Strategic Trade Policy, Spillovers, and Uncertain Mode of Competition:Cournot versus Bertrand*

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Abstract: In this paper we discuss the incentives of a welfare maximizing government to implement strategic trade policy when there is, on the one hand, uncertainty about the relevant market information (like the type of competition, demand function, cost function, etc.), but, on the other hand, the environment of the contest between the firms is specific: there are two firms and the interaction among them is accompanied by technological spillovers from the domestic firm to the foreign firm. The two bench mark oligopoly models**S** Bertrand and Cournot**S**are assumed to be possible types of market competition. In order to analyse the problem of strategic policy under uncertainty, it is first necessary to work out in depth the optimal tariff policy in perfect information setup for both the Cournot and the Bertrand case. We argue, then, that the"informational" criticism of strategic trade policy is less relevant than was previously thought.

Abstrakt: V tomto …lánku diskutujeme podn• ty, které motivují vládu maximalizující všeobecný blahobyt k zavedení obchodní politiky v situaci kdy relevantní informace o trhu jsou nejisté (nap Í typ sout• ñe, poptávková funkce, funkce nákladç, atd.), avšak rámec sout• ñení firem je znám: dv• firmy, jejichñ vzájemná interakce je doprovázena únikem technologických informací z domácí sm• rem k zahrani…ní firm• . K modelování trñní sout• ñe jsou pouñity dva základní modely oligopolu, Bertrandçv a Cournotçv. Pro analýzu strategické politiky za nejistoty je nezbytné propracovat do hloubky optimální tarifní politiku p Í plné informovanosti v obou t• chto modelech. Záv• rem tvrdíme, ñe kritika strategické obchodní politiky op Éná o nedostatek informací je mén• relevantní neñ bylo doposud myšleno.

Key words: Optimal tariff, Bertrand and Cournot competition, spillovers, strategic trade, government's informational constraints, social welfare.

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1. INTRODUCTION

Strategic trade policy has its *raison d'etre* in the circumstances in which imperfect competition prevails. As is well known, its specific forms hinge on the type of imperfect competition in the market. In other words, the nature of market interaction among domestic and foreign firms decisively determines the equilibrium outcome of the game and, in turn, may even determine the optimal type and the optimal level of a selected instrument (e.g. optimal subsidy, quota, tax, tariff, etc.). Thus, for instance, imposing tax on a domestic firm's output is an optimal policy if firms compete in prices, whereas subsidising a domestic firm's output is the proper thing to do if firms compete in quantities. (See Eaton and Grossman, 1988). What is crucial for the successful application of a strategic policy seems to be the knowledge of the actors' behavior (their choice variables and the time structure of their decisions) which allows the government to properly influence the strategic environment (see Spencer, 1986, for more on this). However, new contributions both to oligopoly theory and to strategic trade policy demonstrate that the informational content needed for intervention is far less demanding than suggested by the early strategic trade literature. For example, Maggi (1996) showed that both Bertrand and Cournot outcomes can endogenously arise in a two-stage game in which two firms first set their capacities and then compete in prices in a market with differentiated goods. The key parameter (which is in principle observable) that determines the outcome is the strength of the capacity constraint; if producing ?beyond capacity" is not so costly (implying that the strength of the capacity constraint is weak), the Bertrand outcome arises, whereas the Cournot outcome emerges if capacity has a high commitment value (that is, producing beyond capacities is rather costly). In this framework, it turns out that so-called capacity and investment polices (like subsidising capacity, R&D, etc) are much less sensitive to informational content than, for exapmle, output policy, and government by conducting such a policy cannot do any harm to domestic social welfare irrespective of the mode of competition.

One of the motivations of this paper is to show that the informational content needed by government for (harmless) intervention might be much less than *a priori* expected, even if one retains all ?unfavourable" assumptions like homogenous goods, output policy and exogenous mode of competition. The reason for this could be, for instance, the specific situation in which governments intervene. A government may infer much of the needed information from the very structure of the problem .

The specific situation which serves to illustrate this point is the one in which the international contest between domestic and foreign firms is accompanied by technological spillovers from the domestic firm to the foreign firm. The spillovers are a by-product of domestic innovative activity and they are also reflected in the foreign competitor's unit cost. The foreign firm costlessly, but imperfectly, copies the improvement in production technology. Finally, the government wants to infer what the optimal level of tariff would be without *a apriori* knowing such relevant information as the type of competition between firms, the precise type of R&D production function, etc.

Prior to discussing the government's strategic trade policy under uncertainty, it is necessary to investigate the analogous case of the strategic trade policy in perfect information framework. That is, to analyse the optimal tariff policy when firms compete in prices rather than in quantities in the above described circumstances (technological spillovers from the domestic firm to the foreign competitor) and when the government possesses all relevant pieces of information. This analysis is a prerequisite for the more realistic case of incomplete information.

The paper proceeds as follows: In Section 2, we set forth the assumptions and describe the core model and the role of the tariff in the given setup. Section 3 is devoted to the analysis of the third and second stages of the game in the case when the firms compete in quantities. The impact of tariff on R&D expenditures, consumer surplus and profit in duopoly and constrained monopoly is also examined there. Section 4 is concerned with the central issue **S** optimal (welfare maximizing) market structure and optimal tariff in Cournot competition. Sections 5 focuses on Bertrand competition with the occasional comparison to the results from quantity competition. Section 6 is again devoted to the main topic **S** optimal tariff when firms compete in prices. Section 7 discusses the important issues of capabilities and incentives of conducting strategic trade policy when the relevant pieces of information are not available to the government. Section 8 concludes.

2. THE MODEL

2.1. Assumptions

There are only two countries, "domestic" and "foreign." The market of interest is the domestic market. The domestic and foreign markets are "segmented markets", that is, the firms produce for both markets, but they perceive each other's market as different (e.g. the foreign firm considers the domestic market as different from its own market and, consequently, its optimization problem for the "home" market is independent of its optimization decision for the domestic market, the same is true for the domestic firm). In other words, the arbitrage is not important (because it may be too costly) and no allowances are made for it in the analysis. (See Brander and Spencer, 1982, 1983 and 1984, and Helpman, 1982). The focus on one market is also made possible by assuming the constant marginal cost, and thus, avoiding interactions between markets.

The domestic firm is the only one assumed to conduct R&D.[1] The focus is on the so-called "process innovations." An "R&D production function" captures the effects of R&D on unit costs. The function displays "diminishing returns," that is, every additional dollar invested in decreasing unit costs results in an ever smaller reduction in unit costs.[2]

The nature of the firms' market relationship is modeled by relying on the concept of strategic interaction. We consider sequential (three-stage) games here. In the first stage, the domestic government selects the optimal tariff, anticipating the R&D choice of its firm (in the second stage) and subsequent competition (which may be either in prices or in quantities) between the two firms (in the third stage).

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[1]It may be useful to think about the domestic firm as "West European" and the foreign firm as "East European".

[2]This specification reflects empirical observations and was listed, for instance, as a "stylized fact" in Dasgupta (1986), p. 523.

Finally, we assume that so-called "jumping over the tariff"[3] is not a viable strategy for the foreign firm. The reason for this might be that the entry and capacity costs are so high that foreign direct investments are not attractive. Alternatively, one can think of the domestic firm as belonging to a developed market economy and the foreign firm as being from Eastern Europe or some other less developed country (see Footnote 1), in which case the export of the goods of the latter to the former is a usual type of market interaction.

2.2. The Core Model

Much like in ðigiƒ (1996a), (1996b) the core model in this paper is a model of duopolistic competition between the domestic and the foreign firm.

The domestic firm has unit costs of production C = a - f(x) where f(x) can be viewed as an "R&D production function" with classical properties, f(0) = 0, f'(x)>0 and f"(x) < 0. a is a parameter that can be thought of as pre-innovative unit costs.

The foreign firm benefits through spillovers from the R&D activity carried out by the domestic firm. If it exports its products, the foreign firm also pays a specific tariff *t* per unit of production. Its unit (pre-tariff) cost function is c = a - ß f(x) and ß denotes the level of spillovers. The value of ß can take the values from zero to one, it is perceived as a parameter by the firms, and is assumed to be common knowledge for both parties.

The inverse demand function of the domestic market (assumed to be linear with units chosen such that the slope of the inverse demand function is equal to one) is P = A - Q where $Q = q_s + q_n$ and A > a . Parameter *A* captures the size of the market, whereas q_s and q_n denote the choice variables, that is, the corresponding quantities, of the domestic and the foreign firms.

Social welfare (*W*) is defined as the sum of consumer surplus (*S*) and the firm's profit (*p*). The consumer surplus is defined as

$$S(q) = \int_0^q P(z)dz - qP(q)$$

[3] For examples of "jumping over the tariff" see Motta (1992) or Brandao and Fortunato (1997).

In the case of a linear demand, the above expression becomes: $S_n = (1/2)(q_s+q_n)^2$.

2.3. The Role of Tariff

The economic impact of tariffs has been well established and studied especially in the international trade literature. One lesson of strategic trade policy literature is that government has an incentive to impose a tariff to secure a higher profit or a higher market share for a domestic firm in a situation in which imperfect competition prevails (e.g., see Brander and Spencer, 1982, 1983, and 1984, Krugman, 1984, Helpman and Krugman, 1989, etc.). The announced tariff changes the nature of the "game" among foreign and domestic firms by altering the strategic interactions among them. What is crucial to this result is that the government has the credibility to commit to its policy choice (e.g. tariff) before the firms make their choices. This requirement is usually met in practice and it is consistent with our assumption that the government "moves first" in the game.

Tariffs seem to be a superior instrument over, say, subsidies from the point of view of implementation. Bhattacharjea (1995) discussed several reasons why implementing a subsidy might be troublesome, from the high information content required to implement the optimal subsidy to the distorting effects of taxes necessary to finance the subsidy.

Likewise, the imposition of a tariff is made difficult because of the various bilateral and multilateral agreements under the former GATT. In this light, imposing a tariff requires a very strong argument. One such argument arises, for instance, when a foreign firm violates intellectual property rights. Since the existence of spillovers can be interpreted as violations of intellectual property rights, the domestic government is authorized to impose a so-called "punitive " tariff. To justify the introduction of the tariff, we may assume that ß > 0 and interpret this as a violation of intellectual property rights (see more about the punitive tariff in ðigiƒ, 1996b).

Another important feature of the tariff is that it is a device by means of which the government can influence the market structure. Confining our analysis, for instance, to the simplest case of two firms and quantity competition, there are three possible market patterns which could arise in equilibrium as a consequence of the erected tariff: duopoly, constrained monopoly, and unconstrained monopoly. In this light, the tariff is a device which controls the disparity between the domestic firm's and the foreign firm's unit costs. In other words, a government can, by selecting an appropriate tariff, always raise the tariff so high as to make the difference in unit costs high enough to force the foreign firm to exit and, depending on the height of the tariff, enable the domestic firm to charge either the limit price or monopoly price. The domestic government can instead decide to keep the foreign firm in the market by charging a low tariff or, if the domestic firm initially holds an unconstrained monopoly position, the desirable tariff could even be negative (subsidizing imports). In further considerations, we will neglect the possibility of negative tariff since it is most likely unfeasible.

Thus, in the case of quantity competition, duopoly will be the viable market form unless the tariff reaches a certain critical value (labelled "t_p") at and beyond which the best response of the foreign firm will be to exit the market because the domestic firm has adopted strategic predation strategy as optimal; that is, it has committed to the level of R&D for which the rival firm's optimal production (as well as profit) is zero. By increasing the tariff beyond t_p, the difference in the marginal costs becomes so large that at (and beyond) the value of the tariff (denoted by t_m), the domestic firm gains an unconstrained monopoly position.

In case of price competition, it is clear that the domestic firm with low costs can, depending on the height of tariff, be a constrained (Bertrand) or an unconstrained monopolist.

3. THE COURNOT GAME

3.1. The Case of Duopoly - The Last Two Stages

When the firms compete in quantities, we assume that duopoly is a viable market form before the tariff is set. We now start to solve the game backwards. In the last stage, the firms choose the equilibrium quantities. The domestic firm maximizes[4]

$$\underset{q_n}{Max}[\pi_n] = (A-Q)q_n - Cq_n - x \qquad (1.a)$$

given q_s .

The first-order condition for a maximum is $\partial p_n/\partial q_n = 0$ and it yields $A - 2q_n - q_s - C = 0$.

The optimization problem for the foreign firm means:

$$\underset{q_s}{Max}[\pi_s] = (A-Q)q_s - cq_s - tq_s \qquad (1.b)$$

given q_n and t (t stands for the tariff imposed by the domestic government). The first-order condition is: $A - 2q_s - q_n - c - t = 0$. Solving the reaction functions yields the Cournot outputs and price as a function of R&D investment:

$$q_n(x) = \frac{(A+c-2C+t)}{3} \qquad (2.a)$$

$$q_s(x) = \frac{(A-2c+C-2t)}{3}. \qquad (2.b)$$

Substituting (2.a) and (2.b) into (1.a) yields the domestic firm profit function expressed in terms of R&D investment and tariff:

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[4] We neglect the profits the firms are earning on the foreign markets since they are irrelevant to the maximization problems under consideration.

$$\pi_n(x) = \frac{(A+c-2C+t)^2}{9} - x. \tag{3}$$

In the second stage of the game, the domestic firm selects x in order to maximize its profit. Note that the set of R&D action is given by X where $x \in X = [0, x^q]$ and x^q is the solution of the equation $a - f(x) = 0$.[5] Substituting expressions for C and c into (3) and maximizing with respect to R&D investment, gives the first order condition and (implicitly) x^*_c :

$$\frac{2(2-\beta)(A-\alpha+t+(2-\beta)f(x_c^*))f'(x_c^*)}{9} = 1. \tag{4}$$

The second-order condition requires :

$$\frac{2(2-\beta)[(2-\beta)f'(x_c^*)^2+(A-\alpha+t+(2-\beta)f(x_c^*))f''(x_c^*)]}{9} \leq 0. \tag{5}$$

3.2. The Impact of Tariff on R&D, Profit and Consumer Surplus in Duopoly

We first start with the R&D expenditures. An increase in tariff enhances the R&D expenditures if duopoly is a market form in equilibrium. (Duopoly is a sufficient but not necessary condition for this result to hold.)

LEMMA 1. *$dx_c^*/dt > 0$ if duopoly is the equilibrium market form in a post-tariff situation.*

PROOF. Differentiating (4) with respect to t gives

$$dx_c^*/dt = \frac{f'(x_c^*)}{-[(2-\beta)f'(x_c^*)^2+(A-\alpha+t+(2-\beta)f(x_c^*))f''(x_c^*)]} > 0 \tag{6}$$

[5] We assume that α is big enough that the optimal R&D is always in the interior of the set X.

since the denominator of (6) is positive as can be seen from comparing it with the second order condition.

Thus, the role of the tariff here is not only to be a strategic tool to capture the foreign firm producer surplus, but also to help increase the R&D level towards the socially optimal R&D expenditures. The intuition for this lies in a specific self-reinforcing mechanism (feedback): an increase in tariff increases the unit costs of the competitor and leads to the higher output of the domestic firm in the new equilibrium. The higher the output, the more it pays off to reduce unit costs and, therefore, the higher R&D investments will be. Higher R&D investments enhance cost advantage and higher output will follow.

LEMMA 2. *$d\Pi^*(t)/dt = \partial\Pi^*(t)/\partial t > 0$ for all $t \in [0,t_p)$.*

PROOF. First note that $d\Pi^*(x^*_c,t)/dt = \partial\Pi^*(x^*_c,t)/\partial x \; dx^*_c/dt + \partial\Pi^*(t)/\partial t = \partial\Pi^*(t)/\partial t$ since the first part is zero according to the first order condition. Finally

$$d\Pi^*(t)/dt = \partial\Pi^*(t)/\partial t = \frac{2[A-\alpha+t+(2-\beta)f(x_c^*)]}{9} > 0 \qquad \text{for } t \in [0,t_p) \tag{7}$$

holds.

LEMMA 3. *$dS^*(x^*_c,t)/dt = \partial S^*(x^*_c,t)/\partial x \; dx^*_c/dt + \partial S^*(x^*_c,t)/\partial t$ where*

$\partial S^*(x^*_c,t)/\partial x \; dx^*_c/dt > 0$ and $\partial S^*(x^*_c,t)/\partial t < 0$.

PROOF. First note that

$$S^*(x_c^*,t) = 1/2(q_s^*+q_n^*)^2 = \frac{[2(A-\alpha)-t+(1+\beta)f(x_c^*)]^2}{18}. \tag{8}$$

The sign of $\partial S^*(t)/\partial t$ is then

$$\partial S^*(t)/\partial t = \frac{2(\alpha - A) + t - (1+\beta) f(x_c^*)}{9} < 0 \quad for\ t \in [0,t_p) \quad ,$$

$$\partial S^*(x_c^*,t)/\partial x = \frac{(1+\beta)[2(A-\alpha) - t + (1+\beta) f(x_c^*)] f'(x_c^*)}{9} > 0 \quad for\ t \in [0,t_p).$$

As is well known, the direct effect of tariff on consumer surplus is always negative, since price is higher in the new equilibrium. The indirect effect of the tariff on consumer surplus is, however, always positive in duopoly, since increases in tariff stimulate investment in R&D (see Lemma 1), which in turn increases, output and consumer surplus. Thus, the sign of $dS^*(x^*_c,t)/dt$ is *a priori* ambiguous.

3.3. The Constrained Monopoly and Strategic Predation

Strategic predation (or limit pricing) behavior turns out to be the optimal strategy for the domestic firm in the situation in which, for a given t, predatory profit is equal to or bigger than the profit in duopoly. Equivalently, this strategy becomes optimal if the imposed tariff reaches or exceeds a certain critical level (t_p). The timing of the game remains the same as before. We refer here only to the last two stages: in the second to last stage the domestic firm commits to the R&D level which will force the foreign firm to pick up the zero output in the last stage of the game (This is the best the foreign firm can do in this situation). In the last stage, two firms are supposed to compete in quantities, but the best that the foreign rival can do under the given circumstances is to produce zero quantity and thus exit the market. The domestic firm, which remains in the market, then chooses the monopoly output. However, this output (and correspondingly, this price) is generally different than the output which would result were the domestic firm to select the unconstrained monopoly R&D expenditures.

The corresponding predatory level of R&D (labelled x^*_p) is implicitly obtained by substituting the expressions for C and c into (2b) and equating this expression to zero:

$$\frac{A+\alpha-2t-f(x_p^*)-2(\alpha-\beta f(x_p^*))}{3} = 0. \tag{9}$$

Solving (9) explicitly for tariff t and labelling it as "t_p" yields:

$$t_p = \frac{A-\alpha-(1-2\beta)f(x_p^*)}{2}. \tag{10}$$

Tariff t_p just suffices to eliminate the competitor from the market and we refer to $t \in [t_p, t_m]$ as a "predatory tariff"[6].

Differentiation (9) with respect to t provides us with two important additional lemmas:

LEMMA 4. *$dx^*_p/dt < 0$ if $\beta < 1/2$ provided that predation is the optimal strategy for given t, i.e., that the constrained monopoly is the equilibrium market form.*

PROOF.

$$dx_p^*/dt = \frac{-2}{(1-2\beta)f'(x)} < 0 \quad if \quad \beta < 1/2.$$

The question is, however, what caused such a reverse reaction of the domestic firm here in comparison with its behavior in the duopoly case. (Recall that in duopoly the optimal R&D increases as a response to an increase in the tariff.)

The answer is not difficult once we understand the logic of "predatory" behavior. When the domestic firm predates, and there are small spillovers, it spends more resources on innovative activity than it would if it followed myopic (unconstrained monopoly) profit maximization (see Appendix 1 for formal proof). In other words, the firm commits to higher R&D to induce the exit (or prevent the entry) of the rival. An increased tariff yields the same effect. In fact, the government, by increasing the tariff (assumed to be initially in the predation interval $t \in [t_p, t_m]$),

[6] Note that $t_m = [A - \alpha - (1 - 2\beta) f(x^*_m)]/2$ where x^*_m stands for the R&D investment which an unconstrained monopoly would select. Further, note that $t_m \geq t_p$ (see Appendix 3).

predates somewhat for its firm, and it pays for the firm to decrease its R&D expenditure towards the (monopoly) profit maximizing level of R&D investment after the tariff has been increased. These considerations, however, bear an important policy implication: a tariff set too high will decrease R&D spending, decrease output and, as a result, may have a counterproductive implication for social welfare.

The policy conclusions are exactly reversed in the situation characterized by high spillovers (ß > 1/2).

LEMMA 5. *$dx^*_p/dt > 0$ if ß > 1/2 and predation is an optimal strategy.*

PROOF. Analogous to Lemma 2.

Note that here, the actual level of R&D is lower than the corresponding monopoly R&D (see Appendix 1) due to the high disincentive of spillovers. An increase in tariff lessens the potential competition of the foreign firm and reduces disincentives to invest in R&D, and the optimal response of the profit-seeking firm is to increase the R&D level and thus move again towards the monopoly (or myopic) profit maximizing point. The policy concern now is not to put the tariff too low.

Note that the increased tariff in this case also helps to move the R&D closer to the social optimum and thus, as in duopoly, serves as an "ordinary" policy tool for restoring incentive for R&D investment.

Furthermore, observe that, at the level of spillovers of one-half (ß = 1/2), the optimal level of R&D coincides with the "decision theoretical" solution (see Appendix 1). That is, the selected level of R&D to induce the exit of the foreign firm is the same as if the domestic firm were an unconstrained monopoly, ($t_p = t_m$ at ß = 1/2).

What remains to be discussed is the impact of the tariff on predatory profit and consumer surplus which arises in these circumstances. The domestic firm selects the R&D investment, x^*_p, in such a way as to exclude the foreign firm. Given x^*_p, the second stage payoff is given by

$$Max[\pi_p] = (A - q_p)q_p - Cq_p - x_p \ . \qquad (11)$$

The first-order condition for a maximum yields,

$$d\pi_p/dq_p = 0 \Rightarrow A - 2q_p - C(x_p) = 0 \Rightarrow q = \frac{A - C(x_p)}{2}. \qquad (12)$$

Substituting (12) into (11), gives the predatory profit function $\pi^p(x)$as a function of predatory R&D expenditures:

$$\Pi^p(x_p) = \frac{(A - \alpha + f(x_p))^2}{4} - x_p. \qquad (13)$$

Differentiating with respect to t, reveals only the existence of the indirect effect, $\partial\pi^p/\partial x \ dx^*_p/dt$ since the tariff now influences profit only via its impact on R&D expenditures. The sign of $\partial\pi^p/\partial x \ dx^*_p/dt$ can be easily determined by relying on our previous analysis; when spillovers are low, $dx^*_p/dt < 0$ (see Lemma 4), then $x^*_p > x^*_m$, implying $\partial\pi^p/\partial x < 0$ (see Appendix 1) due to over-investment in R&D aimed at inducing exit. When, on the other hand, $\beta > 1/2$ then $x^*_p < x^*_m$, so that $dx_p/dt > 0$ and $\partial\pi^p/\partial x > 0$ (see Lemma 5 and Appendix 1). Thus, as a corollary, we always have

LEMMA 6. *$d\pi^p/dt = \partial\pi^p/\partial x \ dx_p/dt > 0$*

Thus, the tariff, irrespective of the level of spillovers, improves the profit of the domestic firm, since it dampens the strength of the potential competition of the foreign firm and brings the domestic firm closer to the unconstrained monopoly position.

As far as consumer surplus in the "predation region" is concerned, here also only an indirect effect of tariff exists and its sign is entirely determined by the spillovers level.

LEMMA 7. *$dS^p/dt = \partial S^p/\partial x \ dx_p/dt > 0$ iff $\beta > 1/2$* and vice versa is true if $\beta < 1/2$.

PROOF.

$$\partial S^{p}/\partial x = \beta(A-\alpha-t+\beta f(x))f'[x] > 0 \;\; for \;\; t \in [t_p,t_m]$$

Since $dx^*_p/dt > 0$ for $ß > 1/2$, this implies that $dS^p/dt > 0$ for $ß > 1/2$. By the same token, note that $dS^p/dt < 0$ for $ß < 1/2$.

An increase in R&D expenditures is always beneficial for the consumer surplus. When coupled with large spillovers the overall effect is unambiguously positive since an increase in tariff boosts R&D expenditures in this case. However, when spillovers are small, the optimal reply to an increase in tariff requires cutting R&D expenditures, thus harming the consumer surplus.

4. OPTIMAL TARIFF IN COURNOT COMPETITION

So far, tariff has been considered as though it were arbitrarily set. However, the benevolent domestic government wishes to set not just any, but the optimal, welfare maximizing tariff.[7] So what are the available choices? The social welfare function is represented in a more or less standard way as the sum of consumer surplus and domestic firm's profit:

$$W[x_c^*(t),t] = \Pi^*[x_c^*(t),t] + S^*[x_c^*(t),t]. \qquad (14)$$

Determining the optimal tariff implies the appropriate selection of the optimal (welfare maximizing) market structure. Recall that we assumed duopoly to be a viable market form in the pre-tariff situation. Thus, the government has three options: a) to maintain duopoly by charging a "low" tariff, b) to constrain its firm using the potential competition from abroad by imposing a tariff which forces the foreign firm to exit the domestic market, but does not enable the domestic firm to charge full monopoly price and c) to set the tariff so high that it allows the domestic firm to obtain an unfettered monopoly position.

Let us start with the welfare considerations in duopoly. The marginal social welfare is

[7] A sufficient condition to have optimal positive tariff is a not "too convex" demand function. A linear demand function surely satisfies this requirement. For a full discussion of the sign of an optimal tariff, see Brander and Spencer (1984).

given by

$$dW^*(t)/dt = \partial S^*(t)/\partial x \; dx_c^*/dt + \partial S^*(t)/\partial t + \partial \Pi^*(t)/\partial t.$$

It seems that the government's main problem here is to balance the positive profit effect, $\partial \Pi^*/\partial t$, against the potentially negative consumer surplus effect (recall the ambiguous sign of dS*/dt), but since the direct profit effect always exceeds the direct negative consumer surplus effect, the unambiguous conclusion is summarized in Proposition 1.

Proposition 1.

The optimal tariff, t, is at least as high as t_p. In addition, duopoly is not a welfare maximizing market structure.*

Proof.

The simple sum of the direct profit effect and the direct consumer surplus effect yields:

$$\partial \Pi^*/\partial t + \partial S^*/\partial t = \frac{f(x_c^*)(1-\beta)+t}{3} > 0.$$

Since the indirect consumer surplus effect, $\partial S^*/\partial x \; dx^*_c/dt$, is always positive (see Lemma 3), it unambiguously leads to dW*/dt > 0 at the whole range of tariff rates consistent with duopoly, that is $t \in [0, t_p]$.

This result is related to the standard one found in strategic trade theory which claims that, given the duopoly Cournot competition between the foreign and the domestic firm, imposing a "low" tariff is beneficial in terms of social welfare under fairly general conditions (see Helpman and Krugman, 1989). A sufficient (but not necessary) condition for this standard result to hold is that there be "positive terms of trade effect," which in this context means that the new equilibrium price rises by less than the increase in tariff. This is surely the case with the linear demand function.

However, our result here is more distinctive and precise due to the specific context of the problem. Positive social welfare effects are not constrained only to "low" (near zero) tariffs here, but are also present at a level of tariff for which duopoly is not a viable market form. The optimal tariff argument suggests here that the tariff should be so high that it provokes the expulsion of the foreign firm. Such a strong result is the consequence of two features of our model. The first feature stems from the fact that the domestic firm is a "natural monopoly" because of the increasing returns due to R&D expenditures. Under these circumstances, it is socially optimal to have only one firm serving the market. In addition, an increase in tariff brings about an increase in socially desirable investment in R&D activity and then it makes sense to increase the tariff more than it would otherwise be increased. The second feature is the specification of the social welfare function. Unlike in the usual strategic tariff scenario, we did not include the revenues from the collected tariff in the social welfare function. Allowing for that may change the conclusion of *Proposition 1*, in the sense that the duopoly market form might become optimal under certain circumstances (namely, if R&D efficiency is "small") so that the benefits from tariff revenue would be higher than the losses from not having more than one firm (with natural monopoly characteristics) in the market (see Žigić 1996b).

The next question which naturally arises in this context is, should the tariff be raised even higher than the value of t_p. To answer this question, we have to look back at the consumer surplus and profit functions in the "predatory" and monopoly region. Since only indirect tariff effects exist in the predatory region, marginal social welfare is rendered as:

$$dW^{*p}(t)/dt = \partial S^{*p}/\partial x \; dx_p^*/dt + \partial \Pi^{*p}/\partial x \; dx_p^*/dt.$$

Making use of Lemmas 6 and 7, it becomes clear that $dW^{*P}/dt > 0$ whenever there are large spillovers, implying that the tariff should be put at the maximal value, that is, at the level of t_m. On the other hand, when spillovers are small, there are two conflicting effects—the positive profit effect and the negative consumer surplus effect. However, it can be easily shown (see Appendix 2) that the negative effect always prevails over the positive effect leading to $dW^{*P}/dt < 0$ for small spillovers, which suggests that the optimal tariff stays at t_p.

Proposition 2.

When spillovers are large (ß > 1/2), the socially optimal tariff $t^* = t_m$ *and the welfare maximizing market structure is an unconstrained monopoly. When, on the other hand, spillovers are small (ß <1/2),* t_p *is optimal tariff and the constrained monopoly is socially the most desirable market form.*

This strong result again comes from the fact that we ignored the revenue from the tariff. (Again, if R&D efficiency is rather small, duopoly may be socially optimal when the revenue from tariff matters). Furthermore, the fact that the unconstrained monopoly appears as the welfare maximizing market form is due to the fact that large spillovers produce high disincentive, so that socially desirable R&D expenditures in duopoly are much lower than in monopoly. The constrained monopoly cannot be the optimal market form here, since as soon as the erected tariff reached the level t_p, a further increase in tariff would increase both domestic profit and investment in R&D, which in turn would give rise to an increase in consumer surplus. Thus, the monopoly tariff, t_m, emerges as optimal. However, the policy conclusion here is not that unfettered monopoly is unconditionally the best solution. Obviously, the government may try to use other instruments (e.g. price caps) to regulate the monopoly, provided that this intervention does not adversely affect R&D.

5. BERTRAND COMPETITION

5.1 Optimal R&D Investment

As far Bertrand competition is concerned, we keep all assumptions adopted in Section 2. In addition, we assume, for the time being, that monopoly is not viable for any permissable level of x or any level of ß in the pre-tariff situation[8].

As is well known, the lower cost firm will be the only one serving the market with a price which is slightly below the unit cost of the competitor.

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[8] Without this assumption the equilibrium price will be $p^* = \min[p_m, p_b]$ where "p_m" stands for monopoly price.

Thus, the equilibrium price will be

$$p_b \equiv p = c + t - \epsilon, \tag{15}$$

where p_b refers to Bertrand price. For the sake of simplicity, we assume that e = 0 for the rest of the paper.

Substituting the expression a -ß f(x) for c in (15) and taking e=0, we get the market price expressed in terms of R&D expenditures and accompanying parameters:

$$p = \alpha - \beta f(x) + t. \tag{16}$$

Similarly, the appropriate substitution gives the profit function, expressed in terms of R&D expenditures and parameters

$$\pi(x) = (\alpha - \beta f(x) + t)(A - \alpha + \beta f(x) - t) - (\alpha - f(x))(A - \alpha + \beta f(x) - t) - x \tag{17}$$

where $x \in X = [0, x^q]$ and x^q is the solution of the equation a -f(x) = 0.

In the second stage of the game the domestic firm selects the level of R&D expenditures, anticipating subsequent competition in prices. Maximizing (17) with respect to R&D investment, we obtain (implicitly) x* as the solution of (18)

$$(A - \alpha) f'(x)(1 - \beta) - t(1 - 2\beta) f'(x) + 2\beta f(x)(f'(x) - \beta f'(x)) = 1. \tag{18}$$

The second order condition requires that

$$2\beta f'^2(x) + f''(x)(A - \alpha + 2\beta f(x)) - (1 - 2\beta) f''(x) t \leq 0 \tag{19}$$

and we assume that (19) is always satisfied.

5.2. The Impact of Tariff on R&D, Price, Profit and Consumer Surplus

The impact of tariff on the equilibrium R&D, depends on the level of spillovers. If spillovers are low (ß < 1/2), the increase in tariff leads to a decrease in x*, whereas the opposite holds in a situation in which spillovers are high (ß > 1/2).

LEMMA 8. *dx*/dt < 0 if ß < 1/2.*

PROOF. Applying the implicit function theorem to (4), we get

$$dx^{*}/dt = \frac{(1-2\beta)f'(x)}{(1-\beta)2\beta f'^{2}(x)+f''(x)(A-\alpha+2\beta f(x))-(1-2\beta)f''(x)t}.$$

Note that for the denominator to be negative, the second order condition (18) is sufficient.

$$Sign[dx^{*}/dt] = -Sign[(1-2\beta)] = -1 \;\; if \;\; \beta < 1/2$$

The underlying intuition for these results is analogous to the case of strategic predation discussed in Section 3. Note that here also x* is higher than the level of R&D which an unconstrained monopoly would pick up if ß < 1/2. The increase in tariff raises the unit cost barrier and moves the domestic firm nearer to the monopolistic position. Thus, the higher tariff, the closer domestic firm will be to the (unconstrained) monopoly position and its R&D expenditure will approach x^*_m (where x^*_m is the level of R&D which the profit maximizing monopoly chooses). This specific situation implies that x* decreases until the tariff reaches the level t_m, that is, the lowest level of tariff which secures the unfettered monopoly position of the domestic firm.

LEMMA 9. *dx*/dt > 0 if ß > 1/2.*

PROOF. Analogous to the previous proof.

As should be clear, for ß > 1/2, disincentive to invest in innovative activity is so intense (high spillovers), that it causes the level of R&D expenditures to be even smaller than x^*_m. In this situation an increase in tariff enables R&D expenditures again to approach the monopolistic R&D level, but this time, it implies an increase (rather than a decrease) in R&D expenditures. Again, this result parallels the one from quantity competition if strategic predation (limit pricing) happens to be the optimal strategy. In this case the increase in tariff also leads to an increase in optimal

R&D for ß > 1/2.

Since price is a central strategic variable here, we will briefly look at the impact of tariff on equilibrium price. In the standard one-stage Bertrand game, in which the domestic firm has a post-tariff unit cost advantage, (C < c + t), the pass through of the tariff is 100%, that is, price increases one-to-one with tariff.

In our model, this is generally not the case. "Overshifting" as well as "undershifting" of the price is equally possible. The presence of R&D expenditure leads to the indirect effect of tariff on price, in addition to the "standard" direct effect. The indirect effect of tariff operates via its impact on optimal R&D expenditures, which, in turn, influences the equilibrium output. Whether this indirect effect causes an overshifting or undershifting of price, depends upon the level of spillovers.

The equilibrium price charged by the domestic firm is

$$p^* = \alpha - \beta f(x^*) + t. \qquad (16')$$

It is obvious that $\partial P^*/\partial t = 1$, but a change in tariff exhibits an indirect effect via its influence on the optimal R&D. As we discussed in the previous section, the direction of change in x* due to the change in tariff depends on whether spillovers are high or low. Relying on these results, we state two additional lemmas.

LEMMA 10 (OVERSHIFTING). *dp*/dt > 1 if ß < 1/2.*

PROOF. Differentiating (16') with respect to t yields,

$$dp^*/dt = 1 - \beta f'(x^*) dx^*/dt > 1.$$

In Lemma 8, we have dx*/dt < 0 for ß < 1/2, implying dp*/dt > 1.

LEMMA 11 (UNDERSHIFTING). *dp*/dt < 1 if ß > 1/2.*

PROOF. Analogous to the proof for Lemma 10.

As an aside, note that in the situation in which duopoly competition emerges as an equilibrium market form, the analogous "direct effect" of the tariff is much smaller, whereas the indirect effect is always beneficial (price decreasing), thus offsetting, in part, the direct effect.[9]

LEMMA 12. *d? *(t)/dt = M? *(t)/Mt > 0 for all t e [0,t_m).*

PROOF. First note that d? *(x*,t)/dt = M? *(x,t)/Mx dx*/dt + M? *(t)/Mt = M? *(t)/Mt since the first part is zero according to the first order condition. Thus,

*d*A((*t*)/*dt* ' MA((*t*)/M*t* ' *A*&"&2*t*&(1&2$)*f*(*x*() > 0 *for t* O [0,t_m).

Substituting the value of t_m for t in the above expression, yields d? *(t_m)/dt = 0 and for all t < t_m obviously, d? *(t)/dt > 0.

As expected, the increase in tariff softens potential competition and enables the domestic firm to charge a price which is nearer to the unconstrained monopoly price. If the firm were given a possibility to choose t, they would of course choose tariff t_m since monopoly profit is the biggest one. Recall that for t$$t_m$ tariff has no influence on profit, that is d? *(t)/dt = 0 for t $ t_m.

LEMMA 13. *dS*(x*,t)/dt = MS*(x*,t)/Mx dx*/dt + MS*(x*,t)/Mt < 0 for ß < 1/2.*

PROOF. First note that S*(x*,t) = 1/2 q^{*2} = 1/2 (A - a + ßf (x*) - t)^2. The sign of MS*(t)/Mt is then

M*S*((*t*)/M*t* '"&*A*%*t*&$*f*(*x*() < 0 *for t* O [0,t_m)

As well known, the direct effect of tariff distortion on consumer surplus is always negative because of its effect on the price increase. For small spillovers, the negative effect is exacerbated by the fact that the firm reacts to an increase in tariff by halting its R&D expenditure (see Lemma 8) and thus MS*(x*,t)/Mx dx*/dt is clearly negative as well.

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[9] The equilibrium price in the case of Cournot duopoly, is given by P(x) = [2 " + A + t - f(x) - $f(x)]/3. As can be seen by visual inspection, the direct effect of tariff on price is 1/3, whereas the indirect effect is always positive due to the fact that dx_c*/dt > 0 for all $ (see Lemma 1).

However, the overall effect on the tariff is not known *a priori* for large spillovers because an increase in tariff when spillovers are large gives the firm an incentive to invest more in R&D (see Lemma 9).

6. OPTIMAL TARIFF IN BERTRAND COMPETITION

6.1. The Case when Spillovers are Small (ß < 1/2)

As in Section 4, the social welfare function, in the case in which the domestic firm selects x* as its optimal R&D level, is given below

$$W[x^*(t),t] = \Pi^*[x^*(t),t] + S^*[x^*(t),t].$$

Note that again the set of government strategy actions, T, is defined as $T \in [0,t_m]$.

The shape of the social welfare function, and thus the optimal tariff, will crucially depend on the level of spillovers. For small spillovers (ß < 1/2), as we saw in the previous section, consumer surplus is monotonically decreasing in t, whereas profit is always (independent of the spillover level) monotonically increasing in t. Which effect will prevail? *A priori* economic intuition would suggest that an increase in price is generally more harmful to consumers than helpful for producers, thus we would expect $dW^*(t)/dt < 0$ in this situation. The easiest way to verify this intuition is to compare the two direct effects $\partial \Pi^*(t)/\partial t$ and $\partial S^*(t)/\partial t$. Summing up these two effects gives us

$$\partial \Pi^*(t)/\partial t + \partial S^*(t)/\partial t = -t - f(x)(1-\beta) < 0.$$

Since the marginal social welfare is given by

$$dW^*(t)/dt = \partial S^*(t)/\partial x \; dx^*/dt + \partial S^*(t)/\partial t + \partial \Pi^*(t)/\partial t \qquad (20)$$

and since $\partial S^*(x^*,t)/\partial x \; dx^*/dt < 0$ (see Lemma 13), it is clear that $dW^*(t)/dt < 0$. Thus, we have the corner solution with $t^* = 0$. Maximal welfare is achieved if the tariff is set to zero (or even negative, if it would be feasible). This is not surprising once we recall the magnification effect (overshifting) of the tariff on price in the situation when spillovers are small.

We summarize the above discussion in Proposition 3.

Proposition 3

If spillovers are low,(ß < 1/2), the optimal tariff, t, is zero and the optimal market form is the constrained monopoly.*

6.2. The Case when Spillovers are Large (ß > 1/2)

The situation when spillovers are large is much less clear *a priori* since three scenarios are possible:

a) the described "negative direct effect" of the tariff ($\partial S^*(t)/\partial t$) may still be so strong that it exceeds the "joint positive effect" (that is $\partial S^*(t)/\partial x \; dx^*/dt + \partial ?^*(t)/\partial t$) leading again to the zero tariff in equilibrium.

b) the joint positive effect outweighs the direct negative effect of the tariff on consumer surplus, in which case the monopoly tariff, $t^* = t_m$, will be optimal and the welfare maximizing market structure will be an unconstrained monopoly.

c) the joint positive effect can counterbalance the negative direct effect at some t lying between 0 and t_m implying the interior maximum, $t^* = t \in (0, t_m)$.

We proceed now to search for the conditions that lead to the optimal tariff different from zero. As was already mentioned, ß > 1/2 is only a necessary, but not sufficient condition for $t^* \neq 0$. In addition to the level of spillovers, the other decisive factor that may crucially affect the equilibrium value of the tariff could be the level of innovative efficiency [expressed as the intensity of unit costs reduction and reflected in the values of f(x*) and f '(x*)]. This feature is not captured explicitly by the general R&D production function form. The importance of innovative efficiency comes from the fact that its level would in general affect the incentives to invest in R&D if spillovers change. For instance, it is expected that, other things being equal, the change in spillovers would have a greater impact on R&D investment if R&D efficiency is "larger".[10]

[10] The reason for that is simple; the larger R&D efficiency is, the larger the R&D output for a given R&D effort, x. The competitor therefore captures more of the R&D output if spillovers increase.

Consequently, the intensity of the tariff's impact on R&D investment (and thus on the overall social welfare) will, in turn, depend upon the level of the innovative efficiency. In particular, one may expect that an increase in tariff, other things being equal, influences R&D expenditures more strongly the larger the R&D efficiency is, since the tariff acts as an instrument which restores incentives to invest in innovative activity (see Lemma 9). The larger the R&D efficiency, the stronger the distortions caused by spillovers will be, and the stronger the "recovery" caused by increase in tariff is expected to be. In terms of Equation (20), this implies that the joint positive effect can overturn the direct negative effect at some tariff $t^* = t \in (0, t_m]$.

To account for the important feature of R&D efficiency (and to be more precise about "low" and "large" R&D efficiency) we introduce the R&D production function in an explicit form. The particular R&D production function—$f(x) = (gx)^{1/2}$—we use here, is the one already employed in Chin and Grossman (1990) and Žigić (1996b). The key parameter g is aimed at measuring the above described R&D efficiency.[11]. In addition, we assume that all possible levels of R&D intensity are in the region between zero and four[12]. In this respect, low to middle R&D efficiency implies $g \in (0,2)$ and highly productive R&D activity implies $g \in [2,4)$.

6.2.1 Optimal Tariff when $f(x) = (gx)^{1/2}$

Now we are ready to repeat part of our previous analysis in order to explicitly calculate the optimal tariff. To do this, we simply replace f(x) with $(gx)^{1/2}$. Thus, starting with the first order condition (18) we are now able to obtain the explicit level of optimal R&D expenditures:

$$x^* = \frac{g[(A-\alpha)(1-\beta)-(1-2\beta)^2 t]^2}{4(1-\beta g+\beta^2 g)^2}. \qquad (21)$$

As was already indicated in Subsection 5.1., the underlying assumption of our analysis is

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[11] Note that $f(x) = (gx)^{1/2}$ satisfy all the conditions imposed on the general R&D production function, that is, $f(0) = 0$, $f'(x) > 0$, $f''(x) \leq 0$ and the second order condition is satisfied for this function as well.

[12] Without loss of generality, we constrain g to be such that $g \in (0,4)$. For $g \geq 4$ the profit and welfare function are not well defined (concave).

that the unconstrained monopoly is not a viable option for any level of ß before the tariff is set. Translated into the present framework, this implicitly assumes that the R&D intensity is never high enough to permit the domestic firm to achieve the unfettered monopoly position in the pre-tariff situation. However, if R&D intensity is "large" enough and, in turn, spillovers are not that "big," the domestic firm might be in a position to exercise its unchallenged monopoly power. This means that the accompanying monopoly price is lower or (at best) equal to the competitor's unit costs, that is, $p_m \# p_b$ (where p_m stands for monopoly price). To prevent this, g < 2/(1-ß) has to hold. This requirement reveals several interesting things: first, the unfettered monopoly is not a viable option if g < 2; second, the unconstrained monopoly may appear only if g is large (g > 2) and spillovers are low (ß < 1/2). Thus, the initial assumption of the nonsustainability of monopoly in the pre**S**tariff situation implies g < 2/(1-ß) here.

Imposing a tariff relaxes the above requirement on g, since tariff increases the foreign firm's unit costs. As already discussed, the level of tariff can increase until it reaches the level at which (and beyond which) the domestic firm secures its monopoly position. Since this is the maximal achievable tariff which affects domestic welfare, it will certainly be interesting to analyse when (or if) this tariff can be imposed by the welfare maximizing government. To calculate t_m, all that is necessary is to solve the equality $p_m = p_b + t$. The solution of the above equation gives us

$$t_m \; ' \; \frac{(A\&")(2\&g\%\$g)}{4\&g}.$$

The social welfare function expressed in terms of parameters and tariff can now be obtained by substituting (21) in the general social welfare function with $f(x) = (gx)^{1/2}$. (The function W* is concave and the second order condition is satisfied for all permissable values of parameters). The welfare maximizing government now solves the following problem:

$$\underset{t}{Max}[W(t)]$$

$$st.t\$0 \;\; ¸ \;\; t\#t_m$$

Let us for the moment ignore the constrained character of the maximization problem and solve for t from the first order condition, dW/dt = 0. Denote this solution as t*. The actual expression for t* from the first order condition yields:

$$t^{*} = \frac{(A-\alpha)g(2-\beta(2+2\beta+2g-5\beta^{2}g+3\beta g))}{g(2+\beta(4-8\beta-2g+3\beta g))-4}$$

In order to investigate under which conditions (besides ß >1/2) the welfare maximizing tariff is positive, we may simply solve the inequality t*> 0. This inequality implies that there exists a critical value of g (label it g_c) such that the optimal tariff is exactly zero. This critical value of R&D efficiency, g_c, is defined by,

$$g_c \equiv \frac{2(1-\beta-\beta^{2})}{2\beta-5\beta^{2}+3\beta^{3}} \equiv g_c(\beta) \qquad (22)$$

such that for g > g_c (ß) the optimal tariff is strictly positive (see Fig 1). Equivalently, for any given g, there exists a critical value $ß^c$ (g) beyond which the optimal tariff is positive. This critical value is simply obtained by inverting (22).

First note that the sufficient condition for positive t* is that the spillovers are higher than the particular value of the spillovers, labelled $ß^{c*}$ (see Fig 1). Second, for the given value of ß ∈ (1/2,$ß^{c*}$) the value g_c tells us how big the R&D efficiency has to be if the combined positive effects are to overturn the negative one for t* > 0.

Note that for a value of spillovers slightly above 1/2, the positive optimal tariff would in addition require a very large R&D efficiency. The zone in which we have 0 < t* < t_m is labelled Zone II. The next step is clearly to verify when t* < t_m. In solving this inequality we get the simple condition g < 2/ß (see the border line g_m(ß) = 2/ß in Fig 1). This defines Zone III. It is quite straightforward to check that in Zone III, W_m > W* (where W_m stands for welfare when the domestic firm is an unconstrained monopolist.). Here we stipulate our last proposition:

Proposition 4.

The optimal (welfare maximizing) tariff, t, is positive if* $g > g_c$ *with* $f(x) = (gx)^{1/2}$ *. If, in addition,* $g > g_m$*, the welfare maximizing market structure will be an unconstrained monopoly and* $t^* = t_m$*..*

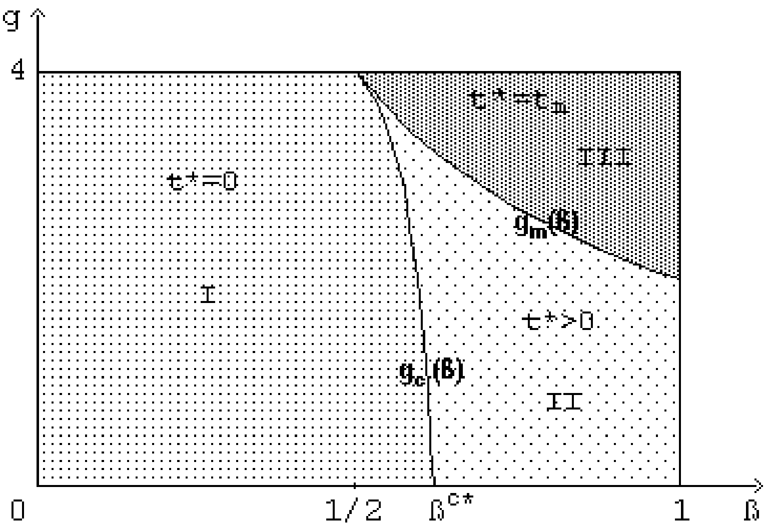

Fig. 1. Optimal tariff, R&D efficiency and the level of spillovers

Zone I in Fig 1 depicts the area in which the optimal tariff is nonetheless zero. **Zone II** yields the positive optimal tariff. As we saw, the level of spillovers ($ß > ß^{c}* > 1/2$) is either rather large so that it justifies a positive tariff in order to boost the rather low (pre-tariff) level of R&D, or if spillovers are between 1/2 and $ß^{c}*$ then, in addition, the level of R&D efficiency begins to matter. The further back from $ß^{c}*$ we go in the direction of 1/2, the higher the level of innovative efficiency needed to justify the positive tariff. In **Zone III** the maximum welfare requires the tariff t_m, which allows for the unchallenged position of the domestic firm. The intuition for the last result is that the large R&D efficiency coupled with large spillovers represents a substantial disincentive for socially beneficial investment in innovative activity and the profit maximizing domestic firm reacts by restricting its R&D activity to a very low level, which is much below the level an unconstrained monopoly would invest in R&D. In addition, a small increase in tariff in this situation is very effective that the increase in R&D investment and output is very strong . Under these circumstances the small increase in tariff even leads to a fall in equilibrium price, so that marginal consumer surplus ($dS^*/dt > 0$) is positive. In other words, even if the government maximizes only consumer surplus, it will pick up t_m in these circumstances. Note also that with no tariff in place, unused R&D opportunities are enormous due to large innovative efficiency. However, the same caveat concerning the unconstrained monopoly being socially optimal applies here: Any regulation of that monopoly which does not hamper R&D investment would be desirable.

7. STRATEGIC TRADE POLICY UNDER UNCERTAINTY

The preceding analysis was based on the implicit assumptions that governments possess all the relevant information about types of competition, demand functions, intensity of R&D, and so on. Under these circumstances government can precisely determine the optimal, welfare maximizing tariff. However, familiar criticism points to the fact that the relevant pieces of information are usually not readily available to a given government and then the practical issue of how strategic policy should be used, or indeed whether it should be used at all, becomes central. Thus, for instance, it is not difficult to demonstrate that not knowing the type of competition (or better, confusing price for quantity competition) causes damage (see Eaton and Grossman, 1988 and Krugman, 1991, among many others). Therefore, the critics conclude that strategic policy has the potential to do such damage that, although it can be useful, it should not be used in practice.

Adopting this criticism of informational content, we now assume that the government in our specific example does not possess relevant pieces of information about costs and demand. It can only observe (or easily obtain) crude information, such as whether the level of spillovers are large or not. Furthermore, the government is assumed to know that the domestic firm is a technological leader and it can also easily observe whether the firm is alone in the market or not.

Imagine now that government is contemplating whether to impose the tariff or not. What can it infer from these crude, but realistic, data?

There are several possibilities which the government can observe in the pre-tariff situation (see Table 1). First, suppose that the government observes the foreign firm competing in the domestic market. If the competition is Bertrand, both firms have to have the same unit costs. However, since the domestic firm is the technological leader who invests in cost-reducing technology and it is very likely that it has lower unit costs (unless the spillovers are complete), the probability of this event is (close to) zero. Therefore, the competitor must be of Cournot type and the positive tariff is surely beneficial. The level of spillovers gives, in addition, the hint whether this tariff should be relatively ?low" (t_p) or it should be (at least) as high as t_m. Imagine now that the government observes small spillovers. As is clear from Proposition 1, small spillovers require

Table 1

Inference about the optimal tariff based on the number of firms observed on the market and the observed (low or high) spillover level

No.of Firms Observed on the Market	Small Spillovers: ß < 1/2	Large Spillovers: ß >1/2
Domestic Firm Only	t* = 0	t* Depends Positively on R&D Efficiency and Spillover Level
Both Firms	$t^* = t_p$	$t^* = t_m$

"low" tariffs. Since the government does not have enough information to precisely set up t_p, it is important that in practice the government (if possible) keep increasing the tariff till the moment when the foreign firm leaves the market. When, on the other hand, spillovers are large, the task is extremely simple; the government should make sure that the tariff is set so high that it allows the domestic firm to compete unfettered.

Further, suppose now that the government observes only its firm on the market and it also observes small spillovers. In this situation several possibilities may arise: the domestic firm is an unconstrained monopoly; the domestic firm undertakes strategic predation, selecting the level of R&D expenditure and output which makes the foreign firm's entry unattractive; finally, the domestic firm competes à la Bertrand, has lower unit costs and covers the whole market. Whichever of these situations is true, (and the government need not know which it is), the optimal tariff is zero. If the domestic firm is an unfettered monopoly, then the tariff has no impact on the firm’s profit or on social welfare. If the domestic firm predates strategically, or if it picks the Bertrand price, the optimal tariff is zero once again, since under these circumstances any increase in tariff would cause a cut in R&D expenditures and a decrease in consumer surplus and, finally, in social welfare (see Propositions 2 and 3).

The situation is slightly more complicated when spillovers are large and only the domestic firm is on the market. In this case, the government knows for sure that there is competition in prices, since neither unconstrained monopoly nor strategic predations are viable options when spillovers are large.[13] However, despite the fact that the government can unambiguously infer the type of competition in this case, it still needs additional information to decide whether to impose a tariff at all. In this situation, the government, has to inquire whether, for instance, spillovers are very high and/or whether the R&D efficiency of the domestic firm is large or not.

8. CONCLUSION

As our analysis has shown, the different types of competition indeed require different optimal levels of tariff. Thus, Cournot competition always requires a positive tariff, whereas Bertrand competition usually requires a zero tariff, unless the spillovers are very large and/or R&D efficiency is rather high. Charging, for instance, a mistakenly positive tariff when there is a Bertrand competition and low spillovers harms social welfare. In this sense, the traditional critique of the sensitivity of the level of the optimal instrument to the type of competition is certainly correct. However, the conclusion that it prevents or discourages the government from intervening, is not borne out in this specific framework. The government in our case can easily learn what the optimal tariff might be from the very structure of the problem while having only crude plausible information like whether spillovers are large or small and how many firms are in the market. In this sense, our analysis complements Maggi's (1996), who found in a more general setting that so-called investment policy (R&D subsides, capacity subsides, etc.) is not harmful

[13] It follows from (9) that in the absence of a tariff, predation is not a feasible strategy for $\$ > 1/2$. Note that from (9) with $t = 0$, $f(x) = (A-") / (1-2\$)$ is defined only for $\$ < 1/2$. As far as monopoly is concerned, note that $p^* = [p_b, p_m] = [1/2(A+"-f(x)), "-\$ f(x)] = "-\$ f(x) = p$ for $\$ > 1/2$.

irrespective of the type of competition. While his result is obtained in a more general framework, it is on the other hand less powerful (if government made a mistake it would not improve things, but it would also do no harm) than ours, since the government in our example could, in general work out the socially beneficial tariff. Since the problems the government faces when deciding whether to intervene or not are always specific (in the sense that the government may often easely learn some additional important information from the structure of the situation), our conjecture is that the "informational" criticism of the strategic trade policy is less relevant than was previously thought. In this sense, much like Maggi, we are also cautioning here that our analysis should not be interpreted in favor of strategic trade policy but as a "...warning that informational constraints are not likely to remove the individual government's economic incentives on export policy" (Maggi, 1996, p 253). This is due either to the different type of policy instrument used (capacity instead of output policy) or the specific structure of the problem and the possible inference of the necessary information for successful intervention.

Appendix 1

Monopoly profit is given by (A.1.1)

$$\Pi^p(x) = \frac{(A - \alpha + f(x))^2}{4} - x \tag{A.1.1}$$

and is maximized at the value of x^*_m. Thus, the derivative of (A.1.1) with respect to x is

$$\partial\Pi/\partial x = \frac{(A - \alpha + f(x))f'(x)}{2} - 1 \tag{A.1.2}$$

with

$$\frac{[A - \alpha + f(x^*_m)]f'(x^*_m)}{2} - 1 = 0 \tag{A.1.3}$$

However, when predation is an optimal strategy, x^*_m is not feasible and the level of R&D expenditures x^*_p is in general different than x^*_m. To show this, note that the "predatory price" has to be such that p = a - ß f(x) + t_p holds. Taking this into account, the predatory profit can be written as

$$\Pi^p(x^*_p) = \frac{(A - \alpha + f(x))(t + (1 - \beta)f(x))}{2} - x \tag{A.1.4}$$

with t = t_p. Differentiating (A.1.4.) with respect to x and evaluating the derivative at t_p gives the following expression:

$$\partial\Pi/\partial x^*_{t = t_p} = \frac{(A - \alpha + f(x))f'(x)}{4} + \frac{(1 - \beta)(A - \alpha + f(x))f'(x)}{2} - 1 \tag{A.1.5}$$

Note (by comparing A1.5 with A.1.3) that the value of (A.1.5) is lower than zero for ß < 1/2 implying $x^*_p > x^*_m$ and that the opposite is true for ß > 1/2 . For ß = 1/2 the two values coincide, implying $x_p = x_m$.

Appendix 2

The first part of Proposition 2 is a corollary of Lemmas 6 and 7:

$$\partial S^{*p}/\partial x \; dx^{*p}/dt > 0 \;\; for \;\; \beta > 1/2 \;\; , \;\; \partial A^{*p}/\partial x \; dx^{*p}/dt > 0 \quad always$$
$$\Rightarrow dW^{*p}/dt > 0 \; \Rightarrow \; t^{*} = t_m$$

When spillovers are small, the argument is slightly more subtle due to two conflicting effects, namely, $\partial S^{*p}/\partial x \, dx^{*p}/dt < 0$ for $\beta < 1/2$ but $\partial A^{*p}/\partial x \, dx^{*p}/dt > 0$. The sketch of the proof relies on the analytical expression for the marginal social welfare given by (A.2.1).

$$dW^{*p}/dt = dx_p^{*}/dt \; \frac{[3(A-\alpha+f(x_p^{*})-4]f'(x_p^{*})}{4} \qquad \text{(A.2.1)}$$

The expression (A.2.1) can be viewed as the product of two factors: dx^{*p}/dt and the remainder. As was already discussed, when spillovers are large, we know that $dW^{*p}/dt > 0$ and by means of Lemma 5, we also know that $dx^{*p}/dt > 0$. This implies that the remaining part of (A.2.1) is positive as well. When, on the other hand, $\beta < 1/2$, Lemma 4 reveals that $dx^{*p}/dt < 0$, and since we now know that the remaining part is positive, it follows that (A.2.1) is negative, implying that the optimal tariff $t^* = t_p$.

Appendix 3

Here we compare t_p with t_m for both small and large spillovers where:

$$t_p = \frac{A-\alpha-(1-2\beta)f(x_p^{*})}{2} \;,$$
$$t_m = \frac{A-\alpha-(1-2\beta)f(x_m^{*})}{2}.$$

If $\beta < 1/2 \Rightarrow x^*_m < x^*_p \Rightarrow f(x^*_m) < f(x^*_p) \Rightarrow t_m > t_p$ because the last member of the above expression, that is, $-(1-2\beta)f(x) < 0$.

If $\beta > 1/2 \Rightarrow x^*_m > x^*_p \Rightarrow f(x^*_m) > f(x^*_p) \Rightarrow t_m > t_p$ because now, $-(1-2\beta)f(x) > 0$.

Finally, when ß = 1/2 Y t_m = t_p = (A - a)/2.

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