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Strategic Trade and Delegated Competition*

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Abstract

Strategic trade theory has been criticized on the grounds that its predictions are overly sensitive to modeling assumptions. For example, Eaton and Grossman (1986) show that Brander and Spencer's (1985) seminal result – i.e., when firms compete by setting quantities the optimal policy involves governments subsidizing their domestic industries – is reversed if the firms compete by setting prices. Applying recent results in duopoly theory, this paper considers three-stage games in which governments choose subsidies, firms' owners choose incentive schemes for their managers, and then the managers compete in the product market. We show that if firms' owners have sufficient control over their managers' behavior, then the optimal strategic trade policy does not depend on whether firms compete by setting prices or quantities. In a linear-demand model in which managers are compensated based on a linear combination of their own firm's profit plus a (possibly negative) multiple of the rival firm's profit, the optimal policy is to subsidize if goods are substitutes and tax if the goods are complements.

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1 Introduction

One of the chief shortcomings of strategic trade theory has been that its predictions are highly sensitive to the modeler's choice of how to characterize the product market competition. For example, the main implication of the Brander and Spencer (1985) model – i.e., governments should subsidize substitute products when firms compete by setting quantities – is reversed if the firms compete by setting prices (Eaton and Grossman, 1986).¹ This disparity leads James Brander to remark in his 1995 survey of the strategic trade literature that:

The Bertrand [price-setting] model is not necessarily any less plausible than the Cournot model as an approximation to actual conduct. Because it is hard to know in practice which of the two models (if either) is appropriate in a given case, the Eaton-Grossman analysis implies that even finding the sign or direction of the optimal policy might be difficult. (Brander 1995, p. 1417)

Paul Krugman echoes this sentiment, saying that the “flurry of excitement” over Brander and Spencer's original theories had died down:

After several years of theoretical and empirical investigation, it has become clear that the strategic trade argument, while ingenious, is probably of minor real importance. Theoretical work has shown that the appropriate strategic trade policy is highly sensitive to details of market structure that governments are unlikely to get right. (Krugman 1993, p.363)

The dependence of optimal trade policy on the nature of product market competition follows from the fact that, despite appearing similar, the strategic interaction between two firms who compete by setting quantities is fundamentally different than the interaction between two firms who compete by setting prices. A number of papers have studied this distinction (Singh and Vives (1984); Cheng (1985); Klemperer and Meyer (1986)). They show that when firms produce differentiated products, the disparity between the price-competition (i.e., Bertrand) and quantity-setting (i.e., Cournot) outcomes arises from the fact that the elasticity of residual demand facing a firm whose opponent holds price constant is greater than the elasticity of demand facing a firm

¹Balboa, Daughety, and Reinganum (2001) provide a recent study of the interaction between assumptions about market structure and optimal strategic trade policy.

whose opponent holds quantity constant, and that price competition is generally “more aggressive” than quantity competition in the sense that it leads to smaller prices and larger quantities.

The industrial organization literature on strategic delegation explores the idea that altering a firm’s behavior can alter equilibrium outcomes. Typical models, such as Fershtman and Judd (1987), Sklivas (1987), Vickers (1985), Fumas (1992), and Miller and Pazgal (2002), consider two-stage duopoly games in which, during the first stage, profit-maximizing owners choose the incentive schemes they will give to their managers. During the second stage the managers choose strategic variables in order to maximize their utility under their incentive schemes. In each case, the owners have an interest in using the incentive scheme they set to influence their manager’s behavior, which in turn alters the equilibrium outcome (prices, quantities, and profits) of the two-stage game.

In recent work, Miller and Pazgal (2001), henceforth MP, provide a bridge between the price vs. quantity competition literature and the strategic delegation literature in which it is shown that if owners have sufficient control over their managers incentives, then the set of equilibrium outcomes of a two-stage delegation game does not depend on whether the managers ultimately compete in prices or in quantities.² Although players in undelegated price competition behave more aggressively than players in undelegated quantity competition, when owners can manipulate their managers’ incentives they make price-setting managers less aggressive and quantity-setting managers more aggressive, mitigating the difference in behavior, and, if owners have sufficient control over their managers’ incentives, eliminating it. For example, when demand is linear and marginal cost is constant, if owners compensate managers based on a linear combination of own and rival profit, which MP term a relative-performance incentive scheme, the equivalence result follows.

In this paper we apply the delegated-competition methodology to the strategic trade problem. In a three-stage game in which governments set subsidies, owners set incentive schemes, and then managers compete in a third country, we show that once the role of delegation in the owner-manager relationship is taken into account, the optimal trade policy depends only on the degree of substitutability of the products, and not on the particular model of product market competition. When demand is linear, marginal cost is constant, and owners choose relative-performance incentive schemes for their managers, we show that if products are substitutes, the equilibrium involves subsidies, while when products are complements, it involves taxes.

²Throughout the paper, we refer to this as the MP equivalence result.

In more general contexts, it is computationally difficult to explicitly derive the optimal strategic trade policy. Nevertheless, it remains the case that the optimal policy does not depend on the mode of product market competition, provided that owners can exercise sufficient control over their managers incentives. In light of this, we argue that the sensitivity of the optimal policy instrument that Eaton and Grossman (1986) identify derives not from the mode of competition, i.e., whether firms compete in prices or quantities, but rather that these alternative models of competition imply different behavior on the part of managers. This suggests that conjectural variations models and other approaches to studying the strategic trade problem that take behavior as primitive may be more appropriate and ultimately more successful than those that attempt to determine the correct model of product market competition. Indeed, since there are generally multiple models of competition that agree with any particular behavior, there may be no such thing as a single correct model.

The rest of this paper proceeds as follows. In section 2 the optimal trade policy is derived in the context of a simple example of relative-performance delegation. While still in the context of the linear model, sections 3 and 4 generalize the result of the example, allowing the goods to be either substitutes or complements, and discuss the geometric intuition of the problem. Section 5 discusses strategic trade policy in more general contexts. Section 6 concludes. Supporting proofs are contained in the Appendix.

2 Strategic Trade and Delegation Games

2.1 An Example

We begin with a simple example of the strategic trade game in which the owners of firms may influence their managers' behavior. Consider two nations. In each nation, a firm produces a product, and the two nations' products are imperfect substitutes. Within each firm, there is an owner and a manager. The owner is residual claimant on the firm's net profit, while the manager makes the actual product market decisions.³ We assume that the products are sold in a third country. The benefit of this strategy is that we can ignore domestic consumer surplus in our

³We use *net profit* to refer to the firm's objective function, profit, net of the subsidy the government imposes. We use *surplus* to refer to the government's objective, which, in the case of third country competition, is the same as gross profit before the subsidy or tax.

measure of national welfare.

We consider three-stage games. In the first stage, the government chooses a per-unit subsidy (or tax) to be imposed on its domestic firm. In the second stage, the owner of the domestic firm, knowing the subsidies chosen by both nations, chooses a relative-performance incentive scheme for its manager. In the third stage, the managers of the firms, knowing the subsidies and incentive schemes chosen by both sides, choose a value of their strategic variable, i.e., a quantity if the product market competition is à la Cournot, or a price if it is à la Bertrand.

Since this is a dynamic game of complete information, our equilibrium concept is subgame perfect Nash equilibrium. We will often refer to the second and third stages of the game as the “delegation game,” and the equilibrium of the second and third stages, taking subsidies as fixed, as the “delegation game equilibrium.”

Denote the two nations by 1 and 2. We refer to the government, owner, and manager in nation i as Gi , Oi , and Mi , respectively. For the purposes of this example, let inverse demand for nation i 's output be:

$$p_i = 10 - q_i - \frac{1}{2}q_j, \quad (1)$$

where p_i denotes good i 's price, q_i denotes its quantity, and subscript $j = 3 - i$ denotes the corresponding variable for other side. The negative coefficient on q_j indicates that the products are substitutes.

Let c_i denote the constant marginal cost of production for side i , and note that c_i will eventually consist of the firm's marginal production cost net of the subsidy set by its government. Hence $c_i = c - s_i$, where c is the common marginal production cost of the two firms and s_i is the side-specific subsidy chosen by Gi . There are no fixed costs of production.

We assume that the incentive scheme set for Mi takes the form:

$$m_i = \pi_i + v_i \pi_j,$$

where v_i is the incentive parameter chosen by Oi , and $\pi_i = (p_i - c_i) q_i$ is the net profit earned by firm i . We refer to such schemes as relative-performance incentive schemes.

We begin by considering the game under the assumption that product market competition takes place in quantities. Manager Mi chooses q_i in order to maximize:

$$m_i = \left(10 - c_i - q_i - \frac{1}{2}q_j\right) q_i + v_i \left(10 - c_j - q_j - \frac{1}{2}q_i\right) q_j. \quad (2)$$

The optimality condition for the manager's problem is given by:

$$-2q_i + 10 - c_i - \frac{1}{2}q_j - \frac{1}{2}v_i q_j = 0, \quad (3)$$

and the equilibrium quantities are found by solving conditions (3) for q_1 and q_2 , yielding:

$$q_i = 2 \frac{30 - 10v_i - 4c_i + (1 + v_i)c_j}{15 - v_i - v_j - v_j v_i}. \quad (4)$$

Expression (4) gives the third-stage equilibrium quantities as functions of the owners' incentive parameters and (implicitly) the governments' subsidy choices. Evaluating firm i 's net profit at quantities (4), profit as a function of incentive parameters v_i and v_j is given by:⁴

$$\pi_i = 2(60 + 10v_i - 10v_j v_i - 8c_i + c_i v_i + c_i v_j v_i + 2c_j - 2v_i c_j) \frac{30 - 10v_i - 4c_i + (1 + v_i)c_j}{(15 - v_i - v_j - v_i v_j)^2}. \quad (5)$$

Next, we move to owner O_i 's optimal choice of incentive parameter v_i in the second stage. The equilibrium values of v_1 and v_2 (as functions of c_1 and c_2) are found by solving the following system for v_1 and v_2 :

$$\frac{d}{dv_1} \pi_1 = 0, \text{ and } \frac{d}{dv_2} \pi_2 = 0,$$

where π_i is as in (5). This yields optimal values:

$$v_i^* = \frac{2c_i - c_j - 10}{2c_i - 7c_j + 50}. \quad (6)$$

Substituting in the optimal values of v_1 and v_2 from (6) into (4) yields quantities:

$$q_i^* = \frac{25}{6} + \frac{1}{6}c_j - \frac{7}{12}c_i, \quad (7)$$

and profit:

$$\pi_i^* = \frac{1}{96} (30 - 4c_i + c_j) (50 + 2c_j - 7c_i). \quad (8)$$

Expressions (6), (7), and (8) characterize the equilibrium of the delegation game when managers compete by setting quantities.

Next, we derive the equilibrium of the delegation game under the assumption that managers compete by setting prices in the product market. Inverting (1) yields direct demand functions:

$$q_i = \frac{20}{3} - \frac{4}{3}p_i + \frac{2}{3}p_j. \quad (9)$$

⁴Although omitted for the sake of brevity, the second-order conditions for a maximum hold as well.

Let Mi be compensated according to the relative-performance incentive scheme, $\tilde{m}_i = \pi_i + z_i \pi_i$, where z_i is the incentive parameter in the price-setting version of the delegation game. Manager Mi chooses p_i in order to maximize:

$$\tilde{m}_i = (p_i - c_i) \left(\frac{20}{3} - \frac{4}{3}p_i + \frac{2}{3}p_j \right) + z_i (p_j - c_j) \left(\frac{20}{3} - \frac{4}{3}p_j + \frac{2}{3}p_i \right).$$

Differentiating with respect to p_i , the optimality condition for Mi 's problem is given by:

$$p_i = \frac{5}{2} - \frac{1}{4}z_i c_j + \frac{1}{2}c_i + \frac{1}{4}(1 + z_i)p_j. \quad (10)$$

The third-stage equilibrium prices are found by solving equations (10) for p_1 and p_2 , yielding:

$$p_i = \frac{-50 - 10z_i + 2z_i c_j - 8c_i + z_j c_i + c_i z_j z_i - 2c_j}{-15 + z_i + z_j + z_i z_j}. \quad (11)$$

Substituting (11) into firm i 's profit, profit as a function of z_i and z_j is written:

$$\begin{aligned} \pi_i = & \frac{2}{3} (50 + 10z_i - 7c_i + c_i z_i - 2z_i c_j + 2c_j) * \\ & \left(\frac{3z_i c_j - z_j z_i c_j + 4c_j - 30z_i - 10z_j z_i + 2c_i z_j z_i - 14c_i + 100}{(-15 + z_i + z_j + z_i z_j)^2} \right). \end{aligned} \quad (12)$$

The equilibrium values of the incentive parameters solve:

$$\frac{\partial}{\partial z_1} \pi_1 = 0, \text{ and } \frac{\partial}{\partial z_2} \pi_2 = 0,$$

where π_i is given by (12). Solving this system yields:

$$z_i^{**} = \frac{c_i - 10}{-c_i - 30 + 4c_j},$$

implying equilibrium prices

$$p_i^{**} = \frac{1}{8}c_j + \frac{15}{4} + \frac{1}{2}c_i. \quad (13)$$

Substituting prices (13) into demand equations (9) yields equilibrium quantities and prices:

$$q_i^{**} = \frac{25}{6} + \frac{1}{6}c_j - \frac{7}{12}c_i, \text{ and} \quad (14)$$

$$\pi_i^{**} = \frac{1}{96} (30 - 4c_i + c_j) (50 + 2c_j - 7c_i). \quad (15)$$

The equilibrium outcome of the delegation game when firms compete by setting quantities, given by q_i^* and π_i^* in (7) and (8), is the same as the equilibrium outcome of the delegation game

when firms compete by setting prices, given by q_i^{**} and π_i^{**} in (14) and (15). Thus the outcome of the delegation game does not depend on the form of product market competition. Further, notice that the outcomes are identical as functions of the firms' costs, and, by extension, as functions of the governments' choices of subsidies. And, since the outcome of the delegation game completely determines the value of the government's objective function in the first stage, it must be that the optimal subsidy policy is the same regardless of the form of product market competition. This is the essence of our results, which we develop in more generality throughout the remainder of the paper.

We now turn to the first stage of the game, in which the government chooses subsidy rates in order to maximize home-country welfare given that owners and managers will play equilibrium strategies in the delegation game. For the rest of this example, let $c = 2$. Hence $c_i = (2 - s_i)$. Making this substitution, the equilibrium quantities and profits in the delegation game (as captured by (7) and (8) or (14) and (15)) can be expressed as functions of the subsidies only as:

$$\begin{aligned} q_i &= \left(\frac{10}{3} - \frac{1}{6}s_j + \frac{7}{12}s_i \right), \text{ and} \\ \pi_i &= \frac{1}{96} (40 - 2s_j + 7s_i) (24 + 4s_i - s_j). \end{aligned}$$

Domestic welfare is given by home-country net industry profit less subsidies paid: $w_i = \pi_i - s_i q_i$.

The optimal subsidy rates are found by solving the following system of optimality conditions:

$$\frac{d}{ds_i} \left(\frac{1}{96} (40 - 2s_j + 7s_i) (24 + 4s_i - s_j) - s_i \left(\frac{10}{3} - \frac{1}{6}s_j + \frac{7}{12}s_i \right) \right) = 0.$$

Solving this system yields $s_1^* = s_2^* = \frac{8}{55}$ for the parameter values in this example.⁵ Thus, in equilibrium, each country subsidizes its home industry. This is true regardless of whether product market competition takes place in prices or quantities.

3 Substitutability and Optimal Policy

We now consider a more general model that allows for the goods to differ in their degree of substitutability. However, for computational efficiency we maintain the assumptions that demand is linear and symmetric with constant (and equal) marginal cost. The three-stage game remains the same as in Section 2. Consequently, we suppress many of the calculations. Complete derivations are available from the authors upon request.

⁵Again, the second order conditions are easily verified.

In order to allow for different levels of substitutability (or even complementarity), we consider inverse demand system:

$$p_i = a - q_i + gq_j,$$

where we assume $a > 0$ and $|g| < 1$ so that both price and quantity competition have well-defined solutions. Marginal cost for each firm is given by $c_i = c - s_i$.⁶ As a regularity condition, we assume $a - c > 0$, which assures that if firm j is not active, i.e., $q_j = 0$, then firm i wishes to produce a positive quantity.

Solving the three-stage game as in the example, the equilibrium trade policy is described in Proposition 1.

Proposition 1 *If the goods are substitutes ($-1 < g < 0$) then the equilibrium trade policy involves subsidization of the domestic industry. If the goods are unrelated, free trade is optimal. If the goods are complements ($0 < g < 1$) then the equilibrium subsidy policy involves taxing the domestic industry.*

Proof. Following the same procedure as above, the equilibrium subsidies in the three stage game are given by:

$$s_i^* = -(a - c) \frac{g^3}{8 - 4g^2 + g^3}.$$

For $|g| < 1$, the denominator is positive, from which it follows that the sign of the optimal subsidy is opposite that of g . ■

The main difference between Proposition 1 and previous results in strategic trade theory such as Brander and Spencer (1985) and Eaton and Grossman (1986) is that the optimal policy depends only on whether the goods are substitutes or complements and not on the form of product market competition.

Figure 1 plots $\frac{s_i^*}{a-c}$ as a function of g , where the normalization by $(a - c)$ controls for market size. The magnitude of the optimal subsidy increases as the goods become closer substitutes, reaching $\frac{1}{3}(a - c)$ when the goods are perfect substitutes. When the goods are unrelated, $g = 0$, free trade is optimal. As g becomes positive, it is optimal to tax the domestic industry, with the optimal tax reaching $\frac{1}{5}(a - c)$ as g approaches 1.

⁶The delegation-game equivalence result also holds for the general linear demand system $p_i = a_i - b_i q_i + g_i q_j$ and firm-specific marginal cost c_i . The restriction here to symmetric demand and marginal cost is merely for convenience.

Figure 1: Magnitude of the optimal subsidy and the degree of substitutability

Although we omit the analysis for the sake of brevity, the equilibrium of the three-stage game resembles the Brander and Spencer (1985) model of strategic trade with substitutes in a number of ways beyond the optimality of subsidies. For example, as in Brander and Spencer, the strategic trade game has the flavor of a Prisoners' Dilemma: each firm has a dominant strategy to deviate from free trade, but it would be Pareto superior if both nations could commit to free trade policies. Further, when taxation is distortionary (i.e., \$1 in subsidy costs the government \$ $k > 1$ to raise), the curve in Figure 1 shifts downward as k increases. Free trade and/or taxation becomes the equilibrium policy for an interval $g \in [g(k), 1]$, where $g(k)$ is a strictly decreasing function of k .⁷

4 Intuition for the Result

4.1 The Standard Strategic Trade Game

To understand Proposition 1, it is instructive to begin by revisiting the intuition behind the optimal policy in the pure (i.e., without delegation) quantity- and price-competition versions of the problem. Throughout the section, we confine ourselves to the linear environment of Section 3.

When firms compete in quantities in a free-trade environment, each point on a firm's reaction

⁷See, for example, as in Neary (1991; 1994) and Gruenspecht (1988), for earlier approaches to the problem of distortionary taxation. Complete analysis the claims in this paragraph are available from the authors upon request.

Figure 2: Optimal policy under quantity competition

function maximizes its profit, given the other firm's strategy choice. Thus, as in Figure 2, the isoprofit line for player 1 through any point on its reaction function, R_1 , is flat. The free-trade equilibrium is at the point where firm 1's reaction function, R_1 , intersects firm 2's reaction function, R_2 .

The basic insight of the Brander and Spencer (1985) analysis is that, since R_2 slopes downward for quantity competition in substitutes, moving down and to the right along R_2 increases player 1's profit, at least for a time. Choosing a positive subsidy makes firm 1 more aggressive, shifting its reaction curve right to R_1^* and moving the equilibrium outcome down and to the right along player 2's reaction curve. Since this increases profit, the government prefers setting a positive subsidy to free trade (or taxation). Indeed, both firms share this incentive, and it persists even when the other firm sets a non-zero subsidy. Hence the equilibrium involves each government subsidizing its domestic industry (see Figure 3).

When firms compete by setting prices, the opposite result obtains. For ease of comparison and a new perspective on the difference between price and quantity competition, we present the projection of the price-setting game into the quantity space in Figure 4. The free-trade equilibrium is given by the intersection of firm 1's price reaction function, r_1 , with firm 2's price reaction function, r_2 . In this linear case, it is straightforward to show firm 1's optimal response in the price-setting game

Figure 3: The equilibrium of the delegation game.

is larger than its optimal response in the quantity-setting game (Singh and Vives, 1984), that r_2 is flatter than r_1 , and that firm 1's profit isoquant is steeper than r_2 at the intersection of r_1 and r_2 (i.e., the free trade equilibrium). Consequently, beginning at the intersection of r_1 and r_2 , firm 1's profit increases as the outcome moves up and to the left along r_2 .

Based on the geometry of the problem, the $G1$ can increase domestic surplus by shifting firm 1's reaction curve inward. The way to do this is to tax the domestic firm, which makes it "less aggressive" and shifts r_1 back toward r_1^* . Again, these incentives are qualitatively unchanged if country 2 chooses a non-zero tax, and therefore the equilibrium involves taxation by each nation.

The difference in the direction of beneficial strategic trade policy in Cournot vs. Bertrand competition has to do with the difference in the relative slopes of the profit isoquants through the equilibrium point and the slope of the other firm's reaction function. In quantity competition, the profit isoquant is flatter, and subsidies improve welfare. In price competition, on the other hand, the isoprofit curve is steeper, and taxation is beneficial. This comparison is at the heart of the Eaton and Grossman (1986) analysis, and will continue to be central to our analysis.

Figure 4: Optimal policy under price competition

4.2 The Delegated Strategic-Trade Game

We now turn to understanding the role of strategic trade policy in the three-stage game. In the third stage, managers optimize their payoffs, given the incentive schemes chosen by each firm and the strategy chosen by the other manager. This defines the managers' reaction functions. In the second stage, the owners of the firm choose their incentive parameters in order to maximize profit, given the incentive parameters chosen by the other owner and the resulting third-stage equilibrium. Holding fixed the other owner's incentive parameters, each owner chooses the incentive parameter that results in the third-stage equilibrium that maximizes its profit. The geometric implication of this is that, at the equilibrium choice of incentive parameters, firm 1's isoprofit line through the equilibrium is tangent to firm 2's reaction curve, and vice versa. This situation is (partially) depicted in Figure 5, where DR_i indicates firm i 's equilibrium reaction curve in the delegation game.

When the firms choose incentive parameters optimally, the equilibrium outcome is the point along firm 2's reaction curve that maximizes firm 1's profit (and vice versa). Hence, shifting firm 1's reaction curve through strategic trade policy cannot increase domestic surplus unless it also influences firm 2's equilibrium incentive parameters (i.e., moves DR_2). However, since each

Figure 5: The equilibrium of the strategic-trade game (no delegation).

owner's optimal choice of incentive parameters depend on the subsidies chosen by *both* governments, varying the subsidy influences both firms' second-stage reaction functions.

Examining the optimal incentive parameters v_1 and v_2 , given by (6), it is easily shown that $\frac{dv_i}{ds_i} < 0$ and $\frac{dv_i}{ds_j} > 0$.⁸ Therefore an increase in s_1 pivots firm 1's optimal reaction curve outward and firm 2's optimal reaction curve downward, as in Figure 6. Hence, following an increase in s_1 , the equilibrium point moves to the right of DR_1 and below DR_2 to the intersection of DR_1^* and DR_2^* . Since firm 1's isoprofit line was originally tangent to DR_2 , this necessarily increases profit. Subsidizing the domestic industry improves domestic surplus, and the optimal policy involves subsidization.

Discussion of the simultaneous determination of equilibrium trade policy in the three-stage game is slightly more complicated, but has the same basic form. Suppose that G2 chooses its

⁸Substituting $c_i = 2 - s_i$ into (6) yields the following expressions for the optimal incentive parameters, given as functions of the subsidies chosen by both nations:

$$\begin{aligned} v_1 &= \frac{8 + 2s_1 - s_2}{-40 + 2s_1 - 7s_2} \\ v_2 &= \frac{8 + 2s_2 - s_1}{-40 + 2s_2 - 7s_1}. \end{aligned}$$

Figure 6: Both reaction curves shift with a change in subsidy.

equilibrium subsidy, s_2^* , and G1 chooses free trade, $s_1 = 0$. Given that G1 does not intervene in the market, O1 chooses v_1 in order to maximize its true profit. Consequently country 1's isoprofit line is tangent to manager 2's reaction curve when $s_1 = 0$ and $s_2 = s_2^*$. As before, increasing s_1 shifts M1's reaction curve to the right and M2's reaction curve downward (through the influence of the subsidy on v_2). Due to the initial tangency of country 1's isosurplus and country 2's reaction curve, this increases country 1's surplus.⁹

When the goods produced by the firms are complements, the firm's net profit increases with the other firm's quantity, and consequently the firm's isoprofit curves bend upward for firm 1 (resp. outward for firm 2) instead of downward (resp. inward), as illustrated in Figure 7. Although this reversal changes the sign of the optimal policy, the remaining geometric relations do not change. The equilibrium of the delegation game under free trade is located at the intersection of DR_1 and DR_2 , with firm 1's profit isoquant tangent to DR_2 at the equilibrium point. When G1 introduces a positive tax on its home industry, O1 responds by pivoting its manager's reaction curve inward: the manager becomes less aggressive. At the same time, O2 responds by making its manager more aggressive, pivoting its reaction curve upward. The result is that the equilibrium of the delegation

⁹Note that this argument holds even though firm 1's reaction curve when $s_1 = 0$ and $s_2 = s_2^*$ is not the same as its reaction curve when $s_1 = s_1^*$ and $s_2 = s_2^*$.

Figure 7: The case of complements.

game moves up and to the right, increasing nation 1's surplus, and the equilibrium of the delegated strategic trade game with complements involves taxes by both governments.

5 Strategic Trade Theory and General Delegation Games

The discussion in the previous section has focused on the case of linear demand, constant marginal cost, and relative-performance incentive schemes. Under these conditions, there is a unique equilibrium of the delegation game, and the optimal trade policy is unambiguous. In more general environments, the delegation game may have multiple equilibria, each of which is supported by complicated incentives. Nevertheless, the MP equivalence result continues to hold in the delegation game: if owners have sufficient control over their managers' incentives, then for any equilibrium of the delegation game when managers set prices there is a corresponding equilibrium of the delegation game when managers set quantities that results in the same final prices and quantities (and vice versa). Consequently, it remains true that if owners have sufficient power to control their managers' incentives, then the optimal trade policy does not depend on the nature of product market competition.

We relegate the formal statement and proof of this result to the Appendix. Here, we focus on

a less formal discussion of what it means for owners to have sufficient control over their managers' incentives. In order to compare price and quantity competition, MP define an **outcome set** as the projection of a manager's best response correspondence (i.e., reaction curve) into the four-dimensional (q_1, q_2, p_1, p_2) -space. The key condition, which MP denote Outcome Set Equivalence (OSE), is that the set of behaviors (i.e., outcome sets) the owner can induce on the part of its manager must be the same regardless of whether the managers choose prices or quantities.¹⁰

If OSE holds, then the difference between price- and quantity-competition in the final stage of the delegation game amounts to nothing more than a difference in the naming of outcome sets. The fundamental game is unchanged, and consequently the set of equilibrium outcomes of the delegation game does not depend on the form of the product market competition.

Proposition 2 *If OSE holds, then, for any choice of subsidies by the governments, the set of equilibrium outcomes of the delegation game is the same regardless of whether the firms compete in prices, quantities, or one firm chooses price and the other chooses quantity.*

Proof. *See the Appendix.* ■

Proposition 2 implies that the set of possible equilibria and outcomes of the delegation game that can arise given particular subsidy choices does not depend on the form of product market competition. Thus, even when there are multiple equilibria in the delegation game, if OSE holds then there is no equilibrium outcome that can arise under one type of product market competition and not the other. And since, just as in the earlier results, the governments care about their subsidy choices only inasmuch as they affect the equilibrium prices and quantities resulting from the delegation game, the fact that the outcomes are independent of the form of product market competition implies that the equilibrium choices of strategic trade policies are independent of the form of product market competition as well.

¹⁰Outcome sets (or some similar construction) are necessary to compare price and quantity competition reaction curves because price reaction curves lie in (p_1, p_2) -space, while quantity reaction curves lie in (q_1, q_2) -space. However, since fixing any two elements of $\{p_1, p_2, q_1, q_2\}$ determines the other two, price and quantity reaction curves are comparable once they are cast in the right frame of reference. Looking at the four-dimensional outcome set is one way to do so. Another would be to project price reaction curves into the quantity space, as we do in the geometric analysis. Thus price reaction curve r_i generates the same outcome set as quantity reaction curve R_i if and only if the projection of r_i into (q_1, q_2) -space coincides with R_i .

Proposition 3 *If OSE holds, then the equilibrium trade policies do not depend on the form of product market competition.*

Proof. *See the Appendix.* ■

Proposition 3 does not provide a method of determining the equilibrium trade policy or even whether subsidizing its domestic industry helps or harms a country. However, if we take seriously the possibility of delegation, it suggests that a “correct” model of the product market should not be necessary in order to answer this question. To put it another way, any conclusion that can be drawn about trade policy knowing the true mode of product market competition is also consistent with any other model of (delegated) competition that leads to the same managerial behavior, and knowing how managers’ behavior changes in response to a subsidy change is sufficient to determine the direction of beneficial change in subsidy policy, even if the government does not have access to the true model of product market competition.

Our OSE condition is strong and would be hard to verify in any practical situation. However, while this is true, it would also be difficult to falsify without the type of detailed knowledge of the inner workings of firms and product markets that is widely believed to be beyond the grasp of government and academic analysts. That is, suppose it were proposed that managers in a particular strategic-trade problem competed by setting quantities. Propositions 2 and 3 establish that the possibility that the observed market behavior arose from delegated price competition could not be ruled out using only data on market prices and quantities. Thus, in addition to establishing that determining equilibrium strategic trade policies cannot depend on the model of product market competition, they also establish that any analysis that claims to establish the “correct” model of product market competition must do so using data other than market outcomes.

6 Conclusion

In this paper, we have argued that the theoretical case for strategic trade policy is not as flawed as the statements from Brander and Krugman quoted in the introduction would suggest. If owners have sufficient control over their managers’ incentives, then the optimal/equilibrium trade interventions do not depend on the nature of product market competition. In the linear model, we showed that owners’ ability to set simple, relative-performance incentive schemes is sufficient for the invariance result to hold. In more complicated environments, more complicated incentive

schemes may be required, but the basic result is robust.

The most general insight to be taken from the results derived here is that, at its base, equilibrium depends on the behavior of managers and not on whether that behavior derives from delegated price- or quantity-setting. Therefore, even though, as Brander suggests, it may be difficult to determine the right model of product market competition, this is not really necessary to solve the strategic trade problem. In fact, our model suggests that, from a descriptive perspective, there may be no such thing as the “correct model.” For this reason we argue that, in approaching the strategic trade problem, the primitive notion should be the behavior of the product market, not the model of the product market.

Our conclusions offer support to Eaton and Grossman’s (1986) conjectural variations-based model of strategic trade and to the empirical strategic trade literature that relies on conjectural variations.¹¹ The conjectural variations approach is often criticized on the grounds that players’ conjectures may be inconsistent in that they posit behavior on the part of their opponents that is not confirmed in the equilibrium. Our delegation approach avoids this criticism. In our model, managers’ behavior is optimal given the incentive schemes set by owners, and owners’ incentive schemes are optimal given the trade policies adopted by the governments. Hence, the managers’ conjectures are, in fact, consistent once the owners’ and governments’ strategies are taken into account. And, since the owners and governments are both optimizing, no inconsistency between conjectures and behavior remains anywhere in the model.

¹¹See Krugman (1989;1212-1213) and Krugman (1994; 1-9) for discussions of empirical strategic trade papers employing the conjectural variations approach, and various essays in Krugman (1994) for studies employing the methodology.

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A Development of Propositions 2 and 3

In this section, we extend the MP equivalence result to the strategic trade context, proving that if owners have sufficient control over their managers' incentives, then the equilibrium subsidies do not depend on the form of product market competition. The derivation consists of two parts. First, following Proposition 3 in MP, we establish that when owners have sufficient control over their managers' incentives, the set of equilibrium outcomes of the delegation game, parameterized by the governments' choices of trade policies (s_1, s_2) , does not depend on the form of product market competition. Second, we show that the equilibrium choices of trade policies do not depend on the form of product market competition.

We begin by making precise what is required for owners to have "sufficient control" over their managers' incentives. Throughout this section, r, t, x, y will stand for elements of the set $\{p, q\}$ and will be used to denote either price or quantity competition in various contexts.¹² Let $q_i(p_1, p_2)$ be the demand function for product i , $\Theta_i^r \subseteq \mathbb{R}^k$ (where k is a positive integer) be the set of incentive parameters available to owner i when her firm competes by setting r , and θ_i^r be a generic element of Θ_i^r . Let $U_i(p_1, p_2, q_1, q_2 | \theta_i^r, t_j, s_1, s_2)$ be manager i 's utility function conditional on owner i 's incentive parameter choice, θ_i^r , strategy choice t_j by manager j , and subsidy choices s_1 and s_2 .

Holding fixed the governments' subsidies, s_1 and s_2 , let the outcome set for manager i consist of all price-quantity quadruples that:

- i) are consistent with the demand system
- ii) represent a utility maximizing choice for manager i given the strategic choice of manager j , the incentive parameters chosen by owner i , and the two governments' subsidy choices.

The outcome set represents the set of price-quantity quadruples that could occur given that manager i responds optimally to the incentives he is given. If firm i competes by setting $r \in \{p, q\}$ and firm j competes by setting $t \in \{p, q\}$, denote the outcome set for player i by:

$$\Omega_i^{rt}(\theta_i^r | s_1, s_2) = \left\{ (p_1, p_2, q_1, q_2) : q_1 = q_1(p_1, p_2), q_2 = q_2(p_1, p_2), \text{ and } r_i \in \arg \max U_i(p_1, p_2, q_1, q_2 | \theta_i^r, t_j, s_1, s_2) \right\}$$

¹²We will use s_i to denote the particular strategy choice by manager i when he competes by setting s . For example, when $s = p$, $s_i = p_i$ stands for the particular price he chooses.

The set of third-stage equilibrium outcomes when incentive parameters θ_i^r and θ_j^t are chosen is given by the intersection of the two managers' outcome sets $\Omega_i^{rt}(\theta_i^r|s_1, s_2) \cap \Omega_j^{tr}(\theta_j^t|s_1, s_2)$.

Now consider the second-stage equilibrium. Owners choose incentive parameters in order to maximize profit subject to the constraint that the resulting prices and quantities comprise a third-stage equilibrium outcome, given the choice of incentive parameters by the other owner and the governments' subsidy choices. Assuming owner i sets $r \in \{p, q\}$ and j sets $t \in \{p, q\}$ in the second stage, in the first stage the owner solves:

$$\begin{aligned} & \max_{\theta_i^r \in \Theta_i^r} (p_i - c_i) q_i \\ \text{subject to} & \quad (p_1, p_2, q_1, q_2) \in \Omega_i^{rt}(\theta_i^r|s_1, s_2) \cap \Omega_j^{tr}(\bar{\theta}_j^t|s_1, s_2), \end{aligned} \tag{16}$$

where $\bar{\theta}_j^t$ is firm j 's equilibrium incentive parameter choice.

A sufficient condition for the equivalence result to hold is that, holding the rival manager's behavior fixed, the set of behaviors (i.e., outcome sets) the owner can induce on the part of its manager must be the same regardless of whether the managers choose prices or quantities.

Formally, this condition can be stated as:

Outcome Set Equivalence (OSE). For player $i \in \{1, 2\}$, for any $s, t, x, y \in \{p, q\}$, and any $\theta_i^s \in \Theta_i^s$, there exists a $\theta_i^x \in \Theta_i^x$ such that $\Omega_i^{xy}(\theta_i^x) = \Omega_i^{st}(\theta_i^s)$.

If condition *OSE* holds, the distinction between price, quantity, and mixed competition reduces to mere differences in the naming of outcome sets. The equivalence of outcomes in the delegation game follows immediately.

Proposition 2: *If OSE holds, then, for any choice of subsidies by the governments, the set of equilibrium outcomes of the delegation game are the same regardless of whether the firms compete in prices, quantities, or one firm chooses price and the other chooses quantity.*

Proof: Suppose that firm i sets r and firm j sets t in the second stage competition. We will show that the same prices and quantities are an equilibrium outcome when firm i sets x and firm j sets y . firm i 's profit maximization problem is:

$$\begin{aligned} & \max_{\theta_i^r \in \Theta_i^r} (p_i - (c_i + s_i)) q_i \\ \text{subject to} & \quad (p_1, p_2, q_1, q_2) \in \Omega_i^{rt}(\theta_i^r) \cap \Omega_j^{tr}(\bar{\theta}_j^t). \end{aligned} \tag{17}$$

The firm does not directly care about the incentive parameters; only the prices and quantities are payoff relevant. The set of feasible prices and quantities is given by:

$$\left\{ (p_1, p_2, q_1, q_2) : (p_1, p_2, q_1, q_2) \in \Omega_i^{rt}(\theta_i^r) \cap \Omega_j^{tr}(\bar{\theta}_j^t) \text{ for some } \theta_i^r \in \Theta_i^r \right\}. \quad (18)$$

By OSE : i) there exists a $\hat{\theta}_j^y \in \Theta_j^y$ such that $\Omega_j^{tr}(\bar{\theta}_j^t) = \Omega_j^{yx}(\hat{\theta}_j^y)$, and ii) the set of feasible outcome sets for manager i when i sets r and j sets t are identical to the set of feasible outcome sets for manager i when i sets x and j sets t . Hence (18) is identical to:

$$\left\{ (p_1, p_2, q_1, q_2) : (p_1, p_2, q_1, q_2) \in \Omega_i^{xy}(\theta_i^x) \cap \Omega_j^{yx}(\hat{\theta}_j^y) \text{ for some } \theta_i^x \in \Theta_i^x \right\}.$$

Since the feasible set in

$$\begin{aligned} & \max_{\theta_i^x \in \Theta_i^x} (p_i - (c_i + s_i)) q_i \\ \text{subject to} & \quad (p_1, p_2, q_1, q_2) \in \Omega_i^{xy}(\theta_i^x) \cap \Omega_j^{yx}(\hat{\theta}_j^y) \end{aligned}$$

is the same as in (17) and only prices and quantities are payoff-relevant, firm i must choose an incentive parameter that results in the same prices and quantities as in (17), provided that one exists. By OSE, there exists a $\hat{\theta}_i^x \in \Theta_i^x$ such that $\Omega_i^{rt}(\bar{\theta}_i^r) = \Omega_i^{xy}(\hat{\theta}_i^x)$, which implies the same prices and quantities, and so $\hat{\theta}_i^x$ is a best response to $\hat{\theta}_j^y$. Reversing the roles of i and j completes the proof. ■

While OSE is sufficient for Proposition 2, it is by no means necessary. MP decompose OSE into two weaker conditions, termed Replication and Feasibility, that also imply Proposition 2. See MP pp. 292-293 for details.

Proposition 3: *If OSE holds, then the equilibrium trade policies do not depend on the form of product market competition.*

Proof: Suppose that $M1$ competes by setting $x \in \{p, q\}$ in the product market, while $M2$ competes by setting $y \in \{p, q\}$. Let $Q^{xy}(s_1, s_2)$ denote the (non-empty) set of equilibrium quantity vectors of the delegation game. In the first stage, the G_i chooses s_i in order to maximize domestic welfare, subject to the constraint that the resulting prices and quantities comprise an equilibrium of

the delegation game. Hence G_i 's problem is written:

$$\begin{aligned} & \max_{s_i} (p_i - c_i) q_i & (19) \\ \text{subject to } & (q_1, q_2) \in Q^{xy}(s_i, s_{3-i}), \text{ and} \\ & q_i = q_i(p_1, p_2). \end{aligned}$$

A pair of trade policies (s_1^*, s_2^*) (along with the resulting equilibrium of the delegation game) comprise an equilibrium of the three-stage strategic trade game if s_i^* solves (19) when $s_{3-i} = s_{3-i}^*$, for $i = 1, 2$.

By Proposition 2, $Q(s_1, s_2)$ is invariant to the form of product market competition whenever Replication and Feasibility hold. Hence $Q^{xy} = Q^{rt}$ for $r, t, x, y \in \{p, q\}$, from which Proposition 3 is immediate.