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A NOTE ON MONOPOLY POWER IN THE SUPPLY OF A NATURAL RESOURCE

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I

Consider a country with a given supply of a natural resource -- say, oil -- and zero extraction and marketing costs.[1/] This country is the single supplier of oil in the world market and it produces no other goods. The rest of the world produces a single consumption good using oil and an aggregate input, say labor, which it owns.[2/] The oil supplying country owns a share of the foreign industry. This raises the following question: How much oil should be marketed in order to maximize the oil-producing country's income, and how is this quantity affected by the production structure and the ownership share of the oil producing country in the foreign country?

Intuitively, one would expect the supply of oil to increase both with the elasticity of substitution between oil and labor and with the ownership share of the oil producing country in the foreign industry. The reason is that the higher the elasticity of substitution the more elastic is the demand for oil, which means weaker monopoly power; while the larger the share of ownership the more harmful is the exploitation of the monopoly power to the oil producing country as an owner of foreign industry. This suggests that restrictions on oil production will decrease over time if the oil producing country's share in foreign industries and the ease at which oil is substituted for other inputs increase over time.

In order to make these considerations concrete, consider a world in which the consumption good is produced by means of a constant elasticity of substitution production function,

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1/ The analysis applies also to a country's indigenous product -- such as coffee -- which can naturally be raised only in a particular region of the world.

2/ This production structure is like that in Schmid (1976).

(1) $F(L,C) \equiv [\alpha L^{-\rho} + (1-\alpha)C^{-\rho}]^{-\frac{\mu}{\rho}}$

where L = labor

C = oil

α = distributive coefficient, $0 < \alpha < 1$

ρ = substitution coefficient, $-1 \leq \rho \leq \infty$

μ = returns to scale coefficient, $0 < \mu \leq 1$

σ = $1/(1+\rho)$ = the elasticity of substitution

Assuming competition in the foreign industry, the oil producing country's income in terms of the consumption good is

(2) $Y = s\ [F(L,C) - F_C(L,C)C - F_L(L,C)L] + F_C(L,C)C$

where

s = the oil producing country's ownership share

The first term on the RHS of (2) represents the oil producing country's share in the foreign industry's profits. The second term represents the return to oil.

The oil producing country's problem is to choose $C \leq \bar{C}$ so as to maximize Y, given L; $\bar{C}$ is the available quantity of oil.

Differentiating Y with respect to C, using (1), we obtain

(3) $\text{sign}\ \frac{dY}{dC} = \text{sign}\ \{(\frac{C}{L})^{\rho}\ \alpha\ [s(1-\mu) - \rho] + (1-\alpha)[\mu + s(1-\mu)]\}$

This implies:

(a) For $-1 \leq \rho \leq 0$, i.e., for an elasticity of substitution larger than or equal to one, the RHS of (3) is always positive, which means that the optimal supply of C is $\bar{C}$. Hence, if the elasticity of substitution is sufficiently large it does not pay to take advantage of monopoly power. Assume now that $\rho > 0$, i.e., $0 \leq \sigma < 1$.

(b) If $\mu = 1$, i.e., there are constant returns to scale, the ownership share has obviously no effect on the choise of C since there are no profits. If, however, there are decreasing returns to scale, i.e., $0 < \mu < 1$, then for $s \geq \rho/(1-\mu)$ the RHS of (3) is always positive, implying that the optimal policy is to sell $C = \overline{C}$. This means that for $\rho/(1-\mu) < 1$ there exist sufficiently large ownership shares for which it does not pay to restrict oil sales.

(c) Consider now the case in which $s < \rho/(1-\mu)$. In this case there exists a C^* at which the RHS of (3) is equal to zero. Since in this case the RHS of (3) is declining in C, then for $C^* \geq \overline{C}$ the optimal policy is not to restrict oil sales. If, on the other hand, $C^* < \overline{C}$, then the optimal policy is to restrict oil sales to $C = C^*$

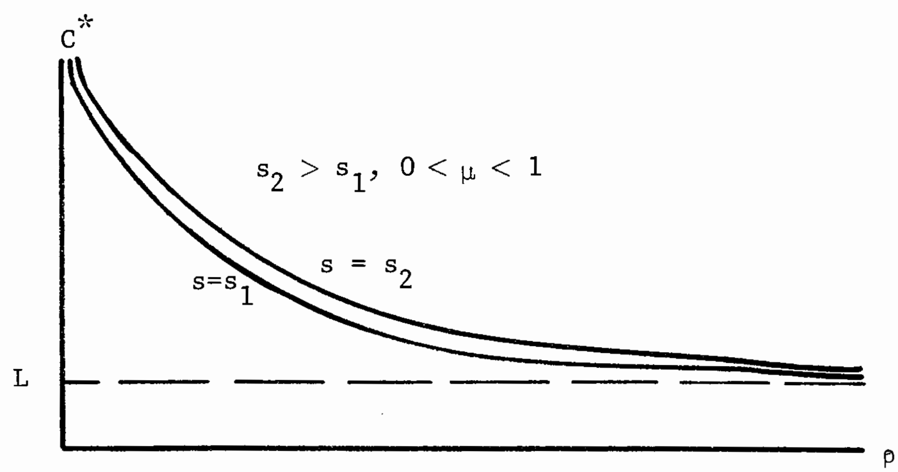

Figure 1

Figure 1 describes the relationship between C^* and ρ for two values of s. These curves are asymptotic to L, the foreign labor supply, and to the vertical axis. They collapse to one curve for $\mu = 1$.

It is seen from Figure 1 that the smaller s and the larger ρ (the smaller the elasticity of substitution) the less restrictive oil sales will be. In the limit, when the elasticity of substitution goes to zero, $\min(L,\overline{C})$ will be the quantity of oil sales. On the other extreme, when the elasticity of substitution goes to one, the quantity of oil sales will be unrestricted.

This analysis suggests the following observation. If there are several oil producing countries and they fully cooperate so that the oil cartel behaves like a multi-plant monopoly, then there is no conflict of interests as long as there is an agreed upon scheme for the distribution of income from oil sales and profits. If, however, there is no such cooperation, a conflict may arise. Assume that country i has capacity $\bar{C}^i$ and a share s^i in the foreign industry. Then, if for example, oil export quotas are proportional to capacity, then countries with $s^i/(\Sigma s^i) > \bar{C}^i/(\Sigma \bar{C}^i)$, i.e., countries with a relatively high share of ownership in the foreign industry as compared to their relative oil capacity, will desire larger oil sales than countries with the opposite characteristics.

II

So far we assumed that the oil producing country has a given ownership share of the foreign industries, and we did not investigate how and why did it acquire this particular share. It is, however, clear that the decision about an optimal restriction of the oil supply and the decision to acquire shares in foreign industries are not independent. This consideration is investigated in what follows.

Suppose that the oil producing country has a two period horizon. In the first period it consumes, buys (sells) shares in foreign industries, borrows (lends), and chooses an optimal supply of oil for the first period. In the second period it chooses an optimal supply of oil for the second period and consumes its proceeds from oil sales and profits. Its decision-problems can be stated as follows:

$$(4) \qquad \max_{x_1, s, C_1, C_2, b} u[x_1, Y^2(s,C_2) + b]$$

$$\text{S.T.} \quad \text{(i)} \quad x_1 + \frac{1}{1+r} b + sV(\cdot) \leq \bar{s}V(\cdot) + Y^1(\bar{s},C_1)$$

$$\text{(ii)} \quad 0 \leq s \leq 1$$

$$\text{(iii)} \quad 0 \leq C_i \leq \bar{C}, \qquad i = 1,2$$

where

$u(\cdot)$ = a utility function defined on the two period consumption streams

x_1 = consumption in period 1

$Y^i(\cdot)$ = income from profits and oil sales in period i, as defined in (2)

s = share of foreign industries owned in period 2

$\bar{s}$ = share of foreign industries owned in period 1 (this is given)

C_i = oil sales in period 1

b = return on lending (positive or negative)

r = the interest rate

$V(\cdot)$ = stock market value of foreign industries as perceived by the home country; may be a function of its decision variables

From (4) it is clear that the type of solution we expect crucially depends on the way the oil producing country thinks its decisions influence the stock market value of foreign industries. For this purpose we consider three cases, of which the first two are rather extreme:

(a) the stock market value of foreign industries does not depend on the oil producing country's decisions;

(b) there is perfect foresight on the part of foreign stockholders, in which case $V(\cdot)$ equals discounted second period profits; i.e., $V(\cdot) \equiv \frac{1}{1+r}\pi^2(C_2) \equiv \frac{1}{1+r}[F^2(L,C_2) - F_C^2(L,C_2)C_2 - F_L^2(L,C_2)L]$; and

(c) the oil producing country considers V as a function of s and C_1, i.e., $V = V(s,C_1)$. V increases in both arguments, since the larger s, foreigners believe that the oil producing country is more concerned with second period profits and hence V is larger; the larger C_1, foreigners believe that the oil producing country has a less restrictive oil export policy, which will also increase second period profits and, hence, will increase V.

(a) <u>$V(\cdot) = \text{constant}$</u>

In this case C_1 is chosen so as to maximize $Y^1(\bar{s},C_1)$ and C_2 is chosen so as to maximize $Y^2(s,C_2)$(s.t. (4 ii) and (4 iii)); this was analyzed in Section I. However, the choice of C_2 is conditional on the choice of s. The first order conditions for x_1 and b are:

(5a) $$u_1 - \lambda = 0$$

(5b) $$u_2 - \lambda \frac{1}{1+r} = 0$$

where λ is the multiplier of (4 i). Hence, we have the standard Fisherian condition:

(6) $$\frac{1}{1+r} = u_2/u_1$$

The first-order condition for s is:

$$u_2 Y_s^2 - \lambda V \quad \begin{cases} \leq 0 \text{ for } s = 0 \\ = 0 \text{ for } 0 \leq s \leq 1 \\ \geq 0 \text{ for } s = 1 \end{cases}$$

Using (5b) and the fact that $Y_s^2 = \pi^2$ (see (2)), this reduces to:

(7) $$\frac{1}{1+r}\pi^2 - V \quad \begin{cases} \leq 0 \text{ for } s = 0 \\ = 0 \text{ for } 0 \leq s \leq 1 \\ \geq 0 \text{ for } s = 1 \end{cases}$$

Hence, if $Y^2(1,C_2)$ is maximized at a $C_2 \leq \bar{C}$ such that the resulting discounted second period profits exceed (or equal) the stockmarket value, then $s^* = 1$ is the solution. If, on the other hand, $Y^2(0,C_2)$ is maximized at a $C_2 \leq \bar{C}$ such that the resulting discounted second period profits fall short of (or equal) the stockmarket value, then $s^* = 0$ is the solution. If neither one of these cases holds, then there exists an $0 < s^* < 1$ such that $Y^2(s^*, C_2)$ is maximized at a $C_2^* \leq \bar{C}$ which makes the discounted second period profits just equal V, and this is the solution. In any case, if the production functions in the two periods differ only in the production parameter ρ, L is constant, and if $\rho_2 < \rho_1$ (implying $\sigma_2 > \sigma_1$) then $s^* \geq \bar{s}$ assures less restrictions on oil sales in the second period than in the first one. If $s^* < \bar{s}$, then the answer is not unambiguous. However, the smaller V, the larger is s^*, which means that for a sufficiently small stockmarket value of foreign industries oil sales restrictions in the second period will <u>be relaxed.</u>

(b) $V(\cdot) \equiv \frac{1}{1+r} \pi^2(C_2)$ (Perfect Foresight)

In this case C_1 is chosen again so as to maximize $Y^1(\bar{s}, C_1)$. The choice of s is irrelevant, since b serves as a perfect substitute for s and they command the same price per unit return. We may choose therefore $s = \bar{s}$ without any loss of generality. Hence, with perfect foresight there is no incentive to change the ownership share.

The first order conditions for x_1 and b are represented by (5). Denoting by $R^2(C_2)$ the last term on the right-hand-side of (2), that is, the revenue from oil sales, the first order condition for C_2 is:

$$u_2[s\pi_C^2 + R_C^2] - \lambda\frac{(s-\bar{s})}{1+r}\pi_C^2 \quad \begin{array}{l} \leq 0 \text{ for } C_2 = 0 \\ = 0 \text{ for } 0 \leq C_2 \leq \bar{C} \\ \geq 0 \text{ for } C_2 = \bar{C} \end{array}$$

which, using (5b), reduces to:

$$\text{(8)} \qquad \bar{s}\,\pi^2(C^2) + R_C^2 \quad \begin{array}{l} = 0 \text{ for } 0 \leq C_2 < \bar{C}_2 \\ \geq 0 \text{ for } C_2 = \bar{C}_2 \end{array}$$

(The condition ≤ 0 was eliminated since $\bar{s}\,\pi_C^2(0) + R_C^2(0) \geqq 0$.)

That is, the policy is to choose C_2 so as to maximize $Y^2(\bar{s},C^2)$. If the elasticity of substitution in the second period is larger than that in the first period oil sales restrictions in the second period, relative to what they were in the first period, will be less severe.

(c) $\underline{V(\cdot) \equiv V(s,C_1)}$

Now, C_2 should be chosen so as to maximize $Y^2(s,C_2)$ given the optimal choice of s. s should be chosen so as to efficiently exploit the monopoly power that exists now in the stock market. Let $MC^V(s,C_1) \equiv V(s,C_1) + sV_2(s,C_1)$ be the marginal cost of purchasing s, then the first order condition for s is:

$$u_2\pi^2 - \lambda\, MC^V \quad \begin{array}{l} \leq 0 \text{ for } s = 0 \\ = 0 \text{ for } 0 \leq s \leq 1 \\ \geq 0 \text{ for } s = 1 \end{array}$$

which, using (5b), becomes:

$$\frac{1}{1+r}\pi^2 - MC^V \quad \begin{cases} \leq 0 \text{ for } s = 0 \\ = 0 \text{ for } 0 \leq s \leq 1 \\ \geq 0 \text{ for } s = 1 \end{cases} \tag{9}$$

Thus, discounted second period profits should be compared with the marginal cost of acquiring control in foreign industries. Since $MC^V(0,C_1) \equiv V(0,C_1)$, then if $V(0,C_1^*) \geq \frac{1}{1+r}\pi^2(C_2^*)$ for C_2^* that maximizes $Y^2(0,C_2)$ i.e., if the stock market value of foreign industries exceeds discounted maximal second period profits, then $s^* = 0$ is the optimal policy. The reason is that in this case any increase in s will increase costs by more than the discounted increase in profits. If, on the other hand, $\frac{1}{1+r}\pi^2(C_2^*) \geq MC^V(1,C_1^*)$ for C_2^* that maximizes $Y^2(1,C_2)$, then $s^* = 1$ is the optimal policy. In all other cases there exists $0 < s^* < 1$ which satisfies $\frac{1}{1+r}\pi^2(C_2^*) = V(s^*,C_1^*)$ where C_2^* maximizes $Y^2(s^*,C_2)$ and this is the optimal solution.

In the previous discussion of cases (a) and (b) we have used C_1^*, the value of C_1 that maximizes $Y^1(\bar{s},C_1)$. However, in the present case the choice of C_1 is not independent of the choise of s. C_1 should be chosen so as to maximize:

$$Y^1(\bar{s},C_1) - s^*V(s^*,C_1) \tag{10}$$

Hence, unless $s^* = 0$, C_1 should not be chosen so as to maximize $Y^1(\cdot)$. Since $V_C > 0$, then if $s^* > 0$, the optimal value of C_1 will now be smaller than in the previous discussion; i.e., it will be smaller than the value of oil sales that maximizes $Y^1(\cdot)$.

Assume that the production functions in the two periods differ only in ρ, that $\rho_2 > \rho_1$, and that L is constant. Then, if $s^* \geq \bar{s}$ we know that second period oil sales will exceed first period oil sales. The reason is that apart from the sbustitution effect and the ownership share effect there exists now a tendency to restrict first period oil sales by more than in cases (a) and (b) in order to reduce foreign stock prices. This is more likely the lower is $V(\cdot)$, the more sensitive V is to changes in C_1, or the less sensitive V is to changes in s.

REFERENCES

1. Schmid, M., "A Model of Trade in Money, Goods and Factors, "Journal of International Economics, Vol. 6, No. 4 (November 1976), pp. 347-362.