THE ANALYSIS OF THE BEHAVIOUR OF GOVERNMENTS AND PRODUCERS IN THE PRESENCE OF ENVIRONMENTAL REGULATIONS AND INTERNATIONAL TRADE

A Master's Thesis
by
S. CEM KARAMAN

Department of Economics

Bilkent University
Ankara

July 2000

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The Institute of Economics and Social Sciences
of
Bilkent University

by

S. CEM KARAMAN

In Partial Fulfilment of the Requirements for the Degree of

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in

THE DEPARTMENT OF ECONOMICS

BILKENT UNIVERSITY
ANKARA

July 2000

I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Arts in Economics.

Assistant Professor Dr. Savaş Alpay
Supervisor

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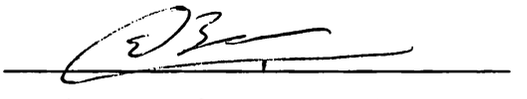

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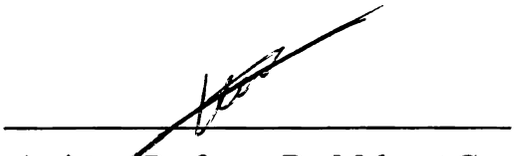

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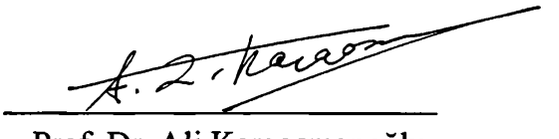

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ABSTRACT

THE ANALYSIS OF THE BEHAVIOUR OF GOVERNMENTS AND PRODUCERS IN THE PRESENCE OF ENVIRONMENTAL REGULATIONS AND INTERNATIONAL TRADE

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In my thesis I analyse the interactions between environmental regulations and international trade. I use a two-country, one-good, two-producer model. The governments may behave strategically in choosing their environmental policy and producers may behave strategically in choosing their R&D investment. Using a game theoretical approach, I try to identify the Nash equilibrium of the game. For identical countries, I consider two cases; simultaneous-move game and sequential-move game. I observe that the producers prefer not to act strategically for any action of governments. If one of the governments move in advance, it will prefer to act strategically. In a simultaneous-move game there is multiple equilibria and no conclusion can be made for the outcome of the game. For non-symmetric country case, I observe that the governments prefer to act strategically and the producers prefer not to act strategically where the game is a simultaneous-move game.

Keywords: environmental regulation, international trade, strategic behaviour

ÖZET

ÇEVRE DÜZENLEMELERİNİN VE ULUSLARARASI TİCARETİN BULUNDUĞU ORTAMDA DEVLETLERİN VE ÜRETİCİLERİN DAVRANIŞLARININ İNCELENMESİ

Karaman, S. Cem

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Tez Yöneticisi: Yrd. Doç. Savaş Alpay

Bu çalişmada, çevre düzenlemeleri ve uluslararası ticaret arasındaki ilişkiyi iki ülke, bir ürün, ve iki üreticinin olduğu bir modelde inceledim. Devletler, çevre düzenlemelerini seçerken stratejik davranıp davranmamayı, üreticiler de Ar&Ge yatırımlarini seçerken stratejik davranıp davranmamayı düşünmektedirler. Oyun teorisi kullanarak, bu oyunun Nash dengesini bulmaya çalıştım. Eş iki ülke için incelediğim iki durumdan birisi, eş zamanlı oyun, diğeri sıralı oyundur. Sonuçta üreticilerin, devletlerin politikaları ne olursa olsun stratejik davranmak istemediklerini tesbit ettim. Sıralı oyunda önce davranan devlet, stratejik davranmayı tercih edecektir. Eş zamanlı oyunda birden çok denge çıkmakta ve oyunun nasıl biteceği hakkında bir sonuca gidilememektedir. Simetrik olmayan eş zamanlı oyun için ise; devletlerin stratejik davranmayı, üreticilerin ise stratejik davranmamayı tercih edeceklerini tesbit ettim.

Anahtar Kelimeler: Çevre Düzenlemeleri, Uluslararası Ticaret, Stratejik Davranış

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CHAPTER 1

INTRODUCTION

In recent years there has been a great concern about the impacts of trade liberalization on environment. It is worried that trade-related goals may generate some distortions in environmental policies. The major concern is that freer trade will lead to laxer environmental standards in order to gain a competitive advantage over the trading partners. Imposition of homogeneous environmental regulations across countries is offered as a solution for this problem. One suggestion is that, if homogeneous environmental regulations are not achieved, those countries which use tougher environmental regulations than their rivals should be able to impose higher tariffs for the imports from countries with laxer environmental regulations. But imposition of higher tarrifs violate GATT agreement, thus may not be applicable. In brief the interaction between trade and environment is interesting and worthwhile to study. This relation between trade and environment attracted many of the economists' attention.

The model first introduced by Brander and Spencer (1985), related to the analysis of export subsidies, is also used in many of the studies about eco-

dumping (eco-dumping refers to; relaxing environmental policies to give the domestic producer an advantage in international markets). In their model there is one domestic firm in domestic country and one foreign firm in foreign country and they produce identical products to be sold in a third market, there is no consumption in producing countries. The behaviour of the firms is modelled as a Cournot duopoly. They use this model to analyse the role of export subsidies as an international trade policy, nevertheless their model is refered by many economists who study the relation between trade and environmental policy. In Brander and Spencer (1985), the governments in each country maximize the domestic surplus that is the profit of the domestic firm net of the subsidy where as in trade-environment studies the domestic surplus is the profit of the domestic firm net of the environmental damage.

At this stage let us mention some of the earlier studies which investigate the interaction between environment and trade. In his study, Kennedy (1994) tries to find the optimum pollution tax in open economies. He argues that imperfect competition in global markets creates inefficient distortion of pollution taxes. He investigates two opposite effects that interact with each other, one to gain competitive advantage over the trading partner and the other to shift the pollution (together with production) to the other country. Then he shows that in case of perfect transboundary pollution the second effect

vanishes. If the pollution is partially transboundary this distorts the pollution taxes that would otherwise be globally efficient.

In a paper by Barrett (1994), another aspect of imperfectly competitive international markets is considered where governments impose weaker environmental standards on industries that are competing. He shows that if the domestic industry is a monopoly, the foreign industry is imperfectly competitive, and industrial competition is Cournot, then the domestic government has an incentive to set a weak environmental standard where weak means that the marginal cost of abatement is less than the marginal damage from pollution. Strategically optimal emission standards are set weaker than the environmentally optimal emission standards.

Another discussion is whether strict environmental regulations will enhance domestic competitiveness or will harm domestic competitiveness. For example in the book of Al Gore, "Earth in the Balance", he argues that strict environmental regulations will promote innovation. It is expected that stringent regulations will be translated into long-run competitive advantage due to changes in cost of production as the result of the innovations. This theory is first developed by Porter and van der Linde (1995), the revisionist school argues that environmental policy stringency (EPS) further improves the

competitiveness of domestic firms through triggered innovation. Their argument was severely criticized by Palmer et al. (1995). Porter and van der Linde (1995) suggested that, stricter environmental regulation forces the firms to innovate, and these firms enjoy higher productivity and hence higher profits in the long run. The criticism was based on the lacking evidence for the Porter hypothesis, where Porter and van der Linde (1995) have only provided case studies in support of their argument. Theoretically, Xepapadeas and de Zeeuw (1999) show that, the trade-off between environmental conditions and profits of the home industry remains, but is less sharp because of the downsizing and modernization of the industry as a result of stricter environmental policy. In a paper by Simpson and Bradford (1996), they discuss this issue and ask under what conditions will more stringent environmental regulation actually increase the profitability of a domestic firm. They show that promoting innovation is a theoretical possibility, but they claim that it is extremely dubious as a practical advice. In their study, they use a three stage game in a two producer, one good model where the governments make a pollution tax decision in the first stage, in the second stage the firms decide how much to invest in R&D and in the final stage the producers decide how much to produce.

Another paper, which works on the relationship between trade and environment, is by Alpay (2000). He argues the two adverse externalities; the

negative externality due to transboundary pollution and the positive externality in the efforts to tackle the transboundary pollution. National environmental policies are subject to this positive externality and due to this positive externality countries leave it to others to take pro-environmental actions and this may result in too little pollution abatement. He shows that this pessimistic conclusion may be unwarranted in 2 x 2 Ricardian model. Moreover he demonstrates that the non-cooperative contribution of countries to global environmental protection exceeds that of the cooperative one due to associated changes in the terms of trade. Thus, international trade is shown to be affecting global environment positively in his model.

Ulph (1996), compares the usage of environmental pollution standards and pollution taxes for a pollution producing good in the presence of international trade. In the previous studies about trade and environment, only the government was given a strategic action. But the producers also have incentives to act strategically. They may act strategically by investing in capacity or R&D. This way they try to shift rents in their own favour. He studied the impact of strategic actions of the government and the producer on relaxing environmental policy. Basically in his model there are two countries that have one government and one producer in each of them. The governments and producers have the choice of acting strategically or not. There are three

stages of the model. In the first stage governments choose the emission level or pollution taxes by acting strategically or not. In the second stage the producers choose their R&D level by acting strategically or not. In the third stage the producers choose their output level. Governments act strategically by recognizing that the output of the rival firm depends on the emission level it sets. Producers act strategically by choosing the level of investment in R&D by considering the associated impact of the level of R&D on the rival firm. When they are not acting strategically they determine the R&D level by minimizing their own production cost plus R&D cost. The producers in each country compete in a third market or world market, so I isolate the disadvantages of imported goods, tariffs and consumer surplus considerations (consumption is excluded from utility of the country). The governments move first. He found that strategic behaviour by producers and governments is greater when governments use emission taxes than when they use emission standards and allowing governments to act strategically increases the incentive for producers to act strategically.

In this thesis, I adopt the model developed by Ulph (1996). Ulph studied the implications of strategic action of governments on the strategic action of producers and implications of strategic action of producers on the strategic action of governments. Also he compared the usage of taxes and standards

(setting the maximum emission level) as a policy. In my study I will not study taxes. Instead I will work with emission standards. In my study I will analyse the behaviour of governments and producers in detail. In particular I will try to find whether the government and/or the producer will choose to act in a strategic manner or not. So I setup a game theoretical model and try to identify the Nash equilibrium of this game. This is a three-stage-game model. As in Ulph, in the first stage governments choose the emission level by acting strategically or not. In the second stage the producers choose their R&D level by acting strategically or not. In the third stage the producers choose their output level. Ulph studied only the symmetric equilibria (both countries are applying the same strategy). Also the welfare implications of the policies are not considered in his work.

In this thesis, the symmetric and non-symmetric cases related to the behaviour of the governments and producers are studied. There are four possible outcomes when the governments of the two countries choose their actions. Then the two producers move by acting strategically or not. There are four possible outcomes for each outcome of the first step. So there are 16 different possible cases. The strategic interaction between two countries' governments and producers has welfare, output and emission consequences. I analyse the game first as simultaneous move game and then as a sequential

move game. In the simultaneous move game the governments in the first stage will choose their R&D level simultaneously. After the level of emission set by the governments is observed, the two producers in two countries will move simultaneously. In the sequential move game, I assume that the government in the domestic country will decide for its strategy first; then the second government chooses its strategy. After the governments' choices, the producers choose their actions. I find the subgame perfect equilibrium of this game.

As a final analysis, I consider the non-symmetric country case, where one country is assumed to be a developed country and the other country is a developing country. It is usually seen that people in developed countries care for the environment much more than the people in developing countries. In this part I will assume that environmental damage will be given more weight in the developed country than the developing country. Thus I assume that the environmental damage parameter in developed country is more than the environmental damage parameter in the developing country. Under this setup I have found that:

If we consider the game as a simultaneous-move game the actions of the governments and producers cannot be predicted in advance. The game may

result even in the worst case where the welfare is lowest and the emissions are the highest.

If we consider the game as a sequential-move game the government who is moving first will prefer to act strategically and the rival country's government will prefer not to act strategically. Moving first is an advantage for the welfare of the country.

The strategic action of producers is only effective when the other producer is acting strategically.

Producers prefer not to act strategically for any strategy of governments. This means that there is no need to consider the producers strategic behaviour.

If we consider the game as a simultaneous-move non-symmetric country game, both of the governments will prefer to act strategically where the producers will prefer not to act strategically.

The thesis is organised as follows: In the next chapter I explained the structure of the model. In the third chapter the analysis of the cases associated with the behaviours of the governments and producers will be analysed. In section 4, I discuss about the results of the game and I put my comments. In section 5 the non-symmetric country case is analysed. Section 5 is the conclusion.

CHAPTER 2

THE MODEL

I use a two-country model with one producer in each of them. The producers are producing a polluting homogeneous good, x, which is sold to a third country. The firms are competing in the third country with their exports. Their revenues depend on the amount of output each of them produce and sell, x and y (x is the output of the domestic country, y is the output of the rival country). I denote the revenue of domestic country by $R(x , y) = x (A - x - y)$. $(A - x - y)$ is the inverse demand function (or price in the third country) and A is a positive constant. It is multiplied with the demand to find the revenue. So their revenue increases with a decrease of the rival's output and decreases with a increase of the rival's output.

The government in each country determines the level of emission producers can make. To simplify the analysis I assumed that one unit of output generates one unit of emission. But the firms can abate some of the pollution they made. So the total emission will be output minus abatement. The governments determine the optimal emission level by maximizing the welfare function of the country where welfare is total revenue minus total cost of

production minus total cost of abatement minus total cost of pollution damage. The producers maximize their profit function which is equal to: total revenue minus total cost of production minus total cost of abatement, using the emission level determined by the government. The governments and producers have the choice of acting strategically or not. The governments act strategically by considering that the output of the rival firm is affected by the choice of its own emission level. The producers act strategically by considering the side effects of their investment in R&D on the rival's output. When they are not acting strategically they determine the R&D level by minimizing their own production cost plus R&D cost.

I assume that the cost of producing output x is $C(x,\varphi) = \varphi x^2/4$ where φ is the technology parameter (or R&D parameter). The firms decide how much to invest in R&D by choosing the φ parameter. The cost of φ is $\frac{1}{\varphi}$, ie. better technology costs more. When the firms are not acting strategically they minimize the total cost function $\varphi\frac{x^2}{4}+\frac{1}{\varphi}$ for any given level of output and minimization of this function results in $\varphi = \frac{2}{x}$ as the optimal R&D level. So in

cases where producers are not acting strategically φ will be chosen as $\frac{2}{x}$. Substituting this into the cost function gives us the total cost:

$$\text{Total cost} = \frac{2}{x}\frac{x^2}{4} + \frac{1}{2/x} = \frac{x}{2} + \frac{x}{2} = x$$

I will call this the efficient cost function.

The producers have the ability of abatement. The cost of abatement is given as $\frac{a^2}{2}$ where a is the abatement level. As assumed above one unit of output generates one unit of emission. Hence the emission level is output, x, minus the abatement level, e, or e = x – a. The pollutant causes damage to the country and the cost of this damage is $\frac{de^2}{2}$ where d is a damage parameter. We assume that the environmental damage is local, not global.

There are three stages of the game. In the first stage, governments choose the emission levels. Then the firms take the emission level given and choose their R&D level. At the final stage the producers choose their output level using the emission level set by the governments and the R&D level set in the second stage. When neither the government nor the producer is acting strategically, the government chooses the emission level ignoring the impact of

its emission level on the determination of the rival's output level and the producer uses its pre-chosen R&D level which is $\varphi = 2 / x$. When only the government acts strategically, it takes into consideration that the output of the rival firm is affected by the choice of its own emission level. The producer does not choose its R&D level specifically. Instead it uses $\varphi = 2 / x$. When only the producer acts strategically; the producer considers the effect of its R&D choice on the outputs of the rival firm by maximizing its profit function with respect to φ, considering x and y depending on φ and the government ignores the effect of its own emission level on the output level of the rival producer.

I will consider four cases pertaining to the behaviour of governments and producers in each country. These are (1) neither the government nor the producer is acting strategically, (2) only the government is acting strategically, (3) only the producer is acting strategically, and (4) both the government and the producer are acting strategically. These cases are for two countries. So overall we can observe 16 different cases related to the behaviour of governments and producers in these two countries. First I will consider the symmetric cases, that is, the two countries are using the same strategy. Then I will consider the non-symmetric cases.

The objective function of the producers is revenue minus production cost, minus abatement cost that is (for the domestic country):

$$\pi_D = (A - x - y)\, x - x - 0.5(x - e)^2.$$

Here production cost function is taken as the efficient cost function.

The objective function of the governments is producers' surplus minus environmental damage that is:

$$W_D = (A - x - y)\, x - x - 0.5(x - e)^2 - 0.5de^2.$$

The profit and welfare function of the rival firm will be:

$$\pi_R = (A - x - y)\, y - y - 0.5(y - \varepsilon)^2.$$

$$W_R = (A - x - y)\, y - y - 0.5(y - \varepsilon)^2 - 0.5d\varepsilon^2.$$

To summarize the symbols used in equations, x and y are the outputs, e and ε are the emission levels, φ and ψ are the R&D levels of the domestic and rival country respectively.

CHAPTER 3

EQUILIBRIUM ANALYSIS

I will first study 4 symmetric cases related to the behaviour of governments and producers. By symmetry I mean that both of the countries are using the same strategy. So these cases are: a- neither the governments nor the producers of both of the countries are acting strategically, b- only the governments of both of the countries are acting strategically, c- only the producers of both of the countries are acting strategically, d- both of the countries' governments and producers are acting strategically. First I will examine the symmetric cases then I will examine the non-symmetric cases.

3.1 Non-strategic Equilibrium (NS versus NS)

The non-strategic equilibrium is neither the producers nor the governments are acting strategically. I call this non-strategic since the governments and producers are acting without thinking the impact their choice on the other country. In the second stage of the game the producers were choosing their R&D level but since the producers are not acting strategically they won't choose their R&D level considering the rival's behaviour. Instead they will use their pre-determined R&D level which leads to the efficient total cost function

$C(x) = x$. I begin from the third stage. In the third stage the producers's objective is to maximize their profit:

$$\max \quad (A - x - y)x - x - 0.5(x - e)^2 \tag{1}$$

The producers take the emission level and the output of the rival as given and choose their output level. The first order condition for the maximization problem in (1) results in:

$$x = (A - 1 + e - y) / 3 \tag{2}$$

the reaction function of the domestic country. Given the symmetry conditions, the rival producer has the following first order condition:

$$y = (A - 1 + \varepsilon - x) / 3 \tag{3}$$

where ε is the emission level of the rival country. Substituting (2) and (3) into each other we get:

$$x = (2A - 2 + 3e - \varepsilon) / 8 \tag{4a}$$

$$y = (2A - 2 + 3\varepsilon - e) / 8 \tag{4b}$$

In the first stage of the game, the government takes the emission level, ε, and the output of the rival country, y, as given and choose e to maximize the welfare function:

$$\max W(e) = (A - x - y)x - x - 0.5(x - e)^2 - 0.5de^2 \tag{5}$$

The first order condition is:

$$(A - 1 - y + e - 3x)\frac{\partial x}{\partial e} + x - e - de = 0$$