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Dynamic Trade Policy

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Abstract

This paper considers a dynamic model of strategic export subsidy/tax game in which governments have an option of choosing open-loop or closed-loop trade policies. In a simple two-period Bertrand duopoly model, it is shown that all subgame-perfect equilibria are asymmetric even when the underlying game is symmetric. (JEL Classification: F12, F13)

I. Introduction

A standard result in export subsidy/tax game models is that if governments can credibly precommit themselves to a particular trade policy, an export subsidy (tax) is optimal when firms engage in quantity (price, respectively) competition Brander and Spencer, [1985]; Eaton and Grossman, [1986] .[1]

Even though most research in strategic trade policy literature deal with a dynamic model in the sense that firms and governments move in sequence, firms in these models make production decisions in a single period and do not compete over time. However, once we consider dynamic production decisions of the firms in a multi-period setting, an additional issue that is not present in a static model is that governments may have an option of choosing the "length" of the trade policy. That is, governments may have to deal with the problem of whether they should precommit themselves to a long-term trade policy or should adopt a series of short-term trade policy for each period. This consideration is particularly important because firm behavior (and hence the national welfare level) would be altered depending on the dynamic structure of the trade policy that governments adopt. Thus, the optimal dynamic structure of the trade policy should be chosen to the best interest of the nation.

Of course, this is not an easy task. For example, if the government precommits to a long-term trade policy at the beginning of the game, then the long-term policy may be criticized in that it is not flexible enough to cope with dynamic trade environment. Similarly, if the government adopts a series of short-term policy and changes the subsidy (or tax) rate for each period, the short-term policy may be criticized on the ground that the policy is not consistent so that the domestic firm may not be able to compete effectively with foreign firms.[2]

A related paper to mine is by Tanaka [1994], who considered a dynamic strategic trade model in which firms compete in quantities over time. He argued that since trades usually occur over time, the *ad hoc* nature of conjectural variations approach in a static model may not fully explain the

2. A related issue is the role of governments' precommitment to a specific policy. Since welfare effects of the optimal export policy crucially depend on details of the trade environments, some governments may want to exercise a high degree of discretion and flexibility instead of precommitting to a specific policy. However, some re-

dynamic aspects of behavior of firms and governments. Thus, he explicitly examined a multi-period model in which he considered an export subsidy game when firms are competing in quantities. Using a linear demand and symmetric duopoly with the same constant marginal cost, Tanaka showed that an export subsidy continues to be an optimal policy, even though the level of optimal subsidy of his dynamic game is lower than that of static game. Furthermore, for his symmetric game model, the optimal trade policy is symmetric (*i.e.*, both governments choose the same subsidy rate in equilibrium).

Tanaka's [1994] model is interesting in that his dynamic model is more realistic than the static model. However, a dynamic extension of static model would be meaningful to the extent that it provides different (or additional) insights from those that we obtain in a static model. In this sense, it appears that Tanaka's dynamic model does not provide more additional insights than a static model. For example, as in the static model, Tanaka's dynamic and symmetric model has the equilibrium in which both governments choose the same subsidy rate.

In this paper, I consider a simple two-period symmetric Bertrand duopoly model in which governments have an option of choosing open-loop or closed-loop trade policies at the beginning of the game. (The specific nature of these two trade policies will be explained later.) As in the case of static Bertrand competition Eaton and Grossman [1986] , I found that an export tax is optimal in my dynamic model.[3]

However, unlike the static case, all subgame-perfect equilibria for the game considered are asymmetric *even when the underlying game is symmetric*. More specifically, in equilibrium, one government chooses a series of short-term trade policy and the other chooses a long-term trade policy. Some intuition behind this somewhat surprising result will be provided presented. Section III contains the analysis and the main result. Section IV concludes the paper.

II. The Model

The model is a dynamic extension of the standard static strategic trade model e.g., Brander and Spencer [1985] . Consider a duopoly with one domestic firm and one foreign firm. This duopoly lasts two periods and competes in prices for a third country market. Following the tradition of the literature, I assume no consumption in producing countries. Let q_k^i and p_k^i denote firm i's (i = 1, 2) output and price in period k =1, 2, respectively.

Assume that products are differentiated and firm i's direct demand in each period is[4]

$$q_k^i = a - p_k^i + bp_k^j, \quad i, j = 1, 2 \quad \text{and} \quad i \neq j, \tag{1}$$

where b represents the degree to which firm i's product is a substitute for firm j's product. A higher value of b means a higher degree of substitutability of the two products. I assume b (0, 1). (This is a standard assumption in industrial organization literature: If each firm raises its price by one dollar, both firms lose sales. In order to highlight the result, I concentrate on the symmetric case: it is assumed that each firm has the identical constant marginal cost, which is set to be zero.[5] I will show that when governments have an option of choosing either an open-loop trade policy or a closed-loop trade policy, asymmetric equilibria are possible even when the underlying game is symmetric.[6]

4. Linear demand functions for differentiated products are common in the literature e.g., Neary [1994]. Our demand function is chosen for analytical tractability.

If governments choose an open-loop trade policy, they precommit tax rates for the two periods; on the other hand, if governments choose a closed-loop policy, they can commit to a first-period tax rate, but they cannot do so for the second-period until the beginning of the second-period. Specifically, I assume the following sequence of moves: (1) Each government independently and simultaneously announces whether it will adopt an open-loop policy or a closed-loop policy.[7] (2) If government i has chosen an open-loop policy, a tax rate for periods 1 and 2, (t_1^i, t_2^i) is announced. On the other hand, if government i has chosen a closed-loop policy, a tax rate for the first-period, τ_1^i is announced. (3) Each firm chooses its price, p_1^i for the first-period. (4) If government i has chosen a closed-loop policy previously, a tax rate for the second-period, τ_2^i is announced. (5) Each firm chooses its price, p_2^i for the second-period.

The profits of firm i in period k with a tax rate r_k^i are given by

$$\pi_k^i = (p_k^i - r_k^i) q_k^i,$$

where q_k^i is determined by (1). Each firm's objective is to maximize the sum of two-period profits, $\pi_1^i + \pi_2^i$. (For expositional simplicity, I assume no discounting. Our result stays the same with an introduction of discounting.) Each government's objective is to maximize its two-period rents, that is, the sum of two-period profits of its firm and the tax revenue to the government. That is, government i's objective is to maximize

$$\begin{aligned} W^i &= (\pi_1^i + \pi_2^i) + (r^i{}_1 q_1{}^i + r^i{}_2\, q_2{}^i) \\ &= p_1{}^i\, q_1{}^i + p_2{}^i\, q_2{}^i. \end{aligned}$$

Let W_{nm}^i denote government i's welfare under possible combinations of trade policies, where n is the government 1's trade policy (either an open-

III. Analysis

The subgame-perfect equilibrium is the solution concept employed to study this dynamic game. I need to consider three cases: (1) both governments choose open-loop policy, (2) both government choose closed-loop policy, and (3) one government chooses an open-loop policy and the other government chooses a closed-loop policy.

Case 1. Suppose that both governments have chosen open-loop policy and tax rates are given by (t_1^i, t_2^i) with $i = 1, 2$. Firm i's problem is

$$\max_{p_1^i, p_2^i} (a - p_1^i + bp_1^j)(p_1^i - t_1^i) + (a - p_2^i + bp_2^j)(p_2^i - t_2^i).$$

Solving the first-order conditions, we have

$$p_k^i = \frac{a(2+b) + 2t_k^i + bt_k^j}{4 - b^2}, \quad i, j = 1, 2, i \neq j, \text{ and } k = 1, 2.$$

Government i's objective is to maximize its welfare:

$$\max_{t_1^i, t_2^i} (a - p_1^i + bp_1^j)p_1^i + (a - p_2^i + bp_2^j)p_2^i.$$

Solving the first-order conditions, we have

$$t_k^i = \frac{ab^2}{4 - 2b - b^2}, \quad i = 1, 2 \text{ and } k = 1, 2.$$

National welfare in this case is

$$W_{OO}^1 = W_{OO}^2 = \frac{4a^2(2 - b^2)}{(4 - 2b - b^2)^2}.$$

Case 2. Suppose that both governments have chosen closed-loop policy rates (t_1^1, t_2^1) and government 2 has chosen a closed-loop policy with tax rates (τ_1^2, τ_2^2). Given t_2^1 and τ_2^2, each firm maximizes its profits in stage 5. Proceeding as usual, we obtain

$$p_2^1 = \frac{a(2+b)+2t_2^1+b\tau_2^2}{4-b^2} \text{ and } p_2^2 = \frac{a(2+b)+2\tau_2^2+bt_2^1}{4-b^2}.$$

In stage 4, government 2 solves

$$\max_{\tau_2^2}(a-p_2^2+bp_2^1)p_2^2.$$

The optimal solution is given by

$$\tau_2^2 = \frac{b^2(2a+ab+bt_2^1)}{4(2-b^2)}. \tag{2}$$

In stage 3, given t_1^1 and τ_1^2, each firm maximizes its profits. Proceeding as usual, we obtain

$$p_1^1 = \frac{a(2+b)+2t_1^1+b\tau_1^2}{4-b^2} \text{ and } p_1^2 = \frac{a(2+b)+2\tau_1^2+bt_1^1}{4-b^2}.$$

In stage 2, government 1 solves

$$\max_{t_1^1,t_2^1}(a-p_1^1+bp_1^2)p_1^1+(a-p_2^1+bp_2^2)p_2^1.$$

Government 2 solves

$$\max_{\tau_1^2}(a-p_1^2+bp_1^1)p_1^2.$$

Solving the first-order conditions and from (2), we have

$$t_1^1 = \frac{ab^2}{4-2b-b^2},\quad t_2^1 = \frac{ab^2(4+2b-b^2)}{16-16b^2+3b^4},$$

$$W_{OC}^2 = \frac{2a^2(2-b^2)}{(4-2b-b^2)^2} + \frac{a^2(2-b^2)(8+4b-4b^2-b^3)^2}{2(16-16b^2+3b^4)^2}.$$

Now it can be shown that $W_{OC}^1 > W_{OO}^1 = W_{CC}^1$ and $W_{OC}^2 > W_{CC}^2 = W_{OO}^2$. Thus, government 2's best response to government 1's open-loop policy is closed-loop policy. Similarly, switching the roles of government 1 and 2 in Case 3 above, we have that government 1' best response to government 2's open-loop policy is closed-loop policy. So, we have the following:

Proposition: There exist two subgame-perfect equilibria in pure strategies. Both subgame-perfect equilibria are asymmetric and in equilibrium one government chooses an open-loop policy and the other chooses a closed-loop policy.

Remarks: If we extend our model to a dynamic Cournot duopoly with a linear demand curve $p_k = a - b(q_k^1 + q_k^2)$ in period $k = 1, 2$, it can be shown, using the similar analysis as above, that to adopt an open-loop trade policy is a dominant strategy for both governments. Explanations for this difference can be made using the results of Dowrick [1986], who showed that for a standard static duopoly with upward-sloping reaction functions (as in price competition), if one firm prefers to be a leader, the other must prefer to be a follower. (Using the terminology of Bulow et al, 1985, prices are strategic complements and reaction functions are upward-sloping.) On the other hand, for a standard static duopoly with downward-sloping reactions functions (as in quantity competition), both firms want to be a leader. (Again, using the terminology of Bulow et al, quantities are strategic substitutes and reaction functions are downward-sloping.)

In our dynamic Bertrand duopoly model, note that the "dynamic reaction function" of government 2 in equation (2) above is upward-sloping.

rival chooses an open-loop policy is that its own prices and profits in asymmetric trade policies are higher than in any of the symmetric cases, because in the asymmetric case the nation adopting an open-loop policy is the "leader" in the second production period and thus has to reduce its output to support the price. Thus, in our dynamic Bertrand duopoly, when one government adopts an open-loop trade policy, the other adopts a closed-loop trade policy.

On the other hand, for a dynamic Cournot duopoly model, it can be shown that dynamic reaction functions of the governments are downward-sloping and thus both governments have an incentive to be a leader. That is, *when firms' strategic variables (i.e., quantities) are strategic substitutes, governments' strategic variables (i.e., trade policies) are also strategic substitutes*. Thus, in a model of dynamic Cournot duopoly, both governments prefer the leadership position and the open-loop policy is the dominant strategy for both governments.

IV. Concluding Remarks

In this paper, I have considered a dynamic model of strategic export subsidy/tax game in which governments have an option of choosing open-loop or closed-loop trade policies. In a simple two-period Bertrand duopoly model, it is shown that in equilibrium, one government chooses a series of short-term trade policy and the other chooses a long-term trade policy.

Before closing, I should mention a limitation of the model: Throughout the paper I have assumed the same demand curve for both periods. This assumption is reasonable since many markets are rather stable over time. On the other hand, if market environments are changing frequently over

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