Chapter 27

STRATEGIC TRADE POLICY

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Contents

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1. Introduction

The meaning of the term "strategic trade policy" is not completely self-evident, and different researchers have used the term in slightly different ways. In this chapter I define strategic trade policy to be trade policy that conditions or alters a strategic relationship between firms. This definition implies that the existence of a strategic relationship between firms is a necessary precondition for the application of strategic trade policy.

By a strategic relationship I mean that firms must have a mutually recognized strategic interdependence. More formally, the payoffs (profits) of one firm must be directly affected by the individual strategy choices of other firms, and this must be understood by the firms themselves. Strategic trade policies would therefore not arise under perfect competition, nor under pure monopoly unless potential entry were an important consideration. Monopolistic competition may or may not incorporate strategic interaction depending on how it is interpreted and modelled, but typically does not [as, for example, in Krugman (1980)]. Accordingly, strategic trade policy as defined here amounts to the study of trade policy in the presence of oligopoly.

The analysis of strategic trade policy is part of a broader research agenda that has been very active since the beginning of the 1980s. Over this period, international trade economists have sought to incorporate oligopoly and other forms of imperfect competition into the formal analysis of international trade and trade policy so as to make contact with important empirical regularities and policy concerns. Traditional trade theory based on perfect competition did not effectively explain phenomena such as intra-industry trade and the high volume of trade between similar countries. Furthermore, such models failed to successfully incorporate some important policy-relevant considerations, such as firm-level increasing returns to scale, learning-by-doing, R&D, and inter-firm strategic rivalries. Convincing treatment of these topics requires imperfect competition. Oligopoly turned out to have particularly interesting implications because it allows trade policy to take on an additional role not present under other market structures. This leads to the central game-theoretic insight of strategic trade policy: intervention to alter the strategic interaction between oligopolistic firms can itself be an important basis for trade policy.

As is often the case in economics, the academic use of the term strategic trade policy differs from the way the term is used in political debate, where it has at least two other distinct meanings. First, strategic trade policy sometimes refers to trade policy that has direct military implications. Secondly, the term strategic is sometimes used simply as a synonym for important; thus strategic trade policy is trade policy targeted toward industries that are thought to be important for some reason. Neither of these definitions is considered further, although an industry that is strategic by one of these definitions might also be strategic in the game theoretic sense used here.

The focus in this chapter will be normative, in that governments will be assumed to maximize some measure of national economic welfare, rather than having their behavior determined by more fundamental individual actions such as voting or lobbying. Political economy is covered in Chapter 28 of this volume. As implied by the definition of strategic trade policy given above, this chapter does not cover trade policy in the presence of monopolistic competition. Building on the positive analysis of trade under monopolistic competition in Helpman and Krugman (1985) and elsewhere, analysis of some associated trade policy issues can be found in Venables (1987) and Lancaster (1991). This chapter also does not cover the substantial literature on pure strategic interactions between governments [started by Johnson (1954)] in which firm-level behavior is either perfectly competitive or suppressed entirely. Much of the material in this area (up to the mid-1980s) is reviewed in McMillan (1986).

Strategic trade policy is such a heavily surveyed field that I will not attempt to provide a full list of earlier surveys, as any such attempt would surely be incomplete and I have no wish to invite the wrath of excluded authors. Widely cited earlier overviews include Dixit (1987), Krugman (1987), and Helpman and Krugman (1989). This chapter begins its coverage of trade policy where the previous volumes of the Handbook of International Economics left off in 1984, so there is some overlap with other published surveys. However, in addition to offering my best attempt at a clear, accurate, and interesting exposition of the main ideas, this chapter seeks to provide significant value added, or at least product differentiation, in several dimensions.

First, I have the obvious opportunity to include more recent material than is discussed in earlier surveys. While this chapter does not come anywhere close to citing all relevant published work, I believe that it is a more complete guide to the literature, at least within the fairly narrow definition of the topic adopted here, than is available in previous surveys. Secondly, there is somewhat more emphasis on the game theoretic structure of strategic trade policy than in most other surveys. Finally, while existing surveys cover a range of levels from highly technical to completely descriptive, my objective is to provide a sufficiently detailed algebraic treatment that a first-year graduate student with little specific knowledge of trade theory or game theory can develop some skill in the technical formulation and analysis of strategic trade policy models. Due to space constraints, however, some material is dealt with purely descriptively.

Section 2 is devoted to the basic game theoretic structure of strategic trade policy. Section 3 sets out what I refer to as the "third-market" model, in which rival oligopolistic exporters from two countries compete only in a third market. The basic strategic export subsidies model is developed in this context, along with some of the more important qualifications and extensions. Section 4 presents the reciprocal-markets model, in which oligopolistic firms in two countries compete in those two countries. In this context, strategic rent-shifting tariffs, subsidies and other instruments are considered. Section 5 reviews some of the major calibrated simulations of strategic trade policy, and Section 6 contains final reflections and concluding remarks.

2. The game theoretic structure of strategic trade policy

The study of strategic trade policy is fundamentally an application of non-cooperative game theory and therefore uses the Nash equilibrium [as first defined by Nash (1950)] as the central equilibrium concept. [A good general reference on game theory is Fudenberg and Tirole (1991).] It is useful to formally define the Nash equilibrium here. Consider a game with n players in which each player i selects strategy s^i from strategy set S^i so as to independently and noncooperatively maximize payoff function $\pi^i(s^1, s^2, \ldots, s^n)$. Let $s^e = (s^{1e}, s^{2e}, \ldots, s^{ne})$ be a feasible vector of strategies, one selected by each player. This vector of strategies is defined to be a Nash equilibrium if, for every player i and every possible strategy choice s^i,

$$\pi^i(s^e) \geq \pi^i(s^e(-i), s^i) \tag{2.1}$$

where $s^e(-i)$ is a vector consisting of the strategies of all players except player i. An equivalent statement is that the Nash equilibrium arises when all players choose strategies such that each player's strategy maximizes that player's payoff, given the strategies chosen by other players.

The Nash equilibrium can be viewed as a rationality concept. If I am a rational participant in a strategic game, in selecting my strategy, I should try to anticipate what strategies my rivals will play and select my best strategy accordingly. I should also recognize that they are trying to anticipate my behavior, and that they know that I am trying to anticipate their behavior. But they know I recognize this, and I know they know, etc. If the Nash equilibrium is unique, it is a consistent solution to this infinite regress problem. Thus the Nash equilibrium has the "no surprises" property that each player plays the strategy anticipated by the other players. The Nash equilibrium is very general in the sense that the strategies can be defined in many ways. A strategy might be a single move such as a one-shot price or quantity decision by a firm, or it might be a complex rule describing some sort of contingent behavior.

The Nash consistency property alone is not sufficient to fully capture the notion of rationality, especially in games with a sequential structure. Consider the following game. A multinational firm is considering building a new plant in a potential host country. There is no other feasible location for the plant. If the firm builds the plant, the firm and the host country would receive net benefits of 10 each. However, the firm would like a subsidy of 5 from the government, raising the firm's benefit by 5 (to 15) and lowering domestic welfare by 5. First the government decides whether to give the firm a subsidy, then the firm decides whether to build the plant. Figure 2.1 illustrates this game in extensive form. The numbers at the bottom of the game tree indicate the payoffs to the government and to the firm, respectively, following from each possible combination of actions.

The payoffs are assumed to be common knowledge (i.e. each player knows them and knows that the other player knows them, etc.). Prior to actually taking their actions, the government and the firm simultaneously decide on their overall strategies.

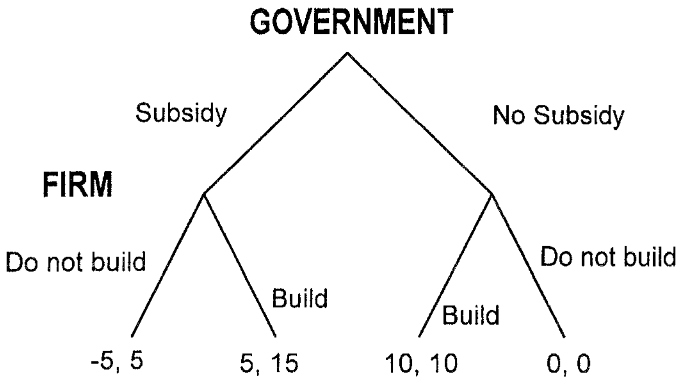

Figure 2.1. *A sequential game*. The first number shows the payoff to government (domestic welfare) and the second shows the payoff to the firm.

There are two Nash equilibria in this game. In one Nash equilibrium, the government's strategy is: ''offer no subsidy'', and the firm's strategy is: ''build the plant whether or not we get the subsidy''. The other Nash equilibrium is for the government's strategy to be: ''provide a subsidy'' for the firm's strategy to be ''build the plant if we get a subsidy and do not build the plant if we do not get a subsidy''.

The second of these two Nash equilibria seems odd. How can not building the plant be part of the firm's equilibrium strategy when the firm would always prefer to build? The answer is that in this Nash equilibrium the firm is never actually called upon to forego the plant, because the part of the game under which this threat arises is not played as part of the equilibrium. It is an ''out-of-equilibrium'' threat, and there is nothing in the Nash equilibrium concept that restricts or disciplines the nature of such threats. Careful inspection shows that the strategies proposed for this equilibrium satisfy condition (2.1). Taking the proposed strategy of the other player as given, neither player has an incentive to deviate.

But giving a subsidy seems irrational in this context, as the government should realize that the firm will always build. However, our intuition about why this is irrational goes beyond the Nash equilibrium and incorporates the idea that even out-of-equilibrium threats should be credible in the sense that a player should actually be willing to carry out a threat if called upon to do so. This requirement seems necessary for sequential rationality. It is equivalent to subgame perfection [first proposed by Selten[1] (1965)], which means that an equilibrium strategy for the full game must have the property that each component of the strategy in every subgame

[1]John Nash and Reinhard Selten were co-winners, along with John Harsanyi, of the 1994 Nobel Prize in Economics for their pioneering work in game theory and its economic applications. Nash's main contribution was the Nash equilibrium and Selten was honored largely for the development of subgame perfection and other 'refinement' concepts.

(including out-of-equilibrium subgames) must itself be a Nash equilibrium in the subgame. This condition can be imposed by backward induction. Starting at the end of each branch of the game tree, we work backwards, asking what each player would do if that part of the game were reached. We assume that earlier players correctly anticipate the outcomes of lower level subgames as we move up the game tree. Any surviving Nash equilibria will be subgame perfect. In the example discussed above, the only remaining Nash equilibrium is that no subsidy is given and the firm builds anyway.

Now consider a game with two firms and a domestic government. The government's payoffs are, as before, taken to be equal to domestic welfare. The government may undertake some trade policy intervention or it may choose not to intervene. To illustrate the point as simply as possible, assume that this is a discrete binary choice, with no discretionary degrees of intervention available. The government moves before the firms. If it intervenes it changes the payoffs to the firms arising from the various possible combinations of actions by the firms. The firms then simultaneously choose their actions. An example of such a game is illustrated in Figure 2.2. The government may choose to intervene or not to intervene. If it does not intervene, then the right hand matrix shows the payoffs to the firms and the government as a function of the strategies chosen by the firms. Firm x may play $x1$ or $x2$ and firm y can play $y1$ or $y2$. In each cell of the payoff matrix, the first number is the payoff to firm x, the second number is the payoff to firm y, and the third number is the payoff to the government (i.e. domestic welfare). If the government chooses to intervene then the payoffs are given by the left-hand matrix. If firm x were a domestic firm and firm y were a foreign firm, then these strategies might be "low output" and "high output", and the intervention might be something like a subsidy to firm x or a tariff on firm y.

This game can be solved by backward induction, insuring that the solution is

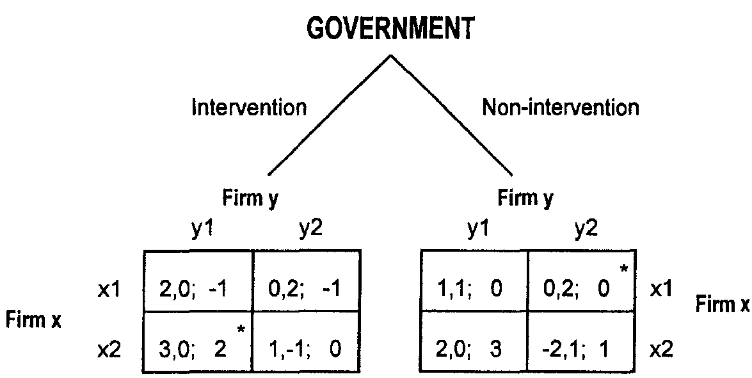

Figure 2.2. *The general structure of strategic trade policy.* In each cell, the first number shows the payoff to firm A, the second number shows the payoff to firm B, and the third number is domestic welfare (the government's payoff).

subgame perfect. If firms find themselves in the right-hand matrix (i.e. where no government intervention has occurred), the solution will be the upper right cell (marked by an asterisk). This is easily seen as $y2$ is a dominant strategy for firm y: if firm x chooses $x1$, then the choice of $y2$ yields 2 rather than 1 to firm y; and if firm x chooses $x2$, then $y2$ yields 1 rather than 0 to firm y. As firm y should certainly choose $y2$, the best firm x can do is to choose $x1$, obtaining 0 rather than the loss of 2 it would suffer if it chose $x2$. The government's payoff would be 0 at the solution.

If, on the other hand, firms were in the subgame represented by the left-hand payoff matrix, $x2$ would be a dominant strategy for firm x, and firm y would accordingly choose $y1$ so as to avoid a loss, yielding the lower left cell (also indicated by an asterisk) as the solution. The payoffs would be 3 for firm x, 0 for firm y, and 2 for the domestic government. Working backwards up Figure 2.2, it then follows that the government would choose intervention, as its payoff would be 2 rather than 0. This is a subgame perfect (or sequentially rational) Nash equilibrium in the 3-player game. Note that the backward induction process presumes that the government correctly anticipates how firms would react to each of its choices.

There are several points to make about this diagram. First, every cell in the left hand payoff matrix has a lower domestic welfare payoff than the corresponding cell in the right hand matrix. This means that government action is costly in a direct sense: conditional on any given strategy combination by the two firms, national welfare would be lower as a result of government action. The national benefit comes about entirely because of the government's ability to alter the strategic interaction between the two firms, leading them to make different strategic choices than they would in the absence of government policy. This strategic effect in this case more than offsets the direct inefficiency of the policy.

The second point to emphasize is the potential generality of this reasoning. This game is similar to the matrix in Krugman (1987) designed to illustrate the reasoning behind the strategic export subsidies analyzed in Brander and Spencer (1985). However, there is nothing in principle that restricts the reasoning to export subsidies as a policy tool, or to any of the other specifics assumed in Krugman (1987) or Brander and Spencer (1985). One could imagine that the policy tool in question might be tariffs, quotas, voluntary export restraints, R&D subsidies or any one of a wide range of policy instruments that can alter the payoffs of oligopolistic firms. Furthermore, we have assumed nothing in particular about where the firms are located, who owns them, or whether the firms' choice variable is price, quantity, an entry decision, R&D, or something else. More firms or more governments could be added, more complicated dynamic or sequential structures could be constructed, and risk and incomplete information could be introduced.

It is not completely obvious that all of these variations could give rise to a payoff structure of the type used in the example. However, the basic insight that strategic interaction between firms creates an opportunity for government action to modify the terms of that interaction is very robust. The precise nature of the implied policy action is, however, very sensitive to the specifics of the underlying model structure.

One necessary assumption is that the government can credibly commit to its policy choice before the firms make their choices. In the game given here, if the government could not commit to its policy and was in a position to renege on its policy action, it would have an ex post incentive to do so. Once firm x has chosen $x2$ and firm y has chosen $y1$, the government would like to withdraw its policy and get to the lower left corner of the right hand matrix, where national welfare (its payoff) is 3 instead of 2. Rational firms would anticipate this. Firm y would then choose $y2$, and firm x would select $x1$, reverting to the non-interventionist equilibrium. Strategic trade policies require some degree of precommitment by governments, as reflected by the assumption that the government moves first in the game tree. Most observers find it plausible that governments often have some sort of commitment advantage, but it is important to be alert for circumstances in which the asymmetry may run in the other direction.

3. Profit-shifting export subsidies in a "third-market" model

3.1. Export subsidies under Cournot duopoly

In the examples given so far, firms' payoffs have been arbitrarily specified as convenient numbers. It is, of course, necessary to model the underlying structure that gives rise to these payoffs. In short, we need to pay some attention to the theory of oligopoly itself. A valuable review of oligopoly theory can be found in Shapiro (1989) and a standard graduate-level textbook is Tirole (1988).

3.1.1. The Cournot model

Much of the analysis of strategic profit-shifting makes use of the Cournot (1838) model of oligopolistic behavior, which can be set out as follows. Assume there are n firms producing a homogeneous product, and consider a representative firm, called firm x, whose profit is denoted π and whose output is denoted x. The other $n-1$ firms produce aggregate output Y and a representative other firm produces output y. The profit of firm x is

$$\pi(x; Y) = xp(x+Y) - C(x)\,, \tag{3.1}$$

where p is the price or inverse demand function (assumed to be downward-sloping) and C is cost. Firms make independent simultaneous one-shot decisions over output levels. Each firm seeks to maximize its own profit. Using a subscript x to denote a derivative taken with respect to x, the first order condition associated with maximization of (3.1) is

$$\pi_x = xp' + p - C_x = 0\,, \tag{3.2}$$

with associated second order condition

$$\pi_{xx} < 0\,, \tag{3.3}$$

where, in this case, $\pi_{xx} = 2p' + xp'' - C_{xx}$. First order condition (3.2) makes it clear that a Cournot equilibrium is a Nash equilibrium in outputs, as (3.2) is implied by (2.1) for the case in which each player's strategy set is simply the set of possible output quantities it might produce in a one-shot simultaneous-move game. The Cournot equilibrium therefore has the same "no surprises" rationality property that any Nash equilibrium has. First order condition (3.2) could be solved in principle for the profit-maximizing choice of x for any given set of output choices by the other firms. This resulting implicit function is the reaction function or best-response function.[2] The common intersection of the n best-response functions (one for each firm) is the Cournot equilibrium.

3.1.2. Strategic substitutes

An additional regularity condition that turns out to be central to the characterization of the Cournot equilibrium is the following.

$$\pi_{xy} < 0\,, \tag{3.4}$$

where $\pi_{xy} = p' + xp''$. This condition obviously holds for all nonconvex demand curves (including linear demand), but it can be violated if demand is very convex. Condition (3.4) is linked to many properties of the Cournot model. It means that each firm's marginal revenue declines as the output of any other firm rises. It is the so-called Hahn stability condition for certain proposed dynamic adjustment mechanisms. (Note, however, that the pure Cournot model is a one-shot static game with no real-time dynamics. Any proposed dynamic adjustment is an extension to the model.) Presuming that second order conditions are globally satisfied, global satisfaction of (3.4) in this context is also the Gale–Nikaido condition for uniqueness of the Cournot equilibrium. Condition (3.4) also ensures that various comparative static properties of the model are "well-behaved". [See Dixit (1986)].

Most importantly, however, condition (3.4) means that strategy variables x and y are strategic substitutes as defined by Bulow, Geanakopolous, and Klemperer (1985). If $\pi_{xy} < 0$, this means that the marginal value, π_x, of increasing firm x's strategy variable decreases when the strategy variable of a rival increases. This implies that an

[2]Note that the response or reaction embodied in the best-response function is purely notional. The reaction function is useful for considering how a firm "thinks through" its strategy selection. It does not, however, capture any real-time action and reaction. In a simultaneous move "one-shot" game, players do not have an opportunity to react to rivals' moves. In the Cournot model, firms make simultaneous output choices, before observing the output choices of rivals, then these output levels are simultaneously revealed, prices adjust to clear the market, payoffs are made, and the game ends.

increase in y would reduce the best-response value of x (i.e. the best-response function for firm x is downward-sloping). If, on the other hand, $\pi_{xy} > 0$, then strategy variables x and y would be ''strategic complements'' for firm x in the sense that an increase in y would raise the best-response value of x. The best-response function for firm x would be upward-sloping in such a case.

3.1.3. The third-market model

Brander and Spencer (1985) incorporated an international Cournot duopoly into a ''third-market'' model to provide a striking demonstration of strategic trade policy. A third-market model is one in which one or more firms from a domestic country and one or more firms from a foreign country compete only in a third market. These firms therefore produce only for export. This simplification turns out to be very useful in allowing the strategic effects of certain trade policies to be seen in pure form, and third-market models have therefore been extensively used in the literature. In a third-market model, a domestic government can do nothing to directly hinder a foreign firm (i.e. there is no scope for import tariffs or quotas), and the natural policy to consider is an export subsidy, whose direct effect is to help a domestic firm vis-à-vis its foreign rival.

The sequential structure of the model consists of two stages. In stage 1 the domestic government sets a subsidy level of s per unit. In stage 2, the domestic and foreign firms simultaneously choose output (or export) levels for the third market. Using backward induction to focus on sequentially rational Nash equilibria for the full game, we consider the second stage of the game first.

3.1.4. Stage 2: Equilibrium outputs and comparative statics

There is a single factor of production in each country, referred to as labor. Labor can be used in the oligopoly sector or it can be used to produce a numeraire good with price 1. Consumers in the foreign and domestic countries consume only the numeraire good. The numeraire good is produced under competitive conditions with constant returns to scale, and labor has the same productivity in the numeraire sector in all countries. Units are selected so that one unit of labor produces one unit of the numeraire good. Assuming that labor is paid its marginal product, the wage is one. In the domestic country, labor input F is required as a fixed input for production of the oligopoly good, and variable input requirements are c units of labor input per unit of output. F and c are therefore simply fixed and variable cost for the domestic oligopolist. Using an asterisk to denote (most) variables associated with the foreign country, foreign fixed cost is denoted F^* and foreign marginal cost is denoted c^*. There is one domestic firm and one foreign firm. The domestic firm produces quantity x and the foreign firm produces quantity y. Profit functions π and π^* for the domestic and foreign firms can therefore be written, respectively, as

$$\pi(x, y; s) = xp(x + y) - cx + sx - F \,, \tag{3.5}$$

$$\pi^*(x, y; s) = yp(x + y) - c^*y - F^* \,, \tag{3.6}$$

with associated first order conditions

$$\pi_x = xp' + p - c + s = 0 \,; \quad \pi^*_y = yp' + p - c^* = 0 \,. \tag{3.7}$$

Conditions (3.3) and (3.4) are also assumed to hold for each firm. By stage 2, subsidy s has been predetermined in stage 1 and is therefore treated as exogenous. Thus the solution to the first order conditions will yield x and y as functions of subsidy s. The comparative static effects $\mathrm{d}x/\mathrm{d}s$ and $\mathrm{d}y/\mathrm{d}s$ can be obtained by totally differentiating first order conditions (3.7) with respect to x, y, and s as follows.

$$\pi_{xx}\,\mathrm{d}x + \pi_{xy}\,\mathrm{d}y + \pi_{xs}\,\mathrm{d}s = 0 \,. \tag{3.8}$$

$$\pi^*_{yx}\,\mathrm{d}x + \pi^*_{yy}\,\mathrm{d}y + \pi^*_{ys}\,\mathrm{d}s = 0 \,. \tag{3.9}$$

Dividing (3.7) and (3.8) through by $\mathrm{d}s$ and using matrix notation yields

$$\begin{bmatrix} \pi_{xx} & \pi_{xy} \\ \pi^*_{yx} & \pi^*_{yy} \end{bmatrix} \begin{bmatrix} \mathrm{d}x/\mathrm{d}s \\ \mathrm{d}y/\mathrm{d}s \end{bmatrix} = \begin{bmatrix} -\pi_{xs} \\ -\pi^*_{ys} \end{bmatrix} \tag{3.10}$$

Noting that $\pi_{xs} = 1$ and $\pi^*_{ys} = 0$ [from (3.7)], these equations can be solved using Cramer's rule to yield

$$\mathrm{d}x/\mathrm{d}s = -\pi^*_{yy}/D > 0 \,; \quad \mathrm{d}y/\mathrm{d}s = \pi^*_{yx}/D < 0 \,, \tag{3.11}$$

where D is the determinant of the left-hand matrix in (3.10). This determinant is $\pi_{xx}\pi^*_{yy} - \pi_{xy}\pi^*_{yx}$. From (3.4), $\pi_{xy}(=p' + xp'') < 0$, so $\pi_{xx}(=2p' + xp'')$ is also negative and larger in absolute value than π_{xy}. A similar pattern applies to π^*_{yy} and π^*_{yx}, implying that D must be positive.

Naturally enough, introducing or increasing an export subsidy to the domestic firm causes the output of the domestic firm to rise and output of the foreign firm to fall. As shown in Figure 3.1, increasing an export subsidy shifts out the best-response function of the domestic firm, because its lower effective cost makes it want to export more for any given export level by the rival. Because x and y are strategic substitutes, as reflected in the downward-sloping best-response functions, we see that the foreign firm is induced to reduce its equilibrium output. It also follows that total quantity rises, price falls, profits of the domestic firm rise, and profits of the foreign firm fall as the domestic export subsidy increases.

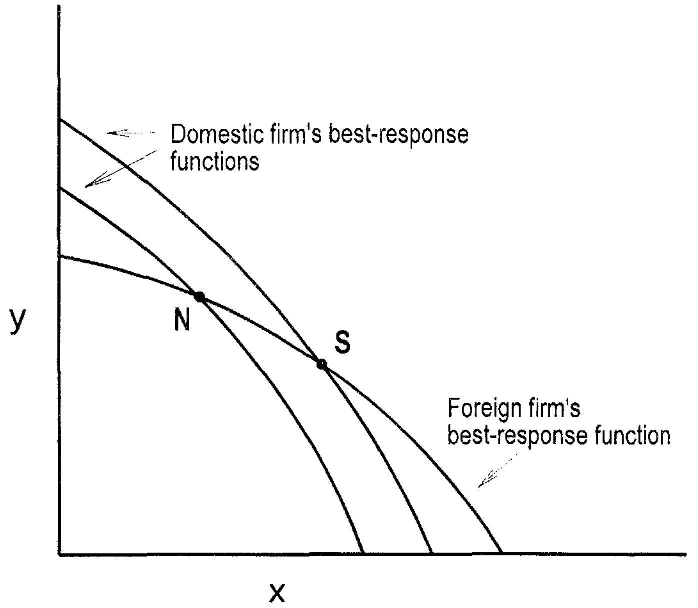

Figure 3.1. *The effects of a domestic export subsidy in a Cournot industry.* An increase in the domestic subsidy causes the output best-response function of the domestic firm to shift out, allowing the domestic firm to increase its market share as the Cournot equilibrium moves from N to S.

3.1.5. Stage 1: The optimal subsidy

We now consider the first stage, when the domestic government sets a subsidy, fully aware of how that subsidy will affect the second-stage values of x and y. The government wishes to maximize domestic welfare, which in this case is equivalent to consumption of the numeraire good, which in turn is equal to net domestic income. Assume that the country's initial endowment of labor is L and that all domestic profits accrue to domestic residents. Then net income is simply $L + \pi - sx$. (The "behind-the-scenes" trade flow is that the numeraire good is exported from the third market to the domestic country in exchange for x.) L is a fixed endowment that can ignored, so incremental domestic welfare, denoted W, is just net profits.

$$W(s) = \pi(x(s), y(s); s) - sx(s)\,. \tag{3.12}$$

At this point it is necessary to clarify some notation. When considering simple functions such as $z = z(x, y)$, the expressions $\mathrm{d}z/\mathrm{d}x$ and z_x are used interchangeably to denote the partial derivative of z with respect to x. The notation $\partial z/\partial x$ is not used. However, in the case of composite functions such as $\pi(x(s), y(s), s)$ it is necessary to distinguish between partial and total derivatives. In such a case, subscript notation such as π_s is used to represent just the pure partial derivative $\partial\pi/\partial s$, while $d\pi/ds$ represents the total derivative.

$$d\pi/ds = \pi_x\, dx/ds + \pi_y\, dy/ds + \pi_s\,. \tag{3.13}$$

The derivative of W [from (3.12)] with respect to s is given by $dW/ds = d\pi/ds - x - s\, dx/ds$. Substituting (3.13) into this expression and noting that $\pi_s(=\partial\pi/\partial s) = x$ yields

$$dW/ds = \pi_x\, dx/ds + \pi_y\, dy/ds - s\, dx/ds\,. \tag{3.14}$$

Noting further that $\pi_x = 0$ by first order condition (3.7) yields

$$dW/ds = \pi_y\, dy/ds - s\, dx/ds\,. \tag{3.15}$$

It is clear from (3.15) that dW/ds is unambiguously positive at $s = 0$ since, from (3.5), $\pi_y = xp'$ is negative (noting that p' is negative) and, from (3.11), dy/ds is also negative. The optimal subsidy can be obtained by setting dW/ds to zero and rearranging.

$$s^0 = \pi_y(dy/ds)/(dx/ds) > 0\,. \tag{3.16}$$

It is useful to link the formula given by (3.16) for the optimal subsidy to the strategic substitutes condition given by (3.4). Substituting for dx/ds and dy/ds from (3.11) into (3.16) yields

$$s^0 = -\pi_y \pi^*_{yx}/\pi^*_{yy}\,. \tag{3.17}$$

The denominator of (3.17) must be negative by second order conditions, and $\pi_y(=xp')$ is negative, essentially because x and y, as homogeneous products, are necessarily gross substitutes in the inverse demand function. Thus the sign of s^0 is implied by the sign of π^*_{yx}. If, as assumed here, x and y are strategic substitutes, then π^*_{yx} is negative, and the optimal subsidy is positive. If x and y were strategic complements $(\pi^*_{yx} > 0)$, then the optimal policy would be to tax exports. In such a case, the tax would be a facilitating device (i.e. facilitating a more collusive outcome) rather than a profit-shifting device.

The optimal subsidy can be viewed in more concrete form if a specific demand function is assumed. In the case of linear demand of the form $p = a - Q$, where $Q = x + y$, expression (3.16) [or (3.17)] reduces to

$$s^0 = a/4 - c/2 + c^*/4\,. \tag{3.18}$$

Linear demand implies that x and y are strategic substitutes, so s^0 must be positive. [Combinations of a, c and c^* that would apparently make s^0 negative in (3.18) are inconsistent with positive domestic output.] Note that the optimal subsidy is increasing in the relative cost advantage of the domestic firm. Firms that ''need'' help to compete with foreign rivals are the least attractive targets for strategic assistance from a welfare-maximizing government's point of view. [Further analysis of firm asymmetries in the strategic subsidies model can be found in De Meza (1986) and Neary (1994).]

3.1.6. Profit-shifting

Expression (3.16) implies the noteworthy result that there is a domestic rationale for offering the domestic firm an export subsidy, even though the subsidy payment itself is just a transfer. The key point is that gross profits to the firm rise by more than the amount of the subsidy, implying a net gain to the domestic economy. The net benefit comes about because the subsidy has the effect of committing the domestic firm to a more aggressive best-response function (as shown in Figure 3.1) which in turn induces the foreign firm to produce less. The optimal domestic subsidy moves the domestic firm to the Stackelberg leader output level, while the foreign firm produces the Stackelberg follower output. In effect, the government is able to convert its first-mover advantage into an equivalent advantage for the domestic firm.

This model fits the structure of Figure 2.2. The domestic government has an incentive to take a prior policy action that alters the strategic interaction between firms. In this case, the subsidy policy implies a terms of trade loss for the domestic country, but there is a profit-shifting effect that more than offsets this terms of trade effect. The subsidy acts to shift profits from the foreign firm to the domestic firm. Profit-shifting can therefore be viewed as a rationale for trade policy intervention that is quite distinct from terms of trade effects and rationalization (or scale) effects.

3.2. Extensions of the Cournot strategic subsidies model

The strategic subsidies model presented in Section 3.1 abstracts from many things that we know to be important. However, quite a few extensions, generalizations, and qualifications can be readily established.

3.2.1. Two active governments: A prisoner's dilemma

Perhaps the first point to observe is that allowing the foreign government to be active simultaneously with the domestic government does not affect the structure of the analysis. In such a case, the foreign firm's profit function given by (3.6) must have s^*y added to it, where s^* is the foreign subsidy. Output levels x and y then depend on both s and s^*, but comparative static effects $\mathrm{d}x/\mathrm{d}s$ and $\mathrm{d}y/\mathrm{d}s$ have exactly the form given in (3.11). Effects $\mathrm{d}x/\mathrm{d}s^*$ and $\mathrm{d}y/\mathrm{d}s^*$ have symmetric structures. In the stage 1 game, we allow governments to simultaneously choose subsidy levels s and s^*. The welfare function, W^*, of the foreign government is the analog of the domestic welfare function given by (3.12). The derivative $\mathrm{d}W/\mathrm{d}s$ has the form given in (3.15) and $\mathrm{d}W/\mathrm{d}s^*$ has an analogous form. Simultaneous solution of the two first order conditions $\mathrm{d}W/\mathrm{d}s = 0$ and $\mathrm{d}W^*/\mathrm{d}s^* = 0$ then yields the solution values of s and s^*, which are given by (3.16), and an analogous expression for s^*. Thus the qualitative properties of the solution are as before. Provided x and y are strategic substitutes, both governments provide positive subsidies. Under symmetry, this government-level game has the general form of a prisoner's dilemma, as both producing countries are worse off at the strategic subsidy equilibrium than they would be under free trade, but each has a unilateral incentive to intervene.

3.2.2. *The opportunity cost of public funds*

In the preceding analysis subsidy dollars and profit dollars have been treated as equivalent. As implied by welfare function (3.12) the government is indifferent about pure transfers from the domestic treasury to the firm's shareholders (or vice versa). In practice, however, raising subsidy revenue imposes distortionary costs on the economy, implying that the opportunity cost of a dollar of public funds would exceed 1. [The discussion in, for example, Ballard et al. (1985) suggests an opportunity cost in the range of 1.17 to 1.56 per dollar raised.] In this case the welfare function would be written as

$$W = \pi - \delta s x \,, \tag{3.11'}$$

where $\delta > 1$. This case has been analyzed by Neary (1994) following similar work by Gruenspecht (1988). Proceeding from (3.11′) yields the following expression.

$$\mathrm{d}W/\mathrm{d}s = xp'\,\mathrm{d}y/\mathrm{d}s - (\delta - 1)x - \delta s\,\mathrm{d}x/\mathrm{d}s \,. \tag{3.15'}$$

If we consider the value of $\mathrm{d}W/\mathrm{d}s$ at $s = 0$, the third term disappears, but it is no longer obvious that $\mathrm{d}W/\mathrm{d}s$ is positive. The first term is positive, as in (3.15), but the second term is negative and may more than offset the first term. Thus, as expected, if δ is sufficiently high, the implied policy is a tax rather than a subsidy.

Two other important concessions to reality lead to essentially the same formulation. First, if the domestic government simply puts less weight on shareholders' welfare than on taxpayers' welfare for income distributional or other reasons, then (3.11′) would apply. In addition, if some of the domestic firm's shareholders are foreign rather than domestic residents, then presumably the share of profits received by foreigners would not count in domestic welfare. In this case the relative weight on profits should be less than the weight on (domestically funded) subsidies, as implied by (3.11′). This point is examined by Lee (1990), and Dick (1993) carries out some related empirical analysis.

3.2.3. Multiple domestic and foreign firms

The analysis so far has been carried out for the case of duopoly, where strategic interactions arise most starkly, but there is always some concern that results obtained for a duopoly might be diluted if the number of firms were to increase. The effect of exogenously increasing the number of firms has been examined by Dixit (1984). Dixit actually carries out the analysis in a reciprocal-markets model (as described in Section 4), but the argument is simplest in a third-market model. With n domestic Cournot firms and n^* foreign Cournot firms, the effect of a domestic subsidy on the ith domestic firm's profit is

$$\mathrm{d}\pi^i/\mathrm{d}s = (\mathrm{d}\pi^i/\mathrm{d}x^i)x^i_s + (n-1)(\mathrm{d}\pi^i/\mathrm{d}x^j)x^j_s + n^*(\mathrm{d}\pi^i/\mathrm{d}y)y_s + \pi^i_s\,, \qquad (3.19)$$

where x^j is the output of a representative domestic rival and y is the output of a representative foreign rival.

Comparing this with expression (3.13) indicates a new consideration, corresponding to the second term of expression (3.19). Specifically, a domestic subsidy now has the effect of increasing the output of domestic rivals. This effect tends to reduce the profit of the ith domestic firm and is an additional cost of a domestic subsidy. If n were large and n^* were negligible, then a subsidy would certainly be damaging to the national interest, as domestic firms would compete excessively from the national point of view. National welfare would be enhanced by imposing an export tax, moving domestic firms closer to the cartel output. (This is just the standard terms of trade argument for intervention.) Conversely, as the number of foreign firms grows relative to the number of domestic firms, a subsidy to the domestic firms becomes more attractive.

3.2.4. Multiple oligopolies

One striking aspect of the early examples of strategic trade policy is their apparent abstraction from traditional general equilibrium considerations. Indeed, the basic ideas have frequently been presented in a purely partial equilibrium setting, although alert readers will have noticed that the economic environment considered in Section 3.1 is a full, albeit highly simplified, general equilibrium model. The assumptions that there is a single factor of production, that the rest of the economy can be aggregated into a single numeraire sector, and that utility is linear in income serve, however, to eliminate many of the usual general equilibrium issues from consideration.

Dixit and Grossman (1986) relax the assumption that there is only one oligopoly in an otherwise undistorted numeraire economy. They assume that there are several Cournot oligopoly industries, with one domestic and one foreign firm each, all with sales only in third markets. They also assume two factors of production, "workers" and "scientists", rather than just one. Scientists are specific to the oligopolistic sector. In the extreme version of the model, production in the oligopoly sector uses a fixed proportions technology, so aggregate output in the sector is constrained to be proportional to the (fixed) supply of scientists. It is clear that such a structure will greatly diminish any value of strategic subsidies, for an expansion of one duopoly firm and the associated profit-shifting benefit must come at the cost of contraction by another duopoly firm and an associated profit-shifting loss. Gains can come only from shifting output toward those firms with the most attractive profit-shifting opportunities and away from those with less attractive opportunities, implying a subsidy for some firms and a tax for others.

If the domestic government were constrained to offer a uniform subsidy and the oligopoly sector were symmetric, then a subsidy would have no benefit and free trade would be optimal. If, more realistically, there are some substitution possibilities between scientists and workers in the oligopoly sector, then the aggregate incentive for a subsidy is restored, although in weakened form. Thus a partial-equilibrium analysis that focuses on just one industry at a time might give an excessively favorable view of strategic intervention.

Dixit and Grossman consider "scientists" to be the scarce resource, but any other input with similar properties would do. Scientists are, however, of particular interest. In practice, there is substantial mobility of scientists across countries, which has led to a long-standing concern with the "brain drain" problem. For an interesting analysis and calibration of strategic trade policy in the presence of internationally mobile scientists see Ulph and Winters (1994) who find, among other things, that R&D subsidies to the high-tech sector are attractive precisely because they attract scientists and engineers from other countries, which has nationally beneficial profit-shifting and terms of trade effects.

3.3. Strategic subsidies and industry conduct

3.3.1. Conjectural variations and conduct parameters

Section 3.2 considered various worthwhile and intuitively plausible extensions and qualifications of the Cournot version of the third-market model. Another important class of extension is to consider oligopoly models other than the Cournot model. A very influential analysis of this type was undertaken by Eaton and Grossman (1986), who replaced the Cournot model with the so-called conjectural variation model. The conjectural variation language has fallen out of favor because of certain associated logical difficulties, but the technical apparatus of the model remains useful. Industry output is Q and the output of the firm in question (called firm x) is x. Output of all other firms is Y, so $X = x + Y$. Suppose we think of industry output as a function of own output. In the absence of subsidies or fixed costs, we can then write

$$\pi(x) = xp(Q(x)) - cx . \tag{3.20}$$

Mechanically writing down a first order condition arising from maximization of (3.29) yields

$$d\pi/dx = p + xp' \, dQ/dx - c = 0 \,, \tag{3.21}$$

where dQ/dx is the covariation of industry output with own output. We can write $dQ/dx = dx/dx + [dY/dx]_v = 1 + \lambda$, where $\lambda = [dY/dx]_v$. The term $[dY/dx]_v$ was referred to as the "conjectural variation" because it reflects the conjecture that firm x makes concerning how other firms' output would co-vary with its own output. First order condition (3.21) can then be written as

$$d\pi/dx = p + xp'(1 + \lambda) - c = 0 \,. \tag{3.22}$$

A Cournot game is a simultaneous-move one-shot game in which outputs are the strategy variables. To say that firms choose outputs simultaneously means that each firm must choose its output before observing the output of its rivals. Before actually playing its output, a firm can consider the consequence of choosing some output other than the Cournot level. It must recognize, however, that even if it surprised other firms by playing some such deviation, by the time other firms observed this deviation, it would be too late for them to change their outputs in response. A consistent interpretation of the Cournot model is that firms commit to output levels, and prices then adjust to clear the market. A firm contemplating a deviation from the Cournot output level would imagine that prices would adjust when outputs were brought to the market, but quantities would not. Therefore, $\lambda = 0$ is the "correct" conjectural variation for the Cournot model. Note that with $\lambda = 0$, (3.22) coincides with (3.2) as required.

A Bertrand game is a simultaneous-move one-shot game in which prices are the strategy variables. The Bertrand model can be thought of as a model in which firms simultaneously commit to price levels, then quantities adjust to clear the market. If one firm contemplates choosing a price other than its Bertrand equilibrium price, it must recognize that if it played this deviant strategy as its part of the simultaneous price announcements made by all firms, then other firms could not, by the definition of the game, adjust their prices. This implies that the output levels of both the deviant firm and the other firms must adjust from their Bertrand equilibrium levels so as to clear the market. In this case, therefore, the firm should anticipate a non-zero covariation between other firms' output and its own. For a Bertrand game, the "correct" conjectural variation in quantities is something other than zero. In fact, with homogenous products, λ takes on the value -1, and we can see from (3.22) that this yields $p = c$, as required by the homogenous product Bertrand model.

From this reasoning, λ may be called a "conduct parameter" and may be regarded as a representation of the effective degree of competitiveness in the industry. λ indexes the range of possible conduct in the industry, from cutthroat competition to full collusion. (If there are n identical firms, then $\lambda = n - 1$ will yield the cartel or monopoly outcome.) This conduct parameter (or conjectural variation) formulation is not a true game form, as strategy spaces are not clearly identified for all values of λ, but it can be a very useful model in empirical applications, because λ can be readily estimated or calibrated, as discussed in Section 5.

3.3.2. *Product differentiation*

For the Cournot model, the assumption of homogeneous (rather than differentiated) products allows simpler notation and improved clarity. Note, however, that everything that has been done so far can be readily extended to the case of differentiated products. With product differentiation, let $p(x, y)$ represent the price of good x, and let $r(x, y)$ be the price of good y. Assume that price is declining in own output and in the rival's output (i.e. that goods are substitutes). Therefore $\pi_y(=xp_y) < 0$. For the Cournot model, provided that we require $\pi_{xy} < 0$ (strategic substitutes), then comparative static effects and trade policy implications apply exactly as already derived. For the duopoly version of the conduct parameter formulation we would rewrite (3.22) as

$$\pi_x = p + xp_x + xp_y\lambda - c = 0 . \tag{3.22'}$$

Under Bertrand competition, the case of product differentiation is more analytically convenient than the homogeneous product case. The homogeneous product case is logically consistent, but demand and profit are discontinuous at the equilibrium price, as a slight increase in price by one firm would cause its sales and price to drop to zero. Any analysis making use of derivatives therefore becomes cumbersome to carry out.

Accordingly, to analyze the effects of market conduct other than Cournot on the strategic export subsidies argument, Eaton and Grossman (1986) use a differentiated product version of the conduct parameter model. [See also Cheng (1988).] Eaton and Grossman considered ad valorem subsidies, but the structure of their results is unaffected if we continue to use specific subsidies. Except for introducing a conduct parameter and reinterpreting the model as allowing product differentiation, the structure is identical to the duopoly model of Section 3.1. The domestic firm's profit can be written as $\pi(x, y(x))$ and foreign profit can be written $\pi^*(x(y), y)$. The associated first order conditions for domestic and foreign firms can then be written as

$$\mathrm{d}\pi/\mathrm{d}x = \pi_x + \pi_y\lambda = 0 , \tag{3.23}$$

$$\mathrm{d}\pi^*/\mathrm{d}y = \pi^*_y + \pi^*_x\lambda^* = 0 , \tag{3.24}$$

where subscripts denote partial derivatives and λ^* is used to denote the foreign firm's conduct parameter.

3.3.3. Optimal subsidies and taxes

As before, expression (3.14) shows the welfare effect of a change in s, where $\mathrm{d}x/\mathrm{d}s$ and $\mathrm{d}y/\mathrm{d}s$ are the actual comparative static effects of s on equilibrium outputs x and y. As just noted, with product differentiation, $\pi_y = xp_y$. Then, from (3.23), $\pi_x = -xp_y\lambda$. Substituting these values for π_x and π_y into (3.14) and defining $\gamma = (\mathrm{d}y/\mathrm{d}s)/(\mathrm{d}x/\mathrm{d}s)$ then gives the expression

$$\mathrm{d}W/\mathrm{d}s = (\gamma - \lambda)xp_y\, \mathrm{d}x/\mathrm{d}s - s\, \mathrm{d}x/\mathrm{d}s\,. \tag{3.25}$$

Setting (3.25) to zero and solving for the optimal subsidy yields

$$s^0 = (\gamma - \lambda)xp_y\,. \tag{3.26}$$

Under Cournot competition, $\lambda = 0$, and this reduces to the Brander–Spencer optimal subsidy for the Cournot model. If, on the other hand, competition is of the Bertrand type, then λ is negative and the optimal "subsidy" turns out to be negative. The domestic government would have an incentive to tax exports, exactly the reverse of the Brander–Spencer result. If market conduct happened to be such that $\lambda = \gamma$, then free trade would be optimal. Expression (3.26) embodies a remarkable result, for the policy conclusion of the strategic subsidies model is seen to be exactly reversed by assuming Bertrand rather than Cournot competition.

3.3.4. A generic strategic model

Consider a "generic" strategic model in which there are two rival firms, firm A and firm B, with strategy variables or activities A and B respectively. The firms choose A and B simultaneously. At this point A and B could be anything, possibly outputs, possibly prices, possibly R&D, or possibly something else. We imagine that activity A might be subsidized or taxed at rate s per unit. We can write the profit of firm A as $\pi(A, B; s)$. Its first order condition is $\pi_A = 0$, and its second order condition is $\pi_{AA} < 0$. The other firm, whose profit is denoted $\pi^*(A, B)$, has comparable first and second order conditions. This structure is exactly parallel to that developed in Section 3.1, except that here we have A and B instead of x and y. It follows immediately that the expression for the optimal subsidy has exactly the same form as (3.17).

$$s^0 = -\pi_B \pi^*_{BA}/\pi^*_{BB}\,. \tag{3.17$'$}$$

The denominator must be negative. Therefore, whether there is an incentive to tax or subsidize activity A depends on the sign of π_B and the sign of π^*_{BA}. If $\pi_B < 0$, then an increase in the rival's strategy variable lowers the profit of firm A. In this case I will refer to activity B as "unfriendly" to firm A. If $\pi_B > 0$, then B is "friendly". As is now familiar, if $\pi^*_{BA} < 0$, then A and B are strategic substitutes (for firm B), and if $\pi^*_{BA} > 0$, then A and B are strategic complements (for firm B). If A and B are outputs of identical or similar products, we have the case of Section 3.1. If strategy variables A and B are prices, we have the Bertrand case as just considered, where A and B will normally be strategic complements, and B will be friendly. The implied policy is that higher prices should bring forth higher subsidies. Because higher prices are associated with lower export demand, this implies an export tax.

Diagrammatically, the Bertrand model implies that price best-response functions of both firms are upward-sloping. A domestic export tax commits the domestic firm to a higher gross price for any given price chosen by the rival, so the domestic firm's price best-response function shifts up. This is illustrated in Figure 3.2 for the case of differentiated products. By committing the domestic firm to a less aggressive best-response function, the domestic government induces the foreign firm to charge a higher price, which in turn benefits the domestic country.

In the Cournot case, the domestic firm would like to threaten production of the Stackelberg output level (which is higher than the Cournot level), if only it could persuade its rival that this threat were credible. Note that because output increases are "unfriendly", we view the possibility of producing the Stackelberg level of output as a "threat". A subsidy makes this threat credible. In the Bertrand case, by way of contrast, the domestic firm would like to charge a higher price than the standard Bertrand level, if only its rival would take such a price as credible. In this case, because price increases are "friendly", we might view this as a "promise" rather than a threat. An export tax makes this promise credible.

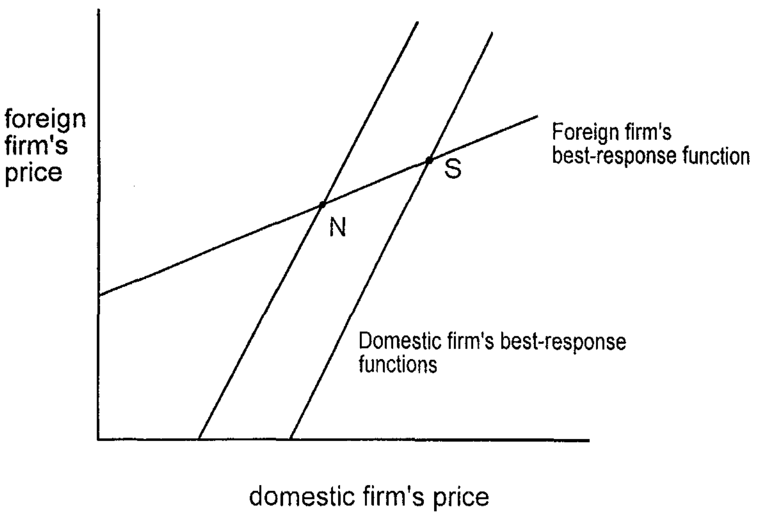

Figure 3.2. *The effects of an export tax in a Bertrand industry.* An increase in a domestic export tax causes the price best-response function of the domestic firm to shift out, inducing an equilibrium price increase for both firms as the equilibrium moves from N to S.

The Bertrand 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.

3.3.5. R&D subsidies

So far, our model of firm behavior is rather spartan in that only output and price decisions have been considered. Many of the industries of greatest policy interest are those where R&D and sunk investments play a prominent role. Furthermore, GATT explicitly forbids export subsidies, but this ban does not extend to R&D subsidies. Possibly for this reason R&D and investment subsidies seem more important empirically than export and production subsidies.

From expression (3.17′) it is possible to immediately infer the implied policy toward R&D by determining whether R&D levels are strategic substitutes and by determining whether R&D is friendly or unfriendly. We would normally expect cost-reducing R&D to be unfriendly in the absence of R&D spillovers, as more R&D means lower production costs, and this can only make rivals worse off. The strategic substitutability or complementarity is less obvious and requires a detailed modelling effort. The first model of strategic R&D subsidies was a three stage third-market model considered by Spencer and Brander (1983). In stage 1 governments consider setting subsidies; in stage 2, firms simultaneously select R&D levels; and in stage 3 firms play a Cournot output game. R&D is assumed to have a deterministic cost-reducing effect. Third stage outputs are functions of second stage R&D levels, implying that the firms themselves use R&D strategically to influence the third stage game. This induces firms to overinvest in R&D relative to cost-minimizing levels. Despite this effect, if only an R&D subsidy is available (i.e. in the absence of export or output subsidies) R&D levels still turn out to be strategic substitutes and the implied policy is an R&D subsidy.

Bagwell and Staiger (1994) consider a similar model, except that they allow the effects of R&D to be explicitly stochastic, making the model both more difficult and more realistic as a representation of real R&D. In light of the Eaton–Grossman policy reversal results described in Section 3.3.2, Bagwell and Staiger consider both Cournot and Bertrand output market competition. Strikingly, for the case in which R&D simply reduces the mean but does not change the variance of the cost distribution, they find that R&D choices are strategic substitutes regardless of the nature of downstream competition. This suggests that R&D subsidies might be more robust than export subsidies as strategic policy tools.

Bagwell and Staiger also incorporate the firm numbers effect discussed in Section 3.2.3 taking into account the potential restraining effect of R&D taxes on domestic firms who would otherwise compete excessively with one another. As before, whether a tax or subsidy is required depends on relative numbers of foreign and domestic firms and on various model parameters. Note, however, that any positive R&D spillovers between domestic firms would favor subsidization. Bagwell and Staiger also show that the incentive to tax or subsidize depends on the structure of uncertainty. In particular, if R&D changes the variance as well as the mean of the cost distribution, then additional strategic considerations arise.

3.4. Timing

An intriguing but under-appreciated aspect of strategic trade policy analysis is the crucial importance of timing in decisions. In the games considered so far, governments are assumed to move before firms. But, as argued persuasively by Carmichael (1987), some interventions may have the reverse order. For example, Carmichael quotes Congressional testimony from a former Chairman of the United States Export–Import Bank that exporting firms (such as Boeing) credibly set their prices before the Exim Bank decides on whether and to what extent to subsidize foreign purchases.

3.4.1. Firms move first

In an effort to analyze the implications of this order of moves, Carmichael considers a third-market model in which foreign and domestic duopolistic firms sell differentiated products. Firms play a Bertrand (price-setting) game, and set prices before the government sets a subsidy or tax rate. Gruenspecht (1988) considers a variation of this model in which government revenue has an opportunity cost exceeding one. The basic insight of these papers can be illustrated most simply using a linear demand structure. The model is a two-stage game. In stage 1 the domestic and foreign firms set prices p and r respectively, then in stage 2 the domestic government sets a per-unit subsidy s, taking producer prices p and r as predetermined and therefore fixed. Thus consumers face a net price of $p - s$ for the domestic good. Consumption demand for domestic exports, x, and foreign exports, y, is therefore written as

$$x = a - (p - s) - br\,; \quad y = a - r - b(p - s)\,, \tag{3.27}$$

where $b < 1$. The second stage objective function maximized by the domestic government is [as given by (3.11′)], $W = \pi - \delta sx$, where $\delta \geq 1$, reflecting a possible distortionary cost of raising government revenue. The domestic firm receives gross price p for its product, s of which comes from the domestic treasury. Domestic welfare can then be written $W = px - cx - F - \delta sx$, where, as before, c and F are marginal and fixed cost. Substituting from (3.27) for x and rearranging then yields

$$W = (p - c - \delta s)(a - (p - s) - br) - F\,. \tag{3.28}$$

Taking p and r as given, the domestic government's welfare-maximizing choice of s is characterized by first order condition $\mathrm{d}W/\mathrm{d}s = 0$, which implies the following solution for s.

$$s = p(1+\delta)/2\delta - c/2\delta - a/2 + br/2\,. \tag{3.29}$$

If there is no distortionary cost of raising government revenue, so profit dollars and subsidy dollars are both given weight 1, then $\delta = 1$, and we see from (3.29) that $\mathrm{d}s/\mathrm{d}p = 1$. This is the case considered Carmichael (1987). It implies that the government would exactly offset stage 1 price increases by the domestic firm with higher subsidies, on a dollar for dollar basis. In essence, given any particular price set by the foreign rival, there is only one profit and welfare maximizing net consumer price for good x. If the domestic firm sets its producer price above this level, a welfare-maximizing government must use its subsidy to restore this net consumer price. Such a government is trapped by its own good intentions.

In this setting, the domestic firm would choose an infinitely high price in stage 1, as this would guarantee an infinite profit. To eliminate this possibility, Carmichael imposes an ''eligibility'' requirement that limits the maximum mark-up. Gruenspecht's analysis allows $\delta > 1$, in which case we can see from (3.29) that $\mathrm{d}s/\mathrm{d}p = (1+\delta)/2\delta < 1$. In this more realistic version, the domestic firm adopts a finite mark-up above the Bertrand level and the domestic government provides a partially offsetting subsidy. These results offer a striking contrast to the Bertrand version of the export subsidy game discussed in Section 3.3.3, where the optimal domestic policy is to tax exports. By having the government move after rather than prior to firms, the optimal tax switches to a subsidy.

3.4.2. Non-intervention as a strategic choice

One interesting feature of Carmichael (1987) is that the subsidy program as a whole is of no value. If the government could simply abolish the program altogether, it would lose nothing by doing so. With the program in place, however, and anticipated by firms, a positive subsidy becomes optimal because of the actions taken by firms prior to the subsidy decision. This suggests that we need to consider the government's prior decision to implement the subsidy program, as distinct from its later decision to select a particular subsidy level.

Because the subsidy is set after firms have made their strategy decisions, the Carmichael–Gruenspecht (CG) model does not fit the general game structure of Figure 2.2, and one might argue that the CG subsidy is not really a strategic trade policy at all, at least as I have defined the term. However, in this case, it is really the decision to implement a subsidy program in the first place that is the strategic trade policy, as this decision certainly affects the strategic rivalry between firms.

The importance of distinguishing between the implementation and design of a policy program, and the level of the policy instrument arises explicitly in papers by Cooper and Riezman (1989), Arvan (1991), and Shivakumar (1993), where governments decide in the first stage what policy instrument they will use, then subsequently decide on the level of the instrument. Hwang and Shulman (1994) confront this issue most directly. They consider a three stage third-market duopoly model. In the first stage (which occurs before the resolution of some uncertainty) a foreign and domestic government simultaneously decide whether to use a subsidy instrument, a strict export quantity control or, most significantly, whether to commit to non-intervention. Following this decision, uncertainty is resolved and, in stage 2, if a government committed itself to use either a subsidy or a strict quantity control, it sets the level of this instrument. If, on the other hand, it committed itself to non-intervention, then it has no further choices to make. In the third stage, firms play a duopoly game. Hwang and Schulman consider duopoly of the Bertrand, Cournot, and Stackelberg types.

It is apparent that non-intervention could arise in one of two ways, either by a stage 1 commitment to non-intervention, or by a stage 1 commitment to a policy instrument followed by a situation in which the optimal subsidy happened to be zero or the optimal quantity control equalled the non-intervention level. The main finding is that by introducing non-intervention as a distinct stage 1 policy choice, non-intervention is much more likely to arise than if the policy regime and the level of the policy instrument are chosen simultaneously. In essence, separating the policy decision into two steps yields a very different game than when these two steps are compressed into a single simultaneous decision. Under the sequential two-step process, a government is able to take into account the effect of its stage 1 decision on its stage 2 optimal instrument level and, more importantly, on its rival's stage 2 decision as well.

This general point can be demonstrated very easily using a somewhat simplified algebraic structure. Let government payoffs in the two countries be denoted W and W^*. Suppose that the policy regime choice is represented by ρ and ρ^*, respectively, for the home and foreign governments, and that the stage 2 instruments are denoted s and s^*. To allow a simple demonstration of the point, assume that ρ is a continuous variable rather than being discrete. If decisions over ρ and s are made simultaneously, then the domestic country faces the problem of maximizing $W(\rho, s; \rho^*, s^*)$, and the associated Nash first order conditions are simply

$$W_\rho = 0\,; \quad W_s = 0\,. \tag{3.30}$$

If, on the other hand, decisions over ρ and s are made sequentially, then second stage solutions for s and s^* must be treated as functions of ρ and ρ^*. Thus the objective function of the domestic firm must be written $W(\rho, s(\rho, \rho^*); \rho^*, s^*(\rho, \rho^*))$. The first stage first order condition is then

$$\mathrm{d}W/\mathrm{d}\rho = W_\rho + W_s\, \mathrm{d}s/\mathrm{d}\rho + W_{s^*}\, \mathrm{d}s^*/\mathrm{d}\rho = 0\,, \tag{3.31}$$

and the second stage first order condition will be $W_s = 0$. Substituting $W_s = 0$ into

(3.31) (i.e. using the envelope theorem) still leaves $\mathrm{d}W/\mathrm{d}\rho = W_{\rho} + W_{s^*}\,\mathrm{d}s^*/\mathrm{d}\rho = 0$. This differs from the first order condition given in (3.30) because of the additional strategic effect represented by the term $W_{s^*}\,\mathrm{d}s^*/\mathrm{d}\rho$. In the Cournot version of the Hwang–Schulman example, this term is the analog of the idea that if one government can commit itself to non-intervention at stage 1, then it reduces the optimal stage 2 subsidy chosen by the other country. This is an additional advantage of non-intervention that does not arise when the regime choice and the subsidy level choice are compressed into a single step. Thus the sequential structure of the game is very important in determining policy incentives.

3.5. Dynamics

Most of the work discussed so far involves games in which each player gets to move just once. Single-move games may have a sequential structure as, for example, when a government moves before firms or when one firm moves before another, but such games have no interactive dynamics. A slightly more sophisticated environment allows for multiple moves, as when firms choose R&D levels followed by output levels. In such a case, firms' strategy choices include the capacity to reciprocally condition output decisions on the R&D decisions of rivals. Thus firms react to each other to a limited extent. Even this game, however, is still a "one-shot" game in that firms have only one R&D decision and one output decision to make.

Single-move and one-shot games do not seem to be a very good description of ongoing commercial or government-to-government rivalries. Perhaps the simplest truly dynamic interaction is a pure repeated game between firms, with a government having a single policy move to make at the beginning of the game. Such a game is considered by Davidson (1984) who considers how tariffs affect the ability of foreign and domestic firms to maintain partial collusion using trigger strategies in an infinitely repeated game.

In a related paper, Rotemberg and Saloner (1989) make the interesting point that the imposition of quotas can significantly weaken the ability of foreign and domestic firms to maintain tacit collusion in an infinitely repeated game. In such a game, firms can support collusive or partially collusive outcomes by selecting trigger strategies that require firms to punish rivals by producing high levels of output (or selecting low prices) if rivals defect from the collusive output or price. If, however, quotas are imposed on foreign firms at the free-trade level of imports (or below), then foreign firms can no longer credibly commit to raising output levels in the domestic market in the event of excessive production by domestic firms. Thus domestic firms no longer face as strong an incentive to restrain their output, because foreign rivals cannot punish them. Therefore, firms are able to sustain a lower level of tacit collusion and the industry may become more competitive as a result of quotas.

The next natural step is consideration of repeated government policy decisions.

Collie (1993) considers an infinitely repeated version of the Brander–Spencer (1985) export subsidies model in which, each period, competing governments set subsidy levels and Cournot duopoly firms select output levels. In keeping with the "folk theorem" of repeated games [see, for example, Fudenberg and Tirole (1991, p. 152)], Collie finds that a wide range of alternative outcomes can be supported by infinite horizon trigger strategies. In particular, free trade can be supported if the countries are sufficiently similar and discount rates are sufficiently low. It would follow easily that governments could sometimes also support the jointly optimal solution in which both would impose taxes. The repeated one-shot solution with subsidies is, of course, also a subgame-perfect Nash equilibrium. The basic structure of these results will presumably apply to any full information infinitely repeated game.

More complex (and realistic) dynamic games would allow for repeated price, output, or other decisions against the background of an evolving state variable (like the R&D stock or capital stock of the firms). Note, however, that any game with a repeated game structure exogenously imposes important aspects of timing. Essentially, within a given "period" the analyst always decides whether players move simultaneously or whether one moves before the other, or whether players alternate moves. This choice is often rather arbitrary.

Probably the most descriptively accurate type of game to consider is the "game of timing". In a game of timing, time is normally treated as a continuous variable. There is some interval, possibly open-ended, within which players can make moves. Thus, for example, a government could set or change a tariff at any time. Timing is therefore endogenous. Typically, making a new move is assumed to be costly and, in addition, players may discount the future. Relatively few dynamic models of this type have been studied in the strategic trade policy literature as such models tend to give rise to considerable computational difficulty.

A partial step in this direction is provided by Dockner and Huang (1990) who examine a trade policy model in which oligopolistic firms interact in differential game fashion, but a government trade policy is set exogenously at the beginning of the game. Another example is Cheng (1987), who examines a dynamic version of the model developed by Spencer and Brander (1983) (and obtains similar results to theirs). Cheng also considers the possibility of technological spillovers between firms, which of course strengthens the case for export or R&D subsidies. Another interesting example is given by Driskill and McAfferty (1989) who provide a differential game version of the Eaton–Grossman (1986) model. Brainard (1994) considers a model in which trade policy influences the timing of possible exit by a domestic firm.

3.6. Asymmetric information

One of the major objections to the theory of strategic trade policy is that it presumes too much knowledge on the part of governments. To implement an optimal tax or subsidy, a government must have a good idea of cost, demand, and the nature of conduct in the industry. We might reasonably believe, however, that governments would be less well-informed about such things than the firms themselves. It therefore seems both inevitable and desirable that the role of asymmetric information be formally investigated in strategic trade policy models.

Perhaps the first observation to make is that firms would have an incentive to mislead governments if they could. Recall the formula given by (3.18) for the optimal domestic export subsidy for a third-market Cournot duopoly model with linear demand.

$$s = a/4 - c/2 + c^*/4 . \tag{3.18}$$

The optimal subsidy increases as domestic cost c falls. If c is not directly observable to the domestic government then, as pointed out by Wong (1991), the domestic firm would have an incentive to persuade the government that its marginal cost is lower than it actually is.

The domestic government might, of course, anticipate the domestic firm's incentive to misrepresent its costs. A formal analysis of this problem is contained in Qiu (1994). Qiu assumes that the domestic firm is one of only two possible types: high-cost or low-cost. The domestic firm knows its own costs, but neither the domestic government nor the foreign firm can observe the firm's type, although each knows the distribution from which the type is drawn. The foreign firm's cost is common knowledge. The domestic government may set a menu of per unit and lump-sum subsidies (or taxes), or it may adopt a uniform subsidy program that would apply to all firms.

This structure is familiar from the large literature on informational asymmetries. However, one interesting innovation is that the model contains both screening and signalling. Screening (an action by the uninformed party) is in this case carried out by the domestic government, but signalling (an action by the informed party) also occurs in the sense that the domestic firm signals its type to the foreign firm via its selection from the menu proposed by the domestic government.

A central question in screening and signalling models is whether the solution is a separating equilibrium, in which different types of domestic firm would opt for different subsidy programs, or whether it is a pooling equilibrium, in which all types would choose the same program. In this case, Qiu shows that a domestic government will (for the Cournot duopoly case) choose a menu of subsidy programs that induces separation by firms. Furthermore, the resulting allocation is the same as the allocation that would occur if the government had full information ex ante about the firm's costs. Interestingly, however, Qiu also considers the case of Bertrand competition and finds that the domestic government would then prefer a uniform subsidy program, leading to a pooling equilibrium. The allocation in this case differs from the full information allocation.

The basic intuition of these results is as follows. A separating equilibrium induces greater variance in the foreign firm's strategy variable (output or price) than a pooling equilibrium. Under separation, the foreign firm infers the true cost of the domestic firm before making its strategy selection and adjusts its output or price accordingly. Under pooling, the foreign firm selects price or quantity on the basis of expected cost and therefore its strategy selection does not vary with the domestic firm's type. The welfare effects of inducing variance in the foreign firm's strategy are opposite in the Cournot and Bertrand models. Under Cournot competition, the domestic country gains under separation relative to pooling when the domestic firm proves to be low cost, because this revelation inhibits the foreign firm's output. The domestic country loses from separation relative to pooling when the domestic firm has high costs because the foreign firm produces more than it would under pooling. However, in the low cost case potential profits are higher, so the gains from getting an advantage in this case outweigh the losses from being disadvantaged by separation when costs are high. Thus separation is preferred.

Under Bertrand competition, however, the gains from separation come in the high cost case because the foreign firm charges a higher price, knowing that the domestic firm's price reaction function is in a less aggressive (i.e. higher-priced) position. The losses from separation come in the low cost case as the foreign firm charges a lower price than it would under pooling. Thus, with Bertrand competition, the gains from separation come when the stakes are low and the losses when the stakes are high, so pooling is preferred. As before, this policy reversal is based on whether the strategy variables are strategic substitutes (as in the Cournot model) or strategic complements (as in the Bertrand model).

Brainard and Martimort (1992) consider the same basic economic environment as Qiu in that they too introduce cost-based informational asymmetries into the third market export subsidies model. However, there are several important differences. In Qiu (1994) subsidies have the added advantage of providing a means by which the domestic firm can credibly reveal its costs to the foreign rival when it is advantageous to do so. Brainard and Martimort assume that the foreign firm observes the cost level of the domestic firm, so only the domestic government is uninformed. Thus the signalling benefit of a subsidy is absent, and Brainard and Martimort obtain the result that the government's lack of information weakens the commitment value of a subsidy and reduces the optimal subsidy relative to what it would be under full information.

Collie and Hviid (1993) consider the complementary case, in which the domestic firm and the domestic government know the domestic firm's costs, but the foreign firm does not. In this case [as in Qiu (1994)] the domestic government has a stronger incentive to use an export subsidy because the government's willingness to use a subsidy signals to the foreign firm that the domestic firm is a low-cost firm, inhibiting the foreign rival and providing benefits to the domestic firm over and above the direct value of the subsidy.

The analysis of the effects of informational asymmetries on strategic trade policy is still in its early stages. However, as is clear from the papers just discussed, the analysis will draw heavily from the large existing body of work on principal-agent models. (In essence, the domestic government is a principal and the domestic firm is an agent.) Furthermore, the application of the agency framework to strategic trade policy will be similar in some respects to its application to regulation, which also comprises a large literature. One problem that strategic trade policy will inherit from the general theory of agency is that the range of possible outcomes will be expanded depending on alternative plausible specifications of the information structure and the equilibrium concepts that may be invoked. When this range of possibilities is multiplied by the range of alternative market structures and alternative dynamic specifications, the set of models to be understood expands significantly.

Nevertheless, such models do need to be understood. The existence of informational asymmetries seems both indisputable and important, and we know that markets with even small informational asymmetries may be qualitatively different from markets with symmetric information. It is quite possible that some robust general insights will emerge. For example, the contrasts between Brainard and Martimort (1992), Collie and Hviid (1993) and Qiu (1994) highlight the possible importance of government policy in facilitating strategic information revelation.

3.7. Entry

So far the number of firms has been taken as exogenous, with firms allowed to earn positive above-normal profits. Indeed, shifting these above-normal profits from one firm to another is a central aspect of strategic trade policy. It is, however, important to consider endogenous entry in response to profitable opportunities. At one extreme, the cost structure in a given market might be such that only a few (or perhaps only one) firm can exist successfully. The one (or few) firms who do establish themselves might be very profitable, but potential entrants would expect to make losses. Thus, even though entry is free, supra-normal profits would exist and strategic trade policy models of the type considered previously would apply. Papers by Brander and Spencer (1981), Dixit and Kyle (1985), and Bagwell and Staiger (1992) explicitly consider the use of strategic trade policy to influence entry in markets of this type.

Another possibility is that cost indivisibilities might be small enough relative to overall demand that entry occurs until the excess profits of the marginal firm are driven to precisely zero. This assumption is often combined with the assumption of symmetry among firms. Then, if a marginal firm earns zero profits, all firms earn zero profits. In such a model, strategic profit-shifting effects disappear, as there are no profits to shift. Often the term ''free entry'' is taken to mean this case, in which profits are entirely absent. It is important to recognize, however, that this is an extreme case in which results may be artifacts of the symmetry assumption. More descriptively accurate models would allow for asymmetries among firms so that infra-marginal firms might earn pure profits even if marginal firms earned precisely zero profits. In such models, free entry would not necessarily eliminate profit-shifting effects. Most of the analysis of zero-profit free entry models has been carried out in the context of the reciprocal-markets model as described in Sections 4.5 and 4.6.

4. Strategic trade policy in the reciprocal-markets model

4.1. Market segmentation and the reciprocal-markets model

The third-market model considered in Section 3 is a very efficient model structure for examining many strategic policy issues. There are, however, additional issues to consider that require a more complete trading structure. Aside from the third-market model, the other environment that has been most extensively used in the analysis of strategic trade policy is what I refer to as the "reciprocal-markets" model, the basic structure of which is set out in Brander (1981).

There are two countries, typically but not necessarily with identical demand and cost conditions. One country is referred to as the domestic country and the other as the foreign country. Within each country, two (or more) goods are consumed. At least one of these goods is produced by oligopolistic firms, some domestic and some foreign. A key assumption of the reciprocal-markets model is that markets are assumed to be segmented in the sense that oligopolistic firms make separate strategic decisions concerning foreign and domestic markets. If output is the choice variable, then firms choose distinct output levels for each market, rather than throwing all their output on a unified or integrated world market and relying on arbitrage to distribute it to different locations. Market segmentation implies that prices in the two countries are treated as independent variables, as under price discrimination. If, however, domestic and foreign countries are symmetric, prices will be the same in both markets and no arbitrage opportunities will exist, despite market segmentation.

4.2. Profit-shifting in a reciprocal-markets model with Cournot oligopoly

Brander and Spencer (1984a,b) use Cournot duopoly and related reciprocal-markets models to investigate the possible use of tariffs to shift profits from a foreign firm (or firms) to domestic claimants. This section presents the Cournot oligopoly case with n domestic firms and n^* foreign firms. The sequence of events is that governments set tariffs in stage 1 and firms choose outputs in stage 2. There are two goods, one produced by Cournot oligopolists producing a homogeneous output. The other good is a competitive numeraire good produced with constant returns to scale in labor, which is the only factor of production. Let x denote domestic sales by a representative domestic firm, while y denotes domestic sales by a foreign firm. Correspondingly, using asterisks to denote variables associated with the foreign country, sales of a domestic firm in the foreign country are denoted x^*, and sales of a foreign firm in the foreign country are denoted y^*. The n domestic firms are identical, as are the n^* foreign firms. Total sales in the two countries are denoted Q and Q^* respectively.

$$Q = nx + n^*y\,; \quad Q^* = nx^* + n^*y^*\,. \tag{4.1}$$

As in Section 3, marginal costs c and c^* are constant, and there are possible fixed costs F and F^*. Domestic and foreign consumer prices are denoted p and p^*, and specific import tariffs set by the domestic and foreign governments are denoted t and t^*. Profits of representative home and foreign firms can then be written

$$\pi = xp(Q) - cx + x^*p^*(Q^*) - (c + t^*)x^* - F\,, \tag{4.2}$$

$$\pi^* = yp(Q) - (c^* + t)y + y^*p^*(Q^*) - c^*y^* - F^*\,. \tag{4.3}$$

Because of market segmentation and because of the constancy of marginal cost, we can proceed by examining just one national market. The Cournot oligopoly first order conditions for representative domestic and foreign firms are simply the application of first order conditions (3.2) to this particular context.

$$\pi_x = xp' + p - c = 0\,; \quad \pi^*_y = yp' + p - c^* - t = 0\,. \tag{4.4}$$

Note that x^* and y^* do not appear in these first order conditions. Similarly, x and y would not enter the first order conditions associated with the foreign market. At a technical level, this is why we can consider the two national markets separately. Conditions (3.3) (second order conditions) and (3.4) (strategic substitutes) are assumed to hold for all firms.

The solution of the first order conditions will yield x and y as functions of t and t^*. This solution will normally have the property that firms will sell in both home and export markets, implying that intra-industry trade occurs, as shown by Brander (1981).

As in Section 3.1, comparative static effects $\mathrm{d}x/\mathrm{d}t$ and $\mathrm{d}y/\mathrm{d}t$ can be obtained by totally differentiating (4.4) with respect to t and the outputs of all firms. Due to the assumption that all firms in a given country are symmetric, this differential system can be written as follows.

$$(n(xp'' + p') + p')\,\mathrm{d}x + n^*\pi_{xy}\,\mathrm{d}y + \pi_{xt}\,\mathrm{d}t = 0\,. \tag{4.5}$$

$$n\pi^*_{yx}\,\mathrm{d}x + (n^*(yp'' + p') + p')\,\mathrm{d}y + \pi^*_{yt}\,\mathrm{d}t = 0\,. \tag{4.6}$$

Dividing through by $\mathrm{d}t$ and expressing the system in matrix form yields

$$\begin{bmatrix} n(xp'' + p') + p' & n^*\pi_{xy} \\ n\pi^*_{yx} & n^*(yp'' + p') + p' \end{bmatrix} \begin{bmatrix} \mathrm{d}x/\mathrm{d}y \\ \mathrm{d}y/\mathrm{d}t \end{bmatrix} = \begin{bmatrix} -\pi_{xt} \\ -\pi^*_{yt} \end{bmatrix}. \tag{4.7}$$

Noting that $\pi_{xt} = 0$ and $\pi^*_{yt} = -1$ [from (4.4)], and letting D represent the determinant of the left-hand matrix in (4.7), which is positive by (3.3) and (3.4), the following comparative static effects can be obtained.

$$\mathrm{d}x/\mathrm{d}t = -n^* \pi_{xy}/D > 0\,; \quad \mathrm{d}y/\mathrm{d}t = (n(xp'' + p') + p')/D < 0\,, \tag{4.8}$$

where the numerators of these expressions are signed using condition (3.4) (i.e. using the assumption that outputs are strategic substitutes). As expected, a tariff on imports reduces domestic sales of foreign firms and increases domestic sales of domestic firms.

If there were just one foreign firm and one domestic firm, these effects could be shown in a best-response function diagram similar to Figure 3.1, except that it is the foreign best-response function that would be shifted. For any given output by the domestic firm, the foreign firm would want to produce less because the tariff raises its effective marginal cost. Therefore, the foreign reaction function would shift in.

With general numbers of firms, it follows easily that a domestic tariff causes foreign profits to fall, domestic profits to rise, and overall price to rise ($\mathrm{d}p/\mathrm{d}t > 0$) and quantity to fall ($\mathrm{d}Q/\mathrm{d}t = n\, \mathrm{d}x/\mathrm{d}t + n^*\, \mathrm{d}y/\mathrm{d}t < 0$). The situation in the foreign country is symmetric, implying that aggregate profits of each firm depend on the tariff levels set by both governments. For the case of linear demand given by $p = a - Q$, comparative static effects can be very readily calculated. In this case $p'' = 0$, $p' = -1$, $D = n + n^* + 1$, and $\pi_{xy} = \pi^*_{yx} = -1$. Expression (4.8) becomes

$$\mathrm{d}x/\mathrm{d}t = n^*/(n + n^* + 1)\,; \quad \mathrm{d}y/\mathrm{d}t = -(n + 1)/(n + n^* + 1)\,, \tag{4.8$'$}$$

and $\mathrm{d}p/\mathrm{d}t = -\mathrm{d}Q/\mathrm{d}t$, where $\mathrm{d}Q/\mathrm{d}t = -n^*/(n + n^* + 1)$.

We now turn to the decision problem faced by the domestic government. Assume that domestic utility derives from utility function

$$u(Q) + m\,. \tag{4.9}$$

This utility function, sometimes referred to as "quasi-linear" or "transferrable", is more general than the utility function used in Section 3, as two goods are now consumed in the domestic country, but it retains the key feature that utility is linear in the numeraire good and hence linear in income. This implies that changes in domestic welfare can, as in Section 3, be represented exactly by conventional surplus measures (i.e. by changes in profit, consumer surplus, and government net revenues). Accordingly, domestic welfare W associated with domestic tariff t and foreign tariff t^* is given by

$$W(t, t^*) = u(Q(t)) - pQ(t) + R(t) + n\pi(t, t^*)\,, \tag{4.10}$$

where $R(t)$ represents tariff revenue n^*ty. Domestic welfare depends on the foreign tariff only through the effect of the foreign tariff on the profits of domestic firms, which are assumed to count fully in domestic welfare. Domestic welfare is maximized by setting the derivative $\mathrm{d}W/\mathrm{d}t$ to zero.

$$\mathrm{d}W/\mathrm{d}t = u'\,\mathrm{d}Q/\mathrm{d}t - p\,\mathrm{d}Q/\mathrm{d}t - Q\,\mathrm{d}p/\mathrm{d}t + \mathrm{d}R/\mathrm{d}t + n\,\mathrm{d}\pi/\mathrm{d}t = 0\,. \tag{4.11}$$

Noting that $u' = p$, that $\mathrm{d}\pi/\mathrm{d}t = (p - c)\,\mathrm{d}x/\mathrm{d}t + x\,\mathrm{d}p/\mathrm{d}t$, and that $Q - nx = n^*y$ yields

$$\mathrm{d}W/\mathrm{d}t = -n^*y\,\mathrm{d}p/\mathrm{d}t + n(p - c)\,\mathrm{d}x/\mathrm{d}t + \mathrm{d}R/\mathrm{d}t = 0\,. \tag{4.12}$$

The first term reflects the loss in consumer surplus associated with paying more for imports, the second term represents the marginal surplus associated with the expansion of domestic production and the third term reflects increased tariff revenue. Both the second and third terms contain profits shifted from the foreign firm to domestic claimants. Substituting $\mathrm{d}R/\mathrm{d}t = n^*y + tn^*\,\mathrm{d}y/\mathrm{d}t$ into (4.12), solving for t, and letting subscripts denote comparative static derivatives gives an expression for the optimal tariff.

$$t^0 + (y(p_t - 1))/y_t - (n/n^*)(p - c)x_t/y_t\,. \tag{4.13}$$

The simplest case to consider is the case of pure foreign monopoly, in which $n = 0$, $n^* = 1$, and $Q = y$. In this case, $\mathrm{d}Q/\mathrm{d}t = 1/\pi^*_{yy}$. If we let $V = yp''/p'$ (the relative convexity of demand), we find that $\pi^*_{yy} = p'(2 + V)$, so $p_t = p'y_t = 1/(2 + V)$ and we can write the optimal tariff (on a foreign monopoly) as

$$t^{0m} = -p'y(V + 1)\,. \tag{4.14}$$

Thus, under simple foreign monopoly, the optimum tariff may be negative, zero, or positive, depending on whether V is less than, equals, or exceeds -1. In the case of linear demand, $V = 0$, and the optimal profit-shifting tariff is definitely positive as obtained by Katrak (1977) and Svedberg (1979). More generally, the condition $V + 1 > 0$ is equivalent to the condition that the marginal revenue curve be steeper than the inverse demand curve, which is certainly the standard case. However, it is possible, if demand is highly convex, that marginal revenue may be less steep than (inverse) demand and, correspondingly, that an import subsidy might be optimal. [See Brander and Spencer (1984a).] In the oligopoly case, the presence of domestic rivals means that foreign profits can be shifted to the domestic firms as well as to the domestic treasury. It is still possible that the optimal "tariff" could be negative (i.e. a subsidy) if demand is very convex, but a profit-shifting tariff is typically implied.

The incentives faced by the foreign government are exactly the same as those faced by the domestic government, as reflected in its objective function, W^*.

$$W^*(t, t^*) = u^*(Q^*) - p^*Q^* + t^*x^* + \pi^*(t, t^*)\,. \tag{4.15}$$

Maximizing W^* with respect to t^* yields a first order condition similar to condition (4.11). Simultaneous satisfaction of (4.11) and (4.15) typically leads to a Nash equilibrium in which both governments use tariffs. This non-cooperative equilibrium in which both governments use tariffs is normally welfare-inferior to the free trade regime where neither uses tariffs.

4.3. Tariffs and subsidies

Section 4.2 considers the case in which government policy is limited to an import tariff (cum subsidy) instrument. Export subsidies or subsidies for local sales could also be considered, as in Dixit (1984). Let s and s^* denote domestic and foreign export subsidies, and let σ and σ^* be subsidies on local sales. (A general production subsidy for the domestic firm is implied if $s = \sigma$.) The effective marginal cost of a domestic firm in its home market would be $c - \sigma$, and its effective marginal cost of export would be $c + t^* - s$. Similar modifications apply to foreign marginal cost. Equation (4.7) would become

$$\begin{bmatrix} n(xp'' + p') + p' & n^*\pi_{xy} \\ n\pi^*_{yx} & n^*(yp'' + p') + p' \end{bmatrix} \begin{bmatrix} \mathrm{d}x \\ \mathrm{d}y \end{bmatrix} = \begin{bmatrix} -\pi_{xt} & -\pi_{x\sigma} & -\pi_{xs^*} \\ -\pi^*_{yt} & -\pi^*_{y\sigma} & -\pi^*_{ys^*} \end{bmatrix} \begin{bmatrix} \mathrm{d}t \\ \mathrm{d}\sigma \\ \mathrm{d}s^* \end{bmatrix}. \quad (4.16)$$

Following characterization of these comparative statics, and corresponding comparative statics for the foreign market, one can then characterize nationally optimal import tariffs, export subsidies, and local sales subsidies for each government, as in Dixit (1984, 1988b). Allowing for a subsidy on local sales shifts the emphasis of the analysis away from trade policy, because a government has an incentive to use such a subsidy simply to offset the output-restricting effect of oligopoly. Even in the absence of trade, this apparent incentive to subsidize monopolies and oligopolies always exits. Such policies seem of limited practical significance, suggesting that the case in which subsidies on local sales are constrained to be zero is perhaps of more interest.

With or without local subsidies, this structure allows for derivation of simultaneous ''countervailing'' effects. Thus, for example, an export subsidy adopted by the foreign government could be ''countervailed'' by a simultaneously chosen domestic import tariff. The reader may find it useful to carry out these calculations for the case of linear demand. The interesting point about these countervailing effects is that they do not eliminate incentives to use active strategic trade policy, and the policy equilibrium normally implies positive subsidies and tariffs.

Using the term ''countervailing'' to describe simultaneous selection of export subsidies and possibly offsetting tariffs is perhaps misleading. In practice the term countervailing carries the presumption that the export subsidy is applied first, then possibly offset by a tariff that is applied later. Collie (1991) considers a model of this type that is otherwise very similar to Dixit (1988b). For concreteness, say that the foreign government moves first, selecting an export subsidy. The domestic country subsequently selects an optimal tariff. Like Dixit, Collie finds that the domestic country would normally adopt a partially but not fully countervailing tariff. In contrast to Dixit (1988b), however, Collie finds that the extent of countervailing is sufficient in most cases to eliminate the foreign country's incentive to use an export subsidy.

This contrast is based purely on timing and is very similar to the contrasts discussed in Section 3.4.2. It is not clear whether the assumption that governments move simultaneously or the assumption that one moves before the other is preferable as governments can, in practice, choose new policies at any time. Spencer (1988) analyzes countervailing of capital or investment subsidies and emphasizes that the institutional structure of GATT and other trade agreements can be invoked for specifying timing in particular applications.

4.4. Comparison of the reciprocal-markets model and the third-market model

Most of the issues addressed by the third-market model are subsumed when considering export subsidies in the reciprocal-markets model, albeit with somewhat less clarity. There would, however, be some additional points of interest in combining the two models into a three country model with the oligopoly good being produced in two countries and consumed in all three. One could, for example, address the interaction of strategic trade policy and regional trade arrangements in such a model, but that takes us beyond the scope of this chapter.

The extensions applied to the third-market model can also be applied here. Specifically, allowing for public funds to have an opportunity cost exceeding 1 (as in Section 3.2.2) is straightforward and implies that tariffs become relatively more attractive and subsidies relatively less attractive. Allowing for consideration of R&D and investment, and allowing for market conduct other than Cournot (such as Bertrand competition) have similar interesting consequences. Very similar issues relating to timing, possible dynamics, and informational asymmetries also arise, although these areas are far from fully explored. There are, moreover, certain issues that have much more significance with reciprocal markets than in a third-market model. One of these issues is the role of home market protection in the presence of learning-by-doing, which is taken up as a calibration exercise in Section 5.2. Other issues include entry, the comparison of segmented and integrated markets, and the comparison of different trade policy instruments, particularly quotas and tariffs.

4.5. Entry

As mentioned in Section 3.7, it is important to consider the effects of free entry in response to profitable opportunities. The analysis already developed applies to situations where indivisibilities are sufficiently large so as allow positive profits for incumbents while preventing further entry.

At the other extreme, it is also worth considering the case in which free entry drives the profit of marginal firms to precisely zero. Most of the associated analysis has been carried out under the assumption of symmetry, in which all firms earn precisely zero profits. Brander and Krugman (1983) consider a reciprocal-markets Cournot model in which firms have declining average costs arising from a fixed cost and constant marginal costs. Entry occurs in both countries until all firms earn zero profits, giving rise to intra-industry trade arises even in the presence of positive transport costs. Despite the apparently unnecessary transport costs that are incurred, free trade is welfare superior to autarky. The central insight is that the zero-profit assumption holds producer surplus at zero, so welfare (which then arises purely from consumer surplus) is monotonically and inversely related to price. Trade increases the level of effective competition, forcing price to fall and exit to occur until surviving firms have increased output and moved down their average cost curves sufficiently to avoid losses at the new lower price. Thus welfare benefits come from rationalization of production.

Venables (1985) considers a similar reciprocal-markets model (with positive transport costs), introducing consideration of tariffs and subsidies. Venables finds that despite the absence of profit-shifting effects, both governments have incentives to use import tariffs and export subsidies. Consider first a tariff imposed by the domestic country. On impact, as the tariff is introduced, if no entry and exit took place and individual firms did not adjust outputs, the domestic price of imports would rise and consumers would switch to domestically produced output. This would bid up the price of domestically produced output and force down the price of foreign output until foreign imports and domestic output would sell for the same price. At this configuration, domestic firms would make profits and foreign firms would make losses. In order for equilibrium to be restored, firms would adjust outputs and, in addition, entry would occur in the domestic economy and exit would occur in the foreign country until the zero-profit condition was re-established.

This effective movement of firms from the foreign country to the domestic country is advantageous to the domestic country because, in the presence of positive transport costs, each firm sells more at home than it exports. Total sales in the domestic market rise, implying that consumer price in the domestic market must fall. Since consumer surplus rises and producer surplus is constant at zero, the domestic country gains. Thus the effect of domestic "protection" is pro-competitive in the domestic market because it induces entry. In addition, the domestic country becomes a net exporter of the imperfectly competitive good and experiences a terms-of-trade improvement due to the tariff, which is a second source of gains. The foreign country experiences exactly opposite effects, leading to a welfare loss. More surprisingly, an optimally chosen export subsidy also leads to gains for the domestic country. An export subsidy has a relocation effect similar to the effect of a tariff. The resulting benefit to the domestic economy is sufficient to ensure gains, even though the domestic economy earns no tariff revenue and subsidizes consumption abroad.

4.6. *Comparison of segmented and integrated markets*

Horstmann and Markusen (1986) investigate the effects of (zero-profit) free entry using a model structure similar to Venables (1985) except that international markets are assumed to be integrated rather than segmented. Firms do not make separate decisions about the two markets, but simply bring all their output to the unified world market. In analyzing this case, there are various effects that arise from either a tariff or a subsidy, and the relative importance of various effects is sensitive to functional forms for demand and cost. However, for most cases considered by Horstmann and Markusen, tariff or subsidy interventions are welfare-reducing for the country attempting them because they induce inefficient entry, driving firms up their average cost curves.

Markusen and Venables (1988) provide a systematic attempt to link strategic trade policy implications to the nature of entry and to whether markets are segmented or unified. As is consistent with the previous papers by Venables (1985) and Horstmann and Markusen (1986), this synthesis shows that tariffs or subsidies improve welfare more (or reduce it less) if markets are segmented rather than unified, and that free entry tends to reduce the attractiveness of tariff or subsidy interventions.

The assumption that markets are segmented rather than integrated is a central aspect of the reciprocal-markets model. For example, in contrast to Brander's (1981) demonstration of intra-industry trade in a simple Cournot reciprocal-markets model, Markusen (1981) uses an otherwise very similar model except that markets are integrated rather than segmented and obtains the result that no intra-industry trade occurs.

In richer models of firm behavior, it is possible that some decisions might be made on a world-wide basis (i.e. under an integrated markets perception) while others might be made on a market-by-market or segmented basis. Venables (1990) considers such a model in which oligopolistic firms in two countries may compete with each other in either Cournot or Bertrand fashion. Firms make a two-stage decision. In stage 1 firms simultaneously decide on world-wide capacity. In the second stage firms decide on market-specific quantities or prices. Venables argues that this structure is more realistic than simple Cournot or Bertrand models. In his analysis, consideration of a prior worldwide capacity stage significantly changes implied trade volumes, but leaves intact the strategic trade policy incentives to subsidize exports and tax imports. There are, however, alternative ways to characterize the distinction between capacity and price and/or quantity decisions in a multi-market setting. [See, in particular, Ben-Zvi and Helpman (1992).]

4.7. Choice of trade policy instruments

A classic question in the theory of international trade policy concerns the relative effects of tariffs and quotas or, more generally, the effects of a variety of possible policy instruments. In perfectly competitive models of trade, tariffs and quotas are normally equivalent, in the sense that the effect of a tariff can be duplicated by an appropriately chosen quota. As Bhagwati (1965) noted, however, this need not be true under imperfect competition. Accordingly, we might expect some interesting comparisons between tariffs and quotas as strategic trade policy tools (i.e. in international oligopoly settings). More generally, we might expect the analysis of quotas under oligopoly to offer additional insights over and above the insights obtained from the analysis of tariffs and subsidies. Quite a few papers have addressed aspects of this question, including Itoh and Ono (1984), Harris (1985), Hwang and Mai (1988), Cooper and Riezman (1989), Krishna (1989), Levinsohn (1989), Das and Donnenfeld (1989), Ries (1993a,b), Anis and Ross (1992) and Ishikawa (1994), among others.

Perhaps the central difference between tariffs and quotas as policy instruments relates to their effects on foreign firms. Any tariff on foreign firms reduces their profits, and a subsidy to domestic firms also tends to reduce the profits of foreign firms. With quotas, on the other hand, there is a much greater possibility that the foreign firms might benefit, particularly if the quota is implemented as a voluntary export restraint (VER), meaning that foreign firms keep any quota rents rather than having to buy quota licenses. In effect, a VER acts as a device that facilitates a more collusive outcome for foreign firms. This implies that a VER is less likely to be in the interest of a domestic welfare-maximizing government.

In the case where there are several foreign firms, it is fairly clear that a quota set below the free trade level of imports has the primary effect of moving the foreign firms closer to the jointly optimal (collusive) output level, and is therefore a facilitating device for collusion. A very restrictive quota could reduce output sufficiently far below the jointly optimal output level that the foreign firms could suffer reduced profits, but there is a substantial range for the quota within which both foreign firms and the domestic firm (or firms) can gain.

A more surprising facilitating effect is demonstrated by Krishna (1989) who considers the case of an international Bertrand duopoly with one foreign and one domestic firm producing slightly differentiated products. She examines the effect of a VER imposed at the free trade level. In a perfectly competitive market, a VER at the free trade level would have no effect. In this Bertrand duopoly case, however, the VER alters the strategic relationship between the two firms, and this may have an important effect on market outcomes.

In order to see whether the free trade prices still constitute a Nash equilibrium after the imposition of a VER at the free trade level, we must ask whether each firm is still doing the best it can given its rival's price. The free trade prices are denoted $p0$ and $r0$ for the domestic and foreign firm respectively. Consider the home firm first.

Taking the rival's price, $r0$, as given, the domestic firm now finds it more attractive to raise its price than before. Prior to the VER, the domestic firm would imagine that if it raised its price, while the rival held price fixed, then it (the domestic firm) would sell less and the foreign firm would sell more. However, with the VER in place, the foreign firm cannot sell more, so the domestic firm suffers fewer lost sales from its price increase than it otherwise would. Thus the VER increases the domestic firm's incentive to raise its price. Letting $p1$ represent the domestic firm's post-VER best-response to foreign price $r0$, it follows that $p1 > p0$.

This argument shows that if the foreign firm kept its price at the free trade level, the domestic firm would raise its price. The foreign firm will not keep its price at the free trade level, however. For example, if it anticipated that the domestic firm would raise its price, then its corresponding best response would also involve a higher price, for its price best-response function is upward-sloping. Thus we can see that a VER imposed at the free trade import level creates incentives for both firms to raise prices.

The actual solution is fairly complicated, because the domestic firm's best-response function turns out to be discontinuous. The solution is illustrated in Figure 4.1, which shows post-VER reaction functions for the two firms. The foreign firm's best-response function is continuous but kinked, as shown. The kink occurs at the initial free trade equilibrium price, reflecting the fact that beyond this point, the foreign firm is constrained by the VER. The domestic firm's best-response function is discontinuous. At the free-trade foreign price, $r0$, the domestic best response is price $p1$. This price is really just a best response to the VER fixed quantity and remains the same for

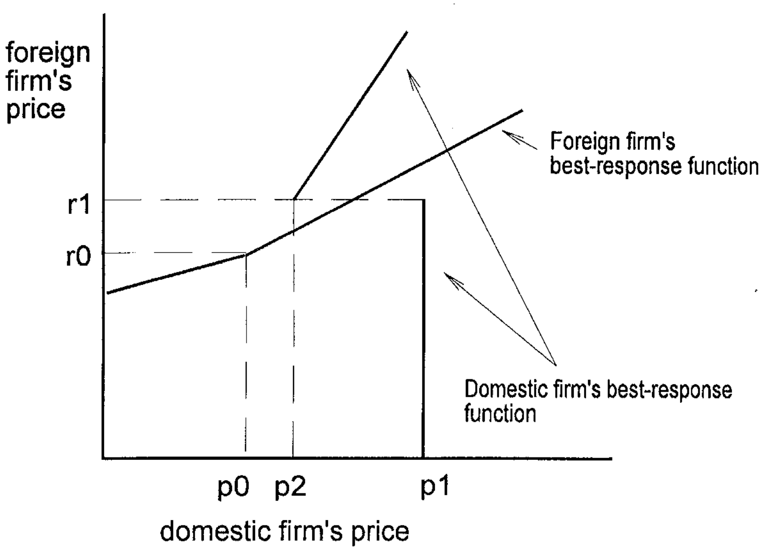

Figure 4.1.

any foreign price for which the VER is binding. However, as we consider increases in the foreign price, at some price the VER ceases to be binding. At this point, the best-response of the domestic firm is given by its old pre-VER best-response function, implying a discrete fall in its price. At this pivotal foreign price, the domestic firm switches from a conciliatory to an aggressive price response.

The "hole" in the domestic firm's best-response function occurs just where the rival's best-response function passes through, as shown in the diagram. Thus there is no single pair of prices (or "pure strategy") that constitutes a Nash equilibrium. The only Nash equilibrium is a "mixed strategy" in which the domestic firm charges price $p1$ with some probability and price $p2$ with some probability. The foreign firm must charge price $r1$. All three of these prices exceed the corresponding free trade prices. Thus Krishna (1989) obtains the striking result that, in this simple Bertrand duopoly model, a VER is unambiguously a "facilitating device" that raises prices and profits at consumers' expense, even if the VER is imposed at the free trade level of imports. [This is in contrast to the dynamic effect of quotas under tacit collusion analyzed by Rotemberg and Saloner (1989) as discussed in Section 3.5.] Note that in Krisha (1989), the VER has important effects even though, on average, the VER is not binding at the solution.

The value of Krisha (1989) is not so much that it is likely to be a literal description of an actual outcome. The paper's important contribution is that it focuses attention on the idea that a VER (and, by extension, any trade policy instrument) can have important effects through the effects on imperfectly competitive rivalries between firms. A closely related possibility is that a VER might lead to a change in the mode of rivalry between firms, as in Harris (1985), who assumes that the imposition of a VER at the free-trade level converts a Bertrand rivalry to a structure in which the domestic firm becomes a Stackelberg price leader. Once again, such a VER acts as a facilitating device.

In addition to the choice between tariffs and quotas, there are many other closely related issues. Even if attention is restricted just to tariffs, there is the question of whether ad valorem or specific tariffs should be chosen. As shown in Brander and Spencer (1984b), under imperfect competition, specific and ad valorem tariffs are not equivalent and their relative attractiveness depends on the functional form of demand and other very specific aspects of the model. More generally, we might consider tariffs with specific and ad valorem components (or more general non-linear tariffs). Various other possible policies could also be used to shift rents under oligopoly, including price controls [De Meza (1979)] discretionary anti-dumping policies [Prusa (1992)], content protection [Krishna and Itoh (1988)], government procurement policies [Branco (1994)] and even trade related intellectual property rights or TRIPS [Taylor (1993)]. More generic domestic policies such as competition policy, environmental policy, and the setting of industrial standards can also be used to influence the strategic structure of international rivalries.

There is a long-standing literature in international trade theory seeking to establish how to efficiently target instruments to distortions. [See, in particular, Bhagwati (1971).] Thus, for example, either an export subsidy or a production subsidy may appear attractive in dealing with a particular distortion, but one instrument may be more efficient than the other. This issue applies in strategic trade policy just as it does in the analysis of trade policy more generally. Krishna and Thursby (1991) seek to establish some general principles in applying instruments to distortions under oligopoly.

4.8. Additional issues

The preceding material in this chapter ignores some worthwhile topics in strategic trade policy that should at least be acknowledged. One such topic concerns labor market rents. Much of the work on strategic trade policy focuses on profits earned by firms in imperfectly competitive product markets, usually against a background of undistorted labor markets. This emphasis might be misplaced, in that deviations from perfect competition in labor markets seem at least comparable in significance to product market deviations. Also, when industrial policy advocates encourage ''high value added production'' they seem to place more weight on high-wage jobs than on high-income shareholders. Evidence presented by Katz and Summers (1989) suggests that much of the rent at stake in international trade policy games accrues to workers. Analysis of strategic trade policy in the presence of active unions is contained in Brander and Spencer (1988), Mezzetti and Dinopolous (1991), and Fung (1995).

It is also important to consider the effects of strategic trade policies when firms have a vertically integrated multinational structure, as in Spencer and Jones (1991, 1992) and Rodrik and Yoon (1989), and to understand the effects of trade policies when firms are not simple profit-maximizers. For example, Fung (1992) considers the effects of trade policies on the so-called ''J-firm'' (for Japan) in which the firm is viewed as a coalition of shareholders and workers. We might also wish to relax the assumption that the structure of firms is exogenous and ask how strategic trade policy might affect the multinational structure of firm operations, as in Levinsohn (1989), Horstmann and Markusen (1992), and Flam (1994). Trade policy might also affect the internal organization of the firm, as in Friedman and Fung (1996). Another lively recent topic in international trade theory, particularly in empirical work, is the effect of trade policy on product quality. Das and Donnenfeld (1989) provide a theoretical analysis of product quality in a strategic trade policy model.

5. Calibration of strategic trade policy models

Any attempt to implement an informed strategic trade policy would require significant industry-specific empirical knowledge. For some questions of interest there may be insufficient data to support statistical estimation of an appropriate model. An alternative way of undertaking empirically-based quantification of economic models is the calibration method pioneered by Shoven and Whalley (1972) and first applied to trade models incorporating imperfect competition by Harris and Cox (1984).

One starts with a model containing general parameters that are to be replaced with specific values. Instead of using multiple observations to estimate these parameter values statistically, parameter values are taken from external sources, subject only to the constraint that the final selected parameter values be consistent with a single base case observation (or perhaps a small number of observations). External sources may include previous econometric work, engineering studies, and the analyst's judgement. Typically the first set of parameter values obtained will not be consistent with the one (or few) observations available, so one or more of the parameter values are modified using a combination of judgement and formal methods until consistency is obtained. It is in this sense that the model is calibrated to the data. A special case of this method is to obtain outside estimates for all parameters but one, then assign this free parameter precisely the value necessary to make the model consistent with the data. Once the model has been calibrated, it can then be used to consider policy experiments such as tariff and subsidy changes.

We should really take account of the fact that outside parameter estimates have uncertainty associated with them. Without this step, some observers have argued that calibration exercises should be viewed essentially as simulations in that they simply show how a given theoretical structure works under the assumption of particular parameter values. The main reason for emphasizing calibration exercises in this chapter is for the light they shed on the theoretical structure of strategic trade policy, rather than because of their empirical significance.

5.1. Calibration of a strategic trade policy model for the U.S. automobile industry

Dixit (1988a) uses a calibration technique to assess the effects of strategic trade policies on the U.S. automobile industry. His underlying model is a reciprocal-markets model with Japanese and American producers where firm conduct is characterized by a conduct parameter model. He focuses on just the U.S. market. Concern about the rising level of Japanese import penetration in the U.S. market led U.S. policy-makers in 1981 to impose a voluntary export restraint (VER) on Japanese imports. Dixit calibrates the model for 1979, 1980, and 1983, then, armed with a calibrated version of the model, evaluates different trade polices. He is primarily interested in how actual U.S. trade policies compared with optimal policies.

The basic logic of Dixit's approach can be seen by taking a first order condition for a representative firm, as given by expression (3.22), then solving for the conduct parameter, λ. We can rewrite (3.22) as

$$\lambda = -1 - (p - c)/xp' , \tag{5.1}$$

or, equivalently, as

$$\lambda = [(p - c)/p][\eta/ms] - 1 , \tag{5.2}$$

where η is the (positive) elasticity of market demand and ms is the market share of this firm. This first order condition forms the core of the model. Typically we have information on price, quantity, and market share that we can take as known. However, the elasticity of demand, marginal cost, and the conduct parameter itself are less likely to be available as data. If we make an attempt to measure marginal cost and to get some estimate of the elasticity of demand, then from (5.2) we can determine what the conduct parameter λ must be in order to fit the data. Alternatively, looking at formulation (5.2) we might assume that the Cournot model is correct, so λ must equal 0, and let η be determined by the data, as is done, for example, in Klepper (1994).

Dixit generalizes the model of Section 3.3.1 slightly by assuming that cars made in the U.S. are differentiated from cars produced in Japan. However, all U.S. cars are homogeneous, as are all Japanese cars. There are n American firms and n^* Japanese firms. Demand is linear. With differentiated products, (5.2) does not apply exactly, but we can write the first order condition of a representative American firm as

$$p - c + x\phi = 0 , \tag{5.3}$$

where, in a Cournot model, $\phi = \mathrm{d}p/\mathrm{d}x$, the slope of U.S. inverse demand for U.S. cars. If the auto industry is not Cournot, then ϕ will differ from this slope. For example, under Bertrand competition, $\phi = 0$. As in the homogeneous product case, market information can be used to calibrate ϕ. Dixit finds that the U.S. industry is more competitive than implied by a Cournot model but less competitive than a Bertrand model would imply.

Dixit considers the case in which only a tariff is available as well as the case in which both a tariff on Japanese imports and a U.S. production subsidy are available. He finds that a considerably higher tariff than was actually in place on Japanese cars would have been welfare-improving for the U.S., whether or not a production subsidy was applied. For the 1979 base case, the actual tariff on an imported Japanese car was \$100 on a price of about \$4000, while the optimal tariff would have been \$570 in the absence of a subsidy and \$408 in combination with an optimal subsidy of \$611. The total U.S. welfare benefit from this combined optimal tariff and subsidy would have been \$309 million, which is small compared to total U.S. surplus in the industry of \$33 billion.

In the base calculations, wages paid to workers are treated as (opportunity) costs. It is likely, however, that some portion of wages is a rent or payment above opportunity cost to auto workers. Taking account of such rents, optimal policy would require an even greater reduction in Japanese imports. Thus, for 1979, with labor rents taken to be about \$1000 per car (corresponding to half the wage bill), the optimum tariff with no subsidy would increase to \$812. Dixit also considers the effect of deadweight taxation costs as a modification to the base case (i.e. without labor rents). Assuming that the deadweight cost of raising government revenue is a modest 20 percent, Dixit finds that the optimum tariff with no subsidy rises to \$791 from its base value of \$570. The joint tariff-subsidy optimum would imply a tariff of \$922 and a tax (or negative subsidy) of \$487.

As recognized by Dixit, there are several aspects of this analysis to be concerned about. Perhaps the biggest concern derives from the calibration of the conduct parameter, as it is essentially treated as a residual. Any error in the data, in model specification, or in outside parameter estimates would be incorporated in the all-important conduct parameter. One possible manifestation of this problem is that measured conduct was markedly different in each of three years studied (1979, 1980 and 1983). Also, despite the apparent volatility of conduct, the policy simulations assume that market conduct (as reflected by the conduct parameter) would be unaffected by policy changes.

In addition, it is hard to take on faith that marginal cost is constant, that demand in the industry is linear, or that the only meaningful product differentiation in the industry is between U.S. and Japanese producers. Similarly, it is not clear how to implement the maintained assumption of symmetric producers in an industry where the firms differ substantially in size. Dixit adopts the standard practice of selecting the number of symmetric firms that would give the same Herfindahl index as given by the actual data, but this could easily be a source of error. It is not even clear how to count firms, as one could reasonably take either corporations (like General Motors) or divisions (like Chevrolet) as the basic decision-making unit. Dixit makes a valiant attempt to address most of these issues through sensitivity analysis, but one must remain cautious about the empirical significance of the results.

The need for such caution is reinforced by a paper by Krishna, Hogan, and Swagel (1994) (denoted KHS). Like Dixit, KHS evaluate the U.S. automobile market, focusing on U.S. and Japanese producers, and they consider the period 1979–85, which includes the three years considered by Dixit. The major difference in the analysis is that KHS wish to allow product differentiation within the U.S. and Japanese auto industries. Accordingly, KHS assume a demand structure that can readily handle such product differentiation. Specifically, demand for automobiles is assumed to derive from a (sub) utility function of the form βS^{α} where S is a nested constant elasticity of substitution (CES) function with two CES subaggregates (one for Japanese cars and one for U.S. cars). This gives rise to nonlinear (and highly convex) demand curves for individual varieties. KHS use the same cost data as Dixit and very similar quantity data. Strikingly, however, KHS find that industry conduct for U.S. producers is more competitive than implied by Bertrand competition (and therefore much more competitive than implied by Cournot behavior) in contrast to Dixit's finding that behavior is between Cournot and Bertrand.

This result is not difficult to explain. With homogenous products in the U.S.

industry, as assumed by Dixit, Bertrand behavior implies marginal cost pricing. Therefore, any excess of price over marginal cost indicates that behavior is less competitive than Bertrand. However, with differentiated products in the U.S. industry, as assumed by KHS, Bertrand competition implies a positive markup of price over marginal cost. Therefore, price may exceed marginal cost and still be consistent with conduct that is more competitive than Bertrand competition, as found by KHS.

In addition, KHS find that the optimal U.S. policy is to subsidize (rather than tax) Japanese imports. This finding is explained by the assumption of highly convex demand, which tends to make an import subsidy optimal under imperfect competition because the gains in consumer surplus from lower prices are large relative to the subsidy cost. [This is shown by expression (4.14) for the monopoly case.]

By changing just one of the major components in Dixit's analysis (the demand structure) KHS obtain qualitatively different results. While the KHS analysis is more sophisticated, there is very little basis for confidence that the KHS analysis is closer to being correct. In particular, while there is little doubt that product differentiation is important in the industry, it is not clear that the functional forms used for demand in KHS are good approximations to actual demand. KHS themselves emphasize that perhaps the major conclusion to be drawn from their work is that results obtained from calibrated models of oligopoly are worryingly sensitive to untested assumptions about model structure.

5.2. Calibration of the 16K RAM computer chip market

Baldwin and Krugman (1988) undertake a strategic trade policy calibration in a market where learning-by-doing is very important, the international market for 16 Kilobyte (16K) Random Access Memory (RAM) computer chips. The 16K RAM chip was first shipped in 1976, became a significant market presence in 1978 (21 million units shipped), reached its peak in 1982 (263 million units shipped), then suffered a sharp loss in market as it was superseded by 64K and 256K RAM chips. Prices followed a dramatic decline, starting at $46 per unit in 1976, falling to $8.53 in 1978, to $2.06 in 1981, and to under a dollar by 1984. This price decline was associated with a decline in production cost, as plant yields tend to rise dramatically with experience. Like the auto industry, the market for RAM chips attracted substantial attention from U.S. policy-makers, in part because of rising penetration by Japanese manufacturers in the market.

Krugman (1984) made an influential contribution to strategic trade policy by proposing that import protection may act as a form of export promotion if the industry in question is subject to significant learning-by-doing or other dynamic economies. More generally, any incentives to apply strategic trade policies might be enhanced by the presence of learning-by-doing of the type that appears to be so important in the production of RAM chips. [See Gatsios (1989) and Neary (1994) for an analysis of subsidies in the presence of learning-by-doing and Head (1994) for an analysis of learning-by-doing in the 19th century steel rail industry, showing that learning-by-doing was as important for trade policy a century ago as it is today. See also Dinopolous, Sappington, and Lewis (1994) for an analysis of strategic trade policy in a model where a domestic firm's rate of learning-by-doing is unobserved by the domestic government.]

Baldwin and Krugman (1988) (denoted BK) construct a calibrated oligopoly model of the 16K RAM market to examine the effects of Japanese home market protection on market outcomes and welfare. The following description follows the version of this model in Helpman and Krugman (1989). BK assume that costs at time t for a representative RAM producer can be written as

$$C(t) = x(t)c[k(t)]\,, \tag{5.4}$$

where $x(t)$ is output at time t, $k(t)$ is cumulative output up to time t, and $c' < 0$, indicating that the marginal cost of production decreases with cumulative output. Note that cumulative output can be written as $k(t) = \int_0^t x(z)\,\mathrm{d}z$. Modelling dynamic oligopoly can be difficult, but BK make two common simplifying assumptions. First, they assume that rivalry between firms is of the open loop variety – as if firms simultaneously choose and commit to their output paths as functions of time at the beginning of game. Secondly, BK assume that the life of the product is sufficiently short that discounting can be ignored, which greatly simplifies the required algebra. Given this structure, the effective marginal cost at time t, denoted $\mu(t)$, can be written as

$$\mu(t) = c(k(t)) + \int_t^T x(z)c'(k(z))\,\mathrm{d}z\,. \tag{5.5}$$

The first term on the right-hand side of (5.5) is just current marginal production cost at time t. The second term reflects the impact of an extra unit of current production at time t on future production costs. This second term is negative for all $t < T$, as higher current production reduces future costs. Thus, except at the last moment of time, when $\mu = c$, marginal production cost c always exceeds effective marginal cost μ.

Marginal production cost $c(k(t))$ declines over time, but so does the future value of the learning effect. Taking the derivative of (5.5) with respect to t and recalling that $x(t) = \mathrm{d}k/\mathrm{d}t$ yields

$$\mathrm{d}\mu/dt = c'(k(t))\,\mathrm{d}k/\mathrm{d}t - x(t)c'(k(t)) = 0\,. \tag{5.6}$$

Thus effective marginal cost is constant over time and must be equal to $c(T)$. This constancy of effective marginal cost simplifies the model, as we can characterize the maximizing decision of a representative firm by the instantaneous condition that $MR = \mu = c(T)$, where MR is current marginal revenue. This leads to a first order condition for a representative American firm much like (5.1), except that c is replaced by μ.

BK are interested in both U.S. and Japanese markets and therefore use a reciprocal-markets model structure (i.e. with segmented markets). They allow for the possibility that conduct might differ in the two countries. They also allow for the possibility that the conduct of Japanese firms operating in either country might differ from the conduct of American firms in that country. Let American conduct in the American market be represented by conduct parameter, λ_u. Then we can rewrite (5.2) for a representative U.S. firm operating in the U.S. market in the following way.

$$\lambda_u = [(p - \mu)/p][\eta/ms_u] - 1\,, \tag{5.7}$$

where ms_u is the market share of a representative U.S. firm in the U.S. market. There is a corresponding condition for Japanese firms in the U.S., for American firms in Japan, and for Japanese firms in Japan. Furthermore, BK want to allow for the alleged Japanese trade barriers against U.S. firms and therefore include a tariff equivalent in the market conduct condition for U.S. firms operating in Japan. Using asterisks to represent variables associated with the Japanese market, the condition representing U.S. market conduct in Japan can be written as

$$\lambda_u^* = [(p^* - (\mu + \theta))/p^*][\eta^*/ms_j] - 1\,, \tag{5.8}$$

where θ is measure of Japanese trade barriers expressed as a tariff equivalent, and ms_j is the share of a representative U.S. firm in the Japanese market.

Conditions (5.7) and (5.8), and the two corresponding conditions for Japanese firms can be calibrated to actual data much as in Section 5.1. Ideally, we would observe prices, quantities, demand elasticities, effective marginal costs, and Japanese protection, then calculate the conduct parameters required to calibrate the model to actual data. The additional difficulty in this case is that it is very hard to "observe" effective marginal cost, μ. To estimate this parameter, BK assume that marginal production cost $c[k(t)]$ has the form $c = Bk^{1-\beta}$, and assume, based on engineering information, that $\beta = 0.28$, which implies very substantial learning economies. They also assume free entry in the strong form that revenue over the product life cycle must equal full cost for each firm. All American firms are assumed to be symmetric to each other, as are Japanese firms. As in Dixit (1988a), BK allow the number of "firm-equivalents" to equal the number of symmetric firms that would generate the actual Herfindahl index. These assumptions allow μ to be calculated from just market prices and quantities (revenues), adjusting properly for transportation costs.

BK also assume that (inverse) demand in the U.S. is of the form $P = AQ^{-\alpha}$, where Q is total U.S. sales, and that Japanese demand has the same functional form. They obtain outside estimates of the elasticity of demand (taking it to be 1.8 for the U.S. market), and are then able to solve an expression like (5.7) for conduct parameter λ_u. U.S. firms are found to have conduct parameters in the U.S. market that are considerably less competitive than Cournot ($\lambda_u = 4.76$). Japanese firms are found to have conduct parameters of about 2.8 in Japan and 8.3 in the U.S. However, expression (5.8) cannot be solved for the U.S. firms' conduct parameter in Japan because the Japanese tariff-equivalent trade barrier cannot be observed. BK therefore assume that American conduct in Japan is the same as in the U.S., i.e. that $\lambda_u = \lambda_j = 4.76$, then use (5.7) to estimate effective Japanese trade barriers. They conclude that Japanese trade barriers were equivalent to a tariff of about 26 percent.

Having carried out this elegant but somewhat heroic calibration exercise, BK are then able to conduct policy experiments to determine the effects of different trade policy regimes on production, trade flows, and, using surplus measures of the type set out in Section 3, on welfare. The main hypothetical policy of interest is the "free trade" case, in which there are no Japanese trade barriers. BK also consider a "trade war" case in which tariffs in each country are set at 100 percent, which is enough to choke off all trade between the two countries. As in Section 5.1, the effects of trade policy variations on U.S. welfare are modest. A trade war would, however, have imposed significant damage on Japan. The main costs of Japanese protection arise from induced proliferation of firms in what is essentially a natural monopoly, which drives firms up their cumulative average cost curves and causes prices to rise.

Most interesting is the comparison of Japanese protection (the base case) with free trade. BK conclude that Japan was a net loser from protection, as consumers paid higher prices and obtained less consumer surplus than they would have under free trade. (Japanese firms are confined by the zero-profit assumption to earn zero surplus in either regime.) However, the policy had a major effect on the pattern of world protection in that no Japanese industry would have emerged (in their model) under free trade. Thus the Japanese policy was "successful" in the sense that it allowed a robust Japanese industry to emerge. Even if we take the view that this calibration exercise tells us more about the theoretical structure of trade models with learning-by-doing than it does about actual empirical magnitudes in the computer chip industry, the finding that a modest level of protection can have very significant effects on the pattern of production and trade is very striking.

5.3. Smith–Venables calibrations of EC industries

In addition to the papers discussed in Sections 5.1 and 5.2, a substantial number of additional strategic trade policy calibration exercises have been carried out. Several of these are contained in Krugman and Smith (1994). Perhaps the most systematic set of industry calibrations are those done by Alisdair Smith and Tony Venables in a series of papers including Smith and Venables (1988), Smith (1994) and Venables (1994). These studies focus on major industries in the European Community, with particular emphasis on the automobile industry. The basic logic of the analysis in these papers is much as in Dixit (1988a), but like Krishna et al. (1994), a more sophisticated demand structure is assumed so as to allow for the substantial product heterogeneity that exists in these markets.

Many of these markets have implicit barriers to trade that are difficult to measure directly. Given the difficulty created by unobserved trade barriers and the difficulty in observing the degree of product differentiation, Smith and Venables are unable to calibrate conduct parameters. Instead they assume a particular form of rivalry and use this to help solve for trade barrier equivalents and the degree of product differentiation. They are able to repeat the exercise for different assumptions about firm rivalry (and many other things) and are therefore able to distinguish between results that are sensitive and those that are robust.

My interpretation of the basic conclusions is as follows. First, given the existence of oligopoly and the possibility of using strategic trade policies, only by great coincidence would the optimal policy for a given country be free trade, and, as in Baldwin and Krugman (1988), the effects of such policies on trade flows and production magnitudes are large. However, the magnitude of welfare changes is small. In the nine industries considered in Venables (1994), in only one does an optimal tariff yield gains in excess of 2.5 percent of the base value of consumption. Export subsidies are even less significant in their welfare effects. Also, the details of policy effects are sensitive to assumed model structure. Policy has a bigger impact under Cournot rather than Bertrand rivalry, as we might expect, because firm profits are higher under Cournot rivalry. If, however, we invoke a (zero profit) free entry assumption this comparison is reversed in many cases (as profit-shifting effects disappear). Without free entry, policy effects are greater under segmented markets than under unified markets. Venables (1994) argues that the implied optimal strategic trade policies are not as sensitive to model specifics as we might anticipate from the theoretical literature, and that there are relatively few ''sign reversals'' where changing some parameter changes the optimal policy from tariff or tax to subsidy. Thus this work appears useful in narrowing down the range of plausible effects. However, as noted by Venables (1994), the calibration methodology is not robust enough, nor are the implied gains large enough, to suggest using calibration exercises as a basis for implementing actual policies.

6. Concluding remarks

Having worked through the many details in this chapter (or having skipped straight to the conclusion), a reader might reasonably ask three questions. First, is strategic trade policy something that a competent government might actually be able to carry out? Secondly, what are the main results and major intellectual contributions of the strategic trade policy literature; and finally, what are the most promising lines of enquiry for further research?

6.1. The practice of strategic trade policy

Most contributors to the analysis of strategic trade policy would view any government attempt to apply strategic trade policy as something of a Pandora's box. As already discussed, the informational requirements for application of strategic trade policies are high. Also, although beyond the scope of this chapter, distortions arising from political economy considerations such as lobbying and other forms of transfer-seeking are a major concern. It seems natural to expect that strategic trade policy can only expand the scope for socially wasteful transfer-seeking [as modeled, for example, in Moore and Suranovic (1993)]. Even if free trade does not emerge as an optimal policy in normative strategic trade policy models, once political economy considerations are taken into account, perhaps it is the best we can do.

It is, however, important not to overstate the case against strategic trade policy activism. The informational requirements are high, but not impossibly high. Most of the relevant pieces of information that a well-meaning government needs are potentially observable, or at least can be reasonably estimated. Spencer (1986), for example, undertakes a coherent examination of how strategic trade policy targeting might be linked to observables. Political systems in some countries might be particularly prone to political economy distortions, but this is not true in all countries. Rodrik (1993) provides a comparison of the consequences of trade policy targeting in four selected countries and concludes that results are mixed, not uniformly bad.

Even if the prospects for forward-looking normative application of strategic policy are poor, using a strategic trade policy lens can aid the retrospective understanding of some trade policy interventions. For example, it has been persuasively asserted that interventionist policies in countries like Japan, Korea and France have had important effects in allowing industries and individual firms in those countries to develop a strong international presence. (Welfare effects are more ambiguous.) Perhaps more interestingly, one could speculate that the pattern of U.S. high technology production and exports is due in large part to three important interventions. Most importantly, U.S. policy has provided very substantial R&D subsidies to many industries through its heavily subsidized and very productive university research sector. In combination with local agglomeration effects, such as those in evidence at "Silicon Valley" near Stanford University, such R&D subsidies have apparently had a large impact. Secondly, the publicly funded defence and space exploration sectors have provided protected markets for U.S. firms not unlike those considered in Krugman (1984). Finally, the Export-Import Bank of the U.S. has, among other things, provided direct export subsidies to very successful high-technology industries, including aircraft production.

Strategic trade policy allows us to understand how apparently modest interventions in these areas could have large effects. If a comparatively small subsidy determines whether a foreign or domestic firm enters a given industry, and there is a significant learning curve, then a large long-run impact can arise. Thus strategic trade policy helps us understand how the history of trade and industrial policies (even if not given those names) has had a major role in influencing the current international pattern of specialization and trade. More detailed discussion of cases in which such policies have allegedly had a major impact can be found in Cohen and Zysman (1987) and Tyson (1993).

6.2. Main results and intellectual contributions of strategic trade policy research

The central contribution of strategic trade policy is that it allows trade theory to address some of the practical concerns that dominate the debate over actual trade policy. Earlier trade policy models based on perfect competition gave more clear answers to policy questions, but were vulnerable to the critique that they either ignored or provided unsatisfactory treatment of major concerns, such as increasing returns, learning-by-doing, R&D, and inter-firm strategic rivalries. Furthermore, many of those actively seeking to influence trade policy represent firms. Economists may assume that all firms earn precisely normal profits, but many private sector decision-makers believe that firms may make losses or (above-normal) profits for systematic reasons (i.e. for reasons beyond simple exogenous randomness or ''luck'') and that government policies have an important impact on those outcomes. Explicit consideration of profits is therefore important.

Reasonable consideration of all these issues is possible using oligopoly as the underlying industry structure. Even if the conclusion is that some proposed intervention is unwarranted, at least we have a reasonable basis for making that statement. In contrast, an assertion about non-intervention based on the assumption that the auto industry or the aircraft industry is perfectly competitive seems less convincing.

Perhaps the most robust finding in the analysis of strategic trade policy is that imperfect competition of the oligopoly type almost always creates apparent unilateral incentives for intervention. When strategic trade policy models were first presented, it was often suggested that some important ''correction'' of the models would eliminate the apparent role for such policies. Perhaps some appropriate characterization of government-level or firm-level rationality, or some plausible informational asymmetry, or entry, or international arbitrage, or general equilibrium effects, or some other powerful force would sweep away the foundations of strategic trade policy. This research agenda provided very valuable scrutiny of the theory of strategic trade policy, but no philosopher's stone that would transmute the normative analysis of strategic trade policy into free trade was found.

This apparent robustness of strategic trade policy incentives is, however, tempered by another important and fairly robust finding. Specifically, even nationally successful strategic trade policies typically have a beggar-thy-neighbor aspect. Thus countries that would otherwise compete with each other at the level of strategic trade policy have an incentive to make agreements that would ameliorate or prevent such rivalries. It should be noted, however, that imperfectly competitive goods tend to be underprovided from the overall world point of view. Therefore, other things equal, policies that subsidize such goods actually tend to enhance overall efficiency. On the other hand, policies that restrict such outputs tend to exacerbate the underlying imperfectly competitive distortion. In any case, decentralized strategic trade policies will not, except by remarkable coincidence, achieve outcomes that approach the world-level normative ideal, suggesting that international trade policy coordination should act as an important restraint on nationally-determined strategic trade policies.

Furthermore, models underlying strategic trade policy imply that the gains from trade are larger than in traditional models. Thus the stakes from getting multilateral agreements right are higher. Strategic trade policy provides valuable insight into the potential design of multilateral trade regimes and, in particular, provides a foundation for understanding how to treat such things as R&D subsidies, capital subsidies, and related policies at the level of international coordination.

One general finding emphasized in the paper is that the design of nationally optimal policy is sensitive to model structure and parameters. This is true of all economic policy, but policy directions seem more fragile in the presence of international oligopoly than in, for example, traditional trade theory based on perfect competition. To a large extent, this sensitivity reflects the nature of oligopoly theory (and real oligopoly conduct). Comparable policy sensitivity arises in the study of regulation, competition policy, and other areas where oligopoly market structures are seriously considered. We cannot always expect simple policy prescriptions in the presence of complex distortions. The task is to focus on simple, powerful, and potentially observable criteria for distinguishing between important general cases.

One such criterion for oligopoly is whether competition between firms is based on strategies that are strategic substitutes or strategic complements. An implication of this approach is that policies that directly promote R&D, investment, or learning-by-doing are likely to be more robust than policies that operate directly on output market variables, as investment-like strategies appear to be natural strategic substitutes in most cases. Two other general findings are that strategic trade policies will of course be more attractive if an industry earns substantial above normal profits and, less obviously, that market segmentation increases the apparent incentives for intervention in the presence of above-normal profits. We also have a good idea of how the relative importance of foreign and domestic competition, comparative foreign and domestic costs, and distortionary taxation affect trade policy incentives.

6.3. Future directions in strategic trade policy research

It is always difficult to predict the direction of any research area, so perhaps I can start by discussing the recent past. The concern that strategic trade policy generates many possibilities has, very naturally, led to substantial emphasis on empirical work so as to determine which possibilities are relevant in particular cases. Over the past few years relative effort has shifted toward empirical work, much of which is reviewed in Chapter 31 of this volume. [See also the edited volumes by Feenstra (1988, 1989).] The cost of computing power continues to fall, good data is increasingly available (especially on CD-ROM), and there are many econometric techniques yet to apply and interesting questions yet to address. Accordingly, it seems likely that the econometric analysis of strategic trade policy will continue to be a very active and fruitful area.

As for theoretical topics, many important gaps are left to be filled, and whole new directions are yet to be explored. In the category of gaps, it is important to analyze industries where free entry drives profits of marginal firms to zero but allows positive profits for inframarginal firms. Such cases require giving up analytically convenient symmetry assumptions and may require extensive use of specific functional forms, but seem worthwhile even so. In addition, the impact of informational asymmetries in strategic trade policy certainly has not been investigated as fully as it might be. Also, while regional trading arrangements are covered elsewhere in this volume, it is worth noting that the analysis of regional and multilateral arrangements in the presence of oligopoly is an active and promising area.

Perhaps the biggest area of incompleteness in strategic trade policy (as in many areas of economics) is the heavy reliance on simple one-shot or static models of both oligopoly and government policy formulation. We know that long-term interactions at the industry and government level are the rule rather than the exception and that they may differ significantly from short-term interactions, especially if we allow for full endogeneity in the timing of moves. However, the appropriate differential game versions of strategic interaction with rational, calculating players seem intractable at this stage. Furthermore, even if we could solve such models effectively, I am not sure that we would believe the results.

We might reasonably believe that players can find a Nash equilibrium in a simple one-shot game. Student subjects seem to do it pretty well, and presumably expert decision-makers in firms and governments are no less capable. Expecting real players to incorporate a sequential rationality requirement such as subgame perfection in simple games is asking a lot more, and experimental subjects have a much harder time with this refinement. Still, as a modelling strategy it seems better to require credible threats than to ignore the issue. However, once we consider requiring players to undertake rational strategic calculations in long and complicated differential games, especially if information is incomplete, we have passed the boundary of reasonable suspension of disbelief. Very few economists can calculate fully rational solutions to differential games of even moderate complexity; actual participants in games would not even try. Furthermore, there is little reason to believe that the relevant environments are stable enough to allow players using the method of trial and error to approach fully maximizing solutions. In light of this, much of the work in current game theory deals with games in which players have limited powers of calculation and use explicit learning strategies in sensible but heuristic ways to guide long-run strategic behavior. Application of such methods to strategic trade policy seems a challenging but potentially fruitful line of enquiry.

Among the most important consequences of any trade policy, strategic or otherwise, arise from its effects on economic growth. The static "one-shot" gains or losses from trade policy changes that are estimated in strategic trade policy models are larger than in traditional trade policy models, but still seem to be of modest size. It is possible that the effect of trade policy on growth might be more important still. This question is, however, not likely to yield a general answer, for we already know that there is apparently no theoretical presumption that the growth effects of trade policy necessarily dominate static distortions. For example, Grossman and Helpman (1991, ch. 6) examine a dynamic model in which a policy that slows growth but reduces an ongoing monopoly distortion may be desirable. This shows that the "growth rate" effect may be less significant than the conventional monopoly distortion effect that shows up in static models. In recent years much progress has been made in incorporating richer theories of the firm into models of trade and growth, as reviewed in Chapter 2 of this volume, but there is much yet to be done in understanding the interaction between strategic trade policy and economic growth. In this general area, as elsewhere in the analysis of strategic trade policy, the questions of greatest policy interest will have a particularly strong empirical component.

Finally, as the world becomes increasingly crowded, the interaction between trade policies and environmental policies will become more important. I would predict that much of the actual trade policy debate over the next decade or two will deal with environmental and resource use issues. Accordingly, since many of the relevant industries are of the oligopoly type, it will be important to integrate resource and environmental concerns into models of strategic trade policy. Relevant early work includes Barrett (1994), Brander and Taylor (1995), Kennedy (1994), and Rauscher (1994), but much remains to be done.

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