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**NON-CREDIBLE POLICIES AND LEAP-FROGGING IN A VERTICALLY  
DIFFERENTIATED INDUSTRY**

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Abstract

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In a vertically differentiated duopoly, where firms first choose quality and then compete in quantities, it is shown that optimal time consistent subsidies and tariffs are always positive. Time consistent subsidies result in domestic monopolies as the foreign firm exits the market. Domestic welfare is greater if the government can precommitment to a subsidy. Time consistent tariffs ensure that the domestic firm always produces the high quality good. Optimal tariffs are always higher under precommitment. Contrary to subsidies, under tariffs non-committal on the part of the domestic government is welfare improving, and domestic welfare is always greater than under both free trade and subsidies.

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Key words: Vertical Differentiation, Non-credible Policies, Commitment, Tariffs, Subsidies, Leapfrogging.

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## 1. Introduction

Brander and Spencer (1984) showed that an activist government can use tariffs as a welfare improving policy tool in an imperfectly competitive market. Government intervention in these markets increases domestic welfare by transferring rents from the foreign to the domestic economy. The majority of the strategic trade policy literature investigates the welfare effects of policy instruments in homogeneous or horizontally differentiated industries. However, its effect in vertically differentiated industries has not been investigated so far. There are several reasons why this is an interesting issue. Trade volume has been increasing inside trading blocks and intra industry trade is a substantial part of this trade. Intra industry trade characterized by different levels of quality is in fact a significant proportion of trade (see, Greenaway, Hine and Millner (1994) among others). Nonetheless, the effects of strategic trade policy in this dimension have not been studied. Further, as a result of the existence of various levels of quality the rent transfer effects to the domestic country are unlike those observed in the existing literature.

Similar to horizontally differentiated markets, in vertically differentiated markets there are two effects of a tariff, the profit transfer and the tariff revenues accruing to the home government. These may, however, work in a fundamentally different manner depending on whether the government is able, or not able, to commit to a specific policy<sup>1</sup>. For instance, the home government can induce leapfrogging by not committing to a tariff when the foreign firm initially produces the high quality good. This results in the home firm producing the high quality good thus making a substantially higher level of profits. This profit transfer from the foreign to the domestic firm is of a higher magnitude in this case. Note, this possibility of leapfrogging, that does not exist in horizontally differentiated markets, changes the market structure fundamentally. Further, the now low quality (leapfrogged) foreign firm pays tariff revenues to the home government. Thus, for the home government taxing a high quality good results in greater rent transfers (profit transfer + tariff revenues) than taxing a low quality good where no leapfrogging takes place.

A similar argument applies when the domestic government subsidizes the home firm and is unable to commit to a subsidy. The subsidy induces exit of the foreign firm and the domestic firm becomes the only (high) quality producer. In this

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<sup>1</sup>Maskin and Newberry (1990) were amongst the first to investigate the issue of credibility in International Trade policy.

case the domestic government pays a higher subsidy than if the foreign firm had remained the high quality producer.

Given that this asymmetry in rent transfers exists the role of public policy in vertically differentiated industries becomes all the more important. There exist some examples where the policy makers target only a certain segment of the market. In the recent trade dispute between the U.S. and Japan, the U.S. government threatened sanctions *only* on the imports of luxury cars made by the Japanese. India allows imports of only luxury wrist watches with a substantial tariff. It seems that policy makers are resorting to policies targeted at specific segments of a market.

Regarding time consistency, Leahy and Neary (1994, 1995) show that the ability of the government to commit, or not, to a policy tool has important welfare implications. If the government can credibly commit to a subsidy, domestic welfare is always higher in their model. By committing to a level of R&D subsidy the government induces a lower level of R&D expenditure for the foreign firm thus improving home welfare. Thereby, it is able to avoid the decrease in the market share of the home firm in case that the foreign firm invests more in R&D. Thus, commitment crucially affects the choice of the strategic variable for the foreign firm and domestic welfare. Further, Goldberg (1995) shows that in a game where the firms first choose capacities, precommitment is not necessary if the home firm invests in capacity. The home firm can thus signal to the government by committing to a capacity and as a result even the time-consistent subsidy is positive (for certain parameter values), though, smaller than the subsidy under precommitment.

In this paper we study the imposition of tariffs and subsidies in a vertically differentiated industry when the government can/cannot credibly commit to a level of tariff/subsidy. A domestic and a foreign firm sell in the home market. We show that, time consistent tariffs ensure that the domestic firm always produces the high quality good. When the foreign firm produces the high quality good, it leapfrogs its rival and starts producing the low quality good. This happens as the foreign firm knows that it will face a much higher tariff if it produces the higher quality. As foreign firm's investment in quality is sunk, once it invests in quality, the domestic government can safely expropriate its gross profits by choosing the appropriate tariff moving last. Domestic welfare is higher under non-credible tariffs than under precommitment. Thus, lack of commitment could be a policy tool in itself at the disposal of the government in the framework of our model.

Further, we present results on time consistent subsidies where we show that contrary to Goldberg the time consistent subsidy is *always* positive and results in a domestic monopoly as the foreign firm exits the market. This happens because firms know that the subsidy the domestic firm receives depends on the quality it will choose. Hence, if the government moves after the firms do the foreign firm will not enter the market and the domestic firm will choose the maximum quality level. As a result precommitment on the part of the domestic government always gives higher domestic welfare. This result is similar to Leahy and Neary where commitment to a subsidy increases domestic welfare.

In Section 2 we present the vertical product differentiation model. In Section 3 we study non-credibility and leapfrogging when the government uses tariffs as a policy tool. Both the cases where the foreign/domestic firm produces the high/low quality good and vice-versa are analyzed. In Section 4 we study credible tariffs for the two cases mentioned above and the welfare implications of the presence, and absence, of precommitment. In section 5 we analyze time consistent subsidies and their welfare implications. Section 6 is the conclusion.

## 2. The model

We consider the simple case of two countries, foreign and domestic. There are two firms, one located in each country and producing a vertically differentiated good. High quality is indexed as  $s_1$  and low quality as  $s_2$ , such that  $s_1 > s_2$  always. We concentrate on the effects of a tariff/subsidy in the domestic market alone. There is a continuum of consumers in the domestic market, each is identified by his taste parameter  $\theta$ , where  $\theta$  is uniformly distributed over the interval  $[0, \bar{\theta}]$  with density one;  $\bar{\theta}$  then represents the size of the market. A consumer  $\theta$  has a unitary demand for the good and his utility function is,

$$U = \begin{cases} (\theta s_i - p) & \text{if he buys one unit of the good of quality } s_i. \\ 0 & \text{otherwise.} \end{cases} \quad (2.1)$$

Total costs are,  $C(s_i, x_i) = cx_i + \frac{s_i^2}{2}$ ,  $i = 1, 2$ . That is, the marginal cost of production is independent of the quality level and the quality costs are fixed costs. This specification of costs captures the distinctive characteristic of (pure) vertical differentiation models. Shaked and Sutton (1983) define a purely vertically

differentiated industry as the one where the costs of quality improvement fall primarily on fixed costs and involve only a modest rate of increase in unit variable costs. Following Sutton (1992), we assume that, as firms bear the quality costs in the first stage, these are sunk costs in the production stage. We further assume, without loss of generality, that the marginal cost,  $c$ , is zero for both firms.

The sequence of moves is as follows. At time '0' the government announces its decision to impose a tariff on the foreign firm (or, give a subsidy to the domestic firm). Note, the government may, or may not, choose to commit to a level of tariff/subsidy. Both cases are subsequently analyzed.

If the government can credibly commit to a tariff/subsidy, then it moves first and chooses the level of tariff/subsidy. Then firms simultaneously choose their qualities  $s_i$  bearing the costs of their quality selection. On the other hand, if the government is unable to commit, the firms select their qualities prior to the policy choice - the level of tariff/subsidy - of the government. In the last stage, firms simultaneously choose quantities. The game is solved using subgame perfectness.

The demand for the low and high quality good is first derived. The consumer indifferent between buying the high, or low, quality good has the taste parameter  $\theta_{12} = \left[ \frac{p_1 - p_2}{s_1 - s_2} \right]$ . The consumer indifferent between buying the low quality good and not buying at all has the taste parameter  $\theta_{02} = \frac{p_2}{s_2}$ . Now, all the consumers for whom  $\bar{\theta} \geq \theta \geq \theta_{12}$  purchase good with quality  $s_1$ . All consumers for whom  $\theta_{12} > \theta > \theta_{02}$  will purchase quality  $s_2$ . Those described by  $\theta < \theta_{02}$  do not buy the good.

The demands for the high and low quality good are given by,

$$D_1(p_1, p_2) = \bar{\theta} - \frac{p_1 - p_2}{s_1 - s_2}; \quad D_2(p_1, p_2) = \frac{p_1 - p_2}{s_1 - s_2} - \frac{p_2}{s_2}$$

This gives us the inverse demands,

$$p_1(x_1, x_2) = \bar{\theta}s_1 - x_1s_1 - x_2s_2; \quad p_2(x_1, x_2) = (\bar{\theta} - x_1 - x_2)s_2 \quad (2.2)$$

### 3. Non-credibility and leapfrogging under tariffs

#### 3.1. Optimal tariffs

As any announcement of the tariff by the government is not credible the firms will ignore any such announcement and will make their quality choice as if the

government chooses its policy after the firms' selection of quality. Non-committal, thus always implies that the government moves *after* the firms have made their quality choice<sup>2</sup>. As will become clear later a non-committal government has the strategic advantage of being a second mover when the policy instrument is a tariff. We analyze both the cases where the foreign firm initially produces the high quality or, the low quality.

### 3.1.1. Foreign firm high-quality

Let  $\bar{t}$  be the specific tariff imposed on the high quality foreign firm. For analytical convenience, define  $t = \frac{\bar{t}}{\bar{\theta}}$ . Then the (gross) profits of firm-1 and firm-2 are,  $\pi_1^G = p_1(x_1, x_2)x_1 - t\bar{\theta}x_1$  and  $\pi_2^G = p_2(x_1, x_2)x_2$ . From the first order conditions (focs) the best response functions for the foreign and the domestic firm are obtained:

$$x_1 = \frac{\bar{\theta}s_1 - s_2x_2 - \bar{\theta}t}{2s_1}; \quad x_2 = \frac{\bar{\theta} - x_1}{2} \quad (3.1)$$

It is now easy to see how the tariff affects the foreign firms' best response function. The tariff effectively increases the marginal cost of the foreign firm. Thus, due to the downward shift of the reaction function, the market share of firm-1 decreases and that of firm-2 increases (see figure 1)<sup>3</sup>.

< figure-1 here >

Then the equilibrium outputs are,

$$x_1^* = \left[ \frac{2s_1 - s_2 - 2t}{4s_1 - s_2} \right] \bar{\theta}; \quad x_2^* = \left[ \frac{s_1 + t}{4s_1 - s_2} \right] \bar{\theta} \quad (3.2)$$

and the equilibrium net profits,  $\pi_i^* = s_i x_i^{*2} - \frac{s_i^2}{2}, i = 1, 2$ .

In the second stage the government decides on the optimal tariff that maximizes total domestic welfare taking as given the quality choices of the foreign and the domestic firm. Total welfare ( $TW$ ) is defined as the sum of consumer surplus ( $CS$ ), the domestic firm's net profits ( $\pi_2^*$ ) and tariff revenues ( $t\bar{\theta}x_1^*$ ).  $CS$  is given by,

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<sup>2</sup>As the tariff is imposed on the firm's per unit output, it seems logical that the firm will always ignore any announcement by a non-committal government made before it (the firm) chooses its quality

<sup>3</sup>This is the market share effect in Brander and Spencer.

$$CS = \int_{\theta_{12}^*}^{\bar{\theta}} (\theta s_1 - p_1^*) d\theta + \int_{\theta_{02}^*}^{\theta_{12}^*} (\theta s_2 - p_2^*) d\theta \quad (3.3)$$

Using (3.2) and (2.2), and after some manipulations, we get:

$$TW = \left[ \frac{s_1^2 + s_1 s_2 + 2s_1 t - 3t^2}{2(4s_1 - s_2)} \right] \bar{\theta}^2 - \frac{s_2^2}{2} \quad (3.4)$$

Given the quality choice of the foreign and the domestic firm, maximizing TW with respect to  $t$ , we obtain the optimal tariff,  $\bar{t}^* = \frac{s_1}{3}\bar{\theta}$ . The tariff that maximizes domestic welfare is proportional to the foreign firm's quality and increases with the size of the market,  $\bar{\theta}$ . Obviously, this optimal tariff is independent of the quality costs as these costs are already sunk for the firms.

### 3.1.2. Foreign firm low-quality

A similar analysis can be conducted when the foreign firm is of low quality. The gross profit functions for the domestic and the foreign firm are as above, except that the tariff revenues,  $t\bar{\theta}x_2$ , are now subtracted from firm-2's profits. From the focs we obtain the best response functions (see figure 2)<sup>4</sup>

$$x_1 = \frac{\bar{\theta}s_1 - x_2s_2}{2s_1}; \quad x_2 = \frac{\bar{\theta}s_2 - x_1s_2 - t\bar{\theta}}{2s_2}$$

< figure-2 here >

Then the equilibrium outputs are

$$x_1^* = \left[ \frac{2s_1 - s_2 + t}{4s_1 - s_2} \right] \bar{\theta}; \quad x_2^* = \left[ \frac{s_1(s_2 - 2t)}{s_2(4s_1 - s_2)} \right] \bar{\theta} \quad (3.5)$$

and the equilibrium net profits,  $\pi_i^* = s_i x_i^{*2} - \frac{s_i^2}{2}$ .

The Government selects a tariff in the second stage that maximizes total domestic welfare which can be now expressed as,

$$TW = \left[ \frac{3s_1^2 s_2 - s_1 s_2^2 + 2s_1 s_2 t - 3s_1 t^2}{2s_2(4s_1 - s_2)} \right] \bar{\theta}^2 - \frac{s_1^2}{2} \quad (3.6)$$

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<sup>4</sup>Once again, due to the tariff the domestic firm gains and the foreign firm loses market share.

From the focus we derive the optimal tariff for the Government. Note, as before the optimal tariff,  $\bar{t}^*$ , is proportional to the foreign firm's quality level and the size of the market, i.e.  $\bar{t}^* = \left(\frac{s_f}{3}\right)\bar{\theta}$ . Also, as previously, the tariff is independent of the quality costs. The following proposition summarizes the results.

**Proposition 3.1.** *For any choice of qualities by the firms, the optimal tariff for a non-committal government on the high, or low, quality foreign firm ( $s_f$ ) is,  $\bar{t}^* = \left(\frac{s_f}{3}\right)\bar{\theta}$ .*

### 3.2. Anticipating government's optimal tariff and leapfrogging

If the foreign firm is certain that the government is unable to commit to a tariff then it will always anticipate the tariff policy that maximizes the total domestic welfare. As the foreign firm's quality costs are already sunk when the government decides its tariff policy, the government will choose a policy so as to expropriate a great part of the foreign firm's *gross* profits. Since the gross profits are higher when the foreign firm produces the high quality good, the government can raise more revenues by imposing a higher tariff on the high quality foreign firm. This is reflected on the fact that the optimal tariff is proportional to the foreign firm's quality, i.e.  $\bar{t}^* = \left(\frac{s_f}{3}\right)\bar{\theta}$ . As is shown below, a high quality foreign firm, faced with the threat of expropriation of its gross profits, always has the incentive to leapfrog its low quality domestic rival. However, if it is the low-quality foreign firm then it still produces the low-quality good. As a result, the foreign firm will always produce the low quality good whenever it faces a non-committal domestic government.

These results are summarized in the following proposition.

**Proposition 3.2.** *A high-quality foreign firm correctly anticipating the welfare maximizing tariff for the government,  $\bar{t}^* = \left(\frac{s_f}{3}\right)\bar{\theta}$ , leapfrogs its low quality rival, thus producing the low quality good. If the foreign firm is low-quality then it still produces the low quality good. Moreover, under non-credible tariffs domestic welfare is greater than under free trade.*

#### 3.2.1. Foreign firm high-quality

We first show that the foreign firm never produces the high quality good if it anticipates that the optimal tariff of the government will be  $\bar{t}^* = \left(\frac{s_f}{3}\right)\bar{\theta}$ . From



(3.2) we get

$$x_1^* = \frac{4s_1 - 3s_2}{3(4s_1 - s_2)}\bar{\theta}; \quad x_2^* = \frac{4s_1}{3(4s_1 - s_2)}\bar{\theta} \quad (3.7)$$

with the net profit functions,  $\pi_i^*(s_1, s_2) = s_i x_i^{*2} - \frac{s_i^2}{2}$ ,  $i = 1, 2$ . Define  $\lambda = \frac{s_2}{s_1}$ . Then the focs in the quality choice stage can be written as,

$$s_1(\lambda) = \left[ \frac{(4 - 3\lambda)(16 + 3\lambda^2)}{9(4 - \lambda)^3} \right] \bar{\theta}^2; \quad s_2(\lambda) = \left[ \frac{16(4 + \lambda)}{9(4 - \lambda)^3} \right] \bar{\theta}^2 \quad (3.8)$$

To show that the foreign firm never produces the high quality good it is sufficient to show that its profits,  $\pi_1(s_1, s_2)$ , are always negative. First, it can be checked that  $\max_{s_1} \pi_1(s_1, s_2) < 0$  for all  $s_2 > 0.0568149\bar{\theta}^2$ . Thus, if the domestic firm chooses quality  $s_2 > 0.0568149\bar{\theta}^2$  the foreign firm never produces the high quality good. We next show that the domestic firm never chooses a quality level  $s_2 \leq 0.0568149\bar{\theta}^2$ . In fact, from the first order conditions of the domestic firm (3.8) we can check that the optimal quality for the domestic firm is always larger than  $0.111\bar{\theta}^2$  (the minimum attained at  $\lambda = 0$ , i.e.,  $s_1 = +\infty$ ). Thus the foreign firm never chooses high quality if it anticipates a policy  $\bar{t}^* = \frac{s_1}{3}\bar{\theta}$ .

### 3.2.2. Foreign firm low-quality

The specific tariff is now applied to the low quality foreign firm. Substituting  $t^* = \frac{s_2}{3}$  in (3.5) we get,

$$x_1^* = \frac{2(3s_1 - s_2)}{3(4s_1 - s_2)}\bar{\theta}; \quad x_2^* = \frac{s_1}{3(4s_1 - s_2)}\bar{\theta} \quad (3.9)$$

and  $\pi_i^*(s_1, s_2) = s_i x_i^{*2} - \frac{s_i^2}{2}$ . Then the focs can be expressed as (with  $\lambda = \frac{s_2}{s_1}$ ),

$$s_1(\lambda) = \frac{4(3 - \lambda)(12 - 5\lambda + \lambda^2)}{9(4 - \lambda)^3} \bar{\theta}^2; \quad s_2(\lambda) = \frac{(4 + \lambda)}{9(4 - \lambda)^3} \bar{\theta}^2 \quad (3.10)$$

Dividing  $s_2(\lambda)$  by  $s_1(\lambda)$  and solving for  $\lambda$  we obtain  $\lambda^* = 0.028584$ . Then from (3.10), (3.9), and (3.6) we obtain:

$$\begin{aligned}
s_1^* &= 0.250007\bar{\theta}^2 & s_2^* &= 0.00714618\bar{\theta}^2 \\
x_1^* &= 0.4988\bar{\theta} & x_2^* &= 0.0839331\bar{\theta} \\
\pi_1^* &= 0.0309505\bar{\theta}^4 & \pi_2^* &= 0.00002481\bar{\theta}^4 \\
\bar{t}^* &= 0.00238206\bar{\theta}^3 & CS &= 0.0314255\bar{\theta}^4 \\
& & TW &= 0.062576\bar{\theta}^4
\end{aligned}$$

Note, while the foreign firm's net profits are positive when it produces the low quality, they are always negative if it produces the high quality. Hence, an initially high-quality foreign firm will leapfrog its domestic rival and instead produce the low quality good. On the other hand, a low quality foreign firm still produces the low quality good after the imposition of the tariff. As we will see below, domestic welfare is higher when the government cannot precommit to a tariff than under free trade. In fact, if the foreign firm produces the higher quality, free trade leads to  $TW = 0.042904\bar{\theta}^4$ ; contrarily, if the foreign firm produces the lower quality  $TW = 0.059643\bar{\theta}^4$  (see figures 5 and 7).

## 4. Optimal tariffs under Credible Policies

### 4.1. Foreign firm high-quality

Suppose now that the government can credibly commit to a specific tariff before the firms select their qualities. The firms choose their qualities in the second stage, given the final period equilibrium quantities (see, (3.2)). Let  $\frac{s_2}{s_1} = \lambda$  and  $\mu = \frac{t}{s_1}$ . The first order conditions can be expressed as:

$$s_1(\lambda, \mu) = \left[ \frac{(2 - \lambda - 2\mu)(8 - 2\lambda + \lambda^2 + 8\mu + 2\lambda\mu)}{(4 - \lambda)^3} \right] \bar{\theta}^2 \quad (4.1)$$

$$s_2(\lambda, \mu) = \left[ \frac{(4 + \lambda)(1 + \mu)^2}{(4 - \lambda)^3} \right] \bar{\theta}^2 \quad (4.2)$$

We first need to determine the interval of tariffs for which the foreign firm stays in the market. Define  $t_m$  as the maximum tariff for which the foreign firm's profits are equal to zero. Using (4.1), (4.2), and the zero profit condition for the foreign firm, and solving for  $(t, s_1, s_2)$  we obtain  $t_m = 0.0276539\bar{\theta}^2$  (the associated quality ratio is,  $\lambda_m = 0.575379$ ). This is the tariff level that leaves the foreign

firm indifferent between staying in the market, or exiting it. Hence, the relevant interval for the tariff is  $t \in [0, 0.0276539\bar{\theta}^2]$ . (Note,  $\mu = t = 0$  corresponds to free trade, and in this case the ratio of qualities is,  $\lambda_0 = 0.358111$ ).

Now, dividing expressions (4.1) and (4.2), and simplifying we obtain<sup>5</sup>,

$$(4 + 17\lambda + 4\lambda^2)\mu^2 + (8 + 2\lambda + 4\lambda^3)\mu = 15\lambda - 12\lambda^2 + 4\lambda^3 - \lambda^4 - 4 \quad (4.3)$$

Solving equation (4.3) for  $\mu$  and choosing the relevant root we get  $\mu(\lambda)$ <sup>6</sup>. Plotting  $\mu(\lambda)$  it is easily seen that  $d\mu/d\lambda > 0$ . Further, substituting  $\mu(\lambda)$  in (4.1) and (4.2) we obtain  $s_1(\lambda)$  and  $s_2(\lambda)$ . By plotting these expressions, it is seen that  $s_2(\lambda)$  is increasing and  $s_1(\lambda)$  is decreasing with  $\lambda$ .

Now, writing  $t(\lambda) = s_1(\lambda) \cdot \mu(\lambda)$ , and plotting, we see that  $d\lambda/dt > 0$  for  $\lambda$  in the range  $[0.358111, 0.575379]$ . Therefore, as the tariff on the imports increases, the foreign firm decreases and the domestic firm increases its quality (see figure-3).

< figure-3 here >

Define average quality,  $s_{AV}$ , as the average of the individual qualities weighted by individual market shares, i.e.,

$$s_{AV} = \frac{s_1^*x_1^* + s_2^*x_2^*}{x_1^* + x_2^*} \quad (4.4)$$

Using (3.2), and plotting we see that average quality increases with the tariff (see figure 4). This is due to the fact that both the market share and quality of the domestic firm increase. This more than compensates for the decrease in quality and output of the foreign firm.

< figure-4 here >

**Proposition 4.1.** *As the specific tariff on imports becomes more restrictive, it leads to quality decrease by the foreign firm and quality increase by the domestic firm. Average quality in the market increases with the tariff.*

<sup>5</sup>These calculations were performed using mathematica.

<sup>6</sup>The analytical expressions of  $\mu(\lambda)$ ,  $s_i(\lambda)$ ,  $t(\lambda)$  etc. are available from the authors upon request.

### 4.1.1. Welfare analysis

We now look at the effects that a credible tariff,  $t$ , has on the firms' profits, consumer surplus and total domestic welfare. Substituting  $s_i(\lambda)$ ,  $i = 1, 2$  and  $t(\lambda)$  in (3.2) and (3.4) and plotting we derive the following results (see figure 5).

< figure-5 here >

As expected, the profits of the high-quality foreign firm,  $\pi_1^*$ , are maximum under free trade and decrease with the level of the tariff (being zero for the maximum tariff  $t_m$ ). As the tariff transfers rents to the domestic producer, the profits of the domestic firm,  $\pi_2^*$ , increase with the tariff and are maximum at  $t_m$ . Consumer surplus decreases initially as total output decreases with the tariff, then increases due to the (average) quality upgrading. Consumer surplus is maximum under free trade. Total domestic welfare is, however, maximized at the maximum tariff  $t_m$ . More interestingly, this maximum level of total domestic welfare ( $\max TW = 0.05315\bar{\theta}^4$ ) is lower than when the government cannot credibly commit to a tariff ( $TW = 0.062576\bar{\theta}^4$ ). This is explained by the fact that profits of the domestic firm increase by an amount larger than the decrease in consumer surplus (as tariff revenues are zero in both cases).

### 4.2. Foreign firm low-quality

Using similar arguments as in the previous case, we can determine the foreign and domestic firms' qualities as functions of the level of tariff imposed on the low quality foreign firm. Let  $\bar{\lambda} = \frac{s_1}{s_2}$  and  $\bar{\mu} = \frac{t}{s_2}$ . Using (3.5), the focs can be expressed as:

$$s_1(\bar{\lambda}, \bar{\mu}) = \frac{(2\bar{\lambda} - 1 + \bar{\mu})(8\bar{\lambda}^2 - 2\bar{\lambda} + 1 - 4\bar{\lambda}\bar{\mu} - \bar{\mu})}{(4\bar{\lambda} - 1)^3} \quad (4.5)$$

$$s_2(\bar{\lambda}, \bar{\mu}) = \frac{\bar{\lambda}^2(1 - 2\bar{\mu})(4\bar{\lambda} + 1 + 8\bar{\lambda}\bar{\mu} - 6\bar{\mu})}{(4\bar{\lambda} - 1)^3} \quad (4.6)$$

The above equations together with the zero profit condition for the foreign firm determine the maximum tariff,  $t_m = 0.010636\bar{\theta}^2$  (and the associated ratio of qualities,  $\bar{\lambda}_m = 3.513$ ). Hence, the relevant range of tariff is given by  $t \in$

$[0, 0.010636\bar{\theta}^2]$ . (Note that the free trade ratio of qualities,  $\bar{\lambda}_0 = 1/\lambda_0$ , is 2.79243).

< figure-6 here >

In Figure-6 the relationship between quality choice and the level of tariff protection is shown<sup>7</sup>. As the tariff becomes more protective both firms lower their qualities. Interestingly, as there is a substantial shift in market shares towards the high quality domestic firm, average quality in the market increases with the tariff. The following proposition summarizes the results.

**Proposition 4.2.** *An increase of the specific tariff on the low quality foreign firm results in quality downgrading by both the firms. However, the average quality in the market increases with the level of the tariff.*

#### 4.2.1. Welfare Analysis

The effects of a tariff on firms' profits, consumer surplus and total domestic welfare are now analyzed. As in the previous case, the profits of the low-quality foreign firm are maximum under free trade and decrease with the tariff (becoming zero for the maximum tariff  $t_m$ ). While the profits of the domestic firm increase with the tariff and are maximum at  $t_m$  (when the foreign firm is indifferent between staying, or exiting the market) (figure-7). Consumer surplus, however, decreases with the tariff due to both, the downgrading of qualities and the restriction of total output. Total welfare again increases with the tariff and reaches its maximum at  $t_m$  (figure-7). This is explained by the fact that profits of the domestic firm increase by an amount larger than the decrease in domestic consumer surplus. Note that, in this case too, the maximum of the domestic welfare ( $0.0624706\bar{\theta}^4$ ) is lower than the welfare attained when the government cannot credibly commit to a specific tariff ( $0.062576\bar{\theta}^4$ )<sup>8</sup>.

< figure-7 here >

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<sup>7</sup>The expressions for  $\bar{\mu}(\bar{\lambda})$ ,  $s_i(\bar{\lambda})$  and  $\bar{i}(\bar{\lambda})$  are available from the authors upon request. Note, that  $d\bar{\lambda}/dt > 0$  for  $\bar{\lambda}$  in the range [2.79243, 3.513].

<sup>8</sup>This slight difference of domestic welfare between the present case and the case of non-credible tariffs cannot be attributed to approximation errors as the optimal tariff is much higher under precommitment ( $t_m = 0.010636\bar{\theta}^2 > t^* = 0.0023806\theta^2$ ).

### 4.3. Discussion

Domestic welfare is higher when the government is unable to commit to a level of tariff than when it can precommit. The reason for the improvement in welfare is as follows. Consider first, the case where the domestic firm initially produces the low quality good. A non-committal government will always choose a tariff that results in leapfrogging. Anticipating a tariff that will expropriate a large part of its gross profits, the foreign firm starts producing the low quality good. Thus, due to the imposition of the tariff the domestic firm becomes the high quality producer. As the high-quality firm has a larger share of the market relative to the low quality firm (and a higher price), the net revenues accruing to the domestic firm substantially increase. Note, this effect is analogous to the effect in Brander and Spencer where the market share of the domestic firm increases due to the imposition of the tariff. However, due to leapfrogging, the increase in the domestic firm's profits is of a much larger magnitude under non-credible tariffs. In either case the domestic government gets tariff revenues. However, as the optimal tariff is lower under non-credible policies and, moreover, is applied on a firm whose market share is smaller, tariff revenues are lower than when the government precommits. Furthermore, even if the level of tariff is lower, consumer surplus turns out to be lower under non-credible policies. However, the positive profit transfer effect dominates the two negative (tariff revenue and consumer surplus) effects, resulting in higher domestic welfare.

On the other hand, an (initially) low quality foreign firm remains a low quality producer under both types of policies. Under non-credible policies, the foreign firm produces a lower quality as it anticipates a tariff that will expropriate its gross profits. Domestic firm also lowers its quality as the competition is relaxed through product differentiation. As in the previous case, the optimal tariff under non-credible policies is lower than under precommitment, and thus tariff revenues are lower, too. Moreover, the consumer surplus is again higher under precommitment. However, the domestic firm's profits increase substantially under non-credible tariffs and more than compensate for the above two negative effects. As a result, domestic welfare increases in this case too.

## 5. Non-credibility and exit-inducing Subsidies

### 5.1. Optimal Subsidies

As in section 3, we assume that the firms make their quality choice as if the government selects the level of subsidy for the domestic firm after the firms have made their quality choice. We will see that, contrary to the case of tariffs, if the policy instrument is a subsidy, the government has instead a second mover disadvantage. Both the cases, the foreign firm initially producing the high or the low quality, are subsequently analyzed.

#### 5.1.1. Foreign firm high-quality

We first consider the output selection stage. Let the per-unit of domestic output subsidy be  $\bar{k}$ . Define  $k = \frac{\bar{k}}{\bar{\theta}}$ . The gross profits of the firms are then,  $\pi_1^G = p_1(x_1, x_2)x_1$  and  $\pi_2^G = p_2(x_1, x_2)x_2 + k\bar{\theta}x_2$ . From the first order conditions the best reply functions for the foreign and the domestic firm are obtained. Solving these we get the equilibrium outputs,

$$x_1^* = \left[ \frac{2s_1 - s_2 - k}{4s_1 - s_2} \right] \bar{\theta}; \quad x_2^* = \left[ \frac{s_1(2k + s_2)}{s_2(4s_1 - s_2)} \right] \bar{\theta} \quad (5.1)$$

and the equilibrium net profits,  $\pi_i^* = s_i x_i^{*2} - \frac{s_i^2}{2}, i = 1, 2$ . Note, that the government decides on the subsidy that maximizes total domestic welfare given the quality choice of the foreign and the domestic firm. Total domestic welfare ( $TW$ ) is defined as the sum of consumer surplus ( $CS$ ) plus domestic firm's net profits ( $\pi_2^*$ ) less expenditures on subsidies ( $k\bar{\theta}x_2^*$ ). Using (2.2), (5.1) and (3.3), it can be checked that,

$$TW = \left[ \frac{s_1(2ks_2 + s_1s_2 + s_2^2 - k^2)}{2s_2(4s_1 - s_2)} \right] \bar{\theta}^2 - \frac{s_2^2}{2} \quad (5.2)$$

Maximizing  $TW$  with respect to  $k$ , we obtain the optimal subsidy,  $\bar{k}^* = s_2\bar{\theta}$ ;  $\bar{k}^*$  is proportional to both, the quality of the domestic firm and the market size. Again, note that the time consistent subsidy is independent of the quality costs.

### 5.1.2. Foreign firm low-quality

The gross profit functions for the domestic and foreign firm are now,  $\pi_1^G = p_1(x_1, x_2)x_1 + k\bar{\theta}x_1$  and  $\pi_2^G = p_2(x_1, x_2)x_2$ , respectively. From the focs we obtain the equilibrium outputs,

$$x_1^* = \left[ \frac{2(k + s_1) - s_2}{4s_1 - s_2} \right] \bar{\theta}; \quad x_2^* = \left[ \frac{s_1 - k}{4s_1 - s_2} \right] \bar{\theta} \quad (5.3)$$

and the net profits,  $\pi_i^* = s_i x_i^2 - \frac{s_i^2}{2}, i = 1, 2$ .

The Government selects a subsidy that maximizes total domestic welfare which is expressed as,

$$TW = \left[ \frac{k^2 - 2ks_1 - 3s_1^2 + s_1s_2}{2(s_2 - 4s_1)} \right] \bar{\theta}^2 - \frac{s_1^2}{2} \quad (5.4)$$

From the focs the time consistent subsidy,  $\bar{k}^* = s_1\bar{\theta}$ , is obtained, which is again proportional to the domestic firm's quality and the size of the market.

**Proposition 5.1.** *For any choice of qualities by the firms, the optimal subsidy for a non-committal government, on the high, or low, quality domestic firm ( $s_d$ ) is,  $\bar{k}^* = s_d\bar{\theta}$ .*

### 5.2. Anticipating government's optimal subsidy and exit

It is easy to see from (5.3) that when the foreign firm produces the low quality good, the optimal subsidy,  $k^* = s_1$ , results in the foreign firm producing an output of zero (hence, making negative profits for any  $s_2 > 0$ ). Thus, the provision of the subsidy results in a domestic monopoly. Moreover, as we will see below, a high quality foreign firm always makes negative profits and thus also stays out of the domestic market. Once more the domestic firm becomes a monopoly.

The intuition is simple. If the foreign firm anticipates that the domestic firm will receive a high subsidy ex-post, and therefore its own gross profits will be lower, it prefers to stay out of the market to avoid the sunk costs of quality (as qualities are chosen in the first stage). Thus, as the foreign firm decides to stay out, the domestic firm will now choose its quality and output as a monopoly. The following proposition summarizes the results (where,  $f$  stands for the foreign firm).



**Proposition 5.2.** *Given any  $s_d > 0$  and  $s_f > 0$ ,  $k^* = s_d$  and  $\pi_f < 0$ . Hence, the foreign firm never produces  $s_f > 0$ , i.e., it always stays out of the market. The domestic firm is then a monopoly.*

**Proof.** It remains to show that the high quality foreign firm will make always negative profits. Substituting  $k^* = s_2$  into (5.1) we obtain:

$$x_1^* = \left[ \frac{2(s_1 - s_2)}{4s_1 - s_2} \right] \bar{\theta}, \quad x_2^* = \left[ \frac{3s_1}{4s_1 - s_2} \right] \bar{\theta} \quad (5.5)$$

and the net profits  $\pi_i^* = s_i x_i^{*2} - \frac{s_i^2}{2}$ ,  $i = 1, 2$ . Setting  $\lambda = \frac{s_2}{s_1}$  from the focs we obtain,

$$s_2(\lambda) = \left[ \frac{9(4 + \lambda)}{(4 - \lambda)^3} \right] \bar{\theta}^2.$$

Since  $s_2(\lambda)$  is increasing in  $\lambda$ , the quality of the domestic firm will be larger than  $s_2(0) = \left(\frac{9}{16}\right) \bar{\theta}^2$ . Further, from (5.5),  $x_1^*$  decreases with  $s_2$ . Hence the foreign firm's profits decrease with  $s_2$ . That is,  $\pi_1^*(s_1, s_2) \leq \pi_1^*(s_1, s_2(0)) \leq \max_{s_1} \pi_1^*(s_1, s_2(0)) = -\left(\frac{81}{512}\right) \bar{\theta}^4$  (by plotting this function we can see that the maximum is attained at  $s_1 = s_2(0) = \left(\frac{9}{16}\right) \bar{\theta}^2$ ). Thus, the high quality foreign firm will always stay out of the market resulting in a domestic monopoly.

### 5.3. A Domestic Monopoly

We now analyze the domestic monopoly case. The monopolist will choose its quality anticipating a subsidy from the government. In the last stage, its profit function is,  $\pi = (\bar{\theta} - q)sq + k\bar{\theta}q$ , and hence its optimal output is:

$$q_m = \bar{\theta} \left[ \frac{s + k}{2s} \right] \quad (5.6)$$

and its net profits are  $\pi_m = sq_m^2 - \frac{s^2}{2}$ . Further, the total domestic welfare is given by:

$$TW = \left[ \frac{(2ks - k^2 + 3s^2)}{8s} \right] \bar{\theta}^2 - \frac{s^2}{2}.$$

Once more, we get  $\bar{k}^* = s\bar{\theta}$ . That is, the optimal subsidy is proportional to the quality of the monopolist (and also to the market size). The profits of the

monopolist under the time consistent subsidy ( $k^* = s$ ) are  $\pi_m = s\bar{\theta}^2 - \frac{s^2}{2}$  and it selects quality,  $s_m = \bar{\theta}^2$ , producing an output level of  $\bar{\theta}$  (note, the monopolist sells to the entire market). Finally, if  $k^* = s_m = \bar{\theta}^2$ , it can be checked that total domestic welfare equals zero.

The intuition is as follows. If the government is unable to precommit to a specific subsidy level, the (resulting) domestic monopolist offers a much higher quality good in the market in order to obtain a high subsidy by the government. As the subsidy it receives is quite high, the monopolist sells to the entire market at a very low price (in fact, the price equals marginal cost in our case). In addition, total subsidies are as high as the sum of producer and consumer surplus, thus resulting in zero domestic welfare.

Now, it is easy to show that any small subsidy under precommitment gives a positive total welfare. Note, under free trade (when both the firms are active in the market) the total domestic welfare is  $0.0429062\bar{\theta}^4$  and  $0.0596441\bar{\theta}^4$ , when the foreign firm are of low and high quality, respectively (see figures 5 and 7). Therefore, any arbitrarily small subsidy would also give a positive total welfare. Thus, the government prefers to precommit if it subsidizes the domestic firm. The proposition below summarizes the results.

**Proposition 5.3.** *Under non-credible subsidies, the (resulting) domestic monopolist covers the entire market ( $q_m = \bar{\theta}$ ) offering a high quality good ( $s_m = \bar{\theta}^2$ ) in order to obtain a high subsidy,  $\bar{k}^* = \bar{\theta}^3$ , from the government. Total domestic welfare under the time consistent subsidy equals zero. It is better for the government to credibly commit to a specific policy measure, since a small subsidy under precommitment results in a greater domestic welfare than under non-credible subsidies.*

## 6. Conclusion

In the absence of commitment we find that domestic welfare is higher when the government's policy tool is a tariff. However, if the government subsidizes the domestic firm precommitment is important as domestic welfare is lower in its absence. If the policy tool is a tariff the optimal time-consistent tariff is proportional to the foreign firms' quality and the foreign firm has no incentives to produce the high quality good. Due to non-commitment the tariff ensures that the domestic

firm always produces the high quality good. The tariff effectively transfers revenues from the (ex-ante) high-quality foreign firm to the (ex-post) high-quality domestic firm. This is similar to the rent transfer effect observed in Brander and Spencer. In our case this effect is more dramatic because quality configurations always change due to the optimal tariff. Therefore, the effect on welfare is even more dramatic. This happens due to the fact that in our vertically differentiated oligopoly model the high-quality firm is always the domestic firm. We thus observe a transfer of rents from two sources. One, due to tariffs. Second, due to non-commitment the domestic firm always produces the higher quality good achieving a much higher level of profits. This increases domestic welfare.

On the other hand, a time consistent subsidy results in the exit of the foreign firm from the domestic market. This results in a domestic monopoly with the monopolist recognizing that the time consistent subsidy depends on its choice of quality. The home firm then chooses the maximum quality possible which results in the total domestic welfare of zero. Recognizing this, the domestic government would rather precommit as any arbitrarily small subsidy under precommitment leads to a positive level of domestic welfare. Precommitment, as in Leahy and Neary, is also the best policy under subsidies.

Our results are important in that they highlight that in a vertically differentiated industry, under tariffs, non-committal on the part of the government is welfare improving while the converse is true under subsidies

A natural question arises here. If the government can commit to a policy instrument, but not to its level (as is the case in this paper) to what instrument will it precommit? Our analysis reveals that a non-committal government will always impose a tariff on the foreign firm. By choosing tariffs it induces the foreign firm to leapfrog the domestic firm thereby producing the low quality good. However, if it chooses subsidies it results in a subsidized domestic monopoly.

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FIGURE-1

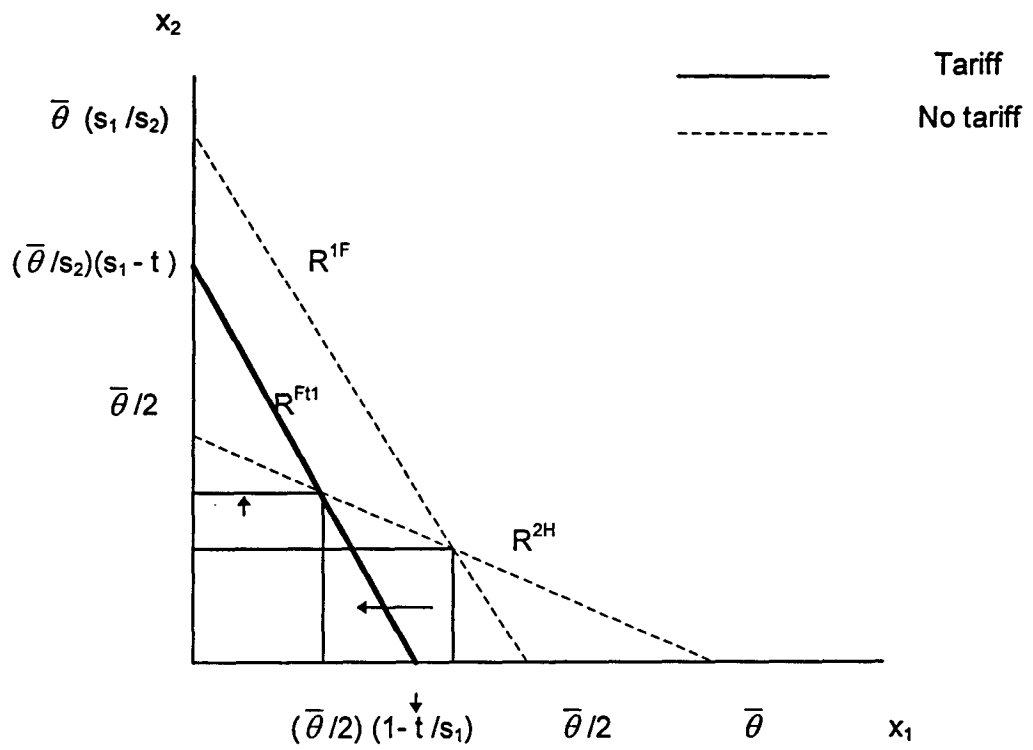


FIGURE-2

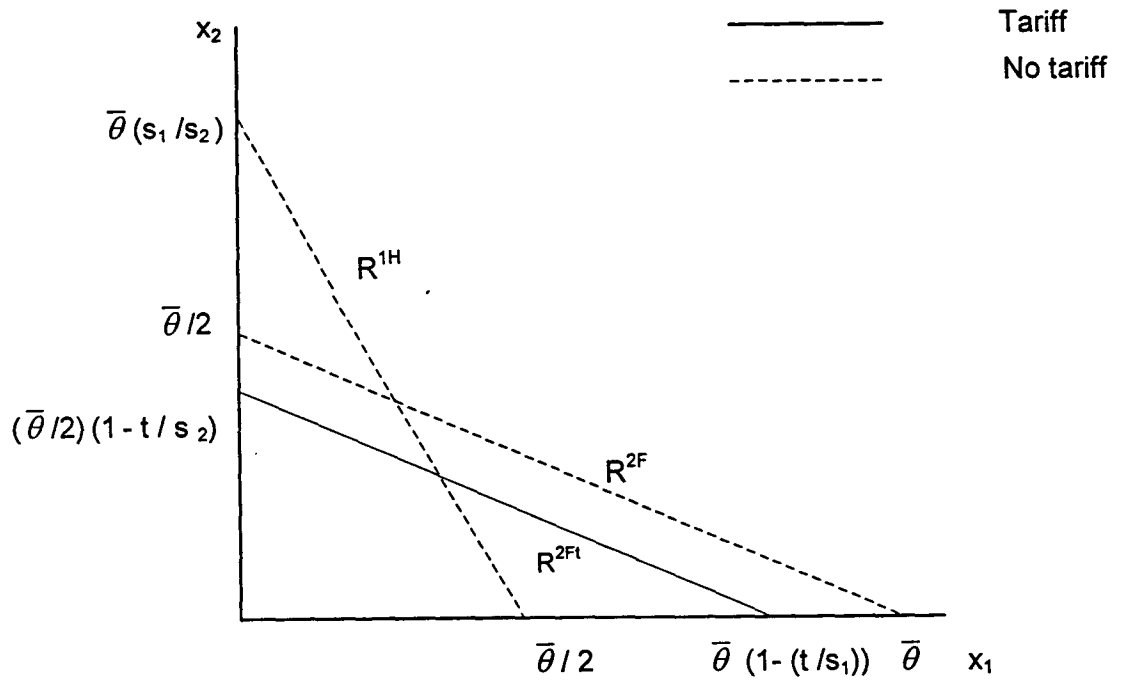


FIGURE-3

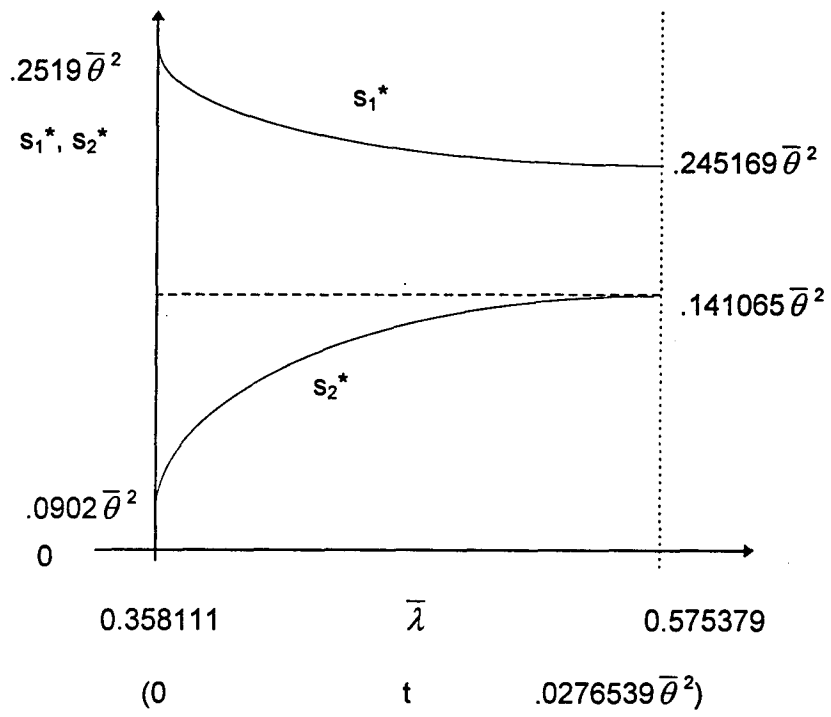




FIGURE-4

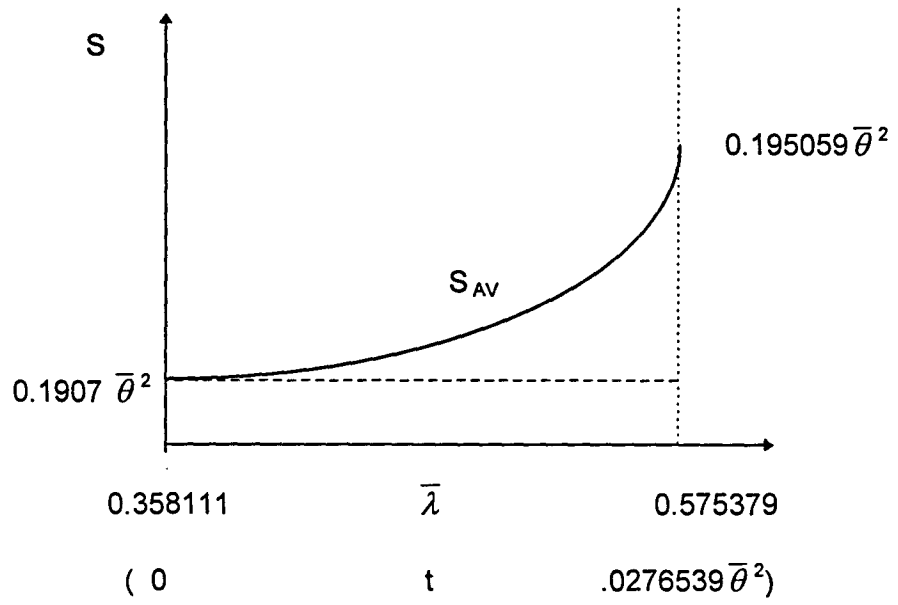


FIGURE-5

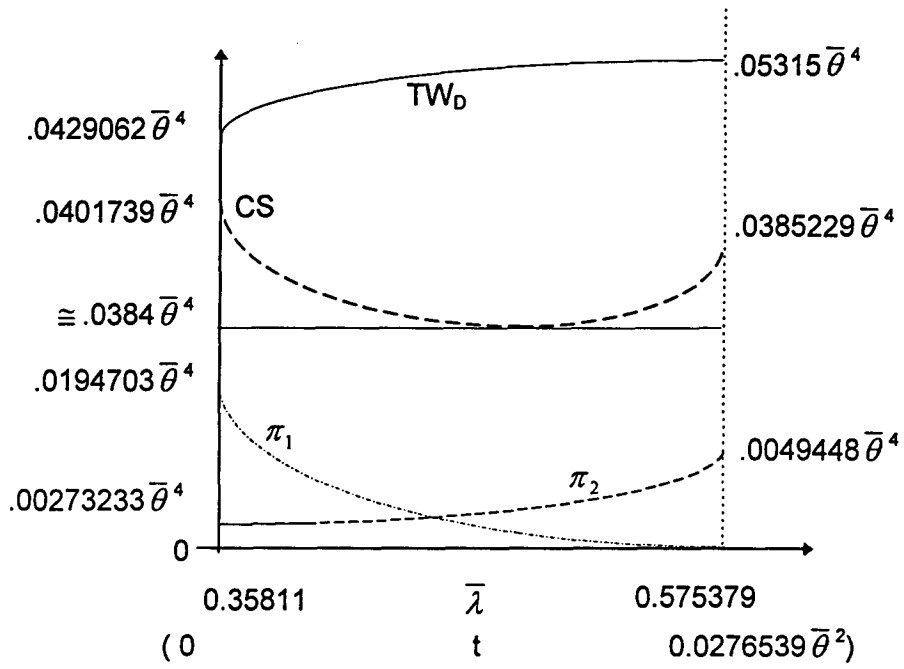


FIGURE-6

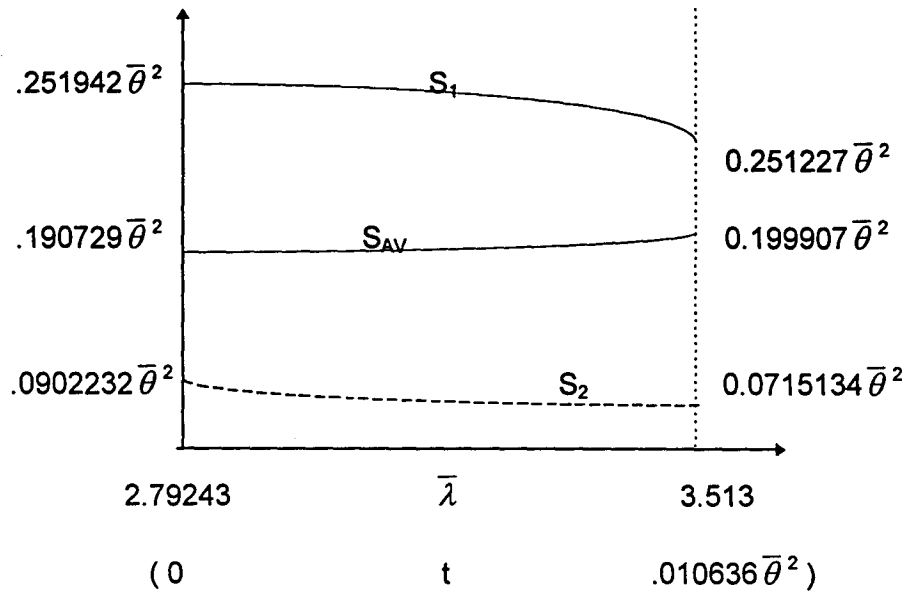
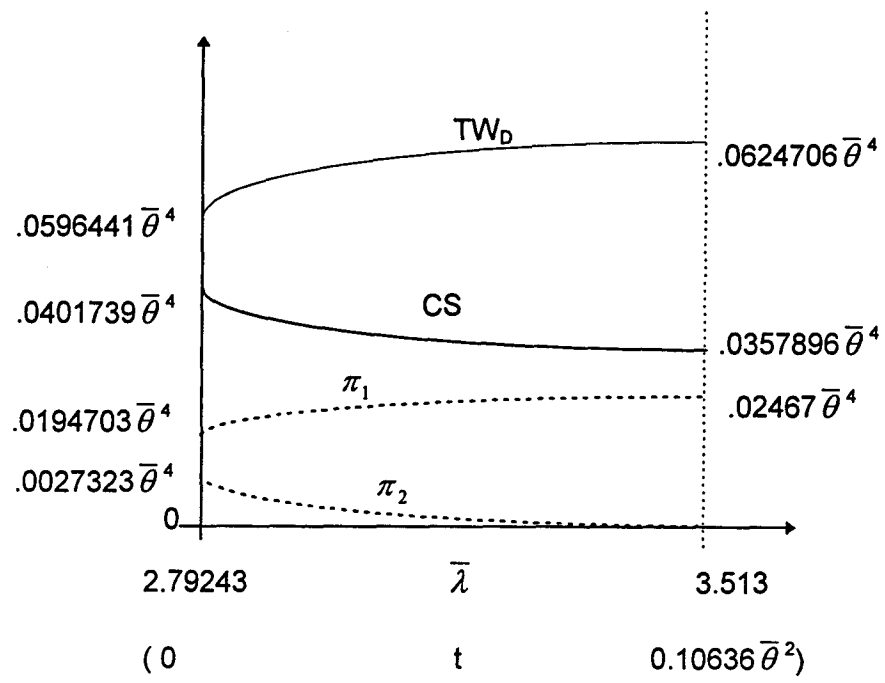


FIGURE-7



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