Optimal Competition Policy for an Oligopolistic Export Industry

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This paper derives the optimal number of firms for an oligopolistic export industry when firms of the industry interact with each other in factor markets as well as in output markets. The optimal number is derived both for a case of unilateral intervention by an exporting country and for a Nash and a Stackelberg policy equilibria between governments of an exporting and an importing countries. It proves to be an increasing function of the ratio of the slope of an export supply curve to the absolute slope of an import demand curve. The nature of policy game between the governments also affects the optimal number of firms of the industry. (*JEL* Classification: F13)

I. Introduction

The purpose of this paper is to examine the optimal competition policy for an oligopolistic export industry when firms of the industry interact with each other in factor markets as well as in output markets. Employing a model of a linear demand and quadratic costs, this paper shows that the ratio of the slope of an export supply curve to the absolute slope of an import demand curve determines the optimal number of firms of the industry.

Substantial amount of attention has been paid to the optimal structure of an export industry when the industry has monopoly power in an international market. It is widely accepted that the international

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monopoly power is best exploited by forming an export cartel (Helpman and Krugman 1989, ch.5).[1] However, with domestic consumption, an export cartel can be welfare-deteriorating, since it may exploit its power in its domestic market as well. This possibility is considered by Auquier and Caves (1979). Brander and Spencer (1984) examine the trade policy interaction between governments of an exporting and an importing countries. The government of the exporting country determines the number of exporting firms while the importing country's government sets the import tariff, each government employing a Nash conjecture about the level of the other's strategy. With a constant marginal cost and without any domestic consumption, the optimal strategy of the exporting country is given as complete cartelization of the industry.

Cowan (1989) extends the analysis of Brander and Spencer (1984) to the case in which the exporting country precommits its competition policy, (i.e., decides the number of exporting firms) prior to the trade policy interaction. Cowan (1989) shows that, in such a case, the optimal number of firms from the viewpoint of the exporting country depends on the degree of convexity of the import demand curve.

Implicit in most of the aforementioned analyses is the assumption that the exporting firms do not interact with each other in their domestic factor markets. This assumption is embodied in the literature in the form of constant marginal costs which are not affected by behavior of firms. Indeed, the assumption of constant marginal costs is widely adopted in the literature of strategic trade policy.[2] Needless to say, this is a very restrictive assumption. The firms of an oligopolistic industry may naturally recognize that they affect each other in factor markets as well as in output markets. Then, the total cost of each firm cannot be expressed simply as a function of its own output.

The present paper relaxes the assumption of constant marginal costs and examines how the optimal structure of an oligopolistic export industry is affected by interaction of the firms in their factor markets as well as in their output markets. This paper is closely related to Dixit and Grossman (1986) in that factor markets of an export industry are explicitly introduced into the model. However, the present analysis differs from Dixit and Grossman (1986) in several respects. First, the present paper analyzes intra-industry interaction between firms in factor

[1] Most of the literature on marketing boards and state trading also takes this for granted. See, for example, Krishna and Thursby (1992).

[2] For instance, see Dixit (1984) and Cowan (1989).

markets, while they consider inter-industry interaction in factor markets. Second, this paper explicitly allows for oligopsonistic interaction between firms. On the other hand, there remains no room for oligopsonistic interaction between firms in their model as they assume that factor markets are perfectly competitive. Finally, this paper focuses on deriving the optimal structure of the industry, while the industrial structure in their analysis is given exogenously.

This paper shows that, in a model of a linear demand and quadratic costs, the optimal number of the exporting firms is given by one plus the ratio of the slope of the industry's export supply curve to the absolute slope of the import demand curve. Thus, this paper shows that complete cartelization need not always be the optimal structure for the export industry. Moreover, conjectures of Brander and Spencer (1984, p. 239) on the industry structure proves to be invalid in this case. The paper also generalizes the analysis of Cowan (1989) to the case of non-constant marginal costs.

The paper is organized as follows. Section II specifies demand and cost conditions for the export industry. Section III derives the optimal structure of the industry, beginning with the case in which the government of an exporting country intervenes unilaterally in international trade. The model is then extended to allow for intervention of the importing country as well. In section IV the optimal structure of the export industry is derived for the cases in which there is domestic consumption and the market is perfectly competitive, respectively. Section IV also considers the case of Cowan (1989). The final section provides a summary and discussion of the findings.

II. The Basic Model

We suppose that the world consists of two countries, labelled 1 and 2, respectively. Consider an export industry of country 1 consisting of n identical firms. Firms produce a homogeneous product. Avoiding the problem raised by Auquier and Caves (1979), we assume that all of the product of the industry is exported to country 2. We also assume that there is no firm of the industry in country 2.[3]

[3]When there exist firms of the same industry in country 2, the analysis in the next section will be significantly affected. However, if they are price-takers or Cournot-Nash players, the qualitative results of this paper are not affected. In such a case, the import demand of country 2 should be viewed as the residual

For ease of analysis, we adopt a partial equilibrium approach and assume that the inverse import demand of country 2 for the product is given by a linear form:[4]

$$P = B - r\sum_i q_i = B - rQ, \qquad r, B > 0, \tag{1}$$

where q_i is the output of the i-th firm, $i = 1, \ldots, n$, and the term $\sum_i q_i$ is denoted by Q.

We now characterize the production technology of the industry. It is assumed that producing one unit of the output requires one unit of the only input y, and that per-unit processing cost m is constant. A natural interpretation of the production technology is to consider the exporting firms as trading companies or marketing boards in charge of international marketing of goods produced by a perfectly-competitive industry. The processing cost m could be viewed as per-unit cost associated with collection, distribution, marketing, etc.

The industry of country 1 supplying the input y is perfectly competitive, and its total cost of production is given by a quadratic form,

$$C(Y) = \left(\frac{1}{2}\right)aY^2 + bY + c, \tag{2}$$

where Y stands for total supply of y. No *a priori* restriction is put on the sign of a. Normally it has a nonnegative value. To obtain an interior solution, it is assumed that $B > (b + m)$. Differentiation of $C(Y)$ gives the input supply for the export industry:

$$C'(Y) = aY + b. \tag{3}$$

Since one unit of the output requires one unit of the input, Q and Y can be interchangeably used in the cost functions. Were the export industry to be perfectly competitive, the industry's export supply curve would be given as

$$P = aQ + b + m. \tag{4}$$

Note that the parameter a denotes the slope of the output supply curve as well as that of the input supply curve since per-unit processing cost is constant. We assume away the possibility of vertical integration of the two industries.

demand, supply by firms of country 2 being subtracted.

[4]Many papers in the literature of international trade adopt the assumption of a linear demand to obtain explicit solutions and to sharpen argument. See, for example, Brander (1981) and Laussel (1992).

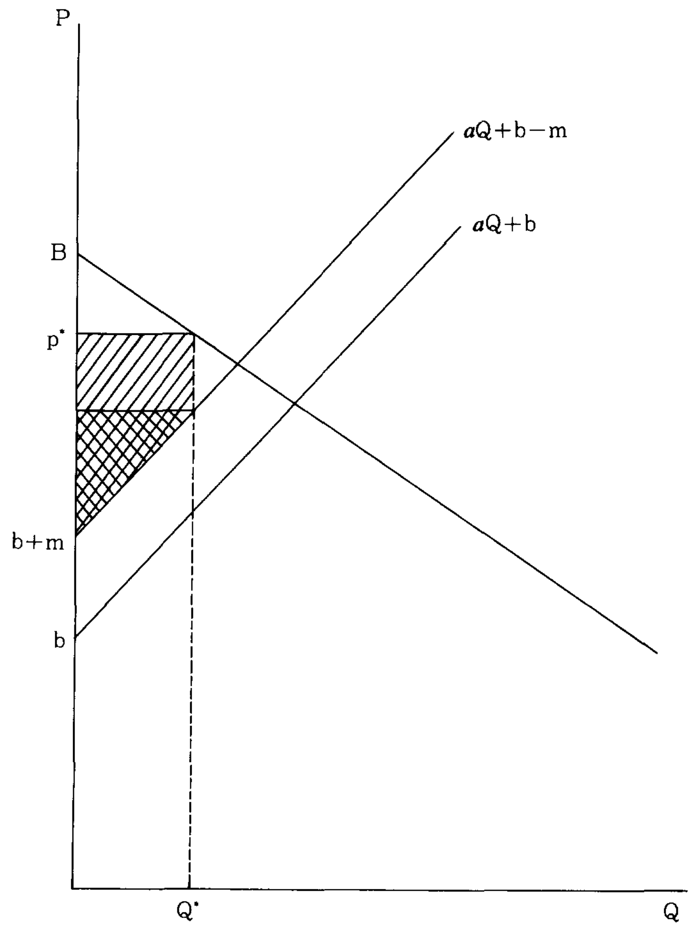

FIGURE 1

The i-th firm's total cost of producing q_i is given by

$$TC^i(q_i) = (aQ + b)\, q_i + mq_i + K, \tag{5}$$

where $(aQ + b)$ represents the unit price the firm pays to y suppliers and m denotes per-unit processing cost. Fixed cost K is assumed to be zero for ease of calculation.[5] Note that behavior of its own and the

[5]When $K > 0$, the optimal number of firms derived in sections III and IV may be viewed as the upper limit to the optimal number of firms. However, if K is

other firms affects the total cost of the i-th firm through their interaction in the input market, unless $a = 0$ so that y supply is given by a horizontal line. By exporting q_i to country 2, firm i obtains total revenue given as

$$TR^i(q_i) = P \cdot q_i = (B - rQ)q_i. \tag{6}$$

Now firm i solves the problem :

$$\begin{aligned} \text{Max } \Pi^i &= TR^i(q_i) - TC^i(q_i) \\ &= (B - rQ)q_i - (aQ + b)q_i - mq_i \\ &= r[(B/r - b/r - m/r - Q)q_i - (a/r)Qq_i]. \end{aligned} \tag{7}$$

w.r.t. q_i.

Define A to be $(B - b - m)/r$, and α to be (a/r). Since $B > (b + m)$, $A > 0$. The variable α is the ratio of the slope of the export supply curve to the absolute slope of the import demand curve.

Since $r > 0$, the solution to (7) is identical to that for the following problem.

$$\text{Max} \frac{\Pi^i}{r} = (A - Q)q_i - \alpha Q q_i \tag{8}$$

w.r.t. q_i.

Note that (8) is equivalent to the problem firm i faces when demand curve is given by $P = (A - Q)$, supply of the input by aQ and $m = 0$. Without any loss of generality, (8) will be employed for analysis instead of (7).

As in most of the literature on strategic trade policy and trade under oligopoly, we assume that the firms are Cournot-Nash competitors, (see, for example, Brander and Spencer 1985, and Dixit 1984). Thus, each firm tries to maximize its own profit with respect to its own output, taking all the other firms' outputs as given. Then, the first-order condition to (8) is given as:

$$\begin{aligned} \frac{\partial \Pi^i}{\partial q_i} &= \frac{\partial TR^i}{\partial q_i} - \frac{\partial TC^i}{\partial q_i} \\ &= [(A - Q - q_i) - (\alpha Q + \alpha q_i)] = 0. \end{aligned} \tag{9}$$

sufficiently small, the analysis in sections III and IV is not affected. Another possible interpretation is that we are considering the case when there already exist a number of firms and the government tries to streamline the industrial structure. Then, K, a sunk cost, does not affect the analysis and hence can be assumed away.

Note that firm i takes into account the fact that its output q_i affects its profit through its effect both on total cost and on total revenue, provided that $\alpha \neq 0$.

III. The Optimal Industrial Structure

In this section we derive the optimal structure for the export industry in terms of the number of exporting firms from the viewpoint of the exporting country. First, we consider the case in which the government of the exporting country intervenes unilaterally in international trade by determining the number of firms to export the product. Then the latter part of the section considers the case in which the government of the importing country also intervenes in international trade through import tariffs.

A. Unilateral Intervention

In the first-stage, the government of the exporting country determines the number of firms to export the product. Subsequently, the firms interact in a Cournot-Nash way and the market is cleared.

National welfare of country 1, W^1, is defined to be the sum of aggregate profits of the export industry and producer surpluses of the input industry. Hence W^1 is calculated as:

$$\begin{aligned} W^1 &= [(A-Q)Q - \alpha Q \cdot Q] + \left(\frac{1}{2}\right)\alpha Q^2 \\ &= (A-Q)Q - \left(\frac{1}{2}\right)\alpha Q^2. \end{aligned} \tag{10}$$

Note that W^1 need not equal the aggregate profits of the export industry even though there is no domestic consumption of the output. This is so because the government cares about producer surpluses of the input industry as well as those of the export industry. Only when $\alpha = 0$, W^1 coincides with the aggregate profits of the export industry. The optimal number of firms from the viewpoint of the exporting country is obtained by maximizing W^1 with respect to n, the firms' behavior being taken into account. By summing equation (9) over i, we obtain

$$\begin{aligned} &\sum_i \{(A-Q) - q_i - \alpha Q - \alpha q_i\} \\ &= n(A-Q) - Q - \alpha n Q - \alpha Q = 0. \end{aligned}$$

Hence,

$$Q = \frac{nA}{(\alpha + 1)(n + 1)}. \tag{11}$$

Substituting (11) into (10), we can express W^1 as a function of n:

$$W^1 = \frac{n(\alpha n + \alpha + 1)}{(\alpha + 1)^2(n + 1)^2} A^2 - \frac{1}{2}\alpha \frac{n^2 A^2}{(\alpha + 1)^2(n + 1)^2}. \tag{12}$$

The first-order condition for welfare maximization is given as

$$W_n^1 \equiv \frac{\partial W^1}{\partial n} = \frac{-A^2(n - \alpha - 1)}{(\alpha + 1)^2(n + 1)^3} = 0. \tag{13}$$

The second-order condition is satisfied. Thus, from (13), it follows that W^1 achieves its maximum when $n = (\alpha + 1)$. That is, the optimal number of firms is given as one plus the ratio of the slope of the export supply curve over the absolute slope of the import demand curve. For example, if $\alpha = 0$, then $n^* = 1$. Hence complete cartelization of the export industry is desirable when the industry has a constant marginal cost. If $\alpha = 1$, then, duopoly is the optimal structure of the industry. If α is not an integer value, the optimal number of firms, n^*, is obtained by comparing the values of W^1 at the two natural numbers nearest to $(\alpha + 1)$.[6] Figure 2 is obtained by so doing.

Note that the optimal number of export firms increases as α increases even though there is no domestic consumption of the product. This result can be explained as follows. The greater α is, i.e., the steeper the supply curve is relatively to the import demand curve, the greater is welfare loss from oligopsony power of the export firms. Hence the optimal number of export firms increases as α increases.

When the integer constraint is not binding, national welfare W^1 is maximized with the optimal number of export firms n^*. However, if the integer constraint is binding, the competition policy cannot achieve the optimal outcome from the viewpoint of the exporting country. In such a case, the competition policy is inferior to policies which can achieve the optimal outcome.[7]

[6]See the appendix for derivation of n^* when α is not an integer value.

[7]The government of the exporting country can achieve the optimal outcome through (combination of) various policies such as vertical integration of the two industries, monopoly cum subsidies, perfect competition cum subsidies, etc. The distinctive advantage, and perhaps the risk, of the competitiion policy is that it is relatively easy to implement.

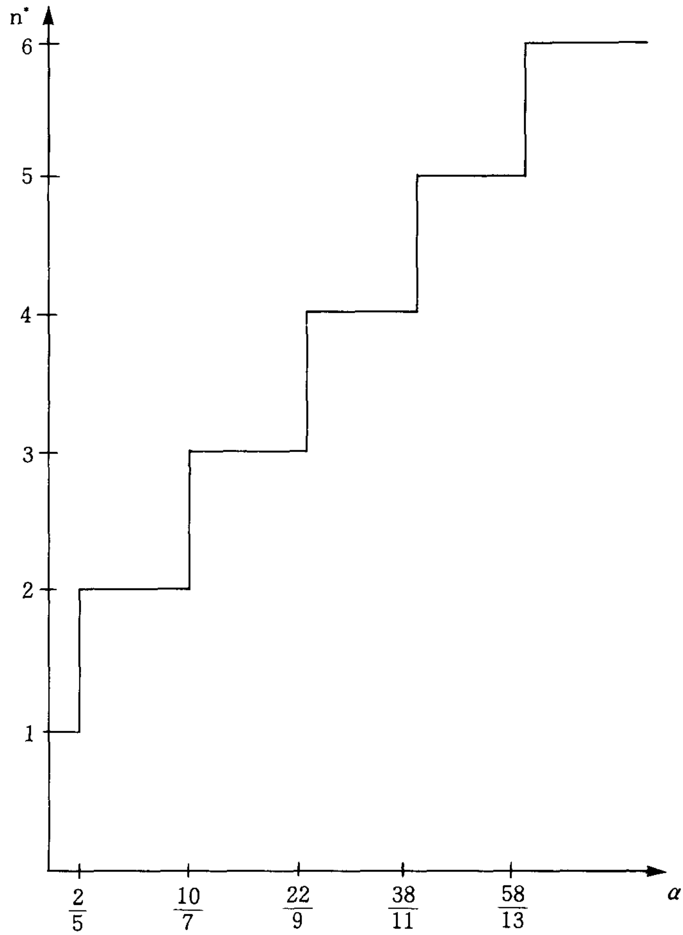

FIGURE 2
THE OPTIMAL NUMBER OF FIRMS

B. Cartels versus Tariffs : Nash and Stackelberg

In the previous part we have analyzed the optimal industrial structure when the government of the exporting country intervenes unilaterally in international trade. In this part we introduce the possibility of policy interaction between governments of the exporting and the importing countries. As in Brander and Spencer (1984) and in III. *A* of this paper, the strategy variable of the exporting country is the number of firms to export goods. The strategy variable of the importing country is the level of a specific import tariff or subsidy.

A noncooperative Nash equilibrium of policy interaction is obtained when each country maximizes its own national welfare with respect to its own strategy variable, taking the level of the other country's strategy as given. Of course, the firms' behavior is duly taken into account by the two governments.

Let T denote the level of a specific import tariff the importing country imposes. Define t to be T/r. Then (8) is rewritten as:[8]

$$\begin{aligned} \text{Max}\frac{\Pi^i}{r} &= (A-Q)q_i - \alpha Q q_i - \frac{T}{r}q_i \\ &= (A-Q)q_i - \alpha Q q_i - tq_i \end{aligned} \tag{8$'$}$$

w.r.t. q_i.

Straightforward calculation as in (11) shows that

$$Q = \frac{n}{(\alpha+1)(n+1)}(A-t). \tag{11$'$}$$

National welfare of country 1, W^1, is calculated as :

$$\begin{aligned} W^1 &= (P-t)Q - \frac{1}{2}\alpha Q^2 \\ &= \frac{n(\alpha n+\alpha+1)}{(\alpha+1)^2(n+1)^2}(A-t)^2 - \frac{1}{2}\alpha\frac{n^2(A-t)^2}{(\alpha+1)^2(n+1)^2}. \end{aligned} \tag{12$'$}$$

National welfare of country 2 is defined to be the sum of consumer surplus and tariff revenue:

$$\begin{aligned} W^2 &= \frac{1}{2}Q^2 + tQ \\ &= \frac{1}{2}\frac{n^2}{(\alpha+1)^2(n+1)^2}(A-t)^2 + t\frac{n}{(\alpha+1)(n+1)}(A-t). \end{aligned} \tag{14}$$

The noncooperative Nash equilibrium of policy interaction between the two countries can be obtained by solving the two first-order conditions:

$$W_n^1 = \frac{\partial W^1}{\partial n} = \frac{-(A-t)^2(n-\alpha-1)}{(\alpha+1)^2(n+1)^3} = 0, \tag{13$'$}$$

[8]Note that the optimal import tariff T^* is equal to r times t^* to be derived in the subsequent discussion.

and

$$W_t^2 = \frac{\partial W^2}{\partial t} = \frac{n^2}{(\alpha+1)^2(n+1)^2}\left[\frac{(\alpha n+\alpha+1)}{n}A - \frac{(2\alpha n+n+2\alpha+2)}{n}t\right] = 0. \quad (15)$$

Upon examination of (13′), one finds that the optimal number of firms is again given by $n^* = (\alpha + 1)$. An interesting point is that the level of specific import tariff does not affect the optimal number of firms provided that the exporting country takes the tariff level as given. This property holds whenever national welfare of country 1, W^1, can be written as the product of a function of t and a function of n, i.e., $W^1(n, t) = f(t) \cdot g(n)$. Note that Figure 2 is valid for a Nash game as well.

From (15) the optimal tariff t^* is calculated as:

$$t^* = \frac{(\alpha n+\alpha+1)}{(2\alpha n+n+2\alpha+2)}A. \quad (16)$$

The optimal tariff t^* decreases as n increases. Figure 3 depicts a noncooperative Nash equilibrium of policy game for a given value of α.[9] The Nash equilibrium is given as the point (n^*, t^*). w^0w^0 and w^1w^1 are iso-welfare loci for country 2, while u^0u^0 and u^1u^1 are those for country 1.

In Figure 3 reaction curve of country 1 is drawn as a vertical line at $n^* = (\alpha + 1)$. This reflects the fact that n^* is not affected by a level of an import tariff if the exporting country takes it as given. On the other hand, the level of the optimal import tariff decreases as the number of export firms increases.

The point (n^*, t^*) in Figure 3 also depicts the policy equilibrium when the exporting country behaves as a Stackelberg follower while the importing country behaves as a Stackelberg leader. In such a case, the importing country sets the import tariff, taking into account response of the exporting country. That is, the importing country maximizes its national welfare along the reaction curve of country 1. Again W^2 is maximized at (n^*, t^*) as w^1w^1 is tangent to the vertical line $n^* = (\alpha + 1)$. Since n^* is not responsive to change in t^*, there is nothing country 2 can gain by moving first. The Stackelberg equilibrium in this case turns out to be identical to the Nash equilibrium.

We now turn to the case when the exporting country acts as a Stackelberg leader. The exporting country's task is to maximize W^1 with respect to n along t^* curve in Figure 3. Insert (16) to W^1 to obtain:

[9] Figure 3 is similar to Figure 4 in Brander and Spencer (1984, p.239) with no domestic consumption. The crucial difference is that n^* in Figure 3 depends on the value of α while n^* in Brander and Spencer (1984) is fixed at $n^* = 1$.

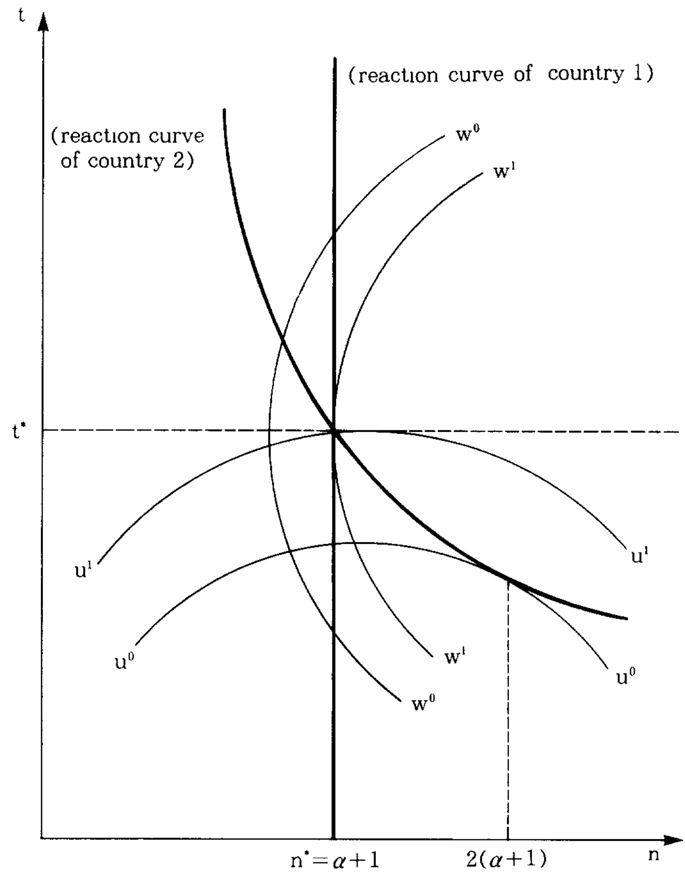

FIGURE 3

$$W^1 = (P-t)Q - \frac{1}{2}\alpha Q^2$$
$$= \frac{A^2}{2}\cdot\frac{(\alpha n^2+2\alpha n+2n)}{(2\alpha n+n+2\alpha+2)^2}. \qquad (12'')$$

Differentiation of W^1 with respect to n and setting it equal to zero yields that $n^* = 2(\alpha + 1)$. For instance, if the industry supply curve is horizontal, i.e., $\alpha = 0$, then the optimal structure of the export industry is duopoly. Compare this result with the Nash equilibrium in which the optimal structure with $\alpha = 0$ is given as monopoly. In general the optimal number of firms is greater when the exporting country behaves as a Stackelberg leader than when it behaves as a Nash player. This can be explained as follows. The optimal import tariff is a decreasing function of a number of export firms: The more competitive the export industry is, the lower the optimal import tariff is. The exporting country balances gains from a lower tariff and an increase in producer surplus of the input industry with a loss in profits of the export industry. The result is that W^1 is maximized by "doubling" the number of firms of the Nash equilibrium.

IV. Some Extensions

In this section we extend the analysis by relaxing some of restrictive assumptions. First, domestic consumption of the exporting country is introduced into the model. The case of a perfectly-competitive export market is also analyzed. Finally, the case of Cowan (1989) is considered in the context of the model of this paper.

A. Domestic Consumption and the Optimal Industrial Structure

We now assume that a portion of the output is consumed in the domestic market of the exporting country as well. Equation (1) is now considered as the world inverse demand. Arbitrage ensures a single price in the world market. At each price a proportion e of the total product is consumed in country 1, $(0 \leq e < 1)$. Then W^1 is revised to include the proportion of consumer surplus as

$$\begin{aligned} W^1 &= (A - Q) - \alpha Q \cdot Q + \frac{1}{2}\alpha Q^2 + e\frac{1}{2}Q^2 \\ &= (A - Q)Q + \frac{1}{2}(e - \alpha)Q^2. \end{aligned} \tag{17}$$

W^1 is again given as a function of n. Following the same procedure as in section III, we obtain $n^* = (\alpha + 1)/(1 - e)$. The larger e is, the greater is n^*. As e approaches 1, n^* goes to infinity, resulting in a perfectly-competitive market structure.

B. Perfectly-Competitive Export Market

The results derived in section III can be applied to the case when the export industry has no international market power while possessing domestic oligopsony power. In such a case, r of the inverse demand curve, $P = B - rQ$, may be considered as approaching zero. Then α ($\equiv$

a/r) for a given value of a goes to infinity. Hence $n^*(= \alpha + 1)$ also goes to infinity, i.e., perfectly-competitive structure is optimal.

C. The Case of Cowan (1989)

The paper now considers the case of Cowan (1989). In Cowan (1989) the exporting country sets the number of firms in the first-stage. In the second-stage the exporting country and the importing country set the export tax and the import tariff, respectively, in a Nash way. In case of a linear demand and a constant marginal cost, Cowan (1989, pp.472 - 6) shows that the optimal structure of the export industry is characterized by an arbitrarily large number of firms, i.e., perfect competition is the optimal industrial structure. This is so because the exporting country can extract surplus in the form of export taxes while lowering the level of import tariff by making the industry perfectly competitive.

Here we examine whether Cowan's result holds when marginal cost is nonconstant. The game specified in section III is slightly modified to allow for export taxes of the exporting country. As in Cowan (1989) the exporting country sets the number of export firms in the first-stage. In the second-stage the two governments set a specific export tax s and a specific import tariff t, respectively, taking each other's choice as given. In the third-stage the firms make output decisions.

Firm i's profit in this case is given as

$$\Pi^i = (A - Q)q_i - \alpha Q q_i + s q_i - t q_i. \tag{8''}$$

Hence Q is calculated, from the first-order condition, as

$$Q = \frac{n}{(\alpha + 1)(n + 1)}(A + s - t). \tag{11''}$$

National welfare of country 1 is given as:

$$\begin{aligned} W^1 &= (P - t)Q - \frac{1}{2}\alpha Q^2 \\ &= \frac{n}{(n + 1)^2(\alpha + 1)^2} \\ &\left\{(n\alpha + \alpha + 1)(A - t)(A + s - t) - ns(A + s - t) - \frac{1}{2}\alpha n(A + s - t)^2\right\}. \end{aligned} \tag{18}$$

National welfare of country 2 is calculated as:

$$W^2 = \frac{1}{2}Q^2 + tQ$$
$$= \frac{1}{2}\frac{n^2}{(n+1)^2(\alpha+1)^2}(A+s-t)^2 + t\frac{n}{(n+1)(\alpha+1)}(A+s-t). \tag{19}$$

In the second-stage, each country determines the level of own strategy, taking the level of the other's strategy variable as given. The optimal levels of s and t can be found by simultaneously solving the first-order conditions as follows :

$$W_s^1 = \frac{\partial W^1}{\partial s} = \frac{n}{(n+1)^2(\alpha+1)^2}\{(n-\alpha-1)t - n(\alpha+2)s + A(\alpha+1-n)\} = 0, \tag{20}$$

and

$$W_t^2 = \frac{\partial W^2}{\partial t} = \frac{n}{(n+1)(\alpha+1)}$$
$$\{(n\alpha+\alpha+1)s - (2n\alpha+n+2\alpha+2)t + (n\alpha+\alpha+1)A\} = 0. \tag{21}$$

Simultaneous solution of (20) and (21) gives

$$s^* = \frac{(\alpha+1-n)}{(\alpha+1)(2n+1)}A, \tag{22}$$

and

$$t^* = \frac{(n\alpha+\alpha+1)}{(\alpha+1)(2n+1)}A. \tag{23}$$

Substitution of s^* and t^* into W^1 and simplification gives

$$W^1 = \frac{(\alpha+2)n^2}{2(\alpha+1)^2(2n+1)^2}A^2. \tag{18'}$$

which is an increasing function of n. In other words, the more competitive the export industry is, the higher is national welfare of the exporting country. Hence, the Cowan's result generally holds even when marginal cost is not constant and firms exercise oligopsony power.

V. Concluding Remarks

This paper has characterized the optimal industrial structure for an oligopolistic export industry when the industry faces a linear demand and the firms are interrelated in the cost side through the industry's quadratic cost function. The optimal number of firms is found to be an increasing function of the ratio of the slope of the export supply curve to the absolute slope of the import demand curve.

The findings of this paper seem to have profound implications for competition policy. Even in the case when export firms as a whole have monopoly power in the international market, a policy that limits the number of export firms can be welfare-deteriorating, if the firms exercise oligopsony power in factor markets. The more vertically related the export industry is, the more likely is that restricting the number of export firms reduces welfare of the exporting country.

The analysis in this paper is based on several specific assumptions on demand and cost conditions, including a linear demand, quadratic costs, and Cournot-Nash behavior of firms. The next item on our research agenda is to generalize these restrictive assumptions.

Appendix

The appendix derives n^* for the case when α is not an integer value. In such a case there exists an integer N such that $N < (\alpha + 1) < (N + 1)$. Hence N and $(N + 1)$ are the two integers nearest to $(\alpha + 1)$.

(1) The case when $\alpha > 0$.
n^* is obtained by comparing $W^1(N)$ and $W^1(N+1)$:

$$W^1(N) = \frac{A^2}{2}\frac{1}{(\alpha+1)^2(N+1)^2}(\alpha N^2 + 2\alpha N + 2N),$$

$$W^1(N+1) = \frac{A^2}{2}\frac{1}{(\alpha+1)^2(N+2)^2}(\alpha(N+1)^2 + 2\alpha(N+1) + 2(N+1)).$$

If $(N-1) < \alpha < \dfrac{2(N^2+N-1)}{(2N+3)}$, then $W^1(N) > W^1(N+1)$.

Hence $n^* = N$.

If $\dfrac{2(N^2+N-1)}{(2N+3)} < \alpha < (N+1)$, then $W^1(N) < W^1(N+1)$.

Hence $n^* = (N + 1)$.

At $\alpha = \dfrac{2(N^2+N-1)}{(2N+3)}$, $n^* = N$ or $(N+1)$.

For example, if $N = 1$, the critical value of α is $(2/5)$,
if $N = 2$, the critical value of α is $(10/7)$, and

if $N = 3$, the critical value of α is (22/9).

(2) The case when $\alpha < 0$.
W^1 is a decreasing function of n when $n > 1$.
Hence $n^* = 1$.

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