

# A Chicken Game of Intraindustry Trade

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## Abstract

We study the strategic interaction between two firms competing in quantities which decide whether or not exporting into each other market. The product is homogeneous and production entails constant returns to scale. Scope effects are present. By dealing with two types of trade costs, namely per unit and ad valorem trade costs, we characterize the set of Nash equilibria showing that one-way trade is a possible outcome of the trade game. In particular, despite the assumption on symmetry between firms, unilateral trade arises whereas trade costs are sufficiently high. The private incentives towards one way trade are then compared with the social ones.

JEL Classification: C72, F12, L13.

Key Words: intraindustry trade, unilateral trade, trade costs, scope economies, oligopoly.

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# 1 Introduction

This paper provides a theoretical explanation of one way trade based on strategic interactions rather than countries asymmetries (comparative advantage), in a perfectly symmetric oligopolistic framework. The traditional explanation of one way trade is in terms of inter-industry trade. This paper is about unilateral intra-industry trade, i.e. our explanation of unilateral trade in a given industry relies on strategic interactions between firms operating in the *same* industry. The novelty of our approach is twofold: first, we use a more general cost function than the one usually adopted in the literature capable of taking into account scope economies. By definition, economies (diseconomies) of scope occurs when the average total cost of production decreases (increases) as a result of increasing the number of different goods being produced, which, in presence of trade, corresponds to the number of markets being served. The idea is that there are joint cost/benefit in serving both the domestic and the foreign market. Secondly, we allow firms to strategically choose whether to export into each other market rather than assuming that two way trade exists *per se*. In a Brander and Krugman (1983) type of model, if international trade is possible, it is implicitly assumed that firms engage in two way trade.<sup>1</sup> Despite the fact that each firm would prefer not to export and act as a monopolist in its own domestic market, the strategic interaction leads to a Prisoner's Dilemma, in which the sub-optimal (from firms' point of view) outcome is reciprocal trade. An interesting stream of literature (Pinto, 1986; Fung, 1991, 1992, *inter alia*) points out that firms could escape this Prisoner's Dilemma through collusion, in infinitely repeated games. Having in mind a 2x2 matrix in which firms can decide to export or not to export into each other market before engaging in price or quantity competition, the existing literature, either static or dynamic, has focussed only on two possible equilibria: two way trade, in a static context, and autarchy in a dynamic context. The possibility of one way trade arising as a possible Nash equilibrium of the trade game, i.e. one firm exports while the rival does not, has been ignored so far. The key result of our analysis is that international trade can be explained by a Chicken game rather than by a Prisoner's Dilemma, meaning that an

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<sup>1</sup>See also Brander (1981).

asymmetric equilibrium (unilateral trade) can come out from firms' strategic interaction in a perfectly symmetric environment. Indeed, our paper shows that even if all trade barriers have been almost completely abolished, this does not automatically imply that firms actually engage in two way trade, as usually assumed when international trade is allowed.

In the second part of the paper, we aim to compare the private with the social incentives towards one way trade, investigating whether there exists a parameter region where the outcome of the trade game played by national governments seeking to maximize domestic welfare corresponds to the one resulting from the interaction between firms.

Throughout the paper we consider two types of trade costs incurred in exporting goods from one country to the other, namely, per unit and *ad valorem* trade costs.<sup>2</sup>

Our main results can be summarized as follows. Under both types of trade costs, one way trade arises as Nash equilibrium of the trade game played by firms if the level of trade costs is sufficiently high. As markets become more integrated, the likelihood of two way trade increases. With regard to the trade game played by planners (governments), we have to distinguish between two scenarios, according to the type of trade cost considered. Under per unit trade costs, exactly as for firms, a sufficiently high level of trade cost is necessary to have one way trade. The comparison with the private incentives towards one way trade unveils that there exist both a conflict region, in which private and social incentives dramatically diverge, and a region in which both the governments and the firms would choose one way trade. The former result is interesting in that, quite surprisingly, one way trade is a socially desirable outcome. Under *ad valorem* trade costs there exists only a conflict area: the private and the social incentives towards one way trade never coincide.

The remainder of this paper is structured as follows. The model is laid out in section 2. Section 3 deals with per unit trade costs, while section 4 looks at *ad valorem* trade costs. Section 5 studies social incentives towards one way

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<sup>2</sup>The existing literature has also looked at another type of trade costs, namely fixed trade costs, accounting for costs of product certification, adjustment to local regulation, costs of maintaining a distribution network, foreign red tape.

trade. Conclusions are provided in section 6.

## 2 The Model

Two firms, firm  $a$  located in country  $A$  and firm  $b$  located in country  $B$ , are engaged in a one shot two stage game: at the first stage each firm chooses simultaneously and non cooperatively whether or not to export into each other market and, at the second stage, both firms compete in quantities (à la Cournot). Let  $q_i$  and  $q_i^*$  denote the output that firm  $i = \{a, b\}$  produces for domestic and foreign consumption, respectively. In each country, the inverse market demand is given by:

$$p_j = 1 - Q_j, \quad j = \{A, B\} \quad (1)$$

where  $Q_A = q_a + q_b^*$  and  $Q_B = q_b + q_a^*$  stand for industry output in country  $A$  and  $B$ , respectively. On the supply side, we assume that production costs are interrelated, i.e. scope effects are present:<sup>3</sup>

$$c_i(q_i; q_i^*) = \alpha q_i + \beta q_i q_i^* + \alpha q_i^*, \quad i = \{a, b\} \quad (2)$$

In order to simplify the analysis, without any loss of generality, we will normalize  $\alpha$  to zero.<sup>4</sup> Parameter  $\beta$  represents the effect of the joint cost/benefit. Negative  $\beta$  indicate the presence of economies of scope.<sup>5</sup> For example, there might be positive spillovers because of learning effects if activities are similar and the learning rate depends on cumulative joint production or network externalities when using a common resource. For positive  $\beta$ , the firm faces diseconomies of scope by serving both markets.<sup>6</sup> These may be due to congestion or switching costs when there are joint capacities, increased maintenance costs of flexible techniques, increasing marginal opportunity cost of capital (imperfect capital

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<sup>3</sup>Bulow, Geanakoplos and Klemperer (1985) use a similar approach to model economies of scope, but consider quadratic unit-costs of each single product.

<sup>4</sup>This does not alter the qualitative results obtained. The resulting cost function is also used by Dixon (1992) when he considers two multiproduct firms.

<sup>5</sup>See Baumol, Panzar and Willig (1982) for the concept of diseconomies of scope. See also Porter (1985), Westland (1992) and Teece (1982).

<sup>6</sup>See Gal-Or (1993), Zimmermann (1979), Westland (1992) on these issues.

markets) or forgone learning effects when activities are dissimilar. Other reasons for diseconomies of scope are costs of control and coordination which rise in the scope of a firm (managerial diseconomies).

Trade is associated with either per unit  $\tau$  or *ad valorem*  $t$  trade costs incurred in exporting goods from one country to the other. Per unit trade costs can be thought primarily as transportation costs and/or specific tariffs, for instance tariffs levied on intermediate goods (see Mujundar, 2004), while *ad valorem* trade costs include general tariffs, insurance costs and exchange rate risks.

We solve the game by backward induction, i.e. we first solve the marketing game and then we proceed to analyzing the first stage, which can be described by the following matrix:

$a \backslash b$	$T$	$NT$
$T$	$\pi(T, T); \pi(T, T)$	$\pi(T, NT); \pi(NT, T)$
$NT$	$\pi(NT, T); \pi(T, NT)$	$\pi(NT, NT); \pi(NT, NT)$

(M1)

Each firm may decide simultaneously and independently to export ( $T$ ) or not to export ( $NT$ ). Although it would be Pareto efficient for firms to agree not to export into each other market, in a one shot game a two way trade arises as a unique Nash equilibrium resulting from a prisoner's dilemma.<sup>7</sup> To the best of our knowledge, the possibility of one way trade being an outcome of the trade game has been ignored. Yet it is fair enough to say that one way trade involving homogeneous products is actually observed to take place among similar countries.

We first look at per unit trade costs. Then we will proceed with analyzing the case of *ad valorem* trade costs.

### 3 Per unit trade costs

Suppose both firms decide to export. As usual in the literature, each firm chooses its output level for domestic and foreign consumption separately. The

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<sup>7</sup>In repeated games, several authors (Pinto, 1986; Fung, 1991; 1992) have shown that autarchy can be sustained as a subgame perfect equilibrium for sufficiently large discount factor.

problem of firm  $a$  is to choose  $q_a$  and  $q_a^*$  so as to maximize its own profit  $\pi_a = p_A q_a + (p_B - \tau) q_a^* - c_a$  and similarly for firm  $b$ . Symmetric Cournot-Nash equilibrium quantities are given by:<sup>8</sup>

$$q = \frac{\beta - 1 - \tau(1 + \beta)}{\beta^2 + 2\beta - 3} \quad (3)$$

$$q^* = \frac{\beta - 1 + 2\tau}{\beta^2 + 2\beta - 3} \quad (4)$$

while equilibrium profit amounts to:

$$\pi(T, T) = \frac{(1 - \tau)(2 - 3\beta + \beta^3) - \tau^2(\beta^2 - 5)}{(1 - \beta)^2(3 + \beta)^2} \quad (5)$$

Now, we consider the case in which only one firm, say firm  $a$ , exports while the rival does not. This is the outcome we are particularly interested in since it involves one way trade. The problem for the exporting firm now consists in setting the monopolist quantity at home and the optimal quantity for foreign consumption being aware of the fact that the rival will react only in its own domestic market. Although consumers in country  $B$  are still served by both firms, now the quantities offered by the two firms differ w.r.t. the previous case. This is due to the fact that costs are interrelated, so the cost of producing for domestic consumption only differs from the cost of producing for both the domestic and the foreign market. In particular, it is higher (lower) if there are diseconomies (economies) of scope. When  $\beta > 0$  we expect that the not exporting firm produces more than it would have by serving also the foreign market. Indeed, with diseconomies of scope the not exporting firm is able to save on costs. Solutions turn out to be:

$$q_a = \frac{-3 + \beta - 2\tau\beta}{2(\beta^2 - 3)}; q_a^* = \frac{\beta - 1 + 2\tau}{\beta^2 - 3} \quad (6)$$

and

$$q_b = \frac{-2 - 2\tau - \beta + \beta^2}{2(\beta^2 - 3)} \quad (7)$$

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<sup>8</sup>Quantities and prices are always admissible if  $\tau < (1 - \beta)/2$ . Second order conditions are always satisfied.

By comparing (7) with (3), it is easy to verify that  $q_b > q$  and that they are equal only when  $\beta = 0$ , i.e. without scope economies.

The profit accruing to the exporting and the not exporting firm write respectively:

$$\pi(T, NT) = \frac{13 - 4\tau(4 - \beta^2)(1 - \beta - \tau) + \beta(2\beta^2 - 8 - 3\beta)}{4(\beta^2 - 3)^2} \quad (8)$$

$$\pi(NT, T) = \frac{(2 + 2\tau + \beta - \beta^2)^2}{4(\beta^2 - 3)^2} \quad (9)$$

When both firms choose not to export into each other market, they are monopolist in their own country: the payoff is  $1/4$  for both.

After having computed all the relevant payoffs, we are now in a position to study the matrix (M1). Suppose firm  $b$  decides not to export. The optimal behavior for firm  $a$  will be to export if  $\pi(T, NT) > \pi(NT, NT)$ . By a direct comparison it turns out that this is always the case. Hence, if  $\pi(NT, T) > \pi(T, T)$  for firm  $b$  then the equilibrium of the trade game will be either  $(NT, T)$  or  $(T, NT)$ . In words, only one firm engages in international trade. By (9) and (5), the threshold of the level of per unit trade costs such that the trade game is a chicken game is:  $\hat{\tau}$

$$\hat{\tau} = \frac{(1 - \beta)(-36 + \beta(24 + \beta(49 + \beta(-8 - 14\beta + \beta^3))))}{2(-36 + \beta(-12 + \beta(37 + \beta(4 - 10\beta + \beta^3))))} \quad (10)$$

**Proposition 1** *If  $\tau > \hat{\tau}$  one way trade arises. If otherwise  $\tau < \hat{\tau}$  two way trade arises.*

The figure below explains our first proposition:

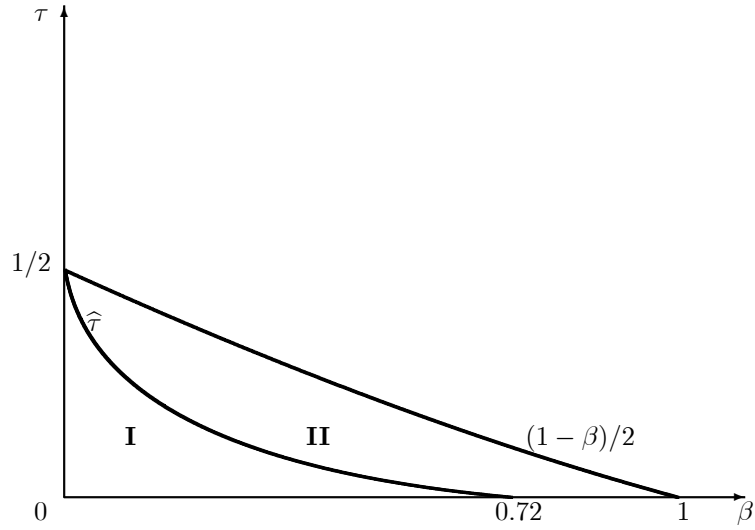


Figure 1

Area I covers the case in which  $\pi(NT, T) < \pi(T, T)$  while, in area II,  $\pi(NT, T) > \pi(T, T)$ . Hence, in area II the trade game is a chicken game with unilateral trade resulting as equilibrium; in area I the traditional two way trade arises.

#### 4 *Ad Valorem* trade costs

Suppose both firms decide to export. The problem of firm  $a$  is to choose  $q_a$  and  $q_a^*$  so as to maximize its own profit, now given by  $\pi_a = p_A q_a + (1 - t) p_B q_a^* - c_a$  and similarly for firm  $b$ . Symmetric Cournot-Nash equilibrium quantities are

given by:<sup>9</sup>

$$q_i = \frac{(t-1)(\beta-1)}{t(\beta-3) - (\beta-1)(3+\beta)} \quad (11)$$

$$q_i^* = \frac{1-t-\beta}{t(\beta-3) - (\beta-1)(3+\beta)} \quad (12)$$

while the equilibrium profit level is:

$$\pi(T, T) = \frac{(1-t)(2+t^2+3t(\beta-1)-3\beta+\beta^3)}{[t(\beta-3) - (\beta-1)(3+\beta)]^2} \quad (13)$$

Assume now firm  $a$  exports while firm  $b$  does not. Proceeding as before, firm  $a$ 's solutions write:

$$q_a = \frac{(1-t)(\beta-3)}{2(-3+3t+\beta^2)}; q_a^* = \frac{-1+t+\beta}{-3+3t+\beta^2} \quad (14)$$

and for firm  $b$ :

$$q_b = \frac{2t + (\beta-2)(1+\beta)}{2(-3+3t+\beta^2)} \quad (15)$$

Using equilibrium quantities we obtain the expressions of equilibrium profits for the exporting and the not exporting firm, respectively:

$$\pi(T, NT) = \frac{(1-t)(13+4t^2+t(-17+\beta(8+\beta))+\beta(-8+\beta(-3+2\beta)))}{4(-3+3t+\beta^2)^2} \quad (16)$$

$$\pi(NT, T) = \frac{(2t + (\beta-2)(1+\beta))^2}{4(-3+3t+\beta^2)^2} \quad (17)$$

In the autarchy case, each firm acts as a monopolist in its own domestic market: as before, the payoff corresponds to  $1/4$  for both. We are now in a position to study the matrix (M1). Following the same steps as before we get a threshold of the level of *ad valorem* trade costs such that the trade game is a chicken game. For expositional purposes let us call this threshold  $\rho_1$ .<sup>10</sup>

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<sup>9</sup>Quantities and prices are always admissible if  $t < 1 - \beta$ . Second order conditions are always satisfied.

<sup>10</sup>The expression of  $\rho_1$  is available upon request. Figure 2 plots  $\rho_1$  in the space  $\beta, t$ .

**Proposition 2** *If  $t > \rho_1$  one way trade arises. If  $t < \rho_1$ , then two way trade arises.*

The following figure compares the *ad valorem* with the per unit trade costs scenario.

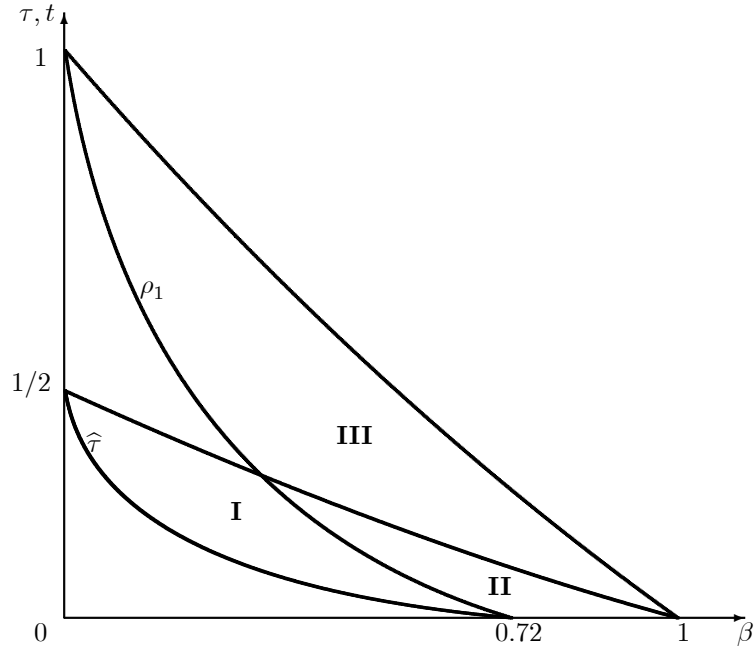


Figure 2

In region I and II we have a trade game of chicken in the case of per unit trade costs; in region II and III we have the same one way trade result in the case of *ad valorem* trade costs; quite interestingly, in region II one way trade arises no matter the type of trade costs.

## 5 Social incentives: planners' trade game

In this section we consider the trade game played by hypothetical national planners (governments) seeking to maximize domestic welfare. We are interested in understanding whether one way trade can be achieved also through the strategic

interaction between the two planners. Secondly, we aim to compare the private with the social incentives towards one way trade, investigating whether there exists a parameter region where the outcome of the trade game played by governments corresponds to the one resulting from the interaction between firms. If so, one way trade is a socially desirable outcome, in that neither planner may improve upon.

As in the previous section, we solve the game by backward induction, i.e. we first solve the marketing game and then we go through the analysis of the first stage, described by the following matrix:

$A \setminus B$	$T$	$NT$	(M2)
$T$	$W(T, T); W(T, T)$	$W(T, NT); W(NT, T)$	
$NT$	$W(NT, T); W(T, NT)$	$W(NT, NT); W(NT, NT)$	

In order to solve the game we use the same methodology as the one adopted to study M1. The unique difference is that now the payoffs are given by welfare instead of profit levels. For the planner in charge of maximizing the welfare in country  $A$ , the objective function is defined by  $W_A = \pi_a + CS_A + R_A$ , where  $CS_A$  is the level of consumers' surplus in country  $A$  and  $R_A$  is the tax revenue collected in country  $A$ , and similarly for country  $B$ . Given the linearity of the market demand,  $CS_j = Q_j^2/2$ , with  $j = \{A, B\}$ . As to  $R_j$ , we have to distinguish between two cases, according to the type of trade costs.

### 5.1 Per unit trade costs

Each government levies a specific tax on each unit of import. Then,  $R_A = \tau q_b^*$  and  $R_B = \tau q_a^*$ . Consider first the case where both the firm located in country  $A$  and the firm located in country  $B$  export. In this situation, consumers' surplus in each country amounts to:

$$CS = \frac{(2 - \tau)^2}{2(\beta + 3)^2} \quad (18)$$

and the welfare level in each country is given by:

$$W = \frac{2\beta^3 + 4\beta^2 - 2\tau\beta^2 + 3\tau^2\beta^2 - 14\beta + 6\tau^2\beta + 4\tau\beta - \tau^2 + 8 - 2\tau}{2(3 - \beta^2 - 2\beta)(1 - \beta)(\beta + 3)} \quad (19)$$

Now, we consider the case in which only one firm, say firm  $a$ , exports while the rival does not. When firm  $a$  exports while firm  $b$  does not, consumers' surplus in the two countries differ as follows:

$$CS_A = \frac{(3 - \beta + 2\tau\beta)^2}{8(\beta^2 - 3)^2} \quad (20)$$

$$CS_B = \frac{(4 - 2\tau - \beta - \beta^2)^2}{8(3 - \beta^2)^2} \quad (21)$$

Clearly, if firm  $b$  does not export the revenue collected by the government in country  $A$  is nil. Taking this into account, we get two different levels of welfare in the two countries:

$$W_A = \frac{35 - 22\beta + 44\tau\beta - 5\beta^2 + 4\tau\beta^2 - 4\tau^2\beta^2 - 32\tau + 32\tau^2 - 8\tau\beta^3 + 4\beta^3}{8(\beta^2 - 3)^2} \quad (22)$$

$$W_B = \frac{24 + 24\tau - 13\beta^2 - 36\tau^2 - 12\tau\beta - 12\tau\beta^2 - 2\beta^3 + 3\beta^4 + 8\tau\beta^3 + 16\tau^2\beta^2}{8(\beta^2 - 3)^2} \quad (23)$$

In the autarchy case, each firm gets  $1/4$  while consumers' surplus amount to  $1/8$ . Since revenues for governments are nil,  $W = 3/8$ . Now, we are in a position to fulfil the matrix M2 and characterize the set of Nash equilibria. In particular, one way trade arises when  $W(T, NT) > W(NT, NT)$  and  $W(T, T) < W(NT, T)$ . Easy computations suffice to check that  $W(T, NT) > W(NT, NT)$  always in the admissible parameter range, and that  $W(T, T) - W(NT, T)$  admits the following root:

$$\tilde{\tau} = \frac{-72 + \beta(144 + \beta(27 + \beta(-147 + \beta(18 + \beta(38 - \beta(5 + 3\beta))))))}{2(-4 + \beta + \beta^2)(18 + \beta(-9 + \beta(-3 + \beta(9 + \beta))))} \quad (24)$$

**Proposition 3** *Under per unit trade costs, one way trade arises as equilibrium if  $\tau > \tilde{\tau}$ , while two way trade arises as equilibrium if  $\tau < \tilde{\tau}$ .*

The following figure compares the social with the private incentives towards one way trade under per unit trade costs:

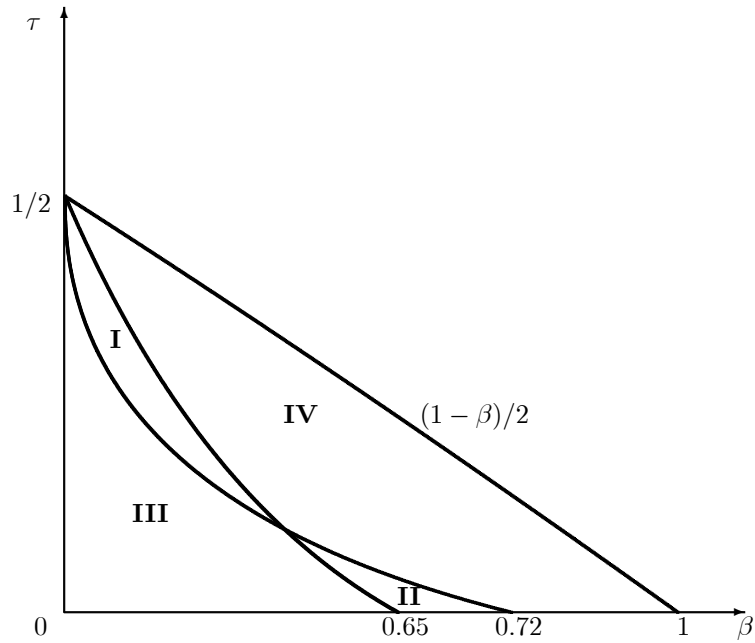


Figure 3

In region IV one way trade is the equilibrium of both the firms' and the planners' trade game. In this region there is no conflict between private and social incentives towards one way trade. In region I, firms choose one way while planners would prefer them to engage in a two way trade; in region II is the opposite, firms choose two way trade but planners would like them to play a chicken game. These two areas clearly depicts two situations of conflict between private and social incentives towards one way trade. Finally, area III corresponds to a case in which two way trade is the equilibrium of both the planners' and the firms' trade game.

## 5.2 Ad Valorem trade costs

Each government levies an *ad valorem* tax on each unit of import. Then,  $R_A = tp_A q_b^*$  and  $R_B = tp_B q_a^*$ . Consider first the case in which both firms are engaged

in a two way trade. In this situation, consumers' surplus in each country writes:

$$CS = \frac{(2t - t\beta - 2 + 2\beta)^2}{2(t\beta - 3t - \beta^2 - 2\beta + 3)^2} \quad (25)$$

and the corresponding welfare level obtains:

$$W = \frac{8 - 16t - 14\beta + 22t\beta + 4\beta^2 + 2\beta^3 + 8t^2 - 8t^2\beta + 3t^2\beta^2 - 6t\beta^2}{2(t\beta - 3t - 2\beta - \beta^2 + 3)^2} \quad (26)$$

Then, let us consider the scenario in which firm  $a$  exports while firm  $b$  does not. As consumers' surplus, we get:

$$CS_A = \frac{(1-t)^2(\beta-3)^2}{8(-3+3t+\beta^2)^2} \quad (27)$$

$$CS_B = \frac{(4t-4+\beta+\beta^2)^2}{8(-3+3t+\beta^2)^2} \quad (28)$$

The equilibrium level of profits of the marketing game in the asymmetric case for the exporting and the not exporting firm write respectively:

$$\pi(T, NT) = \frac{(1-t)(13+4t^2+t(-17+\beta(8+\beta))+\beta(-8+\beta(-3+2\beta)))}{4(-3+3t+\beta^2)^2} \quad (29)$$

$$\pi(NT, T) = \frac{(2t+(\beta-2)(1+\beta))^2}{4(-3+3t+\beta^2)^2} \quad (30)$$

By using the definition of welfare, we obtain the following expressions:

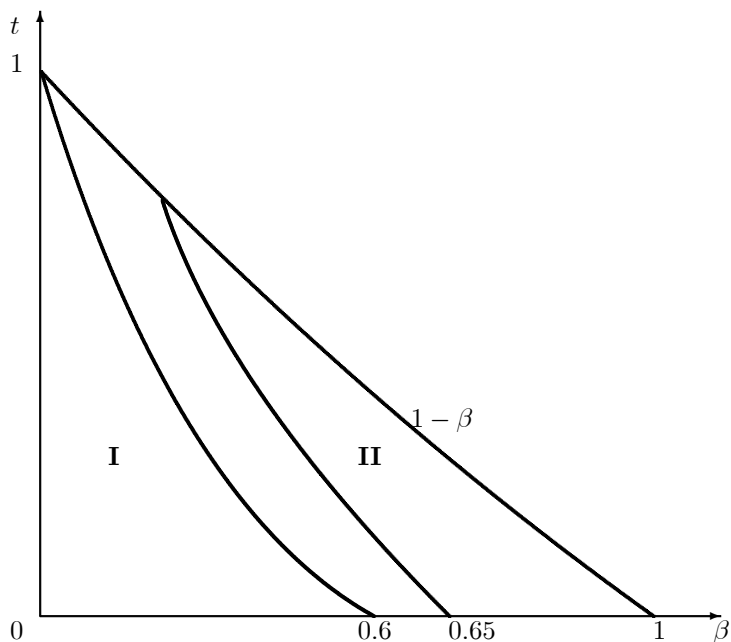
$$W_A = \frac{(1-t)(-5\beta^2 - 22\beta + 35 + t\beta^2 + 22t\beta - 43t + 8t^2 + 4\beta^3)}{8(-3+3t+\beta^2)^2} \quad (31)$$

$$W_B = \frac{24 - 40t - 4t\beta - 13\beta^2 - 2\beta^3 + 8t^2 + 4t^2\beta + 4t^2\beta^2 + 8t\beta^2 + 4t\beta^3 + 8t^3 + 3\beta^4}{8(-3+3t+\beta^2)^2} \quad (32)$$

Proceeding as before in studying M2, we can state the following:

**Proposition 4** *Under ad valorem trade costs, the trade game played by governments is never a chicken game, i.e. one way trade never arises.*

The following figure illustrates the above proposition:



**Figure 4**

We would have had a chicken game if  $W(T, NT) > W(NT, NT)$  and  $W(T, T) < W(NT, T)$ . The case in which  $W(T, NT) > W(NT, NT)$  corresponds to area I, while the case in which  $W(T, T) < W(NT, T)$  corresponds to area II. Clearly, one way trade requires area I and II to overlap, but, in the admissible parameter range, this never happens.

## 6 Conclusions

In this paper we have shown that unilateral trade in a given industry can arise as a result of the strategic interaction between firms facing the decision to export or not to export into each other market. The traditional explanation of one

way trade is in terms of inter-industry trade. Our paper tries to identify a unilateral trade by looking at one industry in isolation, i.e., within the framework usually adopted to study intra-industry trade. To the best of our knowledge, in the literature, intra-industry trade, either in homogeneous or differentiated products, is a two way trade. In a Brander and Krugman (1983) type of model, when international trade is allowed, each firm serves both the domestic and the foreign market. Yet, in the real world, there are plenty of firms serving only their own domestic markets, even if, in line of principle, they might start exporting. By dealing with both per unit and *ad valorem* trade costs, we have shown that unilateral trade can result as an equilibrium of the trade game which has the characteristics of a Chicken game: an asymmetric equilibrium can arise in a perfectly symmetric environment. Furthermore, under per unit trade costs, unilateral trade is also the outcome of the strategic interaction between two hypothetical national governments seeking to maximize domestic welfare, in a significant parameter range.

All the results obtained in this paper crucially depend on the assumption on the existence of scope effects. When scope effects are negligible, two way trade always results from the strategic interaction between firms, so one can avoid to model firms' choice upon exports.

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