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RICE UNIVERSITY

OPTIMAL CONTRACTS
FOR TRADE RESTRICTIONS

by

ESPERANZA PAREDES

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IN PARTIAL FULLFILLMENT OF THE
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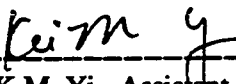
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ABSTRACT

Optimal Contracts for Trade Restrictions

by

Esperanza Paredes

This paper addresses the question of how the government should elicit cost information from a high or low domestic industry to determine socially optimal levels of imports. The results are shown to depend on whether firms in the domestic industry are represented by a trade organization. When firms act independently the optimal contract is costless for the government and two different types of incentive constraints are used to determine it. One of these applies when the costs announced by firms coincide. The other applies when one firm reveals a cost structure and its competitor reveals the opposite cost structure. If a contract to elicit cost information is used and trade organizations are the channel of communication between industry and government only one type of incentive constraint is necessary.

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OPTIMAL CONTRACTS FOR TRADE RESTRICTIONS

Reducing trade barriers increases the amount of competition in a country and may reduce the net profits of domestic firms. In fact, if domestic industries do not possess international standards of productivity when the economy is opened they may be expelled from the market. If a government is concerned with domestic employment as well as domestic consumers' surplus, it may temporarily restrict imports on the condition that home firms invest in cost reduction. Such investment could allow domestic firms to remain in the market and thereby maintain domestic employment.

My analysis formulates contracts or mechanisms that could be used by the government to induce firms to reveal cost information. These contracts establish an amount of protection offered by the government and an investment in research and development that firms are forced to make in exchange.

I first derive the government's behavior when it bases the amount of protection to give on its own costs beliefs. I then formulate the contract when the government is dealing with a trade organization (firms that act as a single agent). Finally, I derive the government's contract when it deals with firms that act separately.

The Basic Model.

To keep the discussion as simple as possible, I focus on an industry in which there are two domestic firms (firm "a" and firm "b") and many foreign firms producing a homogeneous good. Both domestic firms use the same technology producing with either zero or some positive marginal costs. The analysis considers a linear aggregate demand function $Q^d = 1-p$

where p is the domestic price, and uses the Cournot Model to determine the amounts domestic firms decide to produce. Foreign competition is introduced to the model via import quotas. (The notation used for the model is summarized in Appendix 1)

Let Λ_θ denote the marginal costs of firms in an industry. We say that the domestic industry is of type 1 when firms produce with zero marginal costs ($\Lambda_1=0$). We call these low cost firms. Foreign firms fall into this category. We say that the domestic industry is of type 2 if firms within it produce at some positive marginal cost $\Lambda_2>0$. We call these high cost firms. Let q_i , where $i=a,b$, denote the amount produced by each of the two domestic firms in the industry. q_θ denotes the import quota imposed by the government according to the domestic industry type. Thus the aggregate supply Q^s is given by the sum $q_a+q_b+q_\theta$.

$\Pi_{\theta i}$ denotes the net profits of a firm i in a type θ industry; and Π_θ the total net profits in the industry. Any profits derived by foreign firms from selling at some positive price in the country are appropriated by the domestic government through import tariffs.

Following Cournot's methodology, firms determine the amount to produce domestically according to the maximization of their net profits. Each domestic firm computes its net profits the following way: $\Pi_{\theta i} = (p - \Lambda_\theta) q_i = (1 - Q^s - \Lambda_\theta) q_i = (1 - q_a - q_b - q_\theta - \Lambda_\theta) q_i$. Firm a's reaction function is $q_a = \frac{1 - q_b - q_\theta - \Lambda_\theta}{2}$. Firm b's reaction function is $q_b = \frac{1 - q_a - q_\theta - \Lambda_\theta}{2}$. In equilibrium each firm supplies $q_i = \frac{1 - q_\theta - \Lambda_\theta}{3}$. Thus the total supply to the domestic market is $Q^s = 2q_i + q_\theta$ when $q_\theta < 1 - \Lambda_\theta$, and $Q^s = q_\theta$ when $q_\theta \geq 1 - \Lambda_\theta$.

If a government is concerned with consumers' welfare as well as with employment it cares about Producers' surplus (PS_θ) Consumers' surplus (CS_θ)² and about the size of the

¹The market is cleared at $Q^d = Q^s = Q$.

²If we consider the existence of identical consumers with quasilinear utility functions of the form

investment channeled to the industry to promote its development (I_θ). This investment not only generates employment during the current period, but may also affect the market share of domestic firms during the following period, and consequently the level of domestic employment in that particular industry. $-\eta$ denotes the costs in terms of employment derived from the trade barriers and investment that take place during a previous time period.

Each firm in an industry invests $I_{\theta i}$. The investment per industry is given by the sum of each firm's investment and is denoted as I_θ . The present value of the benefits derived from such investment are given by $\delta\psi(I_\theta)$ ³, where $0 \leq \delta \leq 1$ is a time depreciation factor. I will assume that high cost firms invest all their present profits and any possible payments or subsidies offered by the government (S), in cost reduction. This assumption implies the following: $(\delta\psi(I_2) > I_2)$ Low cost firms on the contrary do not need to invest in cost reduction. They already have zero marginal costs.

I assume that the domestic government appropriates those profits which foreign firms earn from selling at some positive price, by charging a tariff over imports. Therefore the Tariff Revenue TR_θ is given by the product price times imports pq_θ .

Given the aggregate demand and supply functions considered above, CS_θ , PS_θ , I_θ and TR_θ are computed as follows:

$q_j - \frac{nq_j^2}{2} + m$, where q_j is the quantity consumed by individual j , where $j=1,2, \dots,n$ and m is the numeraire, then by solving the consumer's problem of maximizing $q_j - \frac{nq_j^2}{2} + m$, s.t. $m + pq_j \leq y$, where y is the individual income, we get demand functions with zero income elasticity. This property allows Consumers' Surplus to be a good approximation of the consumers' welfare derived from the consumption of such good. It also allows the aggregate demand behavior to be consistent with the representative consumer's behavior.

³I assume ψ is an increasing linear function of I_θ and that $\psi(0)=0$.

Table 1

<p>Consumers' Surplus</p> $CS = \int_p^{p^*} Q(p) dp = \int_Q^{Q^*} p(Q) dQ - pQ = \frac{Q^2}{2}$ $\Rightarrow CS = \frac{1}{18} (2 - 2\Lambda_\theta + q_\theta)^2$
<p>Net Profits</p> $\Pi_\theta = p(q_a + q_b)$ $\Pi_\theta = \frac{2}{9} (1 - q_\theta - \Lambda_\theta)^2$
<p>Producers Surplus</p> $PS_\theta = P_\theta - I_\theta + \delta\psi(I_\theta)$ $\Rightarrow PS_\theta = \frac{2}{9} (1 - q_\theta - \Lambda_\theta)^2 - I_\theta + \delta\psi(I_\theta)$
<p>Tariff Revenue</p> $TR_\theta = pq_\theta = \frac{1}{3}(q_\theta - q_\theta^2 + 2q_\theta\Lambda_\theta)$
<p>Investment</p> $I_1 = 0$ $I_2 = \Pi_2(q_\theta) + S$

I assume time is divided into two relevant time periods: 0 represents the transition period from a closed to an open economy status⁴ and 1 represents the open economy period itself. The government is interested in Social Welfare (W) over time. In each time period, Social Welfare $W_t(\Lambda_\theta)$ is determined as the sum of consumers surplus CS_θ , producers surplus

⁴We refer to this transition period as a period in which there might be some foreign competition but the market is still not completely open.

PS_θ , tariff revenue TR_θ , investment in cost reduction I_θ and costs in terms of employment $-\eta$. If the government offers any sort of subsidies or payments (S)⁵ such quantity is subtracted from the sum mentioned above. In period 1 when the economy is opened, the price of the product becomes zero, therefore Consumer Surplus becomes $\frac{1}{2}$, $PS_\theta=TR_\theta=0$ and $1-\eta=0$. Also when firms are low cost $-\eta=0$.

The mathematical expressions for social welfare are shown on table 2.

Table 2

<p>Social Welfare in period t.</p> $W_t(\Lambda_\theta) = CS_\theta + PS_\theta + TR_\theta + I_\theta - \eta$ $W_0(\Lambda_1) = CS_1 + PS_1 + TR_1$ $W_0(\Lambda_2) = CS_2 + PS_2 + TR_2 + I_2$ $W_1(\Lambda_1) = \frac{1}{2}$ $W_1(\Lambda_2) = \frac{1}{2} - \eta$ <p>Present Value of Social Welfare</p> $W(\Lambda_\theta) = W_0(\Lambda_\theta) + \delta W_1(\Lambda_\theta)$

Assume that the government has perfect information on the demand's behavior but imperfect knowledge about firms' costs. If the government has some beliefs ρ that the industry might be of type 1 and $(1-\rho)$ that it might be of type 2, the expected Social Welfare (W) can be estimated as a weighted average of the Present Social Welfare when firms are both low cost and high cost $W = \rho W(\Lambda_1) + (1-\rho)W(\Lambda_2)$

The objective of the government is to determine the amount of imports it will allow in the country in order to maximize the present value of the Social Welfare. I will consider first

⁵We will assume that the government only offers subsidies to the producers and not to the consumers.

how the import quota would be determined if the government based his maximization problem on its own beliefs about the industry's cost structure. I will then proceed to consider a contract to induce firms to reveal their costs.

Socially Optimal Import Quota Based on Government's Beliefs.

When maximizing based on its own expectations the government offers a single import quota ($q_\theta=q$) to any type of industry. The government's objective function (the Maximum of the Expected Present Value of Social Welfare) can be stated as follows:

$$\begin{aligned} \max W &= \max \rho W(\Lambda_1) + (1-\rho)W(\Lambda_2) = \\ &\max \rho \left(CS_1 + PS_1 + TR_1 + \delta \frac{1}{2} \right) + \\ &(1-\rho) \left(CS_2 + PS_2 + I_2 + TR_2 + \delta \left(\frac{1}{2} - \eta \right) \right) \\ &\text{s.t. } 0 \leq q \leq 1 - \Lambda_2^6 \end{aligned}$$

Given the definition of PS_θ the expression is equivalent to:

$$\begin{aligned} &= \max \rho \left(CS_1 + P_1 + TR_1 + \delta \frac{1}{2} \right) + \\ &(1-\rho) \left(CS_2 + P_2 + TR_2 + \delta \left(\frac{1}{2} + \psi - \eta \right) \right) \end{aligned}$$

Substituting the values of CS_θ , Π_θ and TR_θ we get:

$$\begin{aligned} &= \max \rho \left(\frac{1}{18}(2+q)^2 + \frac{2}{9}(1-q)^2 - \frac{1}{3}(q-q^2) + \delta \frac{1}{2} \right) + \\ &(1-\rho) \left(\frac{1}{18}(2+q-2\Lambda_2)^2 + \frac{2}{9}(1-q-\Lambda_2)^2 - \frac{1}{3}(q-q^2+2q\Lambda_2) + \delta \left(\frac{1}{2} + \psi - \eta \right) \right) \end{aligned}$$

⁶The amount produced by domestic firms is positive ($q_i > 0$) only if $q_\theta = q < 1 - \Lambda_\theta$. The government is interested in restricting the amount of imports in the country, only if this induces high cost firms to produce and earn some positive profits which they can invest in cost reduction, i.e., only if $q < 1 - \Lambda_2$.

The First and Second Order Conditions are:

$$\frac{\delta W}{\delta q} = \frac{1}{9} - \frac{1}{9}q + \left(\frac{8}{9}\Lambda_2 + \delta(\psi' - \eta')\right)(1 - \rho)$$

$$\frac{\delta^2 W}{\delta q^2} = -\frac{1}{9} < 0$$

From the F.O.C. we get the optimal import quota

$$q^* = 1 + [8\Lambda_2 + 9\delta(\psi' - \eta')](1 - \rho) \quad 7.$$

where $\psi' < 0$ and $\eta' > 0$

By the S.O.C we know that the optimal import quota q^* gives us a maximum of the objective function. When $-1 \leq [8\Lambda_2 + 9\delta(\psi' - \eta')](1 - \rho) < -\Lambda_2$ then some positive import quota ($0 < q^* < 1 - \Lambda_2$) is offered to firms during the transition period. Due to the way in which the import quota is determined, protection is offered even to those industries that were already competitive. Consequently, low cost firms benefit at the expense of consumers. We will now consider a contract to elicit cost information from private firms.

Firms acting as a single agent.

The way in which firms transmit information to the government varies from country to country. In some countries trade organizations represent all firms interests in an industry, and through them the information is channeled to the government. When this happens we say that firms reveal information as a single agent. Assuming that this is the case, I

$7 \left[\frac{\delta q^*}{\delta d} \cdot \frac{\delta q^*}{\delta(1-r)} < 0; \quad \frac{\delta q^*}{\delta \Lambda_2} > 0 \right]$

consider a contract designed by the government to induce firms represented by a trade organization to reveal information about their costs.

The contract specifies an amount of protection (q_1) offered to trade organizations that claim to represent a type 1 industry and a quota (q_2) offered to those that report themselves as representing a type 2 industry. The contract also specifies incentives or restrictions (T_θ) offered to trade organizations to avoid firms' arbitrage, ie., the possibility that an industry to which an amount of protection is directed chooses to lie about its cost in order to get the protection directed to another type of industry. Firms that announce themselves as high cost are compelled to invest an amount T_2 in cost reduction. Firms that announce low costs receive a payment or subsidy $S=T_1$ from the government.

In summary, bundle (q_1, T_1) is offered to trade organizations that claim to represent a type 1 industry and (q_2, T_2) to those that claim to represent high cost firms. The guidelines to determine such bundles are the following:

- 1) $\Pi_2(q_2) - T_2 \geq 0$
- 2) $\Pi_1(q_1) + T_1 \geq \Pi_1(q_2) - T_2$
- 3) $\delta\psi(\Pi_2(q_2)) \geq \delta\psi(\Pi_2(q_1) + T_1)$
- 4) $0 \leq q_1 \leq 1$
- 5) $0 \leq q_2 \leq 1 - \Lambda_2$
- 6) $T_2 \geq 0$

Assume that the government is able to make firms announce a cost level although they might not reveal the truth. There exists an imperfect credit market, therefore high cost firms are unable to borrow from future periods' profits. If the government does not want to induce firms to have negative profits T_2 cannot exceed the amount of profits generated during the first period. Constraint one comprises that idea. The second and third are the arbitrage or incentive-compatibility constraints. Constraint two is set so that low cost firms prefer revealing their costs rather than announcing themselves as high cost firms.

Constraint three prevents high cost firms from asking for incentive T_1 pretending to be low cost. Finally, constraints 4) and 5) do not allow import quotas to be negative, nor larger than 1 and $1-\Lambda_2$ respectively.

One could consider extending the analysis to allow for the possibility of $T_2 < 0$. But as a matter of modeling strategy, I will assume constraint 6) holds.

The Investment and Producers' Surplus functions will now depend not only on the firms real costs (Λ_r) but also on the costs announced by their trade organization (Λ_a). The specific computation for these functions is summarized in Table 3:

Table 3

	$\Lambda_a = \Lambda_1$		$\Lambda_a = \Lambda_2$	
	I_θ	PS_θ	I_θ	PS_θ
$\Lambda_r = \Lambda_1$	0	$\Pi_1(q_1) + T_1$	0	$\Pi_1(q_2) - T_2$
$\Lambda_r = \Lambda_2$	$\Pi_2(q_1) + T_1$	$\delta\psi(\Pi_2(q_1) + T_1)$	$\Pi_2(q_2)$	$\delta\psi(\Pi_2(q_2))$

The government's objective function is:

$$\begin{aligned} \max W &= \max \rho \left(CS_1(q_1) + PS_1(q_1, \Lambda_1)^8 + TR_1(q_1) + \delta \frac{1}{2} - T_1 \right) + \\ &(1-\rho) \left(CS_2(q_2) + PS_2(q_2, \Lambda_2) + TR_2(q_2) + I_2(q_2, \Lambda_2) + \delta \left(\frac{1}{2} - \eta \right) \right) \\ &= \max \rho \left(CS_1(q_1) + \Pi_1(q_1, \Lambda_1) + TR_1(q_1) + \delta \frac{1}{2} \right) \\ &(1-\rho) \left(CS_2(q_2) + \Pi_2(q_2, \Lambda_2) + TR_2(q_2) + \delta \left(\frac{1}{2} + \psi - \eta \right) \right) \end{aligned}$$

⁸The relevant PS_θ , I_θ for the maximization problem are those for which $\Lambda_a = \Lambda_r = \Lambda_\theta$

It is in the government's own interest to have the lowest possible T_1 . Given that high cost firms invest all their profits in cost reduction, nothing is lost by letting D hold with equality $T_2 = \Pi_2(q_2)$.

Firms acting independently

Now consider the optimal mechanism designed by the government when there is no trade organization gathering firms' interests. The government will now deal with firms separately. The bundles offered to each firm will depend not only on what the firm itself reveals but also on whatever its competitor reveals.

Let the government offer protection q_1 and incentives $T_{1a} = T_{1b}$ to firms "a" and "b" respectively, if both firms reveal themselves as low cost firms. It offers quota q_2 if both firms reveal that they belong to a type 2 industry and ask them in exchange to invest amounts $T_{2a} = T_{2b}$. Finally if firm "i" reveals that it belongs to a type 1 industry and firm "-i" to a type 2 industry, the government offers quota q_1 and incentives T_{Li} , T_{H-i} to firm i and -i respectively.

Then the bundles offered by the government are the following:

(q_1, T_{1a}, T_{1b})	when both firms report low costs
(q_2, T_{2a}, T_{2b})	when both firms report high costs
(q_1, T_{La}, T_{Hb})	when "a" reports low costs and "b" high costs
(q_1, T_{Ha}, T_{Lb})	when "a" reports high costs and "b" low costs

Each firm can use two strategies: it can announce to be low cost no matter what its true costs are, or announce to be high cost. The government wants to prevent that firms reveal false information about their costs. To achieve this goal and to determine the bundles mentioned above the government uses the following guidelines:

- 1) $\Pi_{2i}(q_2) - T_{2i} \geq 0$
- 2) $\Pi_{1i}(q_1) + T_{Li} \geq \Pi_{1i}(q_2) - T_{2i}$
- 3) $\Pi_{1i}(q_1) + T_{1i} \geq \Pi_{1i}(q_1) + T_{Hi}$
- 4) $\delta\psi_i(\Pi_{2i}(q_1) + T_{Hi}) \geq \delta\psi_i(\Pi_{2i}(q_1) + T_{1i})$
- 5) $\delta\psi_i(\Pi_{2i}(q_2)) \geq \delta\psi_i(\Pi_{2i}(q_1) + T_{Li})$
- 6) $0 \leq q_1 \leq 1$
- 7) $0 \leq q_2 \leq 1 - \Lambda_2$

The incentive compatibility restraints are given by restrictions 2), 3), 4) and 5). Constraint 2) says that if a low cost firm "i" believes that its competitor (firm "-i") will use the strategy of announcing high costs, it will announce low costs only if $\Pi_{1i}(q_1) - T_{Li} \geq \Pi_{1i}(q_2) - T_{2i}$. Constraint 3) establishes that if it expects its competitor to announce low costs, low cost firm "i" will do the same thing only if $\Pi_{1i}(q_1) + T_{1i} \geq \Pi_{1i}(q_1) - T_{Hi}$. Constraint 4) and 5) are the incentive compatible constraints for a type 2 industry. A high cost firm will announce high costs when it believes its competitor is announcing low costs if constraint 4) holds. If it believes its competitor will announce high costs firm "i" announces the same thing only if constraint 5) holds.

Constraints 3) and 4) are compatible only if $T_{Hi} = T_{1i}$. Because the government is better off the lowest T_{1i} is, we can let $T_{Hi} = T_{1i} = 0$.

If the T_1^* derived from the maximization problem described in the previous section is strictly positive we can say that the government is better off when no trade organization exists. When firms act independently the optimal contract is costless for the government.

Conclusions.

When an economy is about to be opened the amount of information the government receives from the private sector is an important element to determine policies on imports. When the government has imperfect knowledge about the cost structure in an industry it can determine the import quota based on this knowledge alone. The government can improve social welfare by inducing firms to reveal additional information about their costs.

The way in which firms transmit their demands for protection and their information about costs to the government determines which contracts are the most efficient to make firms reveal their costs. When firms act independently the optimal contract is costless for the government.

When no trade organization exists the optimal contract includes two different types of incentive constraints. One of these applies when the costs announced by firms coincide. The other applies when one firm reveals a cost structure and its competitor reveals the opposite cost structure. If a contract to elicit cost information is used and trade organizations are the channel of communication between industry and government only one type of incentive constraint is necessary.

Appendix 1.

Q^d	= aggregate demand
Q^s	= aggregate supply
p	= domestic price
Λ_θ	= Marginal Costs of firms in type θ industries
θ	= Index of the type of industry according to marginal costs: $\theta=1$ if firms in the industry are low cost, $\theta=2$ for industries with high cost firms.
q_i	= quantity produced by firm i (where $i=a,b$)
q_θ	= amount of imports allowed, according to the type of industry producing it domestically.
q	= import quota offered when the government bases its trade barriers' policy based on its own costs beliefs.
$\Pi_{\theta i}$	= net profits of firm i in a type θ industry.
Π_θ	= total net profits in a type θ industry.
CS_θ	= Consumers' Surplus
PS_θ	= Producers' Surplus
TR_θ	= Tariff Revenue
S	= Subsidies or payments offered to firms by the government.
I_θ	= amount invested by firms in a type θ industry in cost reduction.
$I_{\theta i}$	= investment of a particular firm i in a type θ industry
δ	= discount factor, where $0 \leq \delta \leq 1$
ρ	= Government's beliefs that firms in an industry are low cost
$(1-\rho)$	= Government's beliefs that firms in an industry are high cost
W	= Expected Present Value of Social Welfare
$W(\Lambda_\theta)$	= Present Values of Social Welfare
W_0	= Social Welfare for the transition period
W_1	= Social Welfare for the period in which the economy is completely opened.
$-\tau_1$	= cost in terms of employment when domestic firms lower their share in the domestic market .
ψ	= costs firms have for lowering their share in the market, or from being completely expelled from it when the economy is opened.
T_1	= payments, subsidies or credit facilities the government makes to firms that reveal themselves as low cost.
T_2	= investment firms in a type two industry are compelled to make, if they reveal themselves as high cost.
T_H	= investment required from a firm when it reports high costs given that its competitor reported low costs.
T_L	= investive offered to a firm that reports low costs given that its competitor reported high costs.

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