environmental lobbies on the firms' profits are not known unless we determine these two parameters. However, the quality of the environment in each country will improve with the emergence of green environmental lobbies.

This chapter also considers a case in which the environmentalists are supergreen. We find that the quality of the environment in each Northern country might improve or deteriorate with the emergence of supergreen environmental groups, depending on the amount of pollution

flown from one country to another and the level of emission per unit of output in each country. However, the presence of supergreen environmental interest groups in the industrialized countries will improve the quality of the environment in the North. This might provide some insight for lobbying to limit GHG emissions.

In Chapter 3 and Chapter 4, emission per unit of output, ε, was treated as a constant. In the following chapter, we will assume that the emission-output ratio can be influenced by *environmental* R&D investment conducted by firms. We will see how our results will be affected by this new assumption.

5

INNOVATION, STRATEGIC ENVIRONMENTAL POLICY, AND NORTH-SOUTH TRADE

5.1 Introduction

The prevailing view among many economists is that there is a trade-off between economic competitiveness and environmental quality. Some economists and policy makers believe that there is no conflict between economy and the environment. They claim that in a world in which innovation plays a crucial role, tougher environmental policies might not make an industry less competitive in international markets. The idea is that more stringent environmental regulations might encourage firms to innovate greener technologies ahead of their rivals and hence increase their long-run competitiveness.[1]

This chapter incorporates environmental R&D into the North-South model developed in Chapter 3. The goal is to study how strategic behaviors of an environmental lobby and a

[1] See Michael Porter (1991), and Porter and van der Linde (1995a,b).

domestic firm which competes in an imperfect international market will affect environmental policies. We will assume that different international agreements have ruled out the use of any trade policy.[2] Thus, all the results are derived under the assumption of trade liberalization. As before, in our model, the motivation for an incumbent government to use environmental policy does not arise from the objective to maximize social welfare, but from its selfish desire to maximize its political support.

This chapter also seeks an answer to the question of whether environmentalists, through the pressure they exert on politicians, are successful in raising the quality of the environment, and which interest groups will benefit from the political process. In this political process, an environmental interest group that seeks to influence the environmental policy set by politicians will confront an industry interest group which will be pressing for laxer environmental policies.

Environmental R&D investments are assumed to be undertaken by a firm located in the Northern country. The idea is that environmental regulation adopted by the Northern government induces its domestic firm to innovate greener technologies. This, in turn, will reduce emission per unit of output in the industrialized country of the North. Since cost-reducing or *process* R&D is not central to our focus, it will be ignored in this thesis. Emission tax is the only policy instrument used by the Northern government. Contrary to the Northern country, the government in the South still sees a trade-off between economy and the environment and hence will not pursue an active environmental policy. Given this assumption, the firm operating in the developing country does not have enough incentive to undertake *environmental* R&D.

[2] As already shown in Chapter 3, trade policy can also be incorporated into our model. However, the world trend is to remove barriers to international trade.

This chapter is organized as follows. In Section 5.2, the basic model is presented. The game formulated in this section follows the approach used in the previous chapters. Section 5.3 characterizes the Nash equilibrium. Section 5.4 introduces some functional forms. In this section, more specific results are derived. In Section 5.5, a numerical example is constructed to show how the model works. Section 5.6 contains some concluding results.

5.2 The Model

Consider a commodity whose inverse demand curve is represented by $p: q \rightarrow p(q)$. Suppose that the market for this commodity is located in a country -- called country 1-- and is served by only two firms, with firm 1 located in country 1 and firm 2 located in another country -- called country 2. In our model, country 2 might be a developing nation of the South which is more preoccupied with raising the income of its population than improving the quality of its own environment. In what follows, country 1 and country 2 will frequently be referred to as the home country and the foreign country, respectively.

The production activities of each firm generate a certain amount of pollution, part of which might cross the border and flow into the other country. For each i=1,2, the output of firm i is denoted by q_i. Let k_1 be the level of *environmental* R&D undertaken by firm 1 which is operating in the industrialized country. The total cost of producing q_1 and the pollution generated by q_1 are denoted, respectively, by $c_1(q_1)$ and $e_1(q_1,k_1)$. It is assumed that $e_1(q_1,k_1)$ is increasing in q_1 and decreasing in k_1. Moreover, since we assume that the Southern country does not actively pursue any environmental policy, its domestic firm doses not invest in *environmental* R&D. The pollution generated by q_2 is denoted by $e_2(q_2)$. Let e_{ij} be the transboundary pollution flowing

from country i into country j, $i \neq j$, that arises from the production activities of firm i. The total pollution inflicted on country 1 and on country 2 are, receptively , given by

$$x_1(q_1, q_2, k_1) = e_{11}(q_1, k_1) + e_{12}(q_1, k_1) + e_{21}(q_2),$$

$$x_2(q_1, q_2, k_1) = e_{22}(q_2) + e_{21}(q_2) + e_{12}(q_1, k_1).$$

Let $d_1(x_1)$ and $d_2(x_2)$ be the damage suffered, respectively, by country 1 and country 2 when the level of pollution in these countries are, respectively, given by x_1 and x_2.

Suppose that in country 1 there exists a group of environmentalists who actively seeks to improve the quality of the environment, while in country 2 such a group is practically nonexistent. The existence of environmentalists as a special-interest group in the industrialized nation of the North can be attributed to the high income enjoyed by its citizens and where the quality of the environment becomes more and more important when the country grows richer. In our model, the Southern nation is more preoccupied with raising its income than improving the quality of the environment.

As a special-interest group, environmentalists in the home country behave like a single agent that we call the representative environmentalist. The utility of the representative environmentalist is, as before, assumed to depend on the quality of the environment and the consumption of a numéraire good:

$$u(m, x_1, x_2) = m - \eta_1 \vartheta_1(x_1) - \eta_2 \vartheta_2(x_2).$$

Here m is the amount of the numéraire good consumed; $\eta_1 > 0$, $\eta_2 \geq 0$ are two constants; $\vartheta_1(x_1)$ and $\vartheta_2(x_2)$ denote, respectively, the disutilities caused by the pollution at home and abroad. If $\eta_2 = 0$, the representative environmentalist cares only about his own local environment and he

will be classified as a green. On the other hand, when $\eta_2<0$, his concerns are more global, and he will be classified as a supergreen if η_2 is significantly positive.

It is assumed that the incumbent government in country 1 actively pursues environmental policy and has one policy instrument: an emission tax per unit of emission denoted by τ that it imposes on the domestic firm. *Environmental* R&D investment is assumed to be undertaken by firm 1. The incumbent government in the industrialized nation has utility function that depends on the political contributions it receives and some measure of social welfare. Following conventional applied welfare economics, we assume that social welfare is given by the sum of consumer surplus, producer surplus, and tax revenue minus the pollution damage.

The model is a four-stage game and its extensive form is as follows. In the first stage, the representative environmentalist and the domestic firm announce their political contribution schedules. The political contribution schedule to its own incumbent government announced by the domestic firm is $f_1:(\tau)\rightarrow f_1(\tau)$. Here we interpret $f_1(\tau)$ as the contribution the firm in country 1 offers to its own national government if the latter chooses the policy τ. The schedule announced by the environmentalist at home is $f_2:(\tau)\rightarrow f_2(\tau)$. We interpret f_2 in the same manner as f_1. In the second stage, taking (f_1,f_2) as given, the home government chooses τ to maximize its objective function. In the third stage, the domestic firm chooses its level of *environmental* R&D. In the fourth stage, given the levels of *environmental* R&D and the emission tax, the two firms choose their output levels to maximize profits. We use backward induction to find the subgame-perfect equilibrium for this game.

The fourth stage

Suppose that k_1 is the level of *environmental* R&D chosen by the domestic firm. Given k_1 and τ, the two firms choose their own output levels to maximize profits. If $(q_1^{\#}(k_1,\tau), q_2^{\#}(k_1,\tau))$ is the Cournot equilibrium, then

$$(1) \qquad q_1^{\#}(k_1,\tau) = \underset{q_1}{\text{argmax}} \left[q_1\, p(q_1 + q_2^{\#}(k_1,\tau)) - c_1(q_1) - \tau\, e_1(q_1)\right].$$

$$(2) \qquad q_2^{\#}(k_1,\tau) = \underset{q_2}{\text{argmax}} \left[q_2\, p(q_1^{\#}(k_1,\tau) + q_2) - c_2(q_2)\right].$$

Let $q^{\#}(k_1,\tau) = q_1^{\#}(k_1,\tau) + q_2^{\#}(k_1,\tau)$ be the total output of the two firms under Cournot equilibrium. The profits of firm 1 and firm 2 are given, respectively, by

$$(3) \qquad \begin{aligned} \pi_1(k_1,\tau) &= q_1^{\#}(k_1,\tau)\, p(q^{\#}(k_1,\tau)) - c_1\, q_1^{\#}(k_1,\tau) - \tau_1 e_1(q_1^{\#}(k_1,\tau), k_1), \\ \pi_2(k_1,\tau) &= q_2^{\#}(k_1,\tau)\, p(q^{\#}(k_1,\tau)) - c_2\, q_2^{\#}(k_1,\tau). \end{aligned}$$

The third stage

In the previous stage, the levels of R&D were treated as exogenous. In the third stage, firm 1 takes τ as given and chooses k_1 to maximize its profit. If $k_1^{\#}(\tau)$ is the equilibrium level of *environmental* R&D, then

$$(4) \qquad k_1^{\#}(\tau) = \underset{k_1}{\text{argmax}} \left[\pi_1(k_1,\tau) - r_1\, k_1\right].$$

Where r_1 is cost per unit of R&D for firm 1 and is assumed to be a positive constant. Let

$$(5) \qquad \varphi_1(\tau) = \pi_1(k_1^{\#}(\tau), \tau) - r_1\, k_1^{\#}(\tau), \qquad i=1,2.$$

We can also interpret (5) as the payoff of the domestic firm gross of its political contribution. Also, let $\varphi_2(\tau)$ be the gross payoff of the representative environmentalist, then

(6) $$\pi_2(\tau) = \overline{m} - \eta_1 \vartheta_1(x_1(q_1^{\#}(k_1^{\#}(\tau),\tau), q_2^{\#}(k_1^{\#}(\tau),\tau))) - \eta_2 \vartheta_2(x_2(q_1^{\#}(k_1^{\#}(\tau),\tau), q_2^{\#}(k_1^{\#}(\tau),\tau))).$$

Under the equilibrium $(q_1^{\#}(k_1^{\#}(\tau),\tau), q_2^{\#}(k_1^{\#}(\tau),\tau))$ the consumer surplus, the producer surplus, the tax revenues, and the pollution damage suffered by the home country are given, respectively, by

(7) $$\omega_1(\tau) = \int_0^{q^{\#}(k_1^{\#}(\tau),\tau)} p(q)dq - q^{\#}(k_1^{\#}(\tau),\tau)\ p(q^{\#}(k_1^{\#}(\tau),\tau)).$$

(8) $$\omega_2(\tau) = q_1^{\#}(k_1^{\#}(\tau),\tau)p(q^{\#}(k_1^{\#}(\tau),\tau)) - c_1(q_1^{\#}(k_1^{\#}(\tau),\tau)) - \tau e_1(q_1^{\#}(k_1^{\#}(\tau),\tau), k_1^{\#}(\tau)).$$

(9) $$\omega_3(\tau) = \tau e_1(q_1^{\#}(k_1^{\#}(\tau),\tau), k_1^{\#}(\tau)).$$

(10) $$\omega_4(\tau) = d_1(x_1(q_1^{\#}(k_1^{\#}(\tau),\tau), q_2^{\#}(k_1^{\#}(\tau),\tau), k_1^{\#}(\tau))).$$

Hence, the total welfare, conditioned on the policy choice τ, is given by

(11) $$\omega(\tau) = \omega_1(\tau) + \omega_2(\tau) + \omega_3(\tau) - \omega_4(\tau).$$

Assuming that the home government's objective function is a linear function of the political contributions and social welfare, we can write its utility, conditioned on f_1, f_2, τ, as follows

(12) $$\Gamma(f_1, f_2, \tau) = [f_1(\tau) - f_2(\tau)] + [\alpha\omega(\tau)],$$

where α is a positive constant.

The second stage

In the second stage, taking (f_1, f_2) as given, the home government chooses τ to maximize its objective function. Let $\Re(f_1, f_2)$ be the set of environmental policies that are best responses to (f_1, f_2), i.e.,

(13) $$\Re(f_1, f_2) = \underset{\tau}{\operatorname{argmax}}\ \Gamma(f_1, f_2, \tau).$$

The Nash Equilibrium

A combination of strategies (f_1^*, f_2^*, τ^*) is a Nash equilibrium if the following conditions are satisfied:

a) The chosen environmental policy τ^* represents the home government's best response to f_1^* and f_2^*, i.e., $\tau^* \in \Re(f_1^*, f_2^*)$.

b) For $j, j' = 1, 2$, $j \neq j'$, taking $f_{j'}^*$ as given and the reaction of the home government into account, a best political contribution schedule that lobby j can announce is f_j^*. More precisely, the following inequality must hold for any possible contribution schedule f_j:

$$\sup_{\tau \in \Re(f_j, f_{j'}^*)} [\varphi_j(\tau) - f_j(\tau)] \leq [\varphi_j(\tau^*) - f_j^*(\tau^*)].$$

As we showed in Chapter 3, the inequality in b) is sufficient for f_j^* to be lobby j's best response to $f_{j'}^*$, the political contribution schedule of lobby j'. This inequality is also necessary if f_j^* is best against $f_{j'}^*$.

Assumptions

The following assumptions are imposed upon the model.

Assumption 1: *For $\bar{\tau}$ and $\bar{k}_i$ be positive constants, $\bar{\tau} \geq \tau \geq 0$, $\bar{k}_i \geq k_i \geq 0$.*

Assumption 2: *The demand function $p(q)$ satisfies $p'(q) < 0$, $p(0) > 0$.*

Assumption 3: *For $i = 1, 2$, the total cost function $c_i(q_i)$ satisfies $c_i(0) = 0$, $c_i'(q_i) > 0$, $c_i''(q_i) \geq 0$.*

Assumption 4. *For $i = 1, 2$, the emission function $e_i(q_i, k_i)$ satisfies $de/dq_i > 0$, $d^2e/dq_i^2 \geq 0$ and $de/dk_i < 0$, $d^2e/dk_i^2 < 0$.*

Assumption 5. *For each $i, j = 1, 2$, the disutility function $\vartheta_{ij}(x_j)$ is a strictly increasing and convex function of the pollution level in country j.*

Assumption 6. *For each $j=1,2$, the political contribution schedule $f_j:(\tau) \rightarrow f_j(\tau)$ is a nonnegative and continuous function of τ.*

5.3 Characterization of the Nash Equilibrium

The game just formulated can be solved with the help of the machinery developed in Chapter 3. Propositions 1 through 7 of Chapter 3 also hold for the present game. In particular, the following result is the version of Proposition 4a of that Chapter for the current game.

PROPOSITION 1: *If (f_1^*, f_2^*, τ^*) is a Nash equilibrium that is Pareto efficient for the industry lobby and the representative environmentalist, then*

$$\tau^* \in \underset{\tau}{argmax}\ [\varphi_1(\tau) + \varphi_2(\tau) + \alpha\omega(\tau)]. \tag{14}$$

Under some reasonable hypotheses, the maximization problem (14) will have a unique solution, i.e., the environmental policy adopted by the home government is generally well defined. Also, if τ^* is an interior solution of (14), then the following first-order condition is satisfied

$$D\varphi_1(\tau^*) + D\varphi_2(\tau^*) + \alpha D\omega(\tau^*) = 0. \tag{15}$$

Equation (15) will be use in later sections to determine the emission tax.

To continue with the characterization of the Nash equilibrium, let us define

$$\omega_1^{max} = \max_{\tau}\ [\alpha\omega(\tau)]; \tag{16}$$

(17) $$v_{oj}^{max} = \max_{\tau} [\varphi_j(\tau) + \alpha\omega(\tau)], \quad j=1,2;$$

(18) $$v_{o12}^{max} = \max_{\tau} [\varphi_1(\tau) + \varphi_2(\tau) + \alpha\omega(\tau)].$$

For any combination of strategies $\xi = (f_1, f_2, \tau)$, let

$$\Phi_0(\xi) = f_1(\tau) + f_2(\tau) + \alpha\omega(\tau),$$

$$\Phi_j(\xi) = \varphi_j(\tau) - f_j(\tau), \qquad j=1,2$$

The arguments used to establish Proposition 4c, 4d of Chapter 3can be repeated verbatim to obtain the following result.

PROPOSITION 2: *Let (f_1^*, f_2^*, τ^*) be a Nash equilibrium that is Pareto efficient for the industry lobby and the representative environmentalist in the home country*

a) If $(v_{o12}^{max} - v_{o1}^{max}) + (v_{o12}^{max} - v_{o2}^{max}) \geq v_{o12}^{max} - v_{o}^{max}$, *then the net payoffs for the home government, the domestic firm, and the domestic environmentalist are unique and given, respectively, by*

(i) $\phi_0(\xi^*) = v_{o1}^{max} + v_{o2}^{max} - v_{o12}^{max}$.

(ii) $\phi_1(\xi^*) = v_{o12}^{max} - v_{o2}^{max}$.

(iii) $\phi_2(\xi^*) = v_{o12}^{max} - v_{o1}^{max}$.

c) If $(v_{o12}^{max} - v_{o1}^{max}) + (v_{o12}^{max} - v_{o2}^{max}) \geq v_{o12}^{max} - v_{o}^{max}$, *then the payoff for the home government is unique and given by*

(i) $\phi_0(\xi^*) = v_{o}^{max}$.

the same level of payoff it obtains by including only social welfare in its objective function. On the other hand, the net payoffs for the two domestic special-interest groups are not unique but constitute a line segment defined by the following conditions

(ii) $\phi_1(\xi^*) - \phi_2(\xi^*) = v_{-12}^{\max} - v_{-1}^{\max}$.

(iii) $\phi_1(\xi^*) \leq v_{-12}^{\max} - v_{-2}^{\max}$.

(iv) $\phi_2(\xi^*) \leq v_{-12}^{\max} - v_{-1}^{\max}$.

5.4 The Model Under Some Special Functional Forms

5.4.1 Functional Forms

To gain more insights about the solution of the game, we shall introduce some functional forms for consumers' demand, producers' profits, environmentalist's utility, and pollution damage. These special functional forms allow us to obtain an explicit solution of the game.

Consumers' demand

The general structure of demand facing the two firms should be familiar from previous chapters. The following inverse demand function is assumed

(19) $\qquad p = a - q.$

Producers' profits

As before we assume that the domestic and foreign firms have the same cost function that has the following form

(20) $\qquad c_i(q_i) = cq_i, \qquad i = 1,2.$

where c is marginal cost. Let us assume that the emission function of firm 1 takes the following form

(21) $$e_1(q_1,k_1) = \varepsilon_1(k_1)q_1 = \bar{\varepsilon}\ exp(-k_1)q_1.$$

where $\bar{\varepsilon}$ is a positive constant. When there is no *environmental* R&D (i.e., $k_1=0$), emission per unit of output is equal to $\bar{\varepsilon}$. Since firm 2 -- which operates in the Southern country -- does not invest in *environmental* R&D, its emission per unit of output, ε_2, is equal to $\bar{\varepsilon}$. Note that the *environmental* R&D production function exhibits diminishing returns.

Social Welfare

Let $e_{12}(q_1,k_1)=\rho_{12}\bar{\varepsilon}\ exp(-k_1)q_1$ be the transboundary pollution flowing from country 1 into country 2 as the result of production activities of firm 1. Similarly, let $e_{21}(q_2)=\rho_{21}\bar{\varepsilon}\,q_2$ be the transboundary pollution flowing from the Southern country into the Northern country. The total pollution inflicted on country 1 is then given by

$$x_1(q_1,q_2,k_1) = (1-\rho_{12})\bar{\varepsilon}\ exp(-k_1)q_1 + \rho_{21}\bar{\varepsilon}\,q_2.$$

where $0 \le \rho_{ij} \le 1$ for i,j=1,2; i≠j. The transboundary effects are captured by parameter ρ_{ij}. When $\rho_{ij}=0$, no pollution flows from country i into country j. Similarly, the total pollution in country 2 is

$$x_2(q_1,q_2,k_1) = (1-\rho_{21})\bar{\varepsilon}\,q_2 + \rho_{12}\bar{\varepsilon}\ exp(-k_1)q_1.$$

The following functional form is suggested for the environmental damage in country i

$$d_i(x_i) = x_i^2 \qquad i=1,2.$$

The environmentalist's utility

The disutility function is assumed to be of the following form

$$\vartheta_i(x_i) = (x_i)^2, \quad i=1,2$$

Next, we use the above functional forms to find the equilibrium level of emission tax in a four-stage game.

5.4.2 *Environmental* R&D in the North-South Model

Using the above functional forms we now derive the equilibrium level of emission tax in the presence of *environmental* R&D investment in the North-South model. Let us begin with the last stage of the game. In stage 4, the emission tax τ has been fixed by the home government and *environmental* R&D – in the amount k_1 – has been made by the domestic firm. Taking as given τ and k_1, the domestic and foreign firms play a Cournot game in output levels. If q_2 is the output level of the foreign firm, then the domestic firm's best response to q_2 is obtained by solving the following profit maximization problem

$$(22) \qquad \max_{q_1} \{(a - q_1 - q_2)q_1 - cq_1 - \tau\bar{z}\exp(-k_1)q_1\}.$$

Similarly, if q_1 is the output level chosen by firm 1, then firm 2 – the foreign firm – solves the following profit maximization problem

$$(23) \qquad \max_{q_2} \{(a - q_1 - q_2)q_2 - cq_2\}.$$

The reaction function's obtained by solving (22) and (23) can be used to obtain the following Cournot equilibrium

(24) $$q_1^{\#}(k_1,\tau) = [a - c - 2\tau\bar{\varepsilon}\ exp(-k_1)]/3.$$

(25) $$q_2^{\#}(k_1,\tau) = [a - c + \tau\bar{\varepsilon}\ exp(-k_1)]/3.$$

In the third stage, firm 1 takes τ as given and chooses k_1 to maximize its profit net of the R&D expenditure. By substituting (24) and (25) into (4) we obtain

(26) $$k_1^{\#}(\tau) = \underset{k_1}{\text{argmax}}\ [(\ (a-c)^2 - 4(a-c)\ \tau\bar{\varepsilon}\ exp(-k_1) - 4\tau^2\ \bar{\varepsilon}^2\ exp(-2k_1) - 9r_1k_1\ )/9],$$

in which cost per unit of R&D for firm 1, r_1, is a positive constant.

The first and second derivatives with respect to k_1 of the objective function in (26) are given, respectively, by

(27) $$[4(a-c)\tau\bar{\varepsilon}\ exp(-k_1) - 8\tau^2\ \bar{\varepsilon}^2\ exp(-2k_1) - 9r_1\ ]/9.$$

(28) $$-[4(a-c)\tau\bar{\varepsilon}\ exp(-k_1) - 16\ \tau^2\ \bar{\varepsilon}^2\ exp(-2k_1)]/9.$$

If (26) has an interior solution, then the following first-order condition must hold

(29) $$8\tau^2\ \bar{\varepsilon}^2\ exp(-2k_1) - 4(a-c)\tau\bar{\varepsilon}\ exp(-k_1) - 9r_1 = 0.$$

Observe that (29) is a quadratic equation in which has two solutions given by

(30) $$exp(-k_1^{\#}) = \frac{(a-c) \pm \sqrt{(a-c)^2 - 18r_1}}{4\bar{\varepsilon}\tau}.$$

For the right side of (30) to be real, we need to assume that $(a-c)^2 - 18r_1 \geq 0$. Furthermore, for a maximum, the second-order condition must also be satisfied, i.e., (28) must be negative or, equivalently,

(31) $$4\tau\bar{\varepsilon}\ exp(-k_1)[(a-c) - 4\tau\bar{\varepsilon}\ exp(-k_1)] > 0.$$

In order for (31) to be positive, we must have

(32) $$exp(-k_1) < (a-c)/4\tau\bar{\varepsilon}.$$

The second-order condition, as represented by (32), rules out the larger root in (30). Hence if $k_1^{\#}(\tau)$ is an interior solution of (26), we must have

(33) $$exp(-k_1^{\#}(\tau)) = \frac{(a-c)-\sqrt{(a-c)^2-18r_1}}{4\bar{\varepsilon}\tau}.$$

To learn more about the domestic firm's investment in environmental R&D as τ varies, we shall now analyze the first derivative (27) in more detail. First, observe that (27) is negative if $\tau=0$. Hence, when τ is small, we have $k_1^{\#}(\tau) = 0$, i.e., the domestic firm will not invest in *environmental* R&D. As τ increases from 0, there comes a point, say $\tau = \tau^{min}$, where $k_1^{\#}(\tau)$ begins to rise from 0 in a right neighborhood of τ^{min}. To find this critical value of τ, note that when one set $k_1 = 0$ in (27), this derivative will be negative for $\tau^{min} > \tau \geq 0$, vanishes at $\tau = \tau^{min}$, and rises above 0 in a right neighborhood of τ^{min}. Therefore, τ^{min} is the smaller root of the following quadratic equation in τ:

(34) $$4(a-c)\tau\bar{\varepsilon} - 8\tau^2\bar{\varepsilon}^2 - 9r_1 = 0,$$

i.e.,

(35) $$\tau^{min} = \frac{(a-c)-\sqrt{(a-c)^2-18r_1}}{4\bar{\varepsilon}\tau}.$$

Now when τ is in a right neighborhood of τ^{min}, the domestic firm's investment in *environmental* R&D is positive and given by (33), i.e.,

(36) $$k_1^{\#}(\tau) = -\ln\left[\frac{(a-c)-\sqrt{(a-c)^2-18r_1}}{4\bar{\varepsilon}\tau}\right].$$

Furthermore, using (33) to evaluate the outputs of the domestic and foreign firms – given by (24) and (25) – under Cournot equilibrium, we obtain

(37) $$q_1^{\#}(k_1^{\#}(\tau),\tau) = \frac{(a-c)-\sqrt{(a-c)^2-18r_1}}{6},$$

$$q_2^{\#}(k_1^{\#}(\tau),\tau) = \frac{5(a-c)-\sqrt{(a-c)^2-18r_1}}{12}.$$

Observe the interesting result that the Cournot equilibrium represented by (37) does not depend on τ. Furthermore, as τ continues to rise from the critical level τ^{min}, (37) remains the output levels chosen by the domestic and foreign firms under Cournot equilibrium. Hence, the revenues and production costs for each firm remain the same as τ increases beyond τ^{min}. All that happens is that the domestic firm's investment in *environmental* R&D rises with τ to keep the "effective emission tax per unit of output", namely $\tau \bar{\varepsilon} \exp(-k_1^{\bar{}}(\tau))$, constant. The domestic firm reacts to the rising emission tax τ not by changing output but by increasing investment in environmental R&D to reduce the emission per unit of output. With revenue minus production costs remaining constant and investment in *environmental* R&D rising with τ, there will come a point, say $\tau = \tau^{max}$, when the cost in *environmental* R&D completely offset the profits (revenues minus production costs) obtained by engaging in production. Hence, the domestic firm will shut down when $\tau \geq \tau^{max}$.

Therefore, if the incumbent government in the Northern country, under the influence of a very strong environmental movement, sets the emission tax too high (i.e., $\tau \geq \tau^{max}$), the domestic firm has to leave and the foreign firm captures the whole market and hence will be the big winner of this game. This might provide an example for the case where many consider as conflict between economy and the environment.

As τ varies, the output of the domestic firm and its profits – net of production costs and investment in *environmental* R&D – are depicted in the following figures:

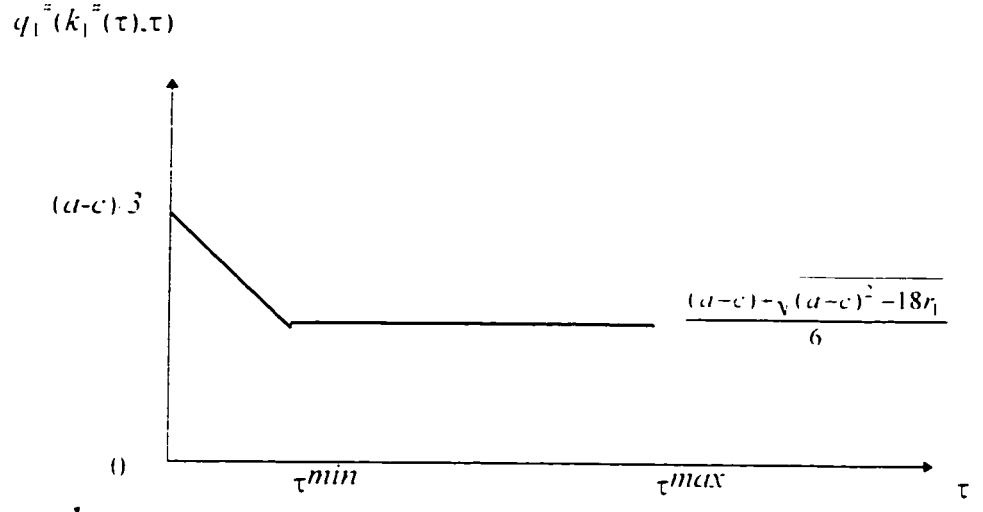


Figure 1

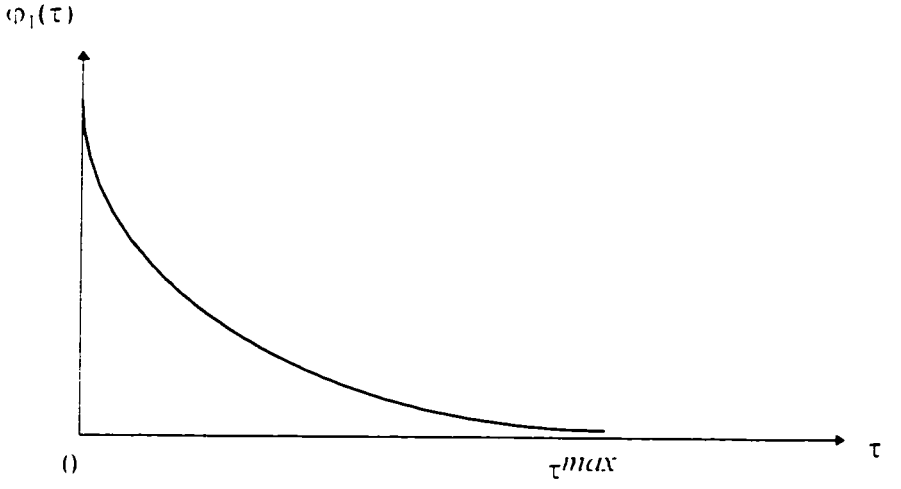


Figure 2

We are now ready for the central results of this chapter.

PROPOSITION 3: *Imagine that at the beginning the environmental lobby does not exist, i.e., the domestic firm and the home government are the only players in the game. Let* $\tau_{01}^{\bullet}$ *be the emission tax chosen by the home government under this scenario, i.e.,*

(38) $$\tau_{01}^{*} \in \underset{\tau}{argmax}\,[\varphi_1(\tau) - \alpha\omega(\tau)].$$

Next, let us introduce the representative environmentalist on the scene and let τ_{012}^{*} *be the emission tax chosen for the game constituted by the domestic firm, the representative environmentalist, and the home government i.e.,*

(39) $$\tau_{012}^{*} \in \underset{\tau}{argmax}\,[\varphi_1(\tau) + \varphi_2(\tau) - \alpha\omega(\tau)].$$

Suppose that there is no transboundary pollution and that the environmentalist cares only about his local environment. Then, under the functional forms adopted in Section 4.1, the following results hold.

(a) $\tau_{012}^{*} \geq \tau_{01}^{*}$ *, i.e., the emergence of the environmental lobby causes the home government to raise the emission tax, with strict inequality holding if* $\tau_{01}^{*} > 0$.

(b) The emergence of the environmental lobby has a positive impact on the local environment. More precisely,

(b1) If $\tau^{min} \geq \tau_{012}^{*}$*, then the domestic firm will not undertake any environmental R&D activities. The improvement in the quality of the home government is brought about by a reduction in output of the domestic firm, which results in a less polluted home environment.*

(b2) If $\tau_{01}^{*} < \tau^{min} < \tau_{012}^{*}$*, then the domestic firm, which did not carry out any environmental R&D activities before, will now engage in these activities and cut back production at the same time. The combined result of these decisions is a cleaner home environment;*

(b3) If $\tau_{012}^{*} > \tau_{01}^{*} \geq \tau^{min}$*, then the domestic firm will maintain its output level. Furthermore, if it has not made any investment in environmental R&D, then a program on*

environmental R&D will be started. On the other hand, if a program on environmental R&D has already begun, then it will be intensified.

PROOF: We have already shown that the output of the domestic firm is strictly decreasing in $\tau^{min} \geq \tau \geq 0$. Hence, the quality of the home environment is strictly increasing in $\tau^{min} \geq \tau \geq 0$ although the domestic firm undertakes no *environmental* R&D activities in this case. When τ rises above τ^{min}, the domestic firm's output remains the same. However, in this case increasing investments in *environmental* R&D reduce emission per unit of output resulting in a cleaner environment. Therefore, $\varphi_2(\tau)$, the representative environmentalist's utility before political contributions is strictly increasing in τ. Using this last result and (38), we can assert that

(40) $$\varphi_1(\tau_{01}^{\bullet}) + \varphi_2(\tau_{01}^{\bullet}) - \alpha\omega(\tau_{01}^{\bullet}) \geq \varphi_1(\tau) + \varphi_2(\tau) - \alpha\omega(\tau)$$

for all $\tau_{01}^{\bullet} \geq \tau \geq 0$. It follows from (39) and (40) that $\tau_{012}^{\bullet} \geq \tau_{01}^{\bullet}$. Furthermore, assuming that $\tau_{01}^{\bullet}$ is an interior solution of (38), we obtain the following first-order condition

(41) $$\varphi_1'(\tau_{01}^{\bullet}) - \alpha\omega'(\tau_{01}^{\bullet}) = 0.$$

Because $\varphi_2(\tau)$ is strictly increasing in τ, we must have

(42) $$\varphi_1'(\tau_{01}^{\bullet}) + \varphi_2'(\tau_{01}^{\bullet}) - \alpha\omega'(\tau_{01}^{\bullet}) > 0.$$

Therefore, $\tau_{012}^{\bullet} \geq \tau_{01}^{\bullet}$, with strict inequality holding if $\tau_{01}^{\bullet} > 0$. Part a) of Proposition 3 is proved. Part b) of this proposition follows directly from the discussion leading to the statement of the proposition. Q.E.D.

Proposition 3 asserts that the emergence of the environmental lobby increases the emission tax in the Northern country. The more stringent environmental policy in turn will raise

environmental R&D investment in the North. Because the combined output of the domestic and foreign firms decline when the emission tax rises, the total amount of pollutants emitted into the global environment (home + abroad) will decrease. It is interesting to observe that the presence of an environmental lobby which is selfish -- in a sense that it only cares about its own local environment -- still can have a positive impact on the global environment.

To make the problem more interesting let us focus on the case in which the domestic firm in the Northern country undertakes *environmental* R&D investment (i.e., $\tau > \tau^{min}$.) Then, the following proposition holds regardless of the environmentalists' type and transboundary pollution.

PROPOSITION 4: *Suppose that at the beginning, the domestic firm and the home government are the only players in the game. Let* τ_{01}^{*} *be the emission tax chosen by the home government under this scenario. Next, we introduce an environmental group into the scene and let* τ_{012}^{*} *be the emission tax chosen for the game constituted by the domestic firm, the representative environmentalist, and the home government. If* τ_{01}^{*} *and* τ_{012}^{*} *are in the right neighborhood of* τ^{min}, *then, under the functional forms adopted in Section 4.1, the following results hold.*

(a) the emergence of the environmental lobby improves the quality of the home and world[3] *environments.*

(b) The presence of the environmental lobby causes the home government to raise the emission tax, i.e., $\tau_{012}^{*} \geq \tau_{01}^{*}$.

---

[3] Following Chapter 3, we assume that the world consists of only two countries -- i.e., one Northern country and one Southern country.

PROOF: If the representative environmentalist is a supergreen, then from (38) and (39) we have

(43) $$\overline{m} - f_2^{\bullet}(\tau_{012}^{\bullet}) - \vartheta(x_1(\tau_{012}^{\bullet}), x_2(\tau_{012}^{\bullet})) \geq \overline{m} - \vartheta(x_1(\tau_{01}^{\bullet}), x_2(\tau_{01}^{\bullet})).$$

If the environmental lobby's political contribution is positive, i.e., if $f_2^{\bullet}(\tau_{012}^{\bullet})>0$, then it follows directly from (43)

(44) $$\vartheta(x_1(\tau_{012}^{\bullet}), x_2(\tau_{012}^{\bullet})) < \vartheta(x_1(\tau_{01}^{\bullet}), x_2(\tau_{01}^{\bullet})).$$

Now, if the environmental lobby only cares about its own local environment, then (44) implies that $x_1(\tau_{012}^{\bullet}) < x_1(\tau_{01}^{\bullet})$.

Next, let us consider the case where the environmental lobby is a supergreen. Since we assumed that the level of emission tax in the absence of environmentalists is already on the right neighborhood of τ^{min}, from (37) we know that the output levels of the domestic and the foreign firms are independent of emission tax. This, in turn, keeps the total environmental damage in the foreign country, $x_2(\tau)$ unaffected by any possible change in the level of environmental policy brought about by the emergence of a supergreen environmental lobby. Thus, (44) implies that $x_1(\tau_{012}^{\bullet}) < x_1(\tau_{01}^{\bullet})$ and (a) must hold.

We know that the output levels of the firms are not affected by a variation in emission tax provided $\tau > \tau^{min}$. Furthermore, from (21) and part (a) of this proposition we have

(45) $$x_1(k_1(\tau_{012}^{\bullet})) < x_1(k_1(\tau_{01}^{\bullet})).$$

This implies

(46) $$k_1(\tau_{012}^{\bullet}) > k_1(\tau_{01}^{\bullet}).$$

Hence, from (36) we must have $\tau_{012}^{\bullet} > \tau_{01}^{\bullet}$. Part (b) of the proposition is established. Q.E.D.

From Chapter 3 we know that in the absence of *environmental* R&D, when the pollution spills over from one country to another, the impacts of a supergreen environmentalist on the emission tax and the local environment are not determinant. However, when the domestic firm in the industrialized country undertakes environmental R&D investments, the emergence of a supergreen environmental lobby raises the emission tax and lowers the damage to the home and world (i.e., the Northern country and the Southern Country) environments regardless of the amount of transboundary pollution.

To confirm some of the results obtained in the propositions, let us consider a case in which $\tau>\tau^{min}$ (i.e., the domestic firm undertakes an *environmental* R&D). Suppose that the representative environmentalist in the Northern country is a green and there is no movement of pollution across the countries (i.e., $\rho_{12}=\rho_{21}=0$). In this case, the derivative of the damage function in country 1 with respect to τ is given by

(47) $$d_1'(\tau) = -9 r_1^2 + 8 \tau^3,$$

which is clearly negative. Hence, an increase in the emission tax lowers the damage to the environment of the industrialized country. The intuition is that for $\tau > \tau^{min}$, when the incumbent government in country 1 increases the emission tax, the output levels of the two firms will not change while the domestic firm induced by higher tax will enhance its *environmental* R&D. This, in turn, lowers the emission per unit of output and hence improves the quality of the home environment. Moreover, since the output level of firm 2 is also independent of τ, in the absence of transboundary pollution, the total pollution and hence the environmental quality of country 2 are independent of the emission tax imposed on firm 1. Thus, an increase in the emission tax also

improves the quality of the world environment through decreasing the damage to the environment of the Northern country.

When the environmentalist is a green, we set η_1 =1 and η_2 =0. The utility of the representative green environmentalist is given by

(48) $$\varphi_2(\tau) = \overline{m} - 9r_1^2 / 16\tau^2,$$

which is clearly an increasing function of the emission tax. Hence, in the green model with no transboundary pollution, an increase in emission tax will have a positive impact on the payoff of environmentalists. However, this result holds regardless of the environmentalists' type and the amount of transboundary pollution. More explicitly, the derivative of the utility of the supergreen environmentalist with respect to the emission tax is given by

(49) $$\varphi_2'(\tau) = (r_1 / 8\tau^3)\{\eta_1(\rho_{12}-1)[9r_1(\rho_{21}-1)-\bar{\varepsilon}\,\tau\,\rho_{21}(5(a-c)-\sqrt{(a-c)^2-18r_1})] + \eta_2\,\rho_{12}[9r_1\rho_{12}-\bar{\varepsilon}\,\tau\,(\rho_{21}-1)(5(a-c)-\sqrt{(a-c)^2-18r_1})]\}.$$

Since $1>\rho_{12}, \rho_{21} \geq 0$ and $5(a-c)-\sqrt{(a-c)^2-18r_1} \geq 0$, then (49) must be positive.[4] Hence, no matter whether the environmentalist is a *green* (i.e., η_2=0) or a *supergreen* (i.e., η_2=1), his utility increases with a rise in the emission tax. This has been made possible by introducing environmental R&D to the North-South model. The reason is that for a sufficiently high level of the emission tax, a tougher environmental policy induces the domestic firm to undertake environmental R&D or enhances its existing R&D program. This, in turn, will lower its emission per unit of output, while keeping the output level of the foreign firm unchanged. Thus, the quality of environments at home and abroad will improve. One should also note that the amount of pollution that flows from one country to another will not alter the above result. It makes the

[4] From (37) we know that $5(a-c)-\sqrt{(a-c)^2-18r_1}$ is equal to $12q_2$ and hence cannot be negative.

result of this chapter very different form those obtained when no *environmental* R&D was possible. As we have shown in Chapter 3, the impact of emission tax on the utility of the representative environmentalist was very sensitive to our assumptions on the environmentalist's type and on the amount of pollution that crosses the borders.

Now we can solve the model to find the equilibrium level of emission tax. When the game is played by the incumbent government and both environmental and industry lobbies, the equilibrium pollution charge is given by

$$(50)\quad \tau^{*} = \{5\bar{\varepsilon}\rho_{21}(1-\rho_{12})(\alpha-\eta_1+\eta_2)(a-c) - A\bar{\varepsilon}[\eta_1\rho_{21}(1-9\rho_{12}) - (1-\rho_{12})(\alpha\rho_{21}-\rho_{12}\eta_2)] + \sqrt{(A-5a+5c)^2\bar{\varepsilon}^2[\alpha\rho_{21}(\rho_{12}-1)-\rho_{12}\eta_2+\rho_{21}(\rho_{12}(\eta_2-\eta_1)-\eta_1)]^2 - 288(1-\alpha)(\rho_{12}-1)^2(\eta_1+\alpha)-\rho_{12}^2\eta_2)r}\}/16(1+\alpha),$$

where $A = \sqrt{(a-c)^2-18r}$. Given α, the equilibrium emission tax τ^{*} depends on the cost per unit of output, c, the emission per unit of output, $\bar{\varepsilon}$, the weight that the incumbent government of the Northern country attaches to social welfare, α, the amount of the emission that spills over from one country to the other captured by ρ_{ij} $(i\neq j)$, and the type of environmentalists denoted by η_1 and η_2.

As an exercise, we take the case in which there is no transboundary pollution (i.e., $\rho_{12}=\rho_{21}=0$) and our representative environmentalist is a green (i.e., $\eta_1=1$, $\eta_2=0$.) Suppose that the weight on the social welfare, α, is one. In this case, when the two lobbies and the incumbent government are present in the economy, from (50), the equilibrium emission tax is given by[5]

$$(51)\qquad \tau_{012}^{*} = \frac{3\sqrt{r}}{2\sqrt{2}}.$$

[5] In this case we obtain two solutions. Since one of them is negative, it is ruled out by assumption 1.

To see how the emergence of an environmental interest group affects the equilibrium emission tax and hence the quality of the environment in the North, we eliminate the environmental lobby from the model. When the game is only between the industry and the government, equilibrium emission tax is given by[7]

$$\tau_{01}^{*} = \frac{3\sqrt{r_1}}{4}. \tag{52}$$

By comparing (51) with (52) it is clear that the emission tax is higher in the presence of the green environmental lobby in the North. We have already shown that a more stringent emission tax raises *environmental* R&D investments and lowers the home and the world environmental damages. It is interesting to observe that the presence of an environmental lobby which is selfish -- in a sense that it only cares about its own national environmental damage -- has a positive impact on the global environment. Furthermore, as we have shown, an increase in the emission tax will lower the gross payoff of the domestic firm in the Northern country and increase the utility of a green environmentalist.

Next, suppose that there is no industry lobby in the economy. The equilibrium emission tax in this case is given by

$$\tau_{02}^{*} = \frac{3\sqrt{r_1}}{2}. \tag{53}$$

If political contributions do not enter the objective function of the home government, the government in the North will maximize social welfare, as defined by (11). In this case, the emission tax is given by[8]

---

[7] As before we have ruled out the negative solution for emission tax.

[8] In the traditional approach, τ_0^{*} is called "socially optimal level of emission tax" because it is obtained by maximizing social welfare.

(54) $$\tau_0^* = \frac{3\sqrt{r}}{2\sqrt{2}}.$$

From (51), (52), (53), and (54) we have $\tau_{02}^* + \tau_0^* = \tau_{012}^* + \tau_{01}^*$. Thus, in the presence of all lobbies in the game, the equilibrium emission tax is also socially optimum. This surprising result differs from the one obtained in Chapter 3. It shows that those pressures exerted by various lobbies on their government offset each other.[8] As is clear, when the green environmental (industry) group is not active, the emission tax is below (above) its socially optimal level.

Next, we consider the impact of the environmental group on the net payoff of the industry. Indeed, we will confirm Proposition 6 of Chapter 3. When the environmentalist is a green, $v_{12}^{max} - v_2^{max}$ and $[(v_{012}^{max} - v_{01}^{max}) - (v_{012}^{max} - v_0^{max})]$ are given, respectively, by

(55) $$\{(a-c)^2 + (a-c)\sqrt{(a-c)^2 - 18r} - 49.5r_1 + 18\bar{m} + 18r_1 \log[(a-c) - \sqrt{(a-c)^2 - 18r}] - \bar{\varepsilon}\sqrt{r_1}\}/18.$$

(56) $$\{(a-c)^2 + (a-c)\sqrt{(a-c)^2 - 18r} - 61.3r_1 + 18\bar{m} + 18r_1 \log[(a-c) - \sqrt{(a-c)^2 - 18r}] - \bar{\varepsilon}\sqrt{r_1}\}/18.$$

It is clear that (55) is greater than (56) and hence, according to Proposition 6 of Chapter 3, the net payoff of the domestic firm will decrease with the emergence of the environmental lobby. To confirm this result, the net payoffs of firm 1 before and after the appearance of the environmental interest group are given, respectively, by

(57) $$v_1^{max} - v_1^{max} = \{(a-c)^2 + (a-c)\sqrt{(a-c)^2 - 18r} - 31.5r_1 + 18r_1 \log[(a-c) - \sqrt{(a-c)^2 - 18r}] - \bar{\varepsilon}\sqrt{r_1}\}/18.$$

(58) $$v_{12}^{max} - v_{02}^{max} = \{(a-c)^2 + (a-c)\sqrt{(a-c)^2 - 18r} - 43.3r_1 + 18r_1 \log[(a-c) - \sqrt{(a-c)^2 - 18r}] - \bar{\varepsilon}\sqrt{r_1}\}/18.$$

Since (57) is greater than (58), the net payoff of the domestic firm is lower in the presence of the environmental interest group.

---

[8] One should bear in mind that this result is made possible when the level of emission tax is high enough to induce the domestic firm to undertake *environmental* R&D and the government has no preferences over the payoffs of lobbies – which means it attaches same weights to the welfare of both lobbies.

To sum up, the emergence of the environmental lobby on the political scene of the industrialized country raises the *environmental* R&D investment, lowers the profit of the domestic firm, and improves the quality of the home and world environments by inducing its incumbent government to adopt more stringent environmental policies. Moreover, when only one lobby is present in the economy, the equilibrium emission tax is either below or above its socially optimal level.

5.5 A Numerical Example

Table 1 presents the results of a numerical example for $\eta_1=1$, $\eta_2=0$, $a=200$, $c=10$, $\bar{\varepsilon}=1$, $\bar{m}=10^2$, $r_1=1$, and $\alpha=1$.

Table 1 Green model without transboundary pollution

	τ	k_1	d_1	φ_1	φ_2	*Joint payoff*
Social Welfare, ω	1.06	4.49	0.5	4005.62	99.5	12027.6
Government plus environmentalist group	1.50	4.84	.25	4005.27	99.8	12127.2
Government plus industry group	0.75	4.15	1.0	4005.96	99.0	16033.4
Government plus both lobbies	1.06	4.49	0.5	4005.62	99.5	16132.7

For $\eta_1=1$, $\eta_2=0$, $a=200$, $c=10$, $\bar{\varepsilon}=1$, $\bar{m}=10^2$, $r_1=1$, and $\alpha=1$. τ = emission tax; d_1 = the environmental damage in country 1; φ_1 = profit of the domestic firm; φ_2 = gross payoff of the representative environmentalist.

As Table 1 shows, when only the industry lobby is present in the model, the equilibrium emission tax is 0.75. After the environmental interest group comes to the scene, the emission tax increases to 1.06. In this case, the profit of the domestic firm decreases from 4005.96 to 4005.62, the quality of the home environment, d_1 improves. This, in turn, raises the gross payoff of the green environmentalist from 99.0 to 99.5.

The higher the equilibrium emission tax, the larger the amount of *environmental* R&D undertaken by the domestic firm in the industrialized country. In Table 1, as the third column from left shows, the amount of *environmental* R&D in the North increases when an environmental group comes to the scene. The table also shows that the emission tax is below (above) its socially optimal level if the environmental (industry) lobby does not offer any political contribution to its government.

From Table 2 one can see, $V_{012}^{max} - V_{0}^{max} = 4105.12$ is greater than $(V_{012}^{max} - V_{01}^{max}) + (V_{012}^{max} - V_{02}^{max}) = 4104.77$. Hence, according to Proposition 6 of Chapter 3, we know that the emergence of the environmental lobby should lower the net payoff of the domestic firm. In this example, the net payoff of the domestic firm decreases from 4005.81 to 4005.46.

Moreover, since in this example $V_{012}^{max} - V_{0}^{max} > (V_{012}^{max} - V_{01}^{max}) + (V_{012}^{max} - V_{02}^{max})$, from Proposition 7 of Chapter 3 we expect the home government's payoff to rise with the emergence of the environmental lobby. As Table 2 shows, the government's net payoff in the presence of the environmental group, i.e., $\phi_0 = V_{01}^{max} + V_{02}^{max} - V_{012}^{max}$, is equal to 12027.9 which is greater than its net payoff in the absence of the green environmental lobby, i.e., $V_{0}^{max} = 12027.6$.

Table 2 Green model without transboundary pollution: Net payoffs

V_{0}^{max}	V_{012}^{max}	$V_{012}^{max} - V_{0}^{max}$	$V_{01}^{max} - V_{0}^{max}$	$V_{1}^{*} = V_{012}^{max} - V_{02}^{max}$	$V_{2}^{*} = V_{012}^{max} - V_{01}^{max}$	$V_{012}^{max} - V_{01}^{max} - V_{012}^{max} - V_{02}^{max}$	$\phi_0 = V_{01}^{max} + V_{02}^{max} - V_{012}^{max}$
12027.6	16132.7	4105.12	4005.81	4005.46	99.31	4104.77	12027.9

For $\eta_1 = 1, \eta_2 = 0, a = 200, c = 10, \bar{\varepsilon} = 1$, and $\alpha = 1$.

The political contribution of the domestic firm and the environmental lobby are, respectively, 0.153 and 0.19. As expected, the political contribution of the environmentalist is higher in this case due to the higher weight that the incumbent government attaches to the welfare of the

domestic firm by including producer surplus as a component of social welfare. The results obtained in Table 2 are also illustrated in Figure 3.

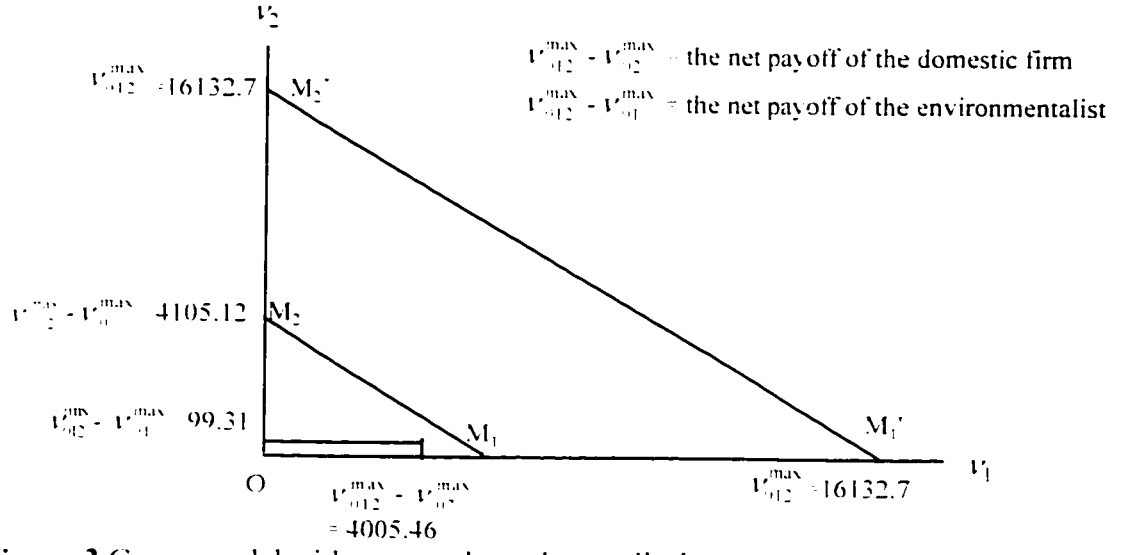


Figure 3 Green model without transboundary pollution

As this figure shows, since C lies below M_1M_2 the Pareto efficient frontier is a single point. Hence, we have a unique solution for this game.

5.6 Conclusion

In this chapter, we extend the models developed in Chapter 3 to include *environmental* R&D. The focus is on the emergence of the environmental movement in the context of North-South trade. The motivation for an incumbent government to use environmental policy arises from its selfish desire to maximize political support.

This chapter seeks an answer to the question of whether environmentalists who confront an industry lobby -- through the pressure they exert on politicians -- are successful in raising environmental standards, and which interest groups will benefit from the political process. We find that environmental regulations adopted by the Northern government, if properly designed, may

induce its domestic firm to investment in *environmental* R&D to reduce its emission per unit of output.

The chapter finds that the equilibrium emission tax in the Northern country depends on the cost and the emission per unit of output, the weight that an incumbent government attaches to social welfare, the amount of pollution that countries transfer to each other, and the type of the representative environmentalists.

When the environmentalist is a green and pollution does not cross borders, we find that the presence of an environmental lobby in the industrialized country might raise *environmental* R&D investment in the North, lower the profit of the domestic firm, and improve the quality of the home and world environments by inducing its incumbent government to adopt more stringent environmental policies.

No matter what the type of the environmentalist or the amount of transboundary pollution is, we find, for sufficiently high levels of emission tax, when *environmental* R&D is introduced to the North-South model, the emergence of an environmental lobby raises the pollution tax and lowers the damage to the home and world environments. These results are different from those obtained in the absence of an R&D program. In Chapter 3, we saw that the presence of an environmental lobby could increase or decrease the emission tax and the quality of the home and the global environments, depending on the amount of transboundary pollution and the environmentalist's type. Furthermore, the chapter shows how the absence of one interest group from the model will deviate the equilibrium emission tax from its socially optimal level.

This chapter also shows that a more stringent emission tax set by the incumbent government in the North can have three different impacts on the domestic firm: (1) if the environmental policy is too low, the domestic firm will not undertake any *environmental* R&D

and it will cut back its output: (2) if the tax is too high, the firm will shut down and the foreign firm will capture the whole market; and (3) if the emission tax is in a certain range, the domestic firm will undertake *environmental* R&D investment and the market share of domestic firm will not be affected. However, as we have shown in this thesis, in a political-economy model there is no guarantee that an incumbent government will choose an environmental policy to keep its domestic firm competitive in the international market.

Finally, while the chapter finds that a more stringent environmental regulation might induce a domestic firm to undertake R&D investments to reduce its emission per unit of output, it fails to confirm that this will raise the firm's profitability or competitiveness in the international market. In fact, it shows that an increase in pollution tax forces the domestic firm to either cut back its output or raise its R&D expenditure. In either case, the profit of the domestic firm in the Northern country declines.

6 CONCLUDING REMARKS

6.1 Summary

This thesis adopts the "political support" approach which was advanced by Stigler (1971) and uses the game-theoretic framework of a first-price menu auction formulated by Bernheim and Whinston (1986) to analyze the political economy of environmental policy when countries are engaged in international trade. More specifically, this thesis seeks to elucidate the endogenous determination of environmental policies in the context of North-South and North-North relations when pollution generated in one country can cross the border and flow into another country.

Taking it as a given *what* environmental and trade policies should be implemented, the contribution of this thesis is to provide a theoretical framework for *how* environmental policy is affected by the political influence of environmental and industry lobbies. Thus, the analysis is positive, not normative. One goal of the thesis is to show

how interactions between different interest groups and national governments may prevent the adoption of socially optimal level of environmental policies.

In this thesis, the objective of an incumbent government for choosing environmental policies is not to maximize social welfare, but to serve its selfish desire to maximize political support. Hence, the assumption that a benevolent dictator will set the policies to maximize social welfare or to correct so-called market failure is not accepted in this thesis. Instead, environmental policy is determined as an outcome of a game played between various interest groups and their incumbent national governments.

In the games formulated in this thesis, special-interest groups announce schedules of political contributions to their own incumbent national government. The contributions vary according to the policies set by the national government. The incumbent governments will consider the political contributions of the interest groups in setting policies. An equilibrium of such a game, played by various special-interest groups and the incumbent national government, then determines endogenously environmental and trade policies. This thesis also seeks an answer to the questions of whether environmentalists, through pressure they exert on politicians, are successful in raising environmental standards.

In the political process, environmental interest groups that seek to influence environmental and trade policies will confront industry interest groups with agendas of their own. Domestic firms in duopolistic industries will be pressing for laxer environmental policy and seeking protection against foreign competition. Environmentalists might be opposed to protection if it leads to more destruction of the environment. Environmentalists

might be pressing for tougher environmental policy and may also have common cause with protectionist tendencies if they believe that liberalized trade will result in the deterioration of environmental quality. The games formulated in this thesis capture some salient aspects of these interactions.

In order to achieve our goals, we formulate several games to explain the political-economy implications of lobbying for environmental and trade regulations by environmentalists and industries in the context of North-South and North-North trade. Our games differ with respect to: one, whether international trade is between Northern countries or between North and South; two, whether or not pollution can spillover from one country to another; three, whether or not environmental lobbies care about the world environment; and four whether or not firms are engaged in *environmental* R&D programs. In our analysis, pollution is modeled as a by-product of production.

More specifically, we find that an equilibrium emission tax depends on the cost and emission per unit of output, the weight that an incumbent government attaches to social welfare, the amount of pollution that countries transfer to each other, and the type of environmentalists. It also makes the case that, in the presence of lobby groups, environmental regulations tend increasingly to serve minority interests at the expense of the majority of society. In general, we show that socially optimal environmental policies can be buried because they are not politically feasible. In another words, we find that since neither industries nor environmentalists are, by assumption, interested in social welfare -- i.e., environmentalists care about pollution alone and industries care about their net profits -- the political equilibrium environmental and trade polices may be above or

below those obtained by maximizing social welfare, depending on the political contributions of interest groups to their incumbent governments.

In Chapter 3, we formulate a game between an industrialized country of the North and a developing nation of the South. The implication of the North-South assumption is that there is a vocal environmental movement in the North that tries to influence its own government's policy on the environment and that only the government of the industrialized country actively pursues environmental and trade policies.

This chapter shows that in the absence of transboundary pollution, the emergence of an environmental lobby that only cares about its local environment raises both the emission tax and the tariff. The end results are a better home environment and a decline in the profit of the both firms. The intuition is that in order to accommodate the environmental lobby, the home government raises the emission tax. To alleviate the impact of a higher emission tax on the domestic firm, it simultaneously raises the tariff. The end result is an improvement of the quality of the home environment at the expense of the firms' profits. Furthermore, when industry lobby doesn't offer any political contribution to the government and hence the game is played between the environmental lobby and an incumbent government, domestic firm's profit is at its lowest level, but the quality of the home environment is at its highest level.

Moreover, this chapter finds that in the absence of transboundary pollution, when the environmental lobby only cares about its local environment, the quality of its home environment deteriorates with free trade. Hence, environmentalists might have an incentive to join protectionist forces. This result might also provide support for the argument that in

the free trade regime, even if the pollution caused by developing countries does not spill over into other countries, nations with lax environmental standards provide their own domestic firms with a cost advantage in the global market place and put pressure on nations with high environmental standards to reduce the rigor of their environmental requirements.

In the presence of transboundary pollution, when an environmental lobby comes to the scene, the net payoff of the firm operating in the Northern country can increase or decrease, depending on the emission per unit of output and the amount of pollution that countries transfer to each other. Nevertheless, in all of the above cases, the quality of the environment in the North improves with the emergence of a green environmental lobby.

This thesis also shows that if the environmental lobby cares about environmental quality both at home and abroad, then the quality of the home environment might be higher or lower with the emergence of an environmental group, depending on the level of emission per unit of output and the coefficient of the pollution spillover from one country to the other. However, the quality of the global environment rises with the emergence of a supergreen environmental lobby in the North.

Chapter 4 analyzes environmental policies from the perspective of two industrialized countries. The implication of the North-North assumption is that there are active environmental groups in both countries. Hence, the incumbent national governments in both countries will actively pursue environmental policies. The two firms are assumed to compete in a market located in a third country. The equilibrium of the game played between the special-interest groups and the incumbent governments determines endogenously the environmental policies in the Northern countries. The

presence of environmental interest groups in the North is also shown to affect the quality of the home environment and the payoffs of the domestic and foreign firms.

The North-North model can be used to analyze trade and the environmental linkages when pollution in one country has international impacts such as acid rain, ozone layer depletion and global warming. In the absence of transboundary pollution, the North-North model shows that the emergence of green environmental lobbies in the North lowers the profits of the domestic and foreign firms and improves the quality of environment in each industrialized country.

In the presence of the green environmentalists, when we allow transboundary pollution, the equilibrium emission tax and the firm's profit in each Northern country may increase or decrease, depending on the amount of pollution transferred from one country to another and the amount of emission per unit of output. While a decrease in the profit of a firm due to environmentalist pressure is not surprising, an increase in its profit is not an obvious result. An increase in profit is also plausible if more environmental restrictions enhance the market power of the firms. This result provides insights for the demand of both the environmentalists and CFC producers for tough environmental regulation. By placing more restrictions on producing CFCs, the environmentalists may wish to prevent further environmental degradation while the CFC producers may wish to secure their oligopoly profits. In this case, the quality of the environment in each industrialized country will improve with the emergence of green environmental lobbies.

In the presence of transboundary pollution, we find that the quality of the environment in each Northern country might improve or deteriorate with the emergence

of supergreen environmental groups, depending on the amount of pollution flown from one country to another and the level of emission per unit of output in each country. However, the presence of supergreen environmental interest groups in the industrialized countries will improve the quality of the environment in the North. This might provide insight for environmentalists lobbying to reduce or limit GHG emissions in the industrialized countries.

The North-North model also shows that, in general, political pollution tax and hence, its corresponding level of environmental damage in the home country, might be below or above their socially optimal levels, depending on the presence or the absence of each interest group and the type of environmentalists.

In Chapter 5, the North-South model is extended to include *environmental* R&D. When the representative environmentalist is a green and pollution does not cross borders, the model shows that the presence of an environmental lobby in the industrialized country might raise *environmental* R&D investments in the North, lower the profit of the domestic firm, and improve the quality of the home and world environments by inducing its incumbent government to adopt more stringent environmental policies. It is interesting to observe that the presence of an environmental lobby which is selfish -- in the sense that it only cares about its own national environmental damage -- has a positive impact on the global environment.

In the case of transboundary pollution, for a sufficiently high level of emission tax, the emergence of an environmental lobby raises the emission tax and lowers the damage to the home and world environments. These results are independent of the

amount of transboundary pollution and type of the environmentalist. Hence, they are different from those obtained in the absence of an R&D program (in Chapter 3) in which the impacts of a supergreen environmental group on the emission tax and the quality of the environment were ambiguous.

Furthermore, Chapter 5 also shows that the absence of either interest lobby from the scene will deviate the equilibrium environmental policy from its socially optimal level. More specifically, if only the industry (environmental) lobby is active, the level of emission tax will be below (above) of its socially optimal level. The reason is that neither industries nor environmentalists are, by assumption, interested in social welfare. The former cares about its profit and the latter is concerned about pollution.

A more stringent emission tax set by an incumbent government in the North can have three different impacts on its domestic firm: (1) if it is set too low, the domestic firm will not undertake any *environmental* R&D investment and it will cut back its output; (2) if it is too high, the firm will shut down and the foreign firm will capture the whole market; and (3) if it is in a certain range, the domestic firm will implement *environmental* R&D program and its market share will not be affected. In a political-economy model, however, there is no guarantee that an incumbent government will choose an environmental policy to keep its domestic firm competitive in the international market.

While this thesis finds that a more stringent environmental regulation, if properly designed and set, may induce a domestic firm to undertake R&D investment, it fails to confirm that this will raise the firm's profitability or competitiveness. Indeed, it is shown

that an increase in pollution tax causes the domestic firm to either cut back its output or raise its R&D expenditure. In either case, the profit of the domestic firm declines.

6.2 Areas of Future Research

A number of areas which could receive more attention will be discussed below. One such area is the issue of transfer payments from the North to the South, the possible stands of interest groups on this issue, and its impact on the global environment. The condition for the transfer of green technology to the Southern countries may also be a target of investigation.

The impact of supergreen environmental movements on the environmental R&D program of firms also requires further study. One possible avenue to investigate is allowing supergreen environmental lobbies located in different countries to form a coalition and coordinate their actions. This may be used to explain the operation of transnational environmental groups, such as Greenpeace and Friends of the Earth.

Environmental R&D subsidies also require attention, particularly since they can enhance firms' incentive to undertake research and development and, at the same time, be used as another policy instrument by governments. Introducing uncertainty into the R&D model to see how the behavior of firms and environmentalists will change is another promising area.

Another aspect that may be worth examining is the role of environmental groups in global environmental decision-making when we allow national governments to play a cooperative game to avoid unnecessary costs associated with a non-cooperative game.

Hence, the models developed in this thesis can be used to construct a model of international environmental policy making which could be used to study some important issues, such as Ozone depletion and international cooperation.

Finally, an area that requires more research is the potential role of various foreign interest groups in influencing the environmental policy at home. Indeed, in a political process, environmental interest groups will face other interest groups. Domestic firms will be pressing for protectionist trade policies and laxer environmental regulations. Depending on whether they gain from the intended environmental and trade regulations, foreign firms which seek to maintain market access for their products, may influence the government in the importing country by offering political contributions. Because the choice of environmental policy instruments by governments is itself an outcome of a political process in which various interest groups and politicians are engaged, the models developed here can be modified to accommodate this case as well.

In the final analysis, we know that the real world is complicated and the behavior of governments is affected by a complex mix of many factors, with political pressure exercised by various interest groups being only one of them. The hope is that this thesis has contributed to the understanding of contemporary environmental policies.

REFERENCES

Abler, David G. and James S. Shortle (1991): "Innovation and Environmental Quality : The Case of EC and US Agriculture," in *Environmental Policy and the Economy*, F.J.Dietz et al (eds). North Holland, the Netherlands.

Aidt, Toke, S. (1997):"Political Internalization of Economic Externalities: The case of Environmental policy in a Politico-Economic Model with Lobby Groups," University of Aarhus Working Paper, no. 1977-10.

Anderson, Kym (1992a): "The Standard Welfare Economics of Policies Affecting Trade and the Environment," in *The Greening of World Trade Issues*, Kym Anderson and Richard Blackhurst (eds.), Harvester Wheatsheaf, Great Britain.

Anderson, Kym (1992b): "Effects on the Environment and Welfare of Liberalizing World Trade: the Case of Coal and Food," in *The Greening of World Trade Issues*, Kym Anderson and Richard Blackhurst (eds.), Harvester Wheatsheaf, Great Britain.

Barrett, Scott (1994): "Strategic Environmental Policy and International Trade," Journal of Public Economics, 54, pp.325-38.

Baumol, William J. and Wallace E. Oates (1988): *The Theory of Environmental Policy*, Cambridge University Press, Cambridge.

Bernheim, B. Douglas and M.D. Whinston (1986): "Menu Auctions, Resource Allocation, and Economic Influence," Quarterly Journal of Economics, 101 (1), February, pp.1-31.

Bhagwati, Jagdish and Robert E. Hudec (1996): *Fair Trade and Harmonization: Prerequisites for Free Trade?*, The MIT Press, Cambridge, Massachusetts.

Bhagwati, Jagdish and T.N. Srinivasan (1996): "Trade and the Environment: Does Environmental Diversity Detract from the Case for Free Trade?" In *Fair Trade and Harmonization: Prerequisites for Free Trade?*, Jagdish Bhagwati and Robert E. Hudec (eds.) Volume 1, The MIT Press, Cambridge, Massachusetts.

Brander, James A. and Barbara J. Spencer (1984): "Trade Warfare: Tariffs and Cartels," Journal of International Economics, 16, pp.227-42.

Brander, James A. and Barbara J. Spencer (1985): "Export Subsidies and International Market Share Rivalry," Journal of International Economics, 18, pp.309-28.

Brock, William A. and Stephen P. Magee (1978): "The Economics of Special Interest Politics: The Case of the Tariff." American Economic Review, Vol. 68, pp.246-50.

Chichilnisky, Graciela (1994): "North-South Trade and the Global Environment," American Economic Review, September, pp.851-75.

Copeland, Brian R. and M. Scott Taylor (1995): "Trade and Transboundary Pollution," American Economic Review, Vol. 85, No.4, pp. 716- 737.

Copeland, Brian R. and M. Scott Taylor (1994): "North-South Trade and the Environment," The Quarterly Journal of Economics, August, pp.754-88.

Dean, Judith M. (1992): "Trade and the Environment: A Survey of the Literature," In *International Trade and the Environment*, World Bank Discussion Paper 159, Patrick Low (ed).Washington D.C.: World Bank.

Devlin, Rose Anne and R. Quentin Grafton (1998): *Economic Rights and Environmental Wrongs: Property Rights for the Common Good*, Edward Elgar, Cheltenham, UK.

Dixit, Avinash (1987): "Anti-Dumping and Countervailing Duties Under Oligopoly," European Economic Review 32, pp. 55-68.

Economist (1993), Trade and the Environment: The Greening of Protectionism, February 27, pp.25-28.

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

Feenstra, Robert, C., and Jagdish N. Bhagwati (1982): "Tariff Seeking and the Efficient Tariff," in *Import Competition and Response*, Jagdish N. Bhagwati (ed.), The University of Chicago Press, Chicago and London.

Feenstra, Robert, C., and Gene M. Grossman, and Douglas A. Irwin (1996): *The Political Economy of Trade Policy*, The MIT Press, Cambridge, Massachusetts.

Fredriksson, Per G. (1997): "The Political Economy of Pollution Taxes in a Small Open Economy," Journal of Environmental Economics and Management 33, pp. 44-58.

Grossman, Gene M. (1993): "Pollution and Growth: What Do We Know?," Centre for Economic Policy Research (CEPR), Discussion Paper Series NO.848, October.

Grossman, Gene M. and Elhanan Helpman (1994): "Protection for Sale," American Economic

Review. September. pp. 833-50.

Grossman. Gene M. and Elhanan Helpman (1995): "Trade Wars and Trade Talks." Journal of Political Economy. vol. 103. no.4. pp. 675-709.

Grossman. Gene M. and Elhanan Helpman (1996): "Electoral Competition and Special Interest Policies" Review of Economic Studies. 63. pp. 265-286.

Grossman. Gene M. and Alan B. Krueger (1993): "Environmental Impacts of a North American Free Trade Agreement." in *The Mexico-U.S. Free Trade Agreement*. Peter M. Garber (ed.). The MIT Press. Cambridge.

Grossman. Gene M. and Alan B. Krueger (1995): "Economic Growth and the Environment." The Quarterly Journal of Economics. May. pp. 353-377.

Hahn. Robert W. (1990): "The Political Economy of Environmental Regulation: Towards a Unifying Framework." Public Choice 65. pp.21-47.

Hempel. Lamont. C. (1996): *Environmental Governance: The Global Challenge*. Island Press. Washington D.C.

Hillman. Arye (1982): "Declining Industries and Political-Support Protectionist Motives." American Economic Review. December. 72(5). PP. 1180-87.

Hillman. Arye L. And Heinrich W. Ursprung (1992): "The Influence of Environmental Concerns on the Political Determination of Trade Policy." in *The Greening of World Trade Issues*. Kym Anderson and Richard Blackhurst (eds.). Harvester Wheatsheaf. Great Britain.

Hillman. Arye L. And Heinrich W. Ursprung (1994): "Greens. Supergreens. and International Trade Policy: Environmental concerns and Protectionism." in *Trade. Innovation. Environment*. Carlo Carraro (ed.). Kluwer Academic Publisher. Dordrecht.

Hoekman. Bernard and Michael Leidy (1992): "Environmental Policy Formation in a Trading Economy: "A Public Choice Perspective." in *The Greening the World Trade Issue*. Kym Anderson and Richard Blackhurst (eds.). Harvester Wheatsheaf. Great Britain.

Ingram. Helen M.. David H. Colnic. and Dean E. Mann (1995): "Interest Groups and Environmental Policy." in *Environmental Politics and Policy*. James P. Lester (ed.). Duke University Press. Durbam and London.

Klepper. Gernot (1992): "The Political Economy of Trade and the Environment in Western Europe." in *International Trade and the Environment*. World Bank Discussion Paper 159.

Patrick Low (ed.) Washington D.C.: World Bank.

Levinson, Arik (1996): "Environmental Regulations and Industry Location: International and Domestic Evidence," in *Fair Trade and Harmonization: Prerequisites for Free Trade?*, Jagdish Bhagwati and Robert E. Hudec (eds.) Volume 1. The MIT Press. Cambridge, Massachusetts.

Levy, Santiago and Sean Nolan (1992): "Trade and Foreign Investment Policies Under Imperfect Competition: Lessons for Developing Countries," Journal of Development Economics 37, pp.31-62.

Lloyd, Peter J. (1992): "The Problem of Optimal Environmental Policy Choice," in *The Greening the World Trade Issue*, Kym Anderson and Richard Blackhurst (eds.), Harvester Wheatsheaf, Great Britain.

Low, Patrick (ed.) (1992): *International Trade and the Environment*, World Bank Discussion Paper 159, Washington D.C.: World Bank.

Low, Patrick and Alexander Yeats (1992): "Do dirty Industries Migrate?" In *International Trade and the Environment*, World Bank Discussion Paper 159, Patrick Low (ed), Washington D.C.: World Bank.

Macdonald, Doug (1991): *The Politics of Pollution*, The Canadian Publisher, Toronto.

Magee, Stephen, Urlham Brock, and Leslie Young (1989): *Black Hole Tariffs and Endogenous Policy Theory: Political Economy in General Equilibrium*, Cambridge University Press. Cambridge.

Mayer, Wolfgang (1984): "Endogenous Tariff Formation," American Economic Review, December, pp.970-85.

McGuire, Martin C. (1982): "Regulation, Factor Rewards, and International Trade," Journal of Public Economics 17, pp.335-54.

McInnis, Daniel F. (1992): "Ozone Layers and Oligopoly Profits," in *Environmental Politics: Public Costs, Private Rewards*, Michael S. Greve and Fred L. Smith, Jr. (eds.), Praeger, New York.

Olsen, Mancur (1965): The Logic of Collective Action, Cambridge: Harvard University Press.

Palmer, Karen, Wallace E. Oates, and Paul R. Portney (1995): "Tightening Environmental Standards: The Benefit-Cost or the No-Cost Paradigm?" Journal of Economic

Perspectives. Volume 9. Number 4. Fall. pp. 119-32.

Pethig. Rudiger (1976): "Pollution. Welfare. and Environmental Policy in the Theory of Comparative Advantage." Journal of Environmental Economics and Management 2. pp.160-69.

Porter. Michael E. (1991): "America's Green Strategy." Scientific America. April. p.168.

Porter. Michael E. and Claas van der Linde (1995a): "An Underlying Logic Links the Environment. Resource Productivity. Innovation. and Competitiveness." Harvard Business Review. September-October. pp.120-34.

Porter. Michael E. and Claas van der Linde (1995b): "Toward a New Conception of the Environment-Competitiveness Relationship." Journal of Economic Perspectives. Volume 9. Number 4. Fall. pp. 97-118.

Rauscher. Michael (1992): "International Economic Integration and the Environment: the Case of Europe." in *The Greening of World Trade Issues*. Kym Anderson and Richard Blackhurst (eds.). Harvester Wheatsheaf. Great Britain.

Roodman. David M. (1996): *Paying the Piper: Subsidies. Politics. and the Environment*. World Watch Paper. 133. Washington D.C.

Siebert. Horst (1985): "Spatial Aspects of Environmental Economics." in *Handbook of Natural Resource And Energy Economics*. A.Kneese and J.A Sweeney (eds). North-Holland. Amsterdam.

Siebert. Horst and J. Eichberger. R. Gronych. and R. Pethig (1980): *Trade and Environment: A theoretical Inquiry*. Elsevier. Amsterdam.

Snape. Richard H. (1992): "The Environment. International Trade. and Competitiveness." in *The Greening the World Trade Issue*. Kym Anderson and Richard Blackhurst (eds.). Harvester Wheatsheaf. Great Britain.

Spencer. Barbara J. and James A. Brander (1983): "International R&D Rivalry and Industrial Strategy." Review of Economic Studies Vol. L(4). No. 163. October. pp. 707-722.

Stigler. George (1971): "The Theory of Economic Regulation." Bell Journal of Economics and Management Science 2. pp. 3-26.

Tullock. Gordon (1989): *The Economics of Special Privilege and Rent Seeking*. Norwell. Massachusetts: Kluwer Academic Publishers.

Ulph, Alistair and David Ulph (1994): "Trade, Strategic Innovation and Strategic Environmental Policy - A General Analysis." Discussion Paper No. 1063, Centre for Economic Policy Research, London, England.

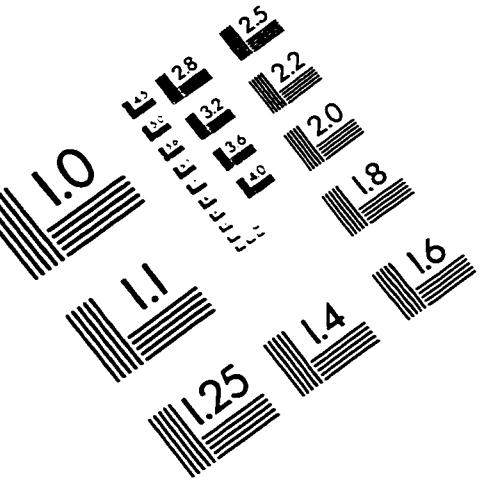
Ulph, Alistair (1994): "Environmental Policy and International Trade - A Survey of Recent Economic Analysis." Nota di Lavoro 53.94, Fondazione Eni Enrico Mattei, Milan.

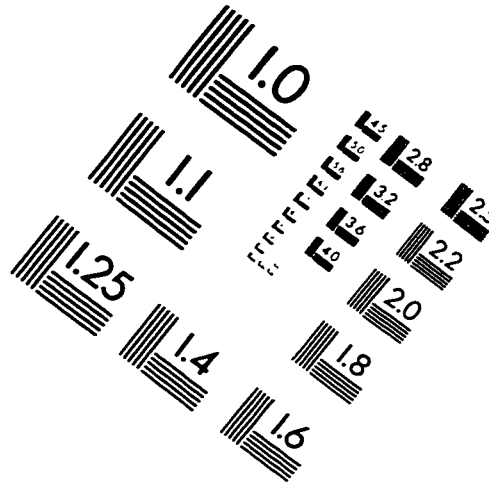
VanGrassteck, Craig (1992): "The Political Economy of Trade and the Environment in the United States," in *International Trade and the Environment*, World Bank Discussion Paper 159, Patrick Low (ed.) Washington D.C., World Bank.

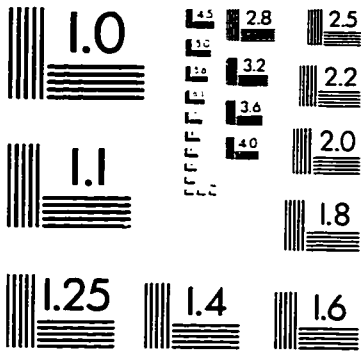
Verbruggen, Harmen (1991): "Political Economy Aspects of Environmental Policy Instruments," in *Environmental Policy and the Economy*, F.J. Dietz et al (eds.), North Holland, the Netherlands.

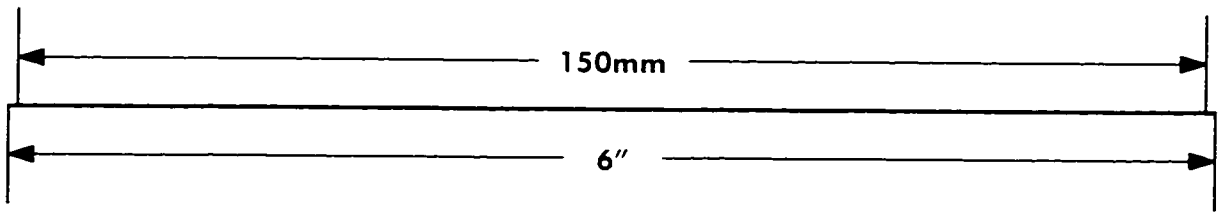
Vogel, David (1990): "Environmental Policy in Europe and Japan," in *Environmental Policy in the 1990s*, Norman J. Vig and Michael E. Kraft (eds.), CQ Press, Washington D.C.

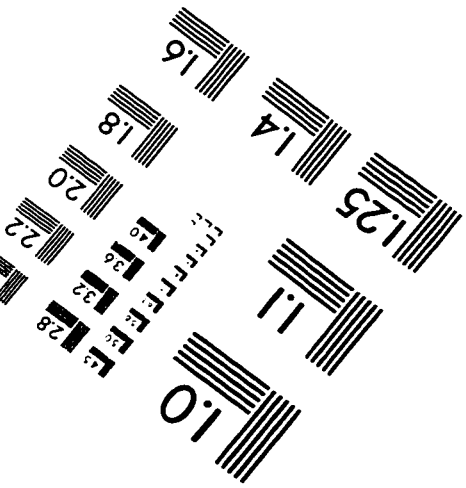
IMAGE EVALUATION TEST TARGET (QA-3)

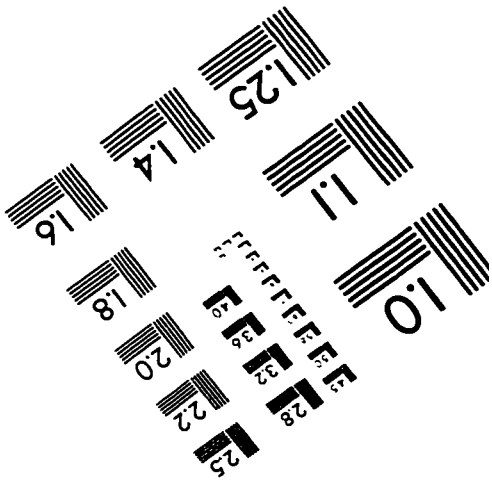












APPLIED IMAGE, Inc
1653 East Main Street
Rochester, NY 14609 USA
Phone: 716/482-0300
Fax: 716/288-5989