Optimal Trade and Industrial Policy under Oligopoly

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OPTIMAL TRADE AND INDUSTRIAL POLICY UNDER OLIGOPOLY*

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We analyze the welfare effects of trade and industrial policy under oligopoly, and characterize optimal intervention under a variety of assumptions about market structure and conduct. When all output is exported, optimal policy with a single home firm depends on the difference between foreign firms' actual responses to the home firm's actions and the responses that the home firm conjectures. A subsidy often is indicated for Cournot behavior, but a tax generally is optimal if firms engage in Bertrand competition. If conjectures are "consistent," free trade is optimal. With domestic consumption, intervention can raise national welfare by reducing the deviation of price from marginal cost.

I. INTRODUCTION

Implicit in many arguments for interventionist trade or industrial policy that have been advanced recently in popular debate appears to be an assumption that international markets are oligopolistic. It can be argued that international competition among firms in many industries is in fact imperfectly competitive, either because the number of firms is few, because products are differentiated, or because governments themselves have cartelized the national firms engaged in competition. They may do so implicitly through tax policy, or explicitly through marketing arrangements.

Government policies that affect the competitiveness of their firms in international markets, as well as the welfare of their consumers, involve not only traditional trade policy (trade taxes and subsidies) but policies that affect other aspects of firms' costs, such as output taxes and subsidies. We refer to intervention of this sort as industrial policy.

Until recently, the theory of commercial policy has considered the implications of intervention only under conditions of perfect

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competition or, more rarely, pure monopoly. As a consequence, this literature cannot respond to many of the arguments that have been advanced recently in favor of activist government policies. Our purpose in this paper is to extend the theory of nationally optimal policy to situations in which individual firms exercise market power in world markets.

The primary implications of oligopoly for the design of trade policy are (i) that economic profits are not driven to zero, and (ii) that a price equal to marginal cost does not generally obtain. The first of these means that government policies that shift the industry equilibrium to the advantage of domestic firms may be socially beneficial from a national perspective. The second feature of oligopolistic competition suggests that trade policy may be a substitute for antitrust policy if policies can be devised that shrink the wedge between opportunity cost in production and marginal valuation to consumers.

A number of recent papers have focused on the profit-shifting motive for trade policy under oligopoly. Brander and Spencer [1985] develop a model in which one home firm and one foreign firm produce perfectly substitutable goods and compete in a third-country market. They consider a Cournot-Nash equilibrium, and find that if the home country's government can credibly precommit itself to pursue a particular trade policy before firms make production decisions (and if demand is not very convex), then an export subsidy is optimal.[1] Dixit [1984] has extended the Brander-Spencer result to cases with more than two firms, and established that an export subsidy in a Cournot oligopoly equilibrium is optimal so long as the number of domestic firms is not too large. Finally, Krugman [1984] shows that under increasing returns to scale, protection of a local firm in one market (e.g., by an import tariff) can shift the equilibrium to the firm's advantage in other markets by lowering its marginal cost of production.

1. Spencer and Brander [1983] study a two-stage game in which a capacity or R&D investment is made at a stage prior to production. In such a setting, export subsidies and R&D subsidies are each welfare improving if implemented separately, but an optimal policy package involves an export subsidy and an R&D tax. Brander and Spencer [1984] extend the basic argument for intervention to situations in which duopolistic competition takes place in the home market. In such cases an import tariff often is beneficial.

These papers all provide examples in which interventionist trade policy can raise national welfare in imperfectly competitive environments. Yet each makes special assumptions about the form of oligopolistic competition, the substitutability of the goods produced, and the markets in which the goods are sold. It is difficult to extract general principles for trade policy from this analysis. Our purpose here is to provide an integrative treatment of the welfare effects of trade and industrial policy under oligopoly, and to characterize the form that optimal intervention takes under a variety of assumptions about the number of firms, their assumptions about rivals' responses to their actions, the substitutability of their products, and the countries where their products are sold.

The paper is organized as follows. In the next section we consider a general conjectural variations model of a duopoly in which a single home firm competes with a foreign firm either in the foreign firm's local market or in a third-country market. We find that the sign of the optimal trade or industrial policy (i.e., whether a tax or subsidy is optimal) depends on the relationship between the home firm's conjectural variation and the actual equilibrium reactions of the foreign firm. We note the form that optimal policy takes in Cournot and Bertrand equilibria and in what Bresnahan [1981] and Perry [1982] have called a "consistent" conjectures equilibrium.

We extend these results to incorporate the interaction between the policies of the home government and an activist foreign government in Section III. Here we consider optimal intervention in a two-stage game in which governments achieve a Nash equilibrium in policies prior to the time that firms engage in product-market competition. In Section IV we further extend the analysis by allowing for oligopoly with arbitrary numbers of firms in each country.

The analysis in Sections II, III, and IV assumes a constant, exogenous number of firms. In Section V we discuss briefly how our results would be modified if firms can enter or exit in response to government policies. Finally, in Section VI we return to the duopoly case and introduce domestic consumption for the first time. This allows us to consider the potential role for trade policy as a (partial) substitute for antitrust policy.

The main findings of the paper are summarized in a concluding section.

II. Optimal Trade Policy and the Role of Conjectural Variations: The Case of Duopoly

In this and subsequent sections we characterize optimal government policy in the presence of oligopolistic competition among domestic and foreign firms in international markets. Each firm produces a single product that may be a perfect or imperfect substitute for the output of its rivals. We specify competition among firms in terms of output quantities with arbitrary conjectural variations.[2] The domestic government can tax (or subsidize) the output of domestic firms, tax (or subsidize) the exports of these firms, and tax (or subsidize) the imports from the foreign rivals of domestic firms. Its objective is to maximize national welfare.

The government acts as a Stackelberg leader vis-à-vis both domestic and foreign firms in setting tax (subsidy) rates.[3] Thus, firms set outputs taking tax and subsidy rates as given. In other words, the government can precommit itself to a specific policy intervention that will not be altered even if it is suboptimal ex post, once firms' outputs are determined. At first we assume the absence of government policy in other countries. We also treat the number of firms as given. The implications of relaxing these assumptions are discussed below.

In this section we consider optimal government policy when oligopolistic competition takes its simplest possible form: a single

2. We recognize the serious limitation of the conjectural variations framework in its attempt to collapse the outcome of what is actually a dynamic process into a static formulation. While there exist extensive-form representations of Cournot and Bertrand competition, such is not the case for other conjectural assumptions, including that of "consistent conjectures" introduced below. Nevertheless, characterizing the equilibrium in terms of conjectural variations does provide a parsimonious representation of alternative assumptions of firm interaction that includes Cournot and Bertrand equilibria as special cases. In addition, this approach highlights the source of the potential benefit from policy intervention, namely, the deviation between conjectured and actual responses.

Ideally, oligopolistic behavior would be modeled as a truly dynamic, multistage game. Since the development of such models remains, as of now, at a fairly nascent stage, and since existing work on optimal trade policy under oligopoly has been formulated in terms of static models, we choose to pursue the simpler conjectural variations approach.

Note that, within the class of static, conjectural variations models, restricting attention to those involving output rivalry entails no loss of generality. Kamien and Schwartz [1983] demonstrate that any conjectural variations equilibrium (CVE) in quantities has a corresponding CVE in prices.

3. Analysis of government policy in international markets typically is based on this assumption. See, e.g., Spencer and Brander [1983]. It may be justified by specifying the political process of establishing policy as time-consuming and costly, or by endowing the government with a reputation for adhering to announced policy.

domestic firm competes with a single foreign firm in a foreign market. In the absence of domestic consumption, government trade policy (export taxes and subsidies) is equivalent to government industrial policy (output taxes and subsidies). We assume that the government places equal weight on the home-firm's profit and government tax revenue in evaluating social welfare. Its objective is therefore one of maximizing national product.

Denote the output (and exports) of the home firm by x and let $c(x)$ be its total production cost, $c'(x) > 0$. Uppercase letters denote corresponding magnitudes for the foreign firm, with $C'(X) > 0$. Pretax revenue of the home and foreign firms are given by the functions $r(x,X)$ and $R(x,X)$, respectively. These satisfy the conditions that

$$r_2(x,X) \equiv \frac{\partial r(x,X)}{\partial X} \leqslant 0$$

$$R_1(x,X) \equiv \frac{\partial R(x,X)}{\partial x} \leqslant 0,$$

i.e., that an increase in the output of the competing product lowers the total revenue of each firm. They are implied by the assumption that the products are substitutes in consumption.[4] Total after-tax profits of the home and foreign firms are given by

$$\pi = (1 - t)r(x,X) - c(x)$$

and

$$\Pi = R(x,X) - C(X),$$

respectively. Here t denotes the ad valorem output (or export) tax.[5] The domestic firm's conjecture about the foreign firm's output response to changes in its own output is given by the parameter γ. The foreign firm's corresponding conjectural variation is Γ.

The Nash equilibrium quantities, given the level of home country policy intervention, are determined by the first-order conditions:

4. The case of complementary goods can be analyzed similarly. When the two goods are complements ($r_2 > 0$), some of the results reported here (e.g., Theorem 1) are reversed.

5. For concreteness, we consider the case of ad valorem taxes and subsidies. Our results would not be affected by the introduction of *specific* taxes and subsidies, as the reader may verify.

$$(1) \qquad (1 - t)[r_1(x,X) + \gamma r_2(x,X)] - c'(x) = 0;$$

$$(2) \qquad R_2(x,X) + \Gamma R_1(x,X) - C'(X) = 0.$$

We assume that the second-order conditions for profit maximization and the conditions for stability of the industry equilibrium are satisfied. We now demonstrate

THEOREM 1. A positive (negative) output or export tax can yield higher national welfare than laissez-faire ($t = 0$) if the home firm conjectures a foreign change in output in response to an increase in its own output that is smaller (larger) than the actual response.

Proof. National product generated by the home firm is given by w, where

$$(3) \qquad \begin{aligned} w &= (1 - t)r(x,X) - c(x) + tr(x,X) \\ &= r(x,X) - c(x). \end{aligned}$$

The change in welfare resulting from a small change in the tax (or subsidy) rate t is

$$(4) \qquad \frac{dw}{dt} = [r_1(x,X) - c'(x)]\frac{dx}{dt} + r_2(x,X)\frac{dX}{dt}.$$

Substituting the first-order condition (1) into (4), we obtain[6]

$$(5) \qquad \frac{dw}{dt} = \left[-\gamma r_2 - \frac{tc'}{1 - t}\right]\left(\frac{dx}{dt}\right) + r_2\left(\frac{dX}{dt}\right).$$

Expression (2) implicitly defines the output of the foreign firm X as a function of domestic output x. Denote this function $\Psi(x)$. The tax rate t does not appear directly as an argument of this function, since t does not appear in expression (2). Therefore, $dX/dt = \Psi'(x)(dx/dt)$. Define $g \equiv (dX/dt)/(dx/dt) = \Psi'(x)$. The term g measures the slope of the foreign firm's reaction curve, i.e., its *actual* reaction to exogenous changes in x. A first-order condition for maximizing national welfare obtains when $dw/dt = 0$,[7] or, incorporating the definition of g into equation (5),

6. We henceforth drop the arguments of the revenue and cost functions and their partial derivatives whenever no confusion is created by doing so. The revenue functions and their partial derivatives are understood to be evaluated at the equilibrium value of (x,X), while the cost functions and their derivatives are evaluated at x or X, whichever is appropriate.

7. The second-order condition for a maximum is satisfied locally as long as (i) the home firm's first- and second-order conditions for profit maximization are satisfied and (ii) the foreign firm's actual response to a change in x does not differ substantially from the response conjectured by the home firm.

$$-r_2(g - \gamma) = tc'/(1 - t). \tag{6}$$

Since $r_2 < 0$, the left-hand and right-hand sides of expression (6) are of the same sign if $1 > t > 0$ and $g > \gamma$, or $t < 0$ and $g < \gamma$. The term $g - \gamma$ is the difference between the actual response of X to a change in x (i.e., $\Psi'(x)$) and the home firm's conjectural variation. When $g > \gamma$, a tax can yield more income than laissez-faire, conversely when $g < \gamma$.

Q.E.D.

An intuitive explanation of this result is as follows. Government policy is implemented before the two firms choose their outputs, which they do simultaneously. Intervention consequently allows the domestic firm to achieve the outcome that would obtain if it were able to act as a Stackelberg leader with respect to its competitor. If $g > \gamma$, then the equilibrium output absent policy involves more domestic output than at the Stackelberg point because the home firm cannot or does not fully account for the foreign firm's reaction to an increase in its own quantity in choosing its output level. Conversely, if $g < \gamma$, the home firm's output more than fully reflects the extent of actual reaction by the rival. The sign of the optimal policy is determined accordingly.

We now turn to some specific conjectural variations that are commonly assumed in models of oligopolistic competition.

A. Cournot Conjectures

Under Cournot behavior, each firm conjectures that when it changes its output the other firm will hold its output fixed. Thus, $\gamma = \Gamma = 0$ in this case, and (6) becomes

$$-gr_2 = tc'/(1 - t). \tag{7}$$

Totally differentiating the equilibrium conditions (1) and (2) to solve for g, we may write this expression as

$$r_2R_{21}/(R_{22} - C'') = tc'/(1 - t). \tag{8}$$

The second-order condition for the foreign firm's profit maximization ensures that the left-hand side of this expression has the sign of R_{21}. Letting t^* denote the optimal export tax (or subsidy, if negative), we have established

PROPOSITION 1. In a Cournot duopoly with no home consumption, $\operatorname{sgn} t^* = \operatorname{sgn} R_{21}$.

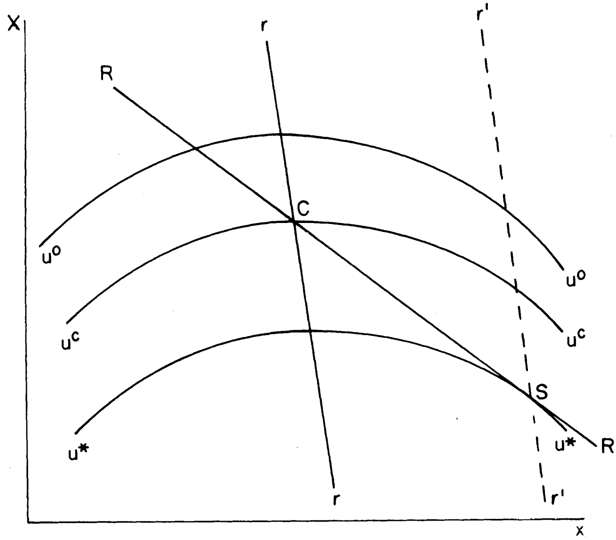

FIGURE 1
Optimal Policy with Cournot Competition

Proposition 1 restates the Brander-Spencer [1985] argument for an export subsidy: this policy raises domestic welfare in a Cournot equilibrium by transferring industry profit to the domestic firm. This point is illustrated in Figure I. In the figure, representative isoprofit loci for the home firm are depicted in output space by u^o, u^c and u^*. Lower curves correspond to higher levels of profit. The Cournot reaction function for the home firm rr connects the maxima of the isoprofit loci. The direction of its slope is given by the sign of r_{12}. The foreign firm's reaction curve RR is found similarly, and its slope is determined by the sign of R_{21}. Linear demand necessarily implies that $r_{12} < 0$ and $R_{21} < 0$, and many, but not all, specifications of demand imply this sign as well.

The Cournot equilibrium is at point C, where the home firm earns a profit corresponding to u^c. Note that among the points along RR, u^c does not provide the highest level of profit to the home firm and therefore does not yield the highest possible level of home country welfare. Rather, maximum profit corresponds to u^*, which would be the equilibrium if the home firm could credibly precommit its output level and thus act as a Stackelberg leader. Lacking this ability, the home country could nonetheless achieve the outcome at u^* in a Nash equilibrium if the home government were to implement a trade policy that shifted the home firm's reaction locus to intersect RR at S. This is the optimal profit-shifting trade policy; it involves an export subsidy under the Cournot assumptions provided that RR is downward sloping (i.e., $R_{21} < 0$). A downward (upward) sloping foreign reaction curve implies a level of output in the Cournot equilibrium that is less (greater) than that at the point of Stackelberg leadership: thus, the sign of the optimal trade policy in this case.[8]

Note that the optimal export subsidy with Cournot competition benefits the home firm (and country) at the expense of the foreign firm. Indeed, the equilibrium with one country pursuing its optimal policy involves smaller (net-of-subsidy) profits for the two firms together than in the laissez-faire equilibrium. Consumers of the product benefit from lower prices when the subsidy is in place, and the net effect on world welfare is positive, since policy pushes prices toward their competitive levels.

B. Bertrand Conjectures

In a Bertrand equilibrium each firm conjectures that its rival will hold its price fixed in response to any changes in its own price. Define the *direct* demand functions for the output of the home and foreign firms as $d(p,P)$ and $D(p,P)$, respectively. The total profits of the two firms are

$$\pi(p,P) = (1 - t)pd(p,P) - c(d(p,P))$$

and

$$\Pi(p,P) = PD(p,P) - C(D(p,P)).$$

Each firm sets its price to maximize its profit, taking the other firm's price as constant. First-order conditions for a maximum imply that

$$\pi_1 = (1 - t)(d + pd_1) - c'd_1 = 0, \tag{9a}$$

$$\Pi_2 = D + (P - C')D_2 = 0. \tag{9b}$$

The actual and conjectured price responses can be translated

8. If products are complements ($r_2 > 0$), the presumption is also in favor of an export subsidy, since in this case most specifications of demand, including the linear, imply that $R_{21} > 0$: the rival expands output when the domestic firm does, to the benefit of the home firm. The home firm consequently produces less, in Cournot competition, than it would as a Stackelberg leader.

into quantity responses by totally differentiating the demand functions to obtain

$$\begin{bmatrix} dx \\ dX \end{bmatrix} = \begin{bmatrix} d_1 \; d_2 \\ D_1 \; D_2 \end{bmatrix} \cdot \begin{bmatrix} dp \\ dP \end{bmatrix}.$$

The Bertrand conjecture on the part of the home firm implies a conjectured quantity response given by

$$(10) \qquad \gamma = \left(\frac{dX}{dp} \bigg/ \frac{dx}{dp} \right) \bigg|_{dP=0} = \frac{D_1}{d_1}.$$

The actual response is

$$g = \frac{dX}{dp} \bigg/ \frac{dx}{dp} = \frac{D_1 - D_2\Pi_{21}/\Pi_{22}}{d_1 - d_2\Pi_{21}/\Pi_{22}}.$$

It is straightforward to show, using the conditions for stability of the industry equilibrium, that the term $g - \gamma$ is positive if and only if $\Pi_{21} > 0$ (the foreign firm responds to a price cut by cutting its price). Applying Theorem 1, we conclude

PROPOSITION 2. In a Bertrand duopoly with no home consumption, $\operatorname{sgn} t^* = \operatorname{sgn} \Pi_{21}$.

If the two products are substitutes (i.e., $d_2 > 0$ and $D_1 > 0$) and returns to scale are nonincreasing ($c'' \geqslant 0, C'' \geqslant 0$), then $\Pi_{21} > 0$ *unless* an increase in its rival's price has a significantly negative effect on the *slope* of the demand curve facing the home firm. In the special cases of either perfect substitutes or linear demands, this sign necessarily obtains. Presumption regarding the sign of the optimal trade intervention when duopolistic behavior is Bertrand is consequently the opposite of that in the Cournot case; that is, an export *tax* is generally required.

Figure II illustrates this result. Representative isoprofit loci of the home firm (in price space) are shown as u^o, u^b, and u^*. Higher curves now correspond to higher profit. The Bertrand reaction curves are depicted by *rr* for the home firm and *RR* for the foreign firm, and the directions of their slopes correspond to the signs of π_{12} and Π_{21}, respectively.

The Bertrand equilibrium absent policy intervention is the intersection of the two curves, at point *B*. Here the home firm earns a profit corresponding to u^b. Given *RR*, a higher profit could

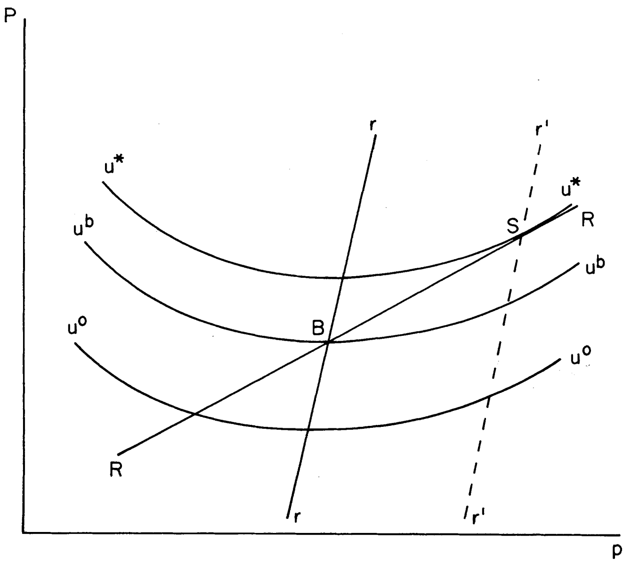

FIGURE II
Optimal Policy with Bertrand Competition

be attained at point S, where the home firm charges a higher price than at B. However, unless the home firm can precommit to the higher price or act as a Stackelberg leader, point S is not achievable under laissez-faire. An appropriate output or export tax shifts the home reaction curve to $r'r'$, whence the Nash equilibrium in the resulting product-market competition yields the superior welfare outcome.[9] Notice that the Bertrand equilibrium for the case in which the foreign reaction curve is upward sloping in price space involves a lower domestic price and therefore a higher domestic output than at the Stackelberg leadership point. This is in contrast to the Cournot outcome, and accounts for the qualitative difference in the policy conclusions.[10]

9. When products are complements, $D_2 < 0$. The presumption then is that $\Pi_{21} < 0$: a price increase by the home firm engenders a price cut by its competitor. So, in this case as well, an export tax is optimal. Such a tax causes the foreign firm to lower its price, increasing the home firm's revenue.

10. Our findings for the cases of Cournot and Bertrand competition can be stated concisely using the phraseology suggested by Bulow, Geanokoplos, and Klemperer [1985]. They introduce the terms "strategic substitutes" and "strategic complements" to denote situations where "more aggressive" behavior on the part of one firm, respectively, lowers and raises the "marginal profitability" of similar

Another contrast with the Cournot outcome is that implementation of the optimal policy by the home government raises profits of the foreign firm. It does so by alleviating oligopolistic rivalry. Of course, the tax affects consumers adversely, and world welfare falls as the equilibrium becomes less competitive.

C. Consistent Conjectures

The final special case we consider is one in which the home firm's conjecture about its rival's response is "consistent," as is the case if the home firm is a Stackelberg leader vis-à-vis its foreign rival or in a "consistent conjectures equilibrium." This second concept, as defined and analyzed by Bresnahan [1981] and Perry [1982] among others, is an equilibrium in which each firm's conjectural variation is equal to the actual equilibrium responses of its rivals that would result if that firm actually were to change its output by a small amount at the equilibrium point.

The slope of the foreign reaction curve in our model is given by g. Thus, the home firm's conjectures about its rival's response are consistent in the sense of Bresnahan and Perry if $\gamma = g$. The following proposition follows immediately from expression (6):[11]

PROPOSITION 3. In a duopoly with consistent conjectures on the part of the home firm and no home consumption, $t^* = 0$.

The optimality of free trade with consistent conjectures on the part of the home firm emerges because there exists no shift of the home firm's reaction curve that can transfer industry profit to that firm, given the response of its rival.

* * *

The duopoly example with no home consumption highlights the profit-shifting motive for trade policy intervention in an imperfectly competitive industry. Under optimal intervention the gov-

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moves by its rival. The classification of goods as strategic substitutes or complements can be made only after the designation of a specific strategy variable, which then gives meaning to the term "more aggressive." For Cournot and Bertrand competition, in which quantity and price are the strategy variables, respectively, their classification hinges on the slope of the reaction curves in the relevant strategy spaces. Accordingly, our Propositions 1 and 2 could be rephrased as follows: *for Cournot and Bertrand competition among (ordinary) substitutes, optimal policy involves subsidizing exports if the goods are strategic substitutes and taxing exports otherwise.* If the goods instead are (ordinary) complements, then the opposite correspondence between strategic substitutes and complements and optimal policy obtains.

11. The second-order condition for a social optimum is satisfied at the free-trade equilibrium if the product-market equilibrium is stable.

ernment uses its first-mover advantage to shift its national firm's reaction function so that it intersects the foreign firm's curve at a point of tangency between the latter curve and a (laissez-faire) isoprofit locus of the home firm. The direction of this shift, and thus the qualitative nature of the optimal policy, depends in general on the sign of the deviation of the home firm's conjectural variation from the slope of the foreign firm's reaction curve.

We now extend the basic result to allow for a foreign policy response, multifirm oligopoly, endogenous market structure, and domestic consumption.

III. Foreign Policy Response

In the analysis up to this point, we have assumed that the foreign rival's government pursues a laissez-faire policy. Imagine now a two-stage game with both governments active in which the governments first arrive at a Nash equilibrium in policy parameters and then duopolistic competition between the firms takes place. For simplicity, we assume no consumption in the rival's country as well. All consumption is elsewhere.

Denoting the foreign ad valorem output or export tax rate as T, the foreign firm's first-order condition for profit maximization, equation (2), becomes

$$(1 - T)[R_2(x,X) - \Gamma R_1(x,X)] - C'(X) = 0. \tag{2'}$$

A Nash equilibrium in policies is a pair of tax-subsidy rates (t,T) such that t maximizes w, given T, and T maximizes $W \equiv R(x,X) - C'(X)$, given t, where equations (1) and (2′) determine x and X.

For $T < 1$, the presence of a foreign tax does not affect the *qualitative* results of the previous section. Theorem 1 is unaffected. For Cournot competition equation (8) is replaced by

$$\frac{r_2(1 - T)R_{21}}{(1 - T)R_{22} - C''} = \frac{tc'}{1 - t}, \tag{8'}$$

so that the sign of t^* remains that of R_{21}. For Bertrand competition the profit of the foreign firm may be written as

$$\Pi(p,P) = (1 - T)PD(p,P) - C(D(p,P)).$$

Appropriate substitution into the previous analysis implies that Proposition 2 is unaffected as well. Similarly, Proposition 3 remains. Consequently, the *direction* of the optimal policy is unaffected by the possible presence of a foreign export tax or subsidy.

A parallel analysis determines the level of T that maximizes W given t. The following results are immediate.

Under Cournot competition between substitutes with $r_{12} < 0$ and $R_{21} < 0$, the perfect Nash equilibrium is for both governments to subsidize exports. Government interventions together move the product-market equilibrium away from the joint-profit-maximizing outcome toward the competitive equilibrium. Graphically, in terms of Figure I, both reaction loci shift outward. Both countries will typically benefit from a mutual agreement to desist from attempts to shift profit homeward via export subsidization. The effect on consumers and on world welfare of such an agreement is, of course, the opposite.

Under Bertrand competition with $\pi_{12} > 0$ and $\Pi_{21} > 0$, the perfect Nash equilibrium is for both governments to tax exports. Intervention moves the equilibrium toward the joint-profit-maximizing point away from the competitive equilibrium. In terms of Figure II both reaction curves shift out. The exporters gain, consumers lose, and world welfare declines.

Finally, if both firms' conjectures are consistent, the perfect Nash equilibrium is laissez-faire.

IV. Optimal Trade Policy: The Case of Multifirm Oligopoly and Consistent Conjectures

In this section we extend our analysis to situations of oligopoly, by allowing for the presence of n home firms and m foreign firms in the industry. For analytical convenience we confine our attention to configurations that are *symmetric,* in the sense that (i) each firm, home or foreign, has the same cost function, (ii) the revenue functions of any two firms i and j (home or foreign) are identical, except that the arguments x^i and x^j are interchanged, and (iii) any two firms producing at the same output level hold the same conjectures about the effect of changes in their own outputs on those of each of their rivals (including each other).

We assume that the conjectures held by all home firms are consistent. We take this as our benchmark case in order that we may isolate the new implications for trade policy that are introduced when the market structure is oligopolistic rather than duopolistic. When conjectures are other than consistent, the optimal trade policy will incorporate an element of the profit-shifting motive, as discussed in Section II, in addition to the terms-of-trade motive that is the focus of our attention in the present section. We also continue to assume that there is no home consumption of the outputs of the oligopolistic industry. This assumption, too, is dictated by our desire to isolate and discuss a single motive for trade policy at a time. Our basic result is stated in

PROPOSITION 4. In a symmetric, oligopolistic equilibrium with n home firms and m foreign firms and no home consumption, if the domestic firms' conjectures are consistent, then the optimal production or export tax is zero if $n = 1$ and positive if $n > 1$.

Proof. See Appendix A.

The result can be understood intuitively by noting that when home firms' conjectures about the responses of foreign firms are consistent, the profit-shifting motive for government intervention is not present. What remains is the standard terms-of-trade argument for export policy. Whenever there is more than a single home country firm and these firms do not collude perfectly, each home firm imposes a pecuniary externality on other domestic firms when it raises its output. Private incentives lead to socially excessive outputs, since home income includes all home firm profits. The government can enforce the cooperative equilibrium in which the home firms act as a group to maximize the home country's total profit by taxing exports or sales. The externality does not arise when there is only one home firm; consequently, free trade is optimal in that case.

Once we depart from the assumption of consistent conjectures, the profit-shifting and the terms-of-trade motives for trade policy intervention can be present simultaneously. Thus, Dixit [1984] finds that for a linear, Cournot, homogeneous-product oligopoly an export subsidy is optimal if the number of domestic firms is not "too large." In this case, the two motives for intervention identified here work in opposition. The two can also be reinforcing, as would generally occur when each of several domestic firms holds Bertrand conjectures.

V. ENDOGENOUS ENTRY AND EXIT

The analysis up to this point has assumed a fixed, exogenous number of firms. This assumption is reasonable if entry costs are large relative to the effect of policies on total profit or if other government policies determined the number of firms. Otherwise, trade and industrial policy is likely to affect the total number of firms in an industry, both domestically and abroad. A thorough treatment of optimal policies with endogenous market structure lies beyond the scope of this paper. Instead, we discuss how endogenous entry and exit would modify some of our previous results.[12]

The first point to make is that allowing for free entry and exit does not necessarily eliminate the profit-shifting motive for trade or industrial policy. All firms may earn positive profits in a free-entry equilibrium if fixed costs are relatively large compared with market size. Then, despite positive returns to firms present in the market, an additional firm could not enter profitably. Alternatively, heterogeneity among firms could imply zero profit for the marginal entrant but positive profits for inframarginal participants. In either of these cases an incentive remains for governments to use policy to shift profits toward domestic participants in the industry. Only if firms are homogeneous and the market can accommodate a large number of them, so that profits of all firms are identically zero, does the profit-shifting motive for trade or industrial policy vanish.

Two new issues are relevant for the formulation of optimal trade and industrial policy when market structure is endogenous. The first arises because policy alters the total number of firms active in an industry in equilibrium. If governments set their policy parameters before firms choose whether or not to incur their fixed costs of entry, or if firms anticipate policies that will be invoked after entry costs are borne, then export or production subsidies will encourage more firms to be active. This entry can raise industry average cost and cause the addition to national product deriving from profit-shifting to be (more than) dissipated in increased entry fees (see Horstmann and Markusen [1984]). Then, a tax on exports or production that discourages entry may be called for even when a subsidy would be optimal given an exogenous market structure.

Second, trade and industrial policy alters the relative num-

12. Horstmann and Markusen [1984] and Venables [1985] analyze the effects of trade policy with free entry for the case of Cournot competition. The first authors assume, as we do in Section VI below, that world markets are integrated. The second assumes segmented national markets. Both assume large numbers of homogeneous firms, so that all firms' profits are zero.

bers of domestic and foreign firms. A subsidy to exports or production in the home country causes foreign firms to exit as domestic firms enter. When residual profits exist, the replacement of foreign firms by domestic ones raises national product. Dixit and Kyle [1985] analyze the potential role for trade policy in deterring foreign entry or encouraging domestic entry.[13] In their analysis, a subsidy can be optimal even if it entails no profit shifting among a *given* set of firms.

VI. TRADE AND INDUSTRIAL POLICY WHEN GOODS ARE CONSUMED DOMESTICALLY

Thus far we have ruled out domestic consumption of the outputs of the oligopolistic industry under consideration. This has allowed us to focus on the profit-shifting and terms-of-trade motives for trade policy. However, by making this assumption, we have neglected a third way in which interventionist trade or industrial policy might yield welfare gains when markets are imperfectly competitive. Since oligopolistic markets are generally characterized by a difference between the price and the marginal cost of a product, there is a potential second-best role for trade and industrial policy (in the absence of first-best antitrust policy) to reduce this distortion.

When domestic consumption is positive, production taxes or subsidies and export taxes or subsidies are no longer identical. In this section we shall consider the welfare effects of both types of policies in the duopoly model of Section II, recognizing that if we were to allow for the existence of more than one domestic firm, the national-market-power motive for taxation of output or exports would also be present. In addition, in order to focus on the considerations for trade and industrial policy introduced by the presence of domestic consumption, we shall continue to use the consistent-conjectures duopoly model as our benchmark case.

To make our point as simply as possible, we assume that the duopolistic competitors produce a single, homogeneous good. We also assume perfect arbitrage with zero transport costs, so that under a production tax or subsidy consumers at home and abroad

13. In Venables [1985] the simultaneous exit of foreign firms and entry of an equal number of domestic firms is beneficial because national markets are segmented and transport costs are present. For a given total number of firms, consumer prices at home are lower the greater is the relative number of domestic participants.

face the same price for the product. Thus, we consider the case of an integrated world market, where the potential second-best role for trade policy as a substitute for domestic antitrust policy is greatest.[14]

A. Production Tax or Subsidy

Let $p(x + X)$ be the inverse world demand function, and let home country direct demand be $h(p)$. The corresponding foreign demand is $H(p)$. If a production tax at rate t is imposed, the profit of the domestic firm is $\pi = (1 - t)p(x + X)x - c(x)$. Consumer surplus at home is $\int_p^\infty h(q)dq$.[15] Domestic tax revenue is tpx. Summing these gives total home country welfare from producing, consuming, and taxing the product:

$$w = px - c + \int_p^\infty h(q)dq.$$

The change in home welfare resulting from a small change in the output tax is

$$\frac{dw}{dt} = (p + xp' - c')\frac{dx}{dt} + xp'\frac{dX}{dt} - h\frac{dp}{dt}.$$

Upon substitution of the first-order condition for the home firm's profit maximization, this becomes

$$\frac{dw}{dt} = \{xp'(g - \gamma) + t[p + xp'(1 + \gamma)]\}\frac{dx}{dt} - h\frac{dp}{dt}. \tag{12}$$

Evaluating (12) at $t = 0$, and imposing the condition that conjectures are consistent ($g = \gamma$), we find that $dw/dt = -hdp/dt$. The choice between a production tax and a production subsidy hinges on which policy lowers the price faced by domestic consumers, thereby reducing the consumption distortion associated with imperfect competition.

It is easy to calculate $dp/dt = p'(x + X)(dx + dX)/dt$. Applying Cramer's rule to the total differentials of the two firms' first-order conditions, we have

14. If world markets are segmented, as has been assumed in a number of the previous studies of trade policy under conditions of oligopoly (e.g., Dixit [1984] and Krugman [1984]), then trade policy can act as a second-best substitute for domestic antitrust policy only to the extent that marginal cost is not constant, so that the quantities supplied by an oligopolist to the various markets are interdependent.

15. We assume that this integral is bounded.

$$\frac{d(x + X)}{dt} = \frac{c'}{\Delta}[(C' - p)X - C''], \tag{13}$$

where Δ is the determinant of the 2×2 Jacobian matrix, and is assumed to be positive for stability. If foreign marginal cost is increasing ($C'' > 0$), then $p > C'$, and the right-hand side of (13) is unambiguously negative. A production subsidy raises world output, and hence lowers world price. Alternatively, if marginal costs at home and abroad are constant ($c'' = 0$ and $C'' = 0$), then the consistent conjectures equilibrium is the Bertrand equilibrium (see Bresnahan [1981]), so that $p = C'$ and $d(x + X)/dt = 0$. In this case the optimal industrial policy is laissez-faire.

PROPOSITION 5. In a homogeneous product duopoly with consistent conjectures and nonzero domestic consumption,
(i) if $c'' = 0$ and $C'' = 0$, then $t^* = 0$,
(ii) if $C'' > 0$, then $t^* < 0$.

B. Trade Tax or Subsidy

Finally, we consider the welfare effects of a small export tax or import subsidy at rate τ.[16] Under this policy domestic consumers pay a price $p(1 - \tau)$ for the good, and home government revenue is $p\tau(x - h)$. The world inverse demand function is now written as $p(x + X, \tau)$, where $p_1 = 1/\{H'(p) + (1 - \tau)h'[p(1 - \tau)]\}$ and $p_2 = ph'[p(1 - \tau)]\, p_1$. Proceeding as before, we find that

$$\left.\frac{dw}{d\tau}\right|_{\tau=0} = hp_1 \frac{d(x + X)}{d\tau} + p_2(x - h).$$

In this case, however, it is no longer possible to sign unambiguously the effect of a small trade tax or subsidy on total world output. In addition, there is a second term that now enters the expression for $dw/d\tau$, which at $\tau = 0$ is unambiguously positive or negative depending upon whether the home country is a net exporter or importer of the product. Given total output, an export tax raises the world price of an export good, while an import tariff lowers the world price of an import good. This standard terms-of-

16. One consequence of our assumption that world markets are integrated is that at most one firm will export. Two-way trade of the sort discussed by Brander [1981] will not emerge as an equilibrium outcome. Thus, our trade policy tool τ, which combines a production tax and a consumption subsidy at equal rates, corresponds to an export tax or an import subsidy, depending on the direction of net industry trade.

trade effect provides a further motive for an export tax or import tariff, just as it does when the market is competitive.

To recapitulate the arguments of this subsection, a trade policy of either sign may raise domestic welfare in a duopolistic market with domestic consumption. When conjectures are consistent, any profit-shifting motive for policy intervention is absent. What remains is a standard terms-of-trade motive on the consumption side, and what might be termed a "consumption-distortion motive," arising from the gap between price and marginal cost. The former always indicates an export tax or import tariff, while the latter may favor either a tax or a subsidy, depending on the precise forms of the demand and cost functions.

V. Conclusions

We have analyzed the welfare effects of trade policy and industrial policy (production taxes and subsidies) for a range of specifications of an oligopolistic industry. A number of general propositions for optimal policy emerge. First, either trade policy or industrial policy may raise domestic welfare if oligopolistic profits can be shifted to home country firms. Policies that achieve this profit shifting can work only if the government is able to set its policy in advance of firms' production decisions, and if government policy commitments are credible. Furthermore, in the duopoly case, profits can be shifted only if firms' conjectural variations differ from the true equilibrium responses that would result if they were to alter their output levels. The choice between a tax and a subsidy in this case depends on whether home firm's output in the laissez-faire equilibrium exceeds or falls short of the level that would emerge under "consistent" or Stackelberg conjectures.

Second, whenever there is more than one domestic firm, competition among them is detrimental to home-country social welfare. In other words, there exists a pecuniary externality when each domestic firm does not take into account the effect of its own actions on the profits of other domestic competitors. A production or export tax will lead domestic firms to restrict their outputs, shifting them closer to the level that would result with collusion. In this familiar way a production or export tax enables the home country to exploit its monopoly power in trade fully.

These propositions are unaffected by extension of the analysis to cases in which optimal interventions are set simultaneously by two policy-active governments. But allowing for endogenous entry and exit introduces two new considerations. First, policy-induced entry (exit) could raise (lower) the average cost of production. When subsidies engender profit shifting, the gain in national income can be dissipated in additional entry fees. Second, policy alters the relative numbers of domestic and foreign firms in an oligopolistic industry. In the presence of residual profits there is a potential role for trade or industrial policy that serves to deter foreign entry or promote domestic entry.

Finally, when there is domestic consumption of the output of the oligopolistic industry, there are two further motives for policy intervention. First, consumers' marginal valuation of the product will generally differ from domestic marginal cost of production due to the collective exertion of monopoly power by firms in the industry. A welfare-improving policy for this reason should increase domestic consumption. When industrial policy is used, a production subsidy will achieve this result, whereas the appropriate trade policy instrument may be either an export (or import) tax or an export (or import) subsidy. Second, there is the usual externality caused by the multiplicity of small domestic consumers, who do not take into account the effect of their demands on world prices. Industrial policy cannot be used to overcome this externality, but if the country is a net exporter (importer), an export (import) tax will have a favorable impact on the country's terms of trade. The formulation of optimal trade or industrial policy in general requires the weighting of these various influences.

APPENDIX A: PROOF OF PROPOSITION 4

The profit of the representative home firm i is

$$\pi^i = (1 - t)r_i(x^1, \ldots, x^n, X^{n+1}, \ldots, X^{n+m}) - c(x^i),$$

where the t denotes the output or export tax imposed on domestic firms. A typical foreign earns

$$\Pi^j = R_j(x^1, \ldots, x^n, X^{n+1}, \ldots, X^{n+m}) - C(X^j).$$

(A foreign policy may be allowed for by defining R^j to be after-tax revenue.) The first-order conditions for profit maximization are

$$\text{(A1a)}\quad (1 - t)r_i^i - c^{i\prime} + (1 - t)\sum_{\substack{j=1\\ j\neq i}}^{n+m} r_j^i\gamma^{ij} = 0, \qquad i = 1, \ldots, n;$$

$$\text{(A1b)}\quad R_i^i - C^{i\prime} + \sum_{\substack{j=1\\ j\neq i}}^{n+m} R_j^i\Gamma^{ij} = 0, \qquad i = n + 1, \ldots, n + m),$$

where γ^{iy} (Γ^{ij}) is the conjecture by the home (foreign) firm i about the output response by firm j, for $j \neq i, j = 1, \ldots, n + m$.

Home-country national product deriving from this industry is

$$\text{(A2)}\qquad w = \sum_{i=1}^{n} (r^i - c^i).$$

Differentiating (A2) with respect to t at $t = 0$, and imposing the condition of symmetry of the initial (free trade) equilibrium gives

$$\text{(A3)}\quad \left.\frac{dw}{dt}\right|_{t=0} = nr_2^1\left[(n = 1)(1 - \gamma)\frac{dx^i}{dt} + m\frac{dX^j}{dt} - m\gamma\frac{dx^i}{dt}\right],$$

where $\gamma = \gamma^{ij}$ for all $j \neq i$, $i = 1, \ldots, n + m$.

Next we differentiate the first-order conditions (A1a) and (A1b) and again impose symmetry (i.e., $dx^i = dx^k$ for $i,k = 1, \ldots, n$ and $dX^j = dX^l$ *for* $j,l = n + 1, \ldots, n + m$) to derive

$$\text{(A4)}\quad \begin{bmatrix} \alpha + (n - 1)\beta & m\beta \\ n\beta & \alpha + (m - 1)\beta \end{bmatrix}\begin{bmatrix} dx^i \\ dX^j \end{bmatrix} = \begin{bmatrix} \lambda dt \\ 0 \end{bmatrix},$$

where

$$\alpha \equiv r_{ii}^i - c^{i\prime} + (n + m - 1)r_{ij}^i\gamma$$
$$\beta \equiv r_{ij}^i + r_{jj}^i\gamma + (n + m - 2)r_{jk}^i\gamma$$
$$\gamma \equiv r_i^i + (n + m - 1)r_j^i\gamma.$$

Note that the free trade equilibrium has symmetry not only among home firms, but also between home and foreign firms, so that about this point $r_i^i = R_j^j$ and similarly for other derivatives. Using this fact and solving (A4) gives

$$\text{(A5a)}\qquad \frac{dx^i}{dt} = \frac{[\alpha + (m - 1)\beta]\lambda}{(\alpha - \beta)[\alpha + (n + m - 1)\beta]}$$

and

$$\text{(A5b)}\qquad \frac{dX^j}{dt} = \frac{-n\beta\lambda}{(\alpha - \beta)[(\alpha + (n + m - 1)\beta)]}.$$

The value of γ determined by imposing the condition that conjectures be consistent is found by perturbing the equilibrium in (A1a) and (A1b) by an exogenous shift in the output of one firm, e.g., x^1, and solving for the full equilibrium response dx^i/dx^1, $i \neq 1$ (see the discussion in Perry [1982], especially footnote 7). Doing so, we find that

$$\gamma = -\beta/[\alpha + (n + m - 1)\beta]. \tag{A6}$$

Finally, we substitute (A5a), (A5b), and (A6) into (A3), and perform some straightforward algebraic manipulations, which yield

$$\left.\frac{dw}{dt}\right|_{t=0} = \frac{n(n-1)r_2^1\lambda}{\alpha + (n + m - 2)\beta}. \tag{A7}$$

The denominator of (A7) must be negative for stability of the industry equilibrium [Seade, 1980]. From the first-order condition (A1a), $\lambda = c^{i\prime}/(1 - t) > 0$. The sign of expression (A7) is consequently opposite to that of r_2^1 if $n > 1$, i.e., positive for goods that are substitutes. For $n = 1$, the expression is zero.

Q.E.D.

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[Footnotes]

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