TRADE POLICIES, TIME CONSISTENCY, QUALITY REVERSALS AND EXIT IN VERTICALLY DIFFERENTIATED INDUSTRIES

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Abstract —————————————————————————————————————

The impact of strategic trade policies, such as import tariffs and domestic output subsidies, is studied in a vertically differentiated duopoly. Firms first choose quality and then compete in quantities or prices in the home market. If the government is unable to commit to a policy the domestic firm then chooses its quality strategically in order to alter the market structure in its favor. Time consistent subsidies are always positive and result in a domestic monopoly as the foreign firm exits the market. Time consistent tariffs are also positive and ensure that the domestic firm always produces the high quality good. Commitment to a subsidy results in greater domestic welfare than under non-commital. Except for the case when, under price competition and the domestic firm producing the low quality good under free trade, non-commital under tariffs by the domestic government is welfare improving.

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1. Introduction

Strategic trade policy focuses on the use of policy instruments such as tariffs, subsidies, or quotas towards import and/or export competing industries. One has learnt from these models that trade policy is sensitive to the assumptions on the patterns of trading and that the optimal policy can vary depending on the different mix of the various policy instruments that one considers. This is precisely the argument that has stimulated a generous research effort in imperfectly competitive markets where governments can use trade policy instruments unilaterally, or bilaterally, to their advantage[1] and sometimes policy instruments are adopted even though they may be jointly suboptimal[2]. Besides the use of trade policy tools to study the profit shifting motive the use of anti-dumping and countervailing duties is analyzed by Dixit (1988). The trade policy equilibrium implies positive subsidies and tariffs. The domestic government can attain the first best outcome by using a tariff on imports and a subsidy towards domestic production to eliminate the oligopoly distortion and to shift rents to the domestic firm. If the government is restricted to use only tariffs then the (second-best) optimal tariff exceeds its fully optimal value.[3]

Subsequent research on trade policy instruments has focussed attention on the time consistency of policies. That is, whether prior commitment to a policy may lead to an ex-post sub-optimal choice of the strategic variable on the part of firms. The principal contribution of this literature is that optimal trade policy instruments are sensitive to the timing of policy moves (see, Carmichael[4] (1987) and Goldberg[5] (1995)) and that credible policies are generally welfare improving

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[1]Brander and Spencer (1984) showed that an activist government can use tariffs as a welfare improving policy tool in an imperfectly competitive market.

[2]Brander and Spencer (1985) using a third-market model, show that the noncoperative equilibrium is characterized by positive production susbsidies for both the exporting coutries. Joint welfare of the producing nations would rise if the subsidy levels were reduced by both governments. Further Eaton and Grossman (1986) show that the choice of the policy variable may be sensitive to whether firms compete in prices or quantities. Contrary to Brander and Spencer (1985) they show that under Bertrand competition the optimal policy is in fact a tax.

[3]Also see Collie (1991). Note, unlike Dixit we do not consider multiple instruments.

[4]In a third market model Carmichael shows that governments perfectly offset stage 1 price increases by the domestic firm with higher subsidies ($\frac{dP}{ds} = 1$, where p is the price and s the subsidy).

[5]Goldberg has shown that precommitment to a policy on the part of the government is not necessary if a home firm invests in capacity. Investing in capacity works as a signal for the home

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(see, Leahy and Neary[6] (1994, 1996, 1999), Neary (1999), Staiger and Tabellini (1988)).

All the above papers limit themselves to using homogenous or horizontal product differentiation models to study the issue of credibility on how trade policy varies, and its implication on welfare. Little attention has been paid to strategic trade policy in vertically differentiated industries. This is surprising given the evidence that trade volume has been increasing inside trading blocks and that 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).

Vertical product differentiation models incorporate firm decision in two stages. In the first stage the firm commits to a quality (bearing sunk costs at that stage) and in the second stage the firm competes in the market. Commitment to quality reflects an important characteristic of oligopolistic markets, i.e., firms bear sunk costs of investing in a strategic variable prior to competing in the market stage. Moreover, as qualities are endogenous a pure-strategy asymmetric equilibrium arises whenever consumers have heterogenous tastes on quality[7] (in the sense that, in a duopolistic market, a single high-, and low-, quality firm emerges in equilibrium).

The existence of asymmetric qualities raises many interesting questions for trade policy. For instance, now trade policy may not only be dependent on trade patterns and credibility (issues pointed out above), it may also depend on whether the active country's firm is of a high-, or low-, quality under free trade. Depending upon the position on the quality ladder of an active country's firm, its government policy can now alter market outcomes in three ways. That is, government policy can not only influence the production plans and qualities of the firms, it can also change the market structure.

In particular, a government can induce reversals in the quality configuration, or

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govenment and as a result even the time consistent subsidy is positive (for some parameter values)

[6]By committing to a R&D subsidy a government induces a lower level of R&D expenditure for the foreign firm thus improving home welfare. Thereby the domestic government 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.

[7]This is a standard result in the literature on vertical differentiation, see e.g. Motta (1993), Tirole (1989), Shaked and Sutton (1982, 1983, 1984), Sutton (1992)). Note, however, that if consumers have homogeneous tastes then there is a symmetric pure strategy equilibrium where both firms produce the same quality (see Eaton and Lipsey, 1989)).

exit, of firms by choosing the appropriate tariff or subsidy. These kinds of policies are also a part of the equilibrium (time consistent) policies that a government has at its disposal. The profit transfer due to such policies now depends on whether the home firm is a high- or low- quality producer under free trade. For example, taxing high quality imports results in greater rent transfers (a greater profit transfer + tariff revenues) than taxing a low quality good where no quality switching takes place (and the profit transfer is of a much lower magnitude). Further, due to the change in the relative quality positions, or exit, of the firms the resulting market structure will now be different from what it was under free trade. Quality switching and exit due to government policies are unique to the vertical product differentiation models and are not observed in horizontal product differentiation models.

The role of trade policy in vertically differentiated industries becomes all the more important given that trade policy instruments have short-, and long-, run effects. That is, not only do trade policy instruments affect short run variables, such as prices and quantities, they also affect long run variables such as quality[8]. Thus, in addition to the fact that in our model the rent transfer effects are asymmetric, we expect to see long run effects on variables such as investment in quality.

In this paper we study the imposition of import tariffs and domestic output 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 selling in the home market, first choose quality and then compete in quantities or prices[9]. 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 under free trade, it will switch qualities and start producing the low quality good instead. This is due to the fact that it knows that ex-post it faces a tariff that is proportional to its quality (that is, the tariff is increasing in its own quality).

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[8]For a discussion of the short- and long- term view of the rent transfer effect, and their discrepancies, in such markets see Grossman (1988).

[9]Note, in vertically differentiated industries the rent transfer effects can be very different between the import competing and the third-country(export competing) models. In third-country models governments cannot impose tariffs or quotas on competing countries and thus government policies cannot provoke leapfrogging. Further, due to natural asymmetries in these models (a high quality firm has a larger market share and makes significantly greater profits than a low quality firm) governments ability to expand domestic firm output and profit is a function of whether they produce the low or high quality good. Hence, qualitatively the two models are not the same.

Since investment in quality is a sunk cost, the domestic government, by moving second, can safely expropriate gross profits of the foreign firm by choosing the appropriate tariff. Thus, time consistent tariffs completely alter the structure of the market for the case when the foreign firm is of high quality under free trade. Under non-credible tariffs domestic welfare is higher than under precommitment (with the exception when the domestic firm is of high quality under free trade and the firms compete in prices). Thus, lack of commitment on the part of the government could in itself be a policy tool in the framework of our model.

Further, we present results on time consistent subsidies where we show that contrary to Goldberg (1995) the time consistent subsidy is *always* positive and results in domestic monopolies (as the foreign firm exits the market). This happens as the domestic firm knows that the subsidy it receives ex-post is increasing in the quality it chooses in the first stage. Hence, if the government moves after the firms the foreign firm will not enter the market and the domestic firm will choose a high quality level[10], selling to the entire domestic market at marginal cost. Independent of the mode of competition, or the equilibrium quality configuration under free trade, time consistent subsidies always alter the market structure. Moreover, domestic welfare is zero under non-credible subsidies as government expenditures on subsidies are high enough so that they offset the increase in consumer surplus. Precommitment on the part of the domestic government thus always results in higher domestic welfare. This result is similar to Neary (1991), Leahy and Neary (1994, 1996, 1999) and Staiger and Tabellini (1988) where commitment to a subsidy increases domestic welfare. Finally, unlike the policy reversal observed in Eaton and Grossman (1986) our qualitative results are invariant under price competition.

In Section 2 we present the benchmark free trade vertical product differentiation model under quantity competition with the equilibrium quality, quantity, and welfare outcomes. In Section 3 non-credibility and quality switching are studied 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, under free trade are analyzed. In Section 4 credible tariffs for the cases mentioned above and their welfare implication with, and without, precommitment are analyzed. In section 5 we analyze time consistent subsidies and their welfare implications on market structure and welfare. In Section 6 we briefly discuss the results under

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[10]This result is qualitatively similar to Carmichael where subsidy depends directly on the price chosen by the domestic firm.

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Bertrand competition. Section 7 is the conclusion.

2. The Basic Model

The simple case of two countries, foreign and domestic is considered. There are two firms, one located in each country and producing a vertically differentiated good. Firms first select the quality of their goods and then compete in the market by choosing their quantities. Quality is endogenous and we denote by s_1 the higher quality, and by s_2 the lower quality offered in the market $(s_1 \geq s_2)$. We concentrate on the effects of trade policies in the domestic market alone. Trade policy can take the form of import tariffs or per-unit domestic output subsidies. There is a continuum of consumers in the domestic market, each identified by his taste parameter θ, where θ is uniformly distributed over the interval $\left[0, \bar{\theta}\right]$ with density one; $\bar{\theta}$ then represents the size of the market. A consumer θ has a unitary demand for the good and his utility function is,

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

To derive the demand for the low and high quality good, we first define the taste parameter of the consumer indifferent between buying the high, or low, quality good as $\theta_{12} = \left[\frac{p_1 - p_2}{s_1 - s_2}\right]$. The consumer indifferent between buying the low quality good and not buying at all has the taste parameter $\theta_{02} = \frac{p_2}{s_2}$. All the consumers for whom $\bar{\theta} \geq \theta \geq \theta_{12}$ purchase good with quality s_1 and all consumers for whom $\theta_{12} \geq \theta \geq \theta_{02}$ purchase quality s_2. Those described by $\theta < \theta_{02}$ do not buy the good at all. Hence the demands for the high and low quality good are,

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

with the inverse demands,

$$p_1(x_1, x_2) = \bar{\theta}s_1 - x_1 s_1 - x_2 s_2; \quad p_2(x_1, x_2) = (\bar{\theta} - x_1 - x_2)s_2 \tag{2.3}$$

Firm i's cost function is $C(s_i, x_i) = cx_i + \frac{s_i^2}{2}$, where x_i represents its output and s_i the quality of its good. The marginal cost of production, c, is constant and independent of quality. Without loss of generality, we assume that marginal cost, c, is

zero for both the domestic and the foreign firm. Quality costs are fixed costs and there are decreasing returns to scale in quality improvement. This specification captures the distinctive characteristics of (pure) vertical product differentiation models. Shaked and Sutton (1983) define a purely vertically differentiated industry as one where the costs of quality improvement fall primarily on fixed costs and involve only a modest, or no, increase in unit variable costs. Quality costs borne in the first stage are treated as sunk in the market competition stage (see Sutton, 1992).

We consider two alternative scenarios. In the first scenario, we let the government set its trade policy in the first stage, acting as a Stackelberg leader towards the firms who decide on their strategic variables (acting as Stackelberg followers). The government either imposes a tariff on imports, or provides an output subsidy to the domestic firm. In the second stage, the domestic and the foreign firm, taking the government's tariff/subsidy as given, select their qualities, bearing the cost of quality. Finally, firms choose their outputs in the last stage.

Note, that a time consistency problem arises in the scenario where the government announces a policy before the firms choose their strategic variables. This happens as firm decisions on quality are long term (involving sunk costs for the firms), while the government policy tool applies on the firms' outputs that can be adjusted in the short term. An ex-ante optimal import tariff, or domestic output subsidy, is not ex-post optimal after the firms have incurred the sunk cost of quality. Therefore, unless it possesses a specific precommitment mechanism, the government has an incentive to modify its trade policy after the firms have decided on their qualities. Policy announcements in this scenario are justifiable only if the domestic government can credibly commit to an import tariff, or a per unit subsidy on domestic output, before firms invest in quality.

However, if the government is unable to precommit to a policy, the domestic and the foreign firm anticipate that the government will choose its ex-post optimal trade policy after the firms select their qualities. In this second, time consistent scenario, firms select their qualities in the first stage anticipating the government's optimal policy. Contrary to the earlier scenario where the government acts as a Stackelberg leader when selecting its trade policy, in the time consistent scenario the domestic and the foreign firm act as Stackelberg leaders selecting their qualities *strategically* to influence the government's choice of tariff/subsidy in the subsequent stage. Needless to say, the domestic firm effectively has the first mover advantage, since one of the domestic government's objectives is to shift rents in

favor of the domestic firm.

We analyze both the (credible) commitment and the time consistent scenario and we compare their market and welfare outcomes with the benchmark case of free trade. In particular, we compare equilibrium qualities, outputs and *market structures*, as well as consumer surplus and domestic welfare under time consistent and precommitment import tariffs and domestic output subsidies with those under free trade. As our focus is on time consistency issues, the solution concept employed to solve for the multi-stage strategic interaction between the domestic and the foreign firm, and the government is the subgame perfect equilibrium.

2.1. Free Trade Equilibrium

We start the analysis by briefly presenting the outcome for the benchmark case. Under free trade and choosing simultaneously, firms first select their qualities and then choose their quantities (for details see Motta (1993)). In the last stage, for any given pair of qualities (s_1, s_2), firm i chooses its quantity to maximize its profits, $p_i(x_i, x_j)x_i - \frac{s_i^2}{2}$, given the quantity of its rival x_j. From the first order conditions (foc), we get the equilibrium quantities,

$$x_1^{FT}(s_1, s_2) = \frac{2s_1 - s_2}{4s_1 - s_2}\overline{\theta}; \quad x_2^{FT}(s_1, s_2) = \frac{s_1}{4s_1 - s_2}\overline{\theta} \tag{2.4}$$

and the equilibrium profits are, $\pi_i^{FT}(s_1, s_2) = s_i(x_i^{FT})^2 - \frac{s_i^2}{2}$.

In the first stage, taking the quality of its rival s_j as given, firm i chooses s_i to maximize $\pi_i^{FT}(s_1, s_2)$. Note that, as $\frac{\partial x_i^{FT}}{\partial s_j} < 0$, firm i has a strategic incentive to overinvest in quality in order to increase its market share in the subsequent stage. Setting $\lambda = \frac{s_2}{s_1}$, dividing the (two) first order conditions, and after some manipulations we get the equilibrium qualities, quantities, profits and total domestic welfare under free trade:

$s_1^{FT} = 0.25194\overline{\theta}^2$	$s_2^{FT} = 0.09022\overline{\theta}^2$	$\overline{s}^{FT} = 0.191\overline{\theta}^2$
$x_1^{FT} = .4508\overline{\theta}$	$x_2^{FT} = .2746\overline{\theta}$	$CS^{FT} = 0.04017\overline{\theta}^4$
$\pi_1^{FT} = 0.01946\overline{\theta}^4$	$\pi_2^{FT} = 0.00273\overline{\theta}^4$	$TW_{fh}^{FT} = 0.04290\overline{\theta}^4$
		$TW_{fl}^{FT} = 0.05964\overline{\theta}^4$

where, $\overline{s} = \frac{x_1 s_1 + x_2 s_2}{x_1 + x_2}$, is the average quality in the market and TW_{fh} (TW_{fl}) is the

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domestic welfare[11] when the foreign firm produces the high (low) quality good and the domestic firm the low (high) quality good. Note that under free trade, there are two asymmetric pure strategy equilibria where one firm is the high quality producer and the other the low quality producer.[12] Domestic firm's profits, as well as domestic welfare, are higher in the equilibrium where the domestic firm is the high quality producer.

3. Optimal Time Consistent Tariffs and Reversals in the Quality Ladder

Consider the case where the government's trade policy tool is an import tariff on the foreign firm. We analyze the case where the government is unable to credibly commit to a tariff and compare equilibrium qualities, quantities, market structure and domestic welfare under time consistent tariffs with those under free trade. In the next section we treat the traditional scenario where the government possesses a mechanism to commit to an import tariff and compare its equilibrium outcome and welfare with those under time consistent tariffs.

As mentioned above, there are two equilibria under free trade: (i) foreign firm of high quality and domestic firm of low quality and (ii) *vice versa*. We consider each of these cases separately. Interestingly, under optimal time consistent tariffs, the foreign firm producing high quality cannot be sustained in equilibrium. In the unique equilibrium of the game, the domestic firm always produces the high quality good. Thus, a (under free trade) high quality foreign firm facing an import tariff from a non-committal government will switch positions in the quality ladder and produce the low quality good instead. The reason is quite simple. If the foreign firm selects a high level of quality in the first stage (thus incurring the sunk costs of quality) the government, having a second mover advantage, sets a high enough tariff so as to expropriate the gross profits of the foreign firm

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[11]Domestic welfare is defined as the (unweighted) sum of domestic firm's profits and consumer surplus. The latter consists of the net surplus of consumers purchasing the high, and the low, quality good and is given by, $CS = s_1[\bar{\theta}^2 - (\bar{\theta} - x_1^*)^2] - p_1^* x_1^* + s_2[(\bar{\theta} - x_1^*)^2 - (\bar{\theta} - x_1^* - x_2^*)^2] - p_2^* x_2^*$.

[12]There is also a symmetric equilibrium in mixed strategies where each firm chooses with some positive probability the higher quality good and otherwise chooses the lower quality good. In line with all the existing literature on vertical product differentiation, we abstain from the analysis of mixed strategy equilibria (see e.g Tirole (1989), Motta (1993), Shaked and Sutton (1982, 1983, 1984), Sutton (1992)).

resulting in negative profits. Given this, the foreign firm always produces the low quality good. Below we examine the two cases. In the rest of the paper we use the following notation; UFT-High/Low Quality refers to the equilibrium in the benchmark case (u)nder (f)ree (t)rade (UFT) always.

(i) UFT-High Quality Foreign Firm

Let $\bar{t}$ be the per-unit output tariff imposed on the high quality foreign firm. For analytical convenience, define $t = \frac{\bar{t}}{\bar{\theta}}$. Then the profits of the foreign and the domestic firm are, $\pi_1 = p_1(x_1, x_2) x_1 - \bar{t}\bar{\theta}x_1 - \frac{s_1^2}{2}$ and $\pi_2 = p_2(x_1, x_2) x_2 - \frac{s_2^2}{2}$, respectively. In the last stage, each firm chooses its output to maximize profits taking the output of its rival as given. From the first order conditions we obtain the best response functions,

$$x_1 = \frac{\bar{\theta}s_1 - s_2 x_2 - \bar{\theta}t}{2s_1}; \quad x_2 = \frac{\bar{\theta} - x_1}{2} \tag{3.1}$$

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 the foreign firm decreases and that of the domestic firm increases[13]. From (3.1) the equilibrium outputs are,

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

and the equilibrium profits, $\pi_i^*(t, s_1, s_2) = s_i x_i^{*2} - \frac{s_i^2}{2}, i = 1, 2$.

In the second stage, the government selects the optimal tariff that maximizes total domestic welfare taking as given the quality choices of the foreign and the domestic firm. Total domestic welfare is the sum of consumer surplus,[14] domestic firm's profits and tariff revenues $(\bar{t}\bar{\theta}x_1^*)$. From (3.2) and (2.3), and after some manipulations, we get:

$$TW(t, s_1, s_2) = \left[\frac{s_1^2 + s_1 s_2 + 2s_1 t - 3t^2}{2(4s_1 - s_2)}\right]\bar{\theta}^2 - \frac{s_2^2}{2} \tag{3.3}$$

From the first order condition we obtain the optimal tariff, $\bar{t}^* = \frac{s_1}{3}\bar{\theta}$. The optimal time consistent import tariff is proportional to the foreign firm's quality and increases with the size of the market, $\bar{\theta}$. The higher is the quality the foreign

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[13]This is the market share effect in Brander and Spencer.

[14]see footnote 1.

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firm chooses in the first stage, the higher is the import tariff it faces. This results in lower market share and profits for the foreign firm. In fact, provided that the domestic firm is the low quality producer, the profits of the foreign firm always turn out to be *negative* independent of the quality level selected by the domestic firm in the first stage. The foreign firm thus has no incentive to produce the high quality good.

To see this, let the domestic and the foreign firm thus select their qualities in the first stage anticipating that the government's optimal tariff will be $\bar{t}^* = \frac{s_1}{3}\bar{\theta}$. Then from (3.2) we obtain the firms' outputs as functions of their qualities,

$$x_1^*(s_1, s_2) = \frac{4s_1 - 3s_2}{3(4s_1 - s_2)}\bar{\theta}; \quad x_2^*(s_1, s_2) = \frac{4s_1}{3(4s_1 - s_2)}\bar{\theta} \tag{3.4}$$

and the profits are, $\pi_i^*(s_1, s_2) = s_i x_i^{*2} - \frac{s_i^2}{2}, i = 1, 2$. Given the quality of its rival each firm chooses its quality level to maximize profits. The first order conditions can be then written as $(\lambda = \frac{s_2}{s_1})$,

$$s_1(\lambda) = \left[\frac{(4 - 3\lambda)(16 + 3\lambda^2)}{9(4 - \lambda)^3}\right]\bar{\theta}^2; \quad s_2(\lambda) = \left[\frac{16(4 + \lambda)}{9(4 - \lambda)^3}\right]\bar{\theta}^2 \tag{3.5}$$

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 the domestic firm never chooses a quality level $s_2 < 0.111\bar{\theta}^2$. In fact, from the first order condition of the domestic firm (3.5) we observe 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. $s_1 = +\infty$). Moreover, it can be checked that $\max_{s_1} \pi_1(s_1, s_2) < 0$ for all $s_2 > 0.0568149\bar{\theta}^2$. Therefore, the foreign firm's profits are always negative whenever the (lower quality) domestic firm sets its quality level optimally. Thus the foreign firm never chooses to be the higher quality producer under time consistent import tariffs. These results are summarized in the following proposition.

Proposition 3.1. *An UFT-high quality foreign firm, anticipating the ex-post optimal tariff $\bar{t}^* = \frac{s_1}{3}\bar{\theta}$, never produces the high quality good under time consistent import tariffs.*

As is shown below, the only possible configuration of qualities in equilibrium is with the domestic firm producing the high-, and the foreign firm the low-, quality

good. The inability of the domestic government to commit to a tariff affects the market structure. This results in a reversal in the quality ladder with the UFT-foreign firm switching qualities and producing the low quality good instead.

(ii) **UFT-low quality foreign firm**

The analysis is similar to when the foreign firm is of high quality. The domestic and the foreign firm's profits are, $\pi_1 = p_1(x_1, x_2)x_1 - \frac{s_1^2}{2}$ and $\pi_2 = p_2(x_1, x_2)x_2 - t\bar{\theta}x_2 - \frac{s_2^2}{2}$, respectively. In the last stage firms simultaneously choose their outputs. From the focs we obtain the best response functions,

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

Then the equilibrium outputs are,

$$x_1^*(t, s_1, s_2) = \left[\frac{2s_1 - s_2 + t}{4s_1 - s_2}\right]\bar{\theta}; \quad x_2^*(t, s_1, s_2) = \left[\frac{s_1(s_2 - 2t)}{s_2(4s_1 - s_2)}\right]\bar{\theta} \tag{3.6}$$

and the equilibrium profits are, $\pi_i^*(t, s_1, s_2) = s_i x_i^{*2} - \frac{s_i^2}{2}$.

The Government selects a tariff in the second stage to maximize total domestic welfare, which from (3.6) and (2.3) can be written as,

$$TW = \left[\frac{3s_1^2 s_2 - s_1 s_2^2 + 2s_1 s_2 t - 3s_1 t^2}{2s_2(4s_1 - s_2)}\right]\bar{\theta}^2 - \frac{s_1^2}{2} \tag{3.7}$$

From the first order condition we derive the optimal tariff for the government, $\bar{t}^* = \left(\frac{s_2}{3}\right)\bar{\theta}$. Note, as before the optimal tariff is proportional to the foreign firm's quality and the size of the market. The optimal time consistent tariff creates a dis-incentive for the foreign firm to invest in quality in the first stage and thus, as is shown below, its quality level will be lower than under free trade.

In the first stage, the firms simultaneously select qualities anticipating that the government will choose an import tariff $\bar{t}^* = \frac{s_2}{3}\bar{\theta}$. From (3.6) we get,

$$x_1^*(s_1, s_2) = \frac{2(3s_1 - s_2)}{3(4s_1 - s_2)}\bar{\theta}; \quad x_2^*(s_1, s_2) = \frac{s_1}{3(4s_1 - s_2)}\bar{\theta} \tag{3.8}$$

and $\pi_i^*(s_1, s_2) = s_i x_i^{*2} - \frac{s_i^2}{2}$. Then the first order conditions can be written as (where $\lambda = \frac{s_2}{s_1}$),

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$$s_1(\lambda) = \frac{4(3-\lambda)(12-5\lambda+\lambda^2)}{9(4-\lambda)^3}\bar{\theta}^2; \quad s_2(\lambda) = \frac{(4+\lambda)}{9(4-\lambda)^3}\bar{\theta}^2 \qquad (3.9)$$

Dividing $s_2(\lambda)$ with $s_1(\lambda)$ and solving for λ we obtain $\lambda^* = 0.028584$[15]. Then from (3.9), (3.8) and (3.7) we obtain the equilibrium qualities, quantities, profits as well as the optimal tariff and total domestic welfare under time consistent import tariffs:

$s_1^* = 0.25001\bar{\theta}^2$	$s_2^* = 0.00715\bar{\theta}^2$	$\bar{s}^* = 0.215\bar{\theta}^2$
$x_1^* = .4988\bar{\theta}$	$x_2^* = .08393\bar{\theta}$	$t^* = 0.00238\bar{\theta}^2$
$\pi_1^* = 0.03095\bar{\theta}^4$	$\pi_2^* = 0.00002\bar{\theta}^4$	$CS^* = 0.03143\bar{\theta}^4$
		$TW^* = 0.06258\bar{\theta}^4$

Proposition 3.2. *Under time consistent import tariffs, there is a unique subgame perfect equilibrium where the foreign firm is always the lower quality producer. If the government cannot precommit to a policy, the optimal tariff induces a reversal in the quality ladder whenever the foreign firm is of high quality under free trade. The qualities offered by the firms under time consistent tariffs are lower than the equilibrium qualities under free trade. However, average quality and domestic welfare are always higher under time consistent tariffs than under free trade.*

Note that, while the foreign firm's profits are positive when it produces the low quality good, they are always negative if it produces the high quality good. Hence, an UFT-high quality foreign firm, anticipating the ex-post optimal tariff $\bar{t}^* = \left(\frac{s_f}{3}\right)\bar{\theta}$ (where s_f is its own quality) will switch qualities and instead produce the low quality good. On the other hand, an UFT-low quality foreign firm still produces the low quality good after the imposition of the tariff. This is due to the fact that the government chooses a tariff so as to expropriate a great part of the foreign firm's *gross* profits as the foreign firm's quality costs are already sunk when the government decides its policy. Since 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.

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[15]This is the unique real root of the equation that is smaller than one.

Due to the imposition of the tariff firms offer lower qualities than under free trade. The foreign firm, faced with the import tariff, offers a lower quality (relative to a UFT-low quality producer) in order to save on costs of quality and thus obtain positive profits. As product differentiation increases, the domestic firm also saves on quality costs by offering a lower quality (relative to the UFT-high quality producer). Note, average quality increases as the tariff shifts the market share from the low quality foreign firm to the high quality domestic firm. Further, the reduction in total output due to the imposition of the tariff outweighs the positive effect of the increase in average quality and results in lower consumer surplus than under free trade.

Finally, domestic welfare is higher under time consistent tariffs independently of whether the foreign firm is of high-, or low-, quality under free trade[16]. The import tariff increases domestic welfare by shifting rents to the domestic firm and tariff revenues to the domestic government. Note that, since the tariff also affects the market structure (by inducing a quality reversal), the rent shifting effect is much stronger when the foreign firm is of high quality under free trade and domestic welfare increases much more relative to when the foreign firm is of low quality (under free trade) . Our finding is in line with the Grossman (1988) critique that the long run view of the rent shifting effect may be very different than the short run view given in Brander and Spencer (1985). In fact in our long run scenario where firms first choose quality and then compete in the market, the rent shifting effect is reinforced due to the reversal in the equilibrium quality configuration induced by the time consistent tariff. The import tariff transforms the UFT-low quality domestic firm into a high quality producer, thus transferring rents to the domestic firm of a much higher magnitude than in the classical Brander and Spencer rent shifting effect.

4. Optimal Tariffs under Government Precommitment

We now assume that the government can precommit to a specific tariff before the firms select their qualities and quantities. Given the import tariff set by the government, the firms (simultaneously) select their qualities in the second stage, and finally choose their outputs (simultaneously). The main question we address in this section is whether a government's ability to precommit to an import tariff

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[16]Note, and as is seen below, under Bertrand competition total welfare only increases if the foreign firm is high quality ex-ante.

leads to higher domestic welfare compared to when the government cannot credibly commit to a policy. If precommitment increases welfare, then the government would have an incentive to build (if possible) some mechanism through which it can precommit to a policy; otherwise, the government will follow a time consistent policy by setting the ex-post optimal level of tariff. Interestingly, and contrary to what has been observed with subsidies[17], government precommitment to an import tariff always leads to lower domestic welfare than under time consistent tariffs.. The reason is simple. A non-committal government, by setting its tariff after the firms have incurred the sunk costs of quality, can expropriate the *gross* profits of the foreign firm. On the other hand, a government who precommits to an import tariff can only shift part of the foreign firm's *net* profits to the home government's treasury and to the domestic firm. When the government moves second, the pie on which it has claims increases and, as a result, domestic welfare increases.

As in the previous section, we consider both the cases where the foreign firm is of high-, and of low-, quality under free trade. The last stage of the game is as above and the equilibrium outputs are given by (3.2), and (3.6), when the foreign firm is the high, and low, quality producer under free trade, respectively. Contrary to the case of time consistent tariffs, the imposition of a tariff from a government who possesses a precommitment mechanism has no impact on the market structure. The domestic and the foreign firm do not switch positions in the quality ladder, even though they adjust their quality level in the presence of the import tariff.

(i) **UFT-high quality foreign firm**

In the second stage the domestic and the foreign firm choose qualities simultaneously to maximize profits, $\pi_i^*(t, s_1, s_2) = s_i x_i^{*2} - \frac{s_i^2}{2}, i = 1, 2$. Defining $\lambda = \frac{s_2}{s_1}$ and $\mu = \frac{t}{s_1}$, from (3.2) the first order conditions can be expressed as:

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

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

First, we determine the interval of tariffs for which the foreign firm stays in the domestic market. Define t_m as the maximum permissible tariff, i.e. the tariff

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[17]See, for example, Leahy and Neary (1995, 1996,1997), Goldberg (1995).

for which the foreign firm's profits are 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 $t_m = 0.02765\bar{\theta}^2$ and the associated quality ratio is, $\lambda_m = 0.57538$. This is the tariff that leaves the foreign firm indifferent between staying in, or exiting, the market. Hence, the relevant interval for import tariffs is $t \in \left[0, 0.02765\bar{\theta}^2\right]$. Further, as $\mu = t = 0$ corresponds to free trade, the associated interval of quality ratios is $\lambda \in [0.35811, 0.57538]$.

By dividing expressions (4.1) and (4.2), and simplifying we obtain an equation involving only λ and μ[18]. Solving this equation for μ and choosing the positive root[19] we get $\mu(\lambda)$. Plotting $\mu(\lambda)$ in the relevant interval of quality ratios 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 $s_2(\lambda)$.[20] By plotting these expressions, it is seen that $s_2(\lambda)$ is increasing and $s_1(\lambda)$ is decreasing with λ, $0.35811 \leq \lambda \leq 0.57538$. Moreover, since $t(\lambda) = s_1(\lambda).\mu(\lambda)$, by plotting we see that $d\lambda/dt > 0$ for λ in the relevant range. Therefore, as the tariff on the imports increases, the foreign firm decreases and the domestic firm increases its quality (see figure-1).

< figure-1 here >

Moreover, using (3.2) and plotting we see that average quality increases with the tariff (figure-1). 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.

Further, substituting $s_i(\lambda)$, $i = 1, 2$ and $t(\lambda)$ in (3.2), we obtain firms' profits, consumer surplus and domestic welfare as functions of λ. By plotting these functions for λ, $0.35811 \leq \lambda \leq 0.57538$, and taking into account that $d\lambda/dt > 0$ in this range, we derive the following results (see figure 2).

< figure-2 here >

As expected, the profits of the high-quality foreign firm, $\tilde{\pi}_1$, are maximum under free trade and decrease with the level of the tariff. As the tariff transfers

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[18]This is an equation which is quadratic in μ, i.e $(4 + 17\lambda + 4\lambda^2)\mu^2 + (8 + 2\lambda + 4\lambda^3)\mu = 15\lambda - 12\lambda^2 + 4\lambda^3 - \lambda^4 - 4$

[19]Since s_1, s_2 and t are positive, μ and λ are also positive, and the relevant root is the positive root of the equation.

[20]The analytical expressions of $\mu(\lambda), s_i(\lambda), t(\lambda)$ etc. are available from the authors upon request.

rents to the domestic producer, the domestic firm's profits, $\tilde{\pi}_2$, increase with the tariff and reach their maximum at the maximum tariff, t_m. Consumer surplus decreases initially as total output decreases with the tariff, then increases due to the average quality upgrading effect. Consumer surplus is maximum under free trade. However, domestic welfare increases with the tariff and is thus maximized at the maximum tariff t_m.

Therefore, as the government sets the import tariff in the first stage to maximize domestic welfare, the optimal precommitment tariff is $\tilde{t} = t_m = 0.02765\bar{\theta}^2$. The foreign firm, faced with the optimal tariff, stays in the market making zero (net) profits. The equilibrium outcome and welfare under government precommitment when the foreign firm is of high quality is,

$\tilde{s}_1 = 0.24517\bar{\theta}^2$	$\tilde{s}_2 = 0.14107\bar{\theta}^2$	$\tilde{\bar{s}} = 0.19506\bar{\theta}^2$
$\tilde{x}_1 = 0.35013\bar{\theta}$	$\tilde{x}_2 = 0.32494\bar{\theta}$	$\tilde{t} = 0.02765\bar{\theta}^2$
$\tilde{\pi}_1 = 0$	$\tilde{\pi}_2 = 0.00494\bar{\theta}^4$	$\widetilde{CS} = 0.03852\bar{\theta}^4$
		$\widetilde{TW} = 0.05315\bar{\theta}^4$

Interestingly, domestic welfare under the optimal precommitment import tariff, $\widetilde{TW}$, is lower than when the government is unable to credibly commit to a tariff ($TW^* = 0.062576\bar{\theta}^4$).

(ii) **UFT-low quality foreign firm**

Using similar arguments as in the previous case, we can determine the foreign and domestic firms' choice of qualities in the second stage as functions of the level of tariff imposed on the low quality foreign firm. Defining $\hat{\lambda} = \frac{1}{\lambda} = \frac{s_1}{s_2}$ and $\hat{\mu} = \frac{1}{\mu} = \frac{t}{s_2}$ and using (3.6), the first order conditions for the domestic and the foreign firm can be written as:

$$s_1(\hat{\lambda}, \hat{\mu}) = \frac{\left(2\hat{\lambda} - 1 + \hat{\mu}\right)\left(8\hat{\lambda}^2 - 2\hat{\lambda} + 1 - 4\hat{\lambda}\hat{\mu} - \hat{\mu}\right)}{\left(4\hat{\lambda} - 1\right)^3} \qquad (4.3)$$

$$s_2(\hat{\lambda}, \hat{\mu}) = \frac{\hat{\lambda}^2\left(1 - 2\hat{\mu}\right)\left(4\hat{\lambda} + 1 + 8\hat{\lambda}\hat{\mu} - 6\hat{\mu}\right)}{\left(4\hat{\lambda} - 1\right)^3} \qquad (4.4)$$

The above equations together with the zero profit condition for the foreign firm determine the maximum permissible tariff, $t'_m = 0.01064\bar{\theta}^2$ and the associated

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ratio of qualities, $\widehat{\lambda}_m = 3.513$. Hence, the relevant range of import tariffs is, $t \in \left[0, 0.01064\overline{\theta}^2\right]$ and the associated interval of quality ratios is, $\widehat{\lambda} \in [2.79243, 3.513]$.

< figure-3 here >

In figure-3 the domestic and the foreign firm's qualities are drawn as functions of the import tariff in the relevant range.[21] As the tariff becomes increasingly protective both firms lower their qualities. Interestingly, due to a substantial shift in market shares towards the high quality domestic firm, average quality in the market increases with the tariff.

Further, the effects of a tariff on firms' profits, consumer surplus and total domestic welfare are 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 at the maximum tariff t'_m). While the profits of the domestic firm increase with the tariff and reach their maximum at t'_m, i.e. when the foreign firm is indifferent between staying in, or exiting, the market (figure-4). Consumer surplus, however, decreases with the tariff due to both, the downgrading of qualities and the restriction of total output. Once more, domestic welfare increases with the import tariff and reaches its maximum at t'_m (figure-4). This is explained by the fact that profits of the domestic firm increase by an amount larger than the decrease in domestic consumer surplus.

< figure-4 here >

In the first stage, the government will set a tariff of $\widetilde{t} = t'_m = 0.01064\overline{\theta}^2$ to maximize domestic welfare. As in the previous case, the foreign firm will stay in the market making however net profits equal to zero. The equilibrium outcome under the optimal precommitment tariff when the foreign firm is low quality is,

$\widetilde{s}_1 = 0.25123\overline{\theta}^2$	$\widetilde{s}_2 = 0.07151\overline{\theta}^2$	$\widetilde{\overline{s}} = 0.19991\overline{\theta}^2$
$\widetilde{x}_1 = 0.4731\overline{\theta}$	$\widetilde{x}_2 = 0.18906\overline{\theta}$	$\widetilde{t} = 0.01064\overline{\theta}^2$
$\widetilde{\pi}_1 = 0.02467\overline{\theta}^4$	$\widetilde{\pi}_2 = 0$	$\widetilde{CS} = 0.03579\overline{\theta}^4$ $\widetilde{TW} = 0.06247\overline{\theta}^4$

Note that, also in this case domestic welfare under government precommitment

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[21]The expressions for $\widehat{\mu}(\widehat{\lambda})$, $s_i(\widehat{\lambda})$ and $t(\widehat{\lambda})$ etc. are available from the authors upon request. Note that $d\widehat{\lambda}/dt > 0$ for $\widehat{\lambda}$ in the range $[2.79243, 3.513]$.

is lower than under time consistent import tariffs ($TW^* = 0.062576\bar{\theta}^4$). The above results are summarized in the following proposition.

Proposition 4.1. *When the government precommits to a tariff, the market structure is unaffected in the sense that a UFT-high (-low) quality foreign firm remains the high (low) quality producer under optimal tariffs. Optimal precommitment tariffs are always higher than the optimal time consistent tariffs. Average quality is higher, but total output is lower, when the government cannot credibly commit to a tariff. Even though consumer surplus is higher when the government precommits to a tariff, domestic welfare is always higher under time consistent tariffs.*

We have seen that, independently of whether the foreign firm is the high-, or low-, quality producer under free trade, the optimal precommitment tariff is the maximum (restrictive) tariff for which the foreign firm stays in the market. The profits of the foreign firm are zero under government precommitment, while they are positive under time consistent tariffs. In the latter case, the foreign firm, acting as a Stackelberg leader, *strategically* chooses a lower quality to induce a low tariff on its imports from the government (see Proposition 1), and thus attains positive profits. As a consequence, optimal time consistent tariffs are always lower than optimal precommitment tariffs. Moreover, the low quality good is of a much lower quality under time consistent tariffs and, in addition, a smaller quantity of it is imported. This, in turn, leads to a lower total output and a smaller amount of tariffs collected under non-credible policies. However, due to a substantial switch of market share towards the domestic firm, which is always the high quality producer under time consistent tariffs, average quality in the market increases. This increase in average quality, however, is not strong enough to compensate for the reduction of total output, and thus consumer surplus is lower when the government cannot precommit to a tariff.

Interestingly, the government can improve domestic welfare by not committing to a specific tariff. Therefore, whenever the trade policy tool is an import tariff, the government has no incentive to build a precommitment mechanism; it would rather set the ex-post optimal tariff after the domestic and the foreign firm have selected their qualities. Since both consumer surplus and tariff revenues are lower under time consistent policies, the improvement in welfare stems exclusively from the rent shifting effect. If the foreign firm is the high quality producer under free trade, the optimal time consistent tariff induces a reversal in the quality ladder

with the domestic firm thus becoming the high quality producer. As the high quality firm has a larger share of the market relative to the low quality firm, and charges a higher price, the net revenues accruing to the domestic firm from the imposition of the time consistent tariff increase substantially. On the other hand, the imposition of an optimal precommitment tariff does not affect the market structure. Thus, although it increases the (low quality) domestic firm's profits, this increase is of a lower order of magnitude and hence the rent shifting effect is much stronger under time consistent policies. As a result, in this case domestic welfare is substantially higher when the government cannot precommit to a tariff.

On the other hand, a UFT-low quality foreign firm remains the low quality producer under both types of policies. Under time consistent tariffs, the foreign firm selects a (much) lower quality as it anticipates a tariff that will expropriate its gross profits. As competition is relaxed through product differentiation, the domestic firm also lowers its quality to save on costs of quality. Domestic firm sales are also higher under time consistent tariffs. Hence the rent shifting effect is stronger than when the government precommits to a policy, and it compensates for the two negative (consumer surplus and tariff revenues) effects, resulting in higher domestic welfare under time consistent tariffs.

5. Optimal Time Consistent Subsidies and Exit

Consider now that the government's policy instrument is a subsidy on domestic output. As the literature has recognized, the strategic role of subsidies differs from that of tariffs. Subsidies serve mainly to correct for market power in the domestic market, and tariffs to shift rents to the domestic firm (see e.g. Dixit (1988), Collie (1991)). In fact, as is shown below, a non-committal government can fully correct for the domestic market imperfection, as the optimal time consistent subsidy leads to marginal cost pricing.

As in section 3, we assume that the firms make their quality choice anticipating that the government will set the ex-post optimal subsidy for the domestic firm given firm qualities. Contrary to the case of tariffs, if the policy instrument is a per-unit output subsidy the government has a second mover disadvantage. The domestic firm, by strategically overinvesting in quality in the first stage, can induce a high subsidy on its output. The foreign firm, anticipating that its domestic rival will receive a high subsidy ex-post, prefers to stay out of the market because it expects gross profits that are not enough to cover its sunk costs of quality. Both

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the case where the foreign firm is the high, or the low, quality producer under free trade are subsequently analyzed.

(i) UFT-high quality foreign firm

Let the per-unit output subsidy be $\overline{k}$. Define $k = \frac{\overline{k}}{\overline{\theta}}$. In the last stage the foreign and the domestic firm choose outputs to maximize their profits, which are $\pi_1 = p_1(x_1, x_2)x_1 - \frac{s_1^2}{2}$ and $\pi_2 = p_2(x_1, x_2)x_2 + \overline{k}\overline{\theta}x_2 - \frac{s_2^2}{2}$, respectively. From the first order conditions we get the equilibrium outputs,

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

and the equilibrium profits are, $\pi_i^*(s_1, s_2, k) = s_i x_i^{*2} - \frac{s_i^2}{2}, i = 1, 2$. In the second stage, the government decides on the subsidy that maximizes domestic welfare given the qualities chosen by the foreign and the domestic firm. Domestic welfare equals consumer surplus plus domestic firm's profits, less expenditures on subsidies $(\overline{k}\overline{\theta}x_2^*)$. Using (2.3) and (5.1), it can be checked that,

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

Maximizing TW with respect to k, we obtain the optimal time consistent subsidy, $\overline{k}^* = s_2\overline{\theta}$; $\overline{k}^*$ is proportional to the quality of the domestic firm and the market size. The domestic firm can thus *strategically* select a higher level of quality in order to obtain a higher output subsidy from its government. In fact, the domestic firm, who has the first mover advantage, will choose a high enough quality level (thus obtaining a high output subsidy) such that the foreign firm can never make positive profits by producing the higher quality good. Anticipating that its rival will receive a high subsidy ex-post the foreign firm stays out of the market to avoid the sunk costs of quality.

To see this, let the foreign and the domestic firm select their qualities in the first stage anticipating the government's (ex-post) optimal subsidy, $k^* = s_2$. Substituting k^* into (5.1) we obtain:

$$x_1^*(s_1, s_2) = \left[\frac{2(s_1 - s_2)}{4s_1 - s_2}\right]\overline{\theta}; \quad x_2^*(s_1, s_2) = \left[\frac{3s_1}{4s_1 - s_2}\right]\overline{\theta} \qquad (5.3)$$

and the profits are, $\pi_i^*(s_1, s_2) = s_i x_i^{*2} - \frac{s_i^2}{2}, i = 1, 2$. From the first order condition of the domestic firm we have $(\lambda = \frac{s_2}{s_1})$,

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

Since $s_2(\lambda)$ is increasing in λ, the quality of the domestic firm will be larger than $s_2(0) = \left(\frac{9}{16} \right) \overline{\theta}^2$. Further, from (5.3), x_1^* decreases with s_2. Hence the foreign firm's profits decrease with s_2. That is, $\pi_1^*(s_1, s_2) \leq \pi_1^*(s_1, s_2(0)) \leq \max_{s_1} \pi_1^*(s_1, s_2(0)) = - \left(\frac{81}{512} \right) \overline{\theta}^4$. Thus, the (under free trade) high quality foreign firm, anticipating that the domestic firm receives a high subsidy ex-post, never produces the high quality good under time consistent subsidies. As is shown below, the foreign firm has no incentive to become the lower quality producer either. Therefore, under time consistent subsidies, the domestic firm becomes a monopolist in the home market.

(ii) **UFT-low quality firm**

In the last stage, the domestic and the foreign firm choose output to maximize their profits, which are $\pi_1 = p_1(x_1, x_2)x_1 + k\overline{\theta}x_1 - \frac{s_1^2}{2}$ and $\pi_2 = p_2(x_1, x_2)x_2 - \frac{s_2^2}{2}$, respectively. From the first order conditions we obtain the equilibrium outputs,

$$x_1^*(s_1, s_2, k) = \left[\frac{2(k + s_1) - s_2}{4s_1 - s_2} \right] \overline{\theta}; \quad x_2^*(s_1, s_2, k) = \left[\frac{s_1 - k}{4s_1 - s_2} \right] \overline{\theta} \qquad (5.4)$$

and the equilibrium profits are, $\pi_i^*(s_1, s_2, k) = s_i x_i^{*2} - \frac{s_i^2}{2}, i = 1, 2$. In the second stage, the Government selects a subsidy that maximizes domestic welfare. From (5.4) and (2.3), we have

$$TW(s_1, s_2, k) = \left[\frac{k^2 - 2ks_1 - 3s_1^2 + s_1 s_2}{2(s_2 - 4s_1)} \right] \overline{\theta}^2 - \frac{s_1^2}{2} \qquad (5.5)$$

From the first order condition the time consistent subsidy, $\overline{k}^* = s_1 \overline{\theta}$, is obtained, which is again proportional to the domestic firm's quality and the size of the market. As in the previous case, by selecting a higher quality the domestic firm can obtain a high enough subsidy from the government, and thus make low quality imports non-profitable. The foreign firm thus has no incentive to produce the lower quality good and stays out of the home market.

To see this, note that under the optimal time consistent subsidy $(k^* = s_1)$ the foreign firm's equilibrium output equals zero (from (5.4)). Thus, in the first stage

the foreign firm's profits are always negative for any $s_2 > 0$. Therefore, under time consistent subsidies, the domestic firm becomes a domestic monopolist, independently of whether the foreign firm is the high-, or the low-, quality producer under free trade.

Proposition 5.1. *The government's inability to commit to a subsidy has a significant impact on market structure. Anticipating the optimal time consistent subsidy, $k^* = s_d$, where s_d is the domestic firm's quality, the foreign firm stays out of the home market and the domestic firm becomes a monopolist.*

We finally analyze the equilibrium outcome under a domestic monopoly. In the last stage, the monopolist chooses its output to maximize profits, $\pi = (\overline{\theta} - x)sx + k\overline{\theta}x - \frac{s^2}{2}$, and hence its optimal output is:

$$x_m(s, k) = \left[\frac{s+k}{2s}\right]\overline{\theta} \tag{5.6}$$

and its profits are, $\pi_m(s, k) = sx_m^2 - \frac{s^2}{2}$. In the second stage, the government chooses the subsidy to maximize the domestic welfare,

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

Once more, $\overline{k}^* = s\overline{\theta}$, i.e. the optimal subsidy is proportional to the quality of the domestic monopolist. Then its profits are, $\pi_m(s) = s\overline{\theta}^2 - \frac{s^2}{2}$. In the first stage, the domestic firm selects its quality to maximize profits. Therefore, $s_m = \overline{\theta}^2$, and as result, $x_m = \overline{\theta}$ i.e. the monopolist sells to the entire home market at a zero price. Finally, as $k^* = s_m = \overline{\theta}^2$, it can be checked that domestic welfare equals zero.

Proposition 5.2. *Under time consistent subsidies, the (resulting) domestic monopolist covers the entire market, at a price equal to marginal cost, offering a high quality good in order to obtain a high subsidy from its government. Optimal time consistent subsidies are higher than optimal precommitment subsidies.*[22] *Domestic*

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[22]This can be seen by numerically evaluating domestic welfare under precommitment for various subsidy levels. The optimal precommitment subsidy is always lower than the optimal time consistent subsidy, $\overline{\theta}^2$. Note that this is in contrast to Goldberg (1995) and Leahy and Neary (1994, 1996, 1999) where time consistent subsidies are unambiguously lower.

welfare under the optimal time consistent subsidy equals zero. Hence, contrary to the case of tariffs, the government's precommitment to a subsidy improves domestic welfare.

The intuition is as follows. Given that, the subsidy depends on domestic quality and that the government is unable to precommit to a specific subsidy level, the (resulting) domestic firm, anticipating that it will be a monopolist in the domestic market, will strategically offer a high quality good in order to obtain a high subsidy. As the subsidy it receives is quite high, the monopolist sells to the entire market at a zero price. In addition, total expenditures on 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 results in positive domestic welfare. Given that under free trade domestic welfare is $0.04291\bar{\theta}^4$ and $0.05964\bar{\theta}^4$, when the foreign firm is of low and high quality, respectively. Any arbitrarily small subsidy would also give positive domestic welfare. Thus, the government prefers to precommit if it chooses to subsidize the domestic firm.

6. Bertrand Competition

Our qualitative results do not change under price competition. Time-consistent subsidies induce exit of the foreign firm and tariffs always ensure that the domestic firm produces the high-quality good. Domestic welfare is higher under time consistent tariffs than under precommitment only if the foreign firm produces the high quality good under free trade. This is due to the fact that the quality switching induced by the tariff gives the domestic firm substantially higher profits than if it were the low quality firm. However, if the domestic firm produces the high quality good under free trade then the rent shifting effect is not big enough and the reduction in consumer surplus results in decrease in domestic welfare. In the case of time consistent subsidies, as is under Cournot competition, the foreign firm exits the market and domestic welfare is always lower than under precommitment subsidies. Contrary to the Eaton and Grossman (1986) result, the qualitative results and the optimal trade policy instruments are not reversed under price competition in our model. We summarize and discuss our main findings for the price competition case and compare them with our results

under Cournot competition[23]. We first present the results for the tariff case and then for subsidies.

6.1. Tariffs

Suppose that the government's policy tool is a tariff on imports. As in quantity competition, the inability of the government to commit to a tariff has an important impact on the market structure. Once more, there is a unique equilibrium under time consistent tariffs, in which the domestic firm is always the high quality producer, independently of whether it is the high-, or low-, quality firm under free trade.[24] The reason for the quality reversal when the foreign firm produces the high quality good under free trade is somewhat different than in the Cournot case. A high quality foreign firm, anticipating expropriation of its gross profits due to a high (ex-post) optimal tariff, lowers its quality substantially to save on sunk costs of quality. However, as the foreign firm's quality is not too high, the (low quality) domestic firm can increase its profits by producing a higher level of quality than its rival and thus becoming the higher quality producer. Thus, when the government is unable to commit to a tariff, a market structure with a high quality foreign firm and a low quality domestic firm cannot be sustained in equilibrium.

As in the Cournot case, the equilibrium qualities under time consistent tariffs are lower than under free trade. Domestic welfare is higher under time consistent tariffs than under both free trade and precommitment tariffs only if the foreign firm is of high quality under free trade. Evidently, due to the quality reversal in this case, domestic firm's profits increase substantially. This strong rent shifting effect dominates the two negative effects (consumer surplus and tariff revenues) and leads to a higher level of welfare when the government cannot credibly commit to a tariff. However, contrary to the Cournot case, if the domestic firm produces the high quality good under free trade, government precommitment to a tariff has a positive value and it leads to higher domestic welfare. The above results are summarized in the following proposition.

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[23] All results are presented in the appendix.

[24] For similar reasons as in quantity competition, there are two asymmetric pure strategy equilibria under free trade: (i) foreign firm of high quality and domestic firm of low quality and (ii) vice versa. Again, the high quality firm obtains higher profits in equilibrium (see Appendix for details).

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Proposition 6.1. *Under time consistent import tariffs and price competition, there is a unique equilibrium where the foreign firm is always the low quality producer. If the government cannot precommit to a policy and the foreign firm produces the high quality good under free trade then the optimal tariff induces a reversal in the quality ladder. The quality offered by both the firms under time consistent tariffs is lower than under free trade. Under time consistent tariffs, domestic welfare is higher (lower) than under both optimal precommitment tariffs and free trade, whenever the foreign firm produces the high (low) quality good under free trade.*

6.2. Subsidies

Suppose next that the government's policy tool is a subsidy on the domestic firm's output. In this case, interestingly, the results are independent of the type of competition in the product market. If the government is unable to precommit to a subsidy, the foreign firm always stays out of the market, independently whether it is of high-, or low-, quality firm under free trade. Thus, the market structure is again influenced by the trade policy. That is, in the unique equilibrium, the domestic firm becomes a heavily subsidized monopolist which offers the high quality good to the entire domestic market at a zero price. Once more, and for the same reasons as in the case of quantity competition, with this high subsidy (that exactly equals quality) total domestic welfare is zero. The results are summarized in the following proposition.

Proposition 6.2. *Under time consistent subsidies price and quantity competition lead to the same equilibrium outcomes. The foreign firm always stays out of the market. In order to obtain a high subsidy from the government the (resulting) domestic monopolist covers the entire market offering a high quality good. Domestic welfare under the optimal time consistent subsidy equals zero. Hence, and contrary to the case of tariffs, government precommitment to a subsidy improves domestic welfare.*

7. Conclusion

We show that in a vertically differentiated industry the impact of trade policies, such as import tariffs and domestic output subsidies, on equilibrium outcomes

and domestic welfare is qualitatively the same. Our result holds regardless of whether the firms compete in prices or quantities in the domestic market. This is in contrast to Eaton and Grossman's finding that the optimal policy is reversed when the market competition changes from quantity to price competition (1986). We instead show that, if the government is unable to commit to a policy, it will set a positive level of tariff, or subsidy, independently of the mode of market competition.

Contrary to homogenous or horizontally differentiated industries, in vertically differentiated industries trade policies may have a dramatic impact on market structure whenever the government cannot commit to a policy. Under time consistent tariffs the domestic firm always produces the high-, and the foreign firm the low-, quality good. Thus, if the foreign firm is of high-, and the domestic firm of low-, quality under free trade, the tariff induces a reversal in the quality ladder. Under time consistent subsidies an (UFT) high-, or low-, quality foreign firm decides not to enter the domestic market knowing that the domestic firm can strategically induce a high subsidy from its government ex-post. The resulting market structure is a domestic monopolist with domestic welfare of zero. Despite the fact that the monopolist prices at marginal cost and that the entire domestic market is covered, domestic governments' expenditures on subsidies are so high that they offset the positive effect on consumer surplus. Since free trade leads to positive domestic welfare, so does the government's commitment to a small subsidy. Thus, with subsidies precommitment always results in higher domestic welfare than non-committal independent of price or quantity competition. Precommitment, as in Leahy and Neary (1996, 1999), is also the best policy regime under subsidies.

The only possible equilibrium, if the policy tool is a tariff, is where the domestic firm always produces the high quality good and the foreign firm the low quality good. This happens as the ex-post optimal tariff is increasing in the foreign firms' quality and the foreign firm has no incentive to produce the high quality good. Domestic welfare is greater than under free trade and under precommitment when the government does not commit to a tariff. This is always true, except if the firms compete in prices and the domestic firm is of high quality under free trade. Therefore, commitment has a positive value (in the sense that it increases domestic welfare) but only if the government's policy tool is a subsidy.

A natural question arises here. If, as in Hwang and Schulman (1993), the government can commit to a policy instrument at the first stage, but not to its

level (as is the case in our 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 can induce the foreign firm to switch qualities thereby producing the low quality good. However, if it chooses subsidies they can result in a subsidized domestic monopoly. Our results are important in that they highlight that non-committal may in-fact be a welfare improving policy in a vertically differentiated industry under tariffs. In fact, non-committal may be the best protection argument for a country. For example, just the retroactive threat of imposing tariffs on Japan caused it to withdraw the export of its high quality cars.

In line with Grossman (1988), we demonstrate that in our model the long term view of the rent shifting effect is, in fact, very different than the short term view as given in Brander and Spencer (1985). The rent transfer effect due to a tariff in our model is often of a higher order of magnitude because quality configurations may change due to the time consistent tariff. An ex-post optimal tariff effectively transfers revenues from the (under free trade) high-quality foreign firm to the (after tariff) high-quality domestic firm. Since due to non-commitment the domestic firm always produces the high quality good and thus earns a much higher level of profits, the effect on domestic welfare is more dramatic than when the government commits to a policy. In the latter case, even though the tariff induces firms to adjust both their long term variables (qualities) and short term variables (outputs or prices), the rent shifting effect is smaller because the market structure is unaffected by the precommitment tariff.

There are a number of limitations in our analysis. First, we do not consider that the government can use multiple instruments, e.g. an import tariff together with a domestic output subsidy (as in Dixit (1988) and Collie (1991)). Whether a government can attain the first best outcome with the use of multiple policy tools and if so what set of tools would be necessary to achieve this target is a question for further investigation. Our analysis leads us to conjecture that, if the government is unable to commit, the first best outcome cannot be attained with the combination of import tariffs and output subsidies. Second, we do not study retaliation games between the foreign and domestic governments. This issue would be especially interesting in the case where a non-committal domestic government provides subsidies to the domestic firm. Especially if retaliation by the foreign government would alter the foreign firm's decision to stay out of the domestic market.

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Appendix: The Bertrand case.

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1. The Bertrand Competition Case

Let us now assume that the domestic and the foreign firm compete in prices in the home market, with all the other specifications of the model remaining the same. We first present the equilibrium outcome under free trade, and then analyze the cases where (i) the government's trade policy is a tariff on the foreign firm's imports and (ii) its policy is a subsidy on the domestic firm's output. Both the time consistent trade policy scenario and the government's commitment to a policy scenario will be considered and compared in each case. Recall that the demands for the high and low quality good are,

$$x_1(p_1,p_2) = \bar{\theta} - \frac{p_1 - p_2}{s_1 - s_2}; \quad x_2(p_1,p_2) = \frac{p_1 - p_2}{s_1 - s_2} - \frac{p_2}{s_2} \qquad (1.1)$$

Under free trade, in the last stage firm i chooses its price to maximize its profits, $x_i(p_i,p_j)p_i - \frac{s_i^2}{2}$, taking as given the price of its rival p_j and the qualities selected in the first stage (for details, see Motta, 1993). From the reaction functions,

$$p_1 = \frac{\bar{\theta}(s_1 - s_2) + p_2}{2} \; ; \quad p_2 = \frac{s_2 p_1}{2s_1} \qquad (1.2)$$

we get the equilibrium prices,

$$p_1^*(s_1,s_2) = \frac{2s_1(s_1 - s_2)\bar{\theta}}{4s_1 - s_2} \; ; \quad p_2^*(s_1,s_2) = \frac{\bar{\theta}s_2(s_1 - s_2)}{(4s_1 - s_2)} \qquad (1.3)$$

and the equilibrium profits are, $\pi_1^*(s_1,s_2) = \frac{(p_1^*)^2}{s_1 - s_2} - \frac{s_1^2}{2}$ and $\pi_2^*(s_1,s_2) = \frac{s_1(p_2^*)^2}{(s_1 - s_2)s_2} - \frac{s_2^2}{2}$.

In the first stage, firm i chooses s_i to maximize $\pi_i^*(s_1,s_2)$ taking as given the quality of its rival s_j. Defining the ratio of qualities, $\lambda = \frac{s_2}{s_1}$, and dividing the two first order conditions, after some manipulations we get the free trade equilibrium qualities, prices, profits, consumer surplus and domestic welfare:

$$s_1^{ft} = .25331\bar{\theta}^2 \qquad s_2^{ft} = .04824\bar{\theta}^2 \qquad \lambda^{ft} = \frac{s_2^{ft}}{s_1^{ft}} = 0.19043$$

$$p_1^{ft} = .10766\bar{\theta}^3 \qquad p_2^{ft} = .01025\bar{\theta}^3 \qquad CS^{ft} = 0.04322\bar{\theta}^4$$

$$\pi_1^{ft} = 0.02444\bar{\theta}^4 \qquad \pi_2^{ft} = 0.00153\bar{\theta}^4 \qquad TW_{fh} = 0.04475\bar{\theta}^4$$

$$TW_{fl} = 0.06766\bar{\theta}^4$$

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where TW_{fh} (TW_{fl}) is the domestic welfare under free trade when the foreign firm produces the high (low) quality good and the domestic firm the low (high) quality good. Note that under free trade, there are two asymmetric (pure strategy) equilibria where one firm is the high quality producer and the other the low quality producer. Domestic firm's profits, as well as domestic welfare, are higher in the equilibrium where the domestic firm is the high quality producer.

2. Import tariffs

Suppose that the government's trade policy tool is an import tariff on the foreign firm. Under the government commitment scenario, the government selects a tariff on the imports, then the domestic and the foreign firm choose their qualities and finally the firms set their prices. On the other hand, if the government is unable to commit to a tariff, the foreign and the domestic firm first choose their qualities, then the government optimally sets the level of the tariff given the qualities selected by the firms, and finally firms set the prices of their goods. In this time consistent scenario, the firms can strategically choose their qualities in the first stage in order to induce a more favorable treatment by the goverment or to diminish the consequences from the imposition of the tariff. As the government's objective is to maximize domestic welfare, it is effectively the domestic firm that makes use of its strategic advantage. In case that the foreign firm is the high quality producer under free trade, the domestic firm has always incentive to produce a higher quality than its rival's whenever the latter faces an import tariff from a non-commital government. Therefore, foreign firm high quality producer and domestic firm low quality producer cannot be sustained in equilibrium if the government cannot commit to an import tariff. The optimal time consistent import tariff will induce a reversal in the quality ladder, with the domestic firm becoming the high quality producer and the foreign firm the low quality producer.

On the other hand, if the foreign firm produces the low quality under free trade, it will still produce the low quality good when it faces an import tariff from a non-commital government. The imposition of the tariff, however, will lead both the domestic and the foreign firm to produce lower qualities than under free trade. In fact, this is the only possible equilibrium configuration of qualities whenever the government cannot commit to a tariff. As the qualities offered in the domestic market are lower under optimal time consistent tariffs, consumer surplus is lower than under free trade. Total domestic welfare increases but only

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if the foreign firm is the higher quality producer under free trade. This is due to a substantial rent shifting effect resulting from the reversal in the quality ladder with the domestic firm becoming the high quality producer, and thus gaining much higher profits than under free trade. In contrast, if under free trade the domestic firm is the high quality producer, the imposition of the optimal time consistent tariff reduces domestic welfare, because the rent shifting effect is not strong enough to compensate for the reduction in the consumer surplus. These results are summarized in the following Proposition.

Proposition 2.1. *The optimal time consistent import tariff is proportional to the quality of the foreign firm, s_f, that is, $\bar{t}^* = \frac{s_f(s_1-s_2)}{3s_1-2s_2}\bar{\theta}$. Under optimal time consistent tariffs, the foreign firm always produces the low quality good and the domestic firm the high quality good in equilibrium. The equilibrium qualities offered in the domestic market are lower than under free trade, and thus consumer surplus is lower. Under time consistent tariffs, total domestic welfare is higher (lower) than under both optimal precommitment tariffs and free trade, whenever the foreign firm is the high (low) quality producer under free trade.*

We first determine the optimal import tariff under the time consistent scenario. We distinguish two cases. First, the foreign firm is the high quality producer under free trade and second, the foreign firm is the low quality producer under free trade.

(i) **UFT-high quality foreign firm.** Define $t = \frac{\bar{t}}{\bar{\theta}}$, where $\bar{t}$ is the import tariff. The profits of the foreign and the domestic firm are, $\pi_1 = x_1\,(p_1, p_2)\,(p_1 - t\bar{\theta}) - \frac{s_1^2}{2}$ and $\pi_2 = x_2\,(p_1, p_2)\,p_2 - \frac{s_2^2}{2}$, respectively. In the last stage, each firm maximizes its profits taking as given the import tariff, $\bar{t}$, the qualities offered in the market (s_1, s_2), and the price of its rival. From the first order conditions the best response functions for the foreign and the domestic firm are:

$$p_1 = \frac{\bar{\theta}(s_1 - s_2) + p_2 + \bar{\theta}t}{2}; \qquad p_2 = \frac{\bar{\theta}s_2 p_1}{2s_1} \qquad (2.1)$$

Then the equilibrium prices are,

$$p_1^* = \left[\frac{2s_1(s_1 - s_2 + t)}{4s_1 - s_2}\right]\bar{\theta}; \qquad p_2^* = \left[\frac{s_2(s_1 - s_2 + t)}{4s_1 - s_2}\right]\bar{\theta} \qquad (2.2)$$

and the equilibrium profits, $\pi_1^* = \frac{(p_1^* - t\bar{\theta})^2}{s_1 - s_2} - \frac{s_1^2}{2}$ and $\pi_2^* = \frac{s_1(p_2^*)^2}{(s_1 - s_2)s_2} - \frac{s_2^2}{2}$.

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In the second stage, the government selects the tariff that maximizes total domestic welfare taking as given the quality choices of the foreign and the domestic firm. Total domestic welfare is the sum of consumer surplus, the domestic firm's profits and tariff revenues, $t\bar{\theta}x_1^*$. Using (2.2) and (1.1), and after some manipulations, we get:

$$TW = \left[\frac{s_1^3 + s_1^2 s_2 - 2s_1 s_2^2 + 2s_1^2 t - 2s_1 s_2 t - 3s_1 t^2 + 2s_2 t^2}{2\left(4s_1 - s_2\right)\left(s_1 - s_2\right)}\right]\bar{\theta}^2 - \frac{s_2^2}{2} \quad (2.3)$$

¿From the first order condition, it can be easily seen that the optimal import tariff is $\bar{t}^* = \frac{s_1(s_1-s_2)}{3s_1-2s_2}\bar{\theta}$.

(ii) **UFT-low quality foreign firm.** Simirarly, if the foreign firm is of low quality under free trade, the profits of the domestic and the foreign firm are, $\pi_1 = x_1\left(p_1, p_2\right)p_1 - \frac{s_1^2}{2}$ and $\pi_2 = x_2\left(p_1, p_2\right)\left(p_2 - t\bar{\theta}\right) - \frac{s_2^2}{2}$. In the last stage, firms set simultaneously their prices to maximize profits, given the import tariff and the qualities offered in the market. From the first order conditions we obtain the best response functions,

$$p_1 = \frac{\bar{\theta}(s_1 - s_2) + p_2}{2}; \quad p_2 = \frac{\bar{\theta}t s_1 + p_1 s_2}{2s_1}$$

Then the equilibrium prices are,

$$p_1^* = \left[\frac{s_1(2s_1 - 2s_2 + t)}{4s_1 - s_2}\right]\bar{\theta}; \quad p_2^* = \left[\frac{s_1 s_2 + 2s_1 t - s_2^2}{4s_1 - s_2}\right]\bar{\theta} \quad (2.4)$$

and the equilibrium profits are, $\pi_1^* = \frac{(p_1^*)^2}{s_1 - s_2} - \frac{s_1^2}{2}$ and $\pi_2^* = \frac{s_1(p_2^* - t\bar{\theta})^2}{(s_1 - s_2)s_2} - \frac{s_2^2}{2}$.

In the second stage, the government selects a tariff to maximize total domestic welfare, which from (2.4) and (1.1) equals,

$$TW = \left[\frac{s_1(3s_1^2 s_2 - 3s_1 s_2^2 + 2s_1 s_2 t - 3s_1 t^2 - 2s_2^2 t + 2s_2 t^2)}{2s_2(4s_1 - s_2)(s_1 - s_2)}\right]\bar{\theta}^2 - \frac{s_1^2}{2} \quad (2.5)$$

¿From the first order condition, the optimal import tariff is, $\bar{t}^* = \frac{s_2(s_1-s_2)}{3s_1-2s_2}\bar{\theta}$.

We next show that a UFT-high quality foreign firm, anticipating the optimal import tariff, can never produce the high quality good in equilibrium. Let us

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assume, for the moment, that the foreign firm produces the high quality and the domestic firm the low quality good. As the optimal tariff is proportional to its quality, the foreign firm has no incentive to produce a very high quality level. It turns out that in the candidate equilibrium, the foreign firm will produce a higher quality than the domestic firm which is, however, rather low. As a result, given the quality choice of its rival, the domesic firm has an incentive to jump up in the quality ladder and become the higher quality producer. Thus, the proposed quality configuration of foreign high and domestic low cannot be sustained in equilibrium.

In particular, given $\bar{t}^* = \frac{s_1(s_1-s_2)}{3s_1-2s_2}\bar{\theta}$, the firms equilibrium prices and profits become (from (2.2)),

$$p_1^* = \frac{4s_1(2s_1-s_2)(s_1-s_2)}{(4s_1-s_2)(3s_1-2s_2)}\bar{\theta}; \quad p_2^* = \frac{2s_2(s_1-s_2)(2s_1-s_2)}{(4s_1-s_2)(3s_1-2s_2)}\bar{\theta} \qquad (2.6)$$

and $\pi_1^* = \frac{(p_1^*-\bar{t}\bar{\theta})^2}{s_1-s_2} - \frac{s_1^2}{2}$, and $\pi_2^* = \frac{s_1(p_2^*)^2}{(s_1-s_2)s_2} - \frac{s_2^2}{2}$. In the first stage, each firm maximizes its profits taking the quality of its rival as given. Defining $\lambda = \frac{s_1}{s_2}$, and dividing the focs, we obtain the equilibrium quality ratio, $\lambda^* = \frac{s_1^*}{s_2^*} = 2.04551$. Then from the focs we obtain the equilibrium qualities, prices and profits of the foreign and the domestic firm, $s_1^* = 0.12160\bar{\theta}^2$, $s_2^* = 0.05945\bar{\theta}^2$, $p_1^* = 0.05291\bar{\theta}^3$, $p_2^* = 0.01293\bar{\theta}^3$, $\pi_1^* = 0.00052\bar{\theta}^4$ and $\pi_2^* = 0.00374\bar{\theta}^4$. Moreover, $\bar{t}^* = 0.03073\bar{\theta}^3$, $CS = 0.02215\bar{\theta}^4$ and $TW = 0.03686\bar{\theta}^4$. However, this cannot be an equilibrium. Suppose that the foreign firm chooses $s_l = s_1^* = 0.12160\bar{\theta}^2$. Then the domestic firm has an incentive to "leapfrog" its rival and produce a higher quality $s_h > s_l$. In this case the optimal government's tariff will be $t^* = \frac{s_l(s_h-s_l)}{3s_h-2s_l}$ and the profits of the domestic firm are $\pi_h^* = \frac{(p_h^*)^2}{s_h-s_l} - \frac{s_h^2}{2}$ where

$$p_h^* = \frac{3s_h(2s_h-s_l)(s_h-s_l)}{(3s_h-2s_l)(4s_h-s_l)}\bar{\theta}$$

By plotting $\pi_h^*(s_h,s_l)$ for $s_h > s_l = 0.12160\bar{\theta}^2$, it can be easily seen that for sufficiently high s_h, the domestic firm's profits are higher than $\pi_2^* = 0.00374\bar{\theta}^4$ (In fact, the maximum profits are approximately equal to $0.0213\bar{\theta}^4$). Further, we check if the foreign firm has incentive to remain the high quality producer by selecting a (high) quality different than s_1^*. Clearly, if it chooses a quality

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$s_1 < s_1^*$, the domestic firm has an even stronger incentive to become the high quality producer. On the other hand, the foreign firm has no incentive to choose a quality much higher than s_1^*, since in this case its (net) profits will be lower than if it were producing the lower quality good (see below). It can be checked that, for all these values of s_1, the domestic firm has an incentive to switch position in the quality ladder and become the high quality producer. Therefore, the only possible configuration of qualities in equilibrium is the domestic firm producing the high quality and the foreign firm producing the low quality.

We now determine the equilibrium outcome when the foreign firm is the low quality producer. Since $t^* = \frac{s_2(s_1-s_2)}{3s_1-2s_2}$, from (2.4) we get the equilibrium prices and profits,

$$p_1^* = \frac{3s_1(2s_1-s_2)(s_1-s_2)}{(3s_1-2s_2)(4s_1-s_2)}\bar{\theta}; \quad p_2^* = \frac{s_2(s_1-s_2)(5s_1-2s_2)}{(3s_1-2s_2)(4s_1-s_2)}\bar{\theta}$$

and $\pi_1^* = \frac{(p_1^*)^2}{s_1-s_2} - \frac{s_1^2}{2}$; $\pi_2^* = \frac{s_1(p_2^*-t\bar{\theta})^2}{(s_1-s_2)s_2} - \frac{s_2^2}{2}$. In the quality selection stage, each firm maximizes its profits taking the quality of its rival as given. Defining $\lambda = \frac{s_1}{s_2}$, from the first order conditions we obtain the equilibrium ratio of qualities $\lambda^* = \frac{s_1^*}{s_2^*} = 38.3633$. Then the equilibrium qualities, prices, outputs and profits are:

$$s_1^* = 0.25004\bar{\theta}^2; \qquad s_2^* = 0.00652\bar{\theta}^2$$

$$p_1^* = 0.12310\bar{\theta}^3; \qquad p_2^* = 0.00268\bar{\theta}^3$$

$$x_1^* = 0.50551\bar{\theta}; \qquad x_2^* = 0.08314\bar{\theta}$$

$$\pi_1^* = 0.03097\bar{\theta}^4; \qquad \pi_2^* = 0.00002\bar{\theta}^4$$

Moreover, $\bar{t}^* = 0.00215\bar{\theta}^3$, $CS^* = 0.03224\bar{\theta}^4$ and $TW^* = 0.06339\bar{\theta}^4$. Finally, it can be checked that no firm has an incentive to leapfrog its rival in the quality ladder. As a result, this is the unique equilibrium outcome under optimal time consistent import tariffs. Interestingly, under the time consistent tariff scenario, the domestic firm is always the high quality producer.

Furthermore, it can be seen that if UFT the foreign firm produces the high quality good, the imposition of the tariff leads to an increase in total domestic welfare: under free trade $TW_{fh} = 0.04475\bar{\theta}^4$, while under optimal time consistent tariffs $TW^* = 0.06339\bar{\theta}^4$. In contrast, if UFT the foreign firm produces the low quality good, the imposition of the tariff reduces domestic welfare, since under

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free trade $TW_{fl} = 0.06766\overline{\theta}^4$. These results are due to two opposing effects. First, qualities offered in the domestic market are lower under time consistent tariffs than under free trade, i.e. $s_1^* = 0.25004\overline{\theta}^2 < s_1^{FT} = .25331\overline{\theta}^2$ and $s_2^* = 0.00652\overline{\theta}^2 < s_2^{FT} = .04824\overline{\theta}^2$, thus leading to a lower consumer surplus. Second, there is a positive rent shifting effect due to the imposition of the tariff. This effect is strong and dominates the quality downgrading effect whenever the domestic firm switches position in the quality ladder, i.e. whenever UFT the foreign firm is the higher quality producer. If there is no quality reversal, the rent shifting effect is dominated by the negative quality downgrading effect, thus leading to lower domestic welfare.

Finally, we compare the equilibrium outcomes under the time consistent import tariffs scenario and the government commitment to a tariff scenario. In the latter, the government precommits to an import tariff, then the domestic and the foreign firm select their qualities and finally they set their prices in the domestic market.

Suppose first that the foreign firm is the high quality producer under free trade. The last stage of the game is as in case (i) above (see (2.2)). In the second stage, given the government's tariff on imports, the domestic and the foreign firm select their qualities. Define $\frac{s_2}{s_1} = \lambda$ and $\mu = \frac{t}{s_1}$. Each firm chooses its quality to maximize its profits taking as given the quality of its rival. The first order conditions of this problem can be expressed as, $s_1(\lambda, \mu)$ and $s_2(\lambda, \mu)$. We first determine the interval of tariffs for which the foreign firm stays in the domestic market. Let t_m be the maximum tariff, i.e. the tariff for which the foreign firm's profits equal zero. Using the focs and the zero profit condition for the foreign firm, and solving for (s_1, s_2, t) we obtain $s_{1m} = 0.24510\overline{\theta}^2$, $s_{2m} = 0.07433\overline{\theta}^2$ and $t_m = 0.04525\overline{\theta}$, with the associated quality ratio being $\lambda_m = 0.30328$. 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 import tariff is $\overline{t} \in \left[0, 0.04525\overline{\theta}^3\right]$. (Note that $\mu = \overline{t} = 0$ corresponds to free trade, and in this case the ratio of qualities is $\lambda^{FT} = 0.19043$).

Further, by dividing the focs, we obtain an equation involving only λ and μ. Solving this equation for μ and choosing the positive root we get $\mu(\lambda)$. Plotting $\mu(\lambda)$ in the relevant range of λ, $0.19043 \leq \lambda \leq 0.30328$, it can be seen that $d\mu/d\lambda > 0$. Further, substituting $\mu(\lambda)$ in the focs we obtain $s_1(\lambda)$ and $s_2(\lambda)$. By plotting these expressions in the relevant range of λ, it can be checked that $s_2(\lambda)$ is increasing in λ, while $s_1(\lambda)$ is initially (slightly) increasing and then decreasing

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in λ. Moreover, $t(\lambda) = s_1(\lambda).\mu(\lambda)$. By plotting $t(\lambda)$ in the relevant range of λ, we see that $dt/d\lambda > 0$. Therefore, as the tariff on imports increases, the foreign firm's quality initially increases slightly and then decreases, while the domestic firm's quality increases.

We next turn to the impact of a precommitment tariff, t, on the firms' profits, consumer surplus and total domestic welfare. Substituting $s_i(\lambda), i = 1, 2$ and $t(\lambda)$ in (2.2) and (2.3) and plotting we obtain the following results. First, the profits of the high-quality foreign firm, $\tilde{\pi}_1$, are maximum under free trade and decrease with the level of the tariff (reaching zero for the maximum tariff, t_m). Second, as the import tariff transfers rents to the domestic producer, the profits of the domestic firm, $\tilde{\pi}_2$, increase with the tariff and are equal to $0.00330\bar{\theta}^4$ for the maximum tariff. Third, consumer surplus decreases with the tariff. Finally, total domestic welfare increases with the tariff, and thus reaches its maximum at the maximum tariff $\bar{t}_m = 0.04525\bar{\theta}^3$. Therefore, the optimal precommitment tariff is $\tilde{t} = \bar{t}_m = 0.04525\bar{\theta}^3$, which is much higher than the optimal time consistent tariff, $\bar{t}^* = 0.00215\bar{\theta}^3$. More interestingly, the maximum level of total domestic welfare is $\widetilde{TW} = 0.05886\bar{\theta}^4$, which is lower than when the government cannot credibly commit to a tariff $(TW^* = 0.06339\bar{\theta}^4)$.

Suppose next that the foreign firm is the low quality producer under free trade. We have seen that in this case total domestic welfare under free trade is (strictly) higher than under time consistent tariffs. This, in turn, implies that any small enough import tariff, and thus the optimal precommitment tariff, will lead to a higher total domestic welfare than under time consistent tariffs.

3. Subsidies on the domestic firm's output

Suppose now that the government's trade policy tool is a subsidy per unit of output of the domestic firm. Under the government commitment scenario, the government selects a subsidy, then the domestic and the foreign firm choose their qualities and finally the firms set their prices. Under time consistent subsidies, the foreign and the domestic firm first choose their qualities anticipating the government's optimal subsidy, then the government sets the ex-post optimal subsidy level (given the qualities selected by the firms), and finally firms set the prices of their goods. In the latter scenario, the domestic firm can strategically choose its quality in the first stage in order to induce a more favorable subsidy by the

goverment. Effectively, if the foreign firm is the high quality producer under free trade, the domestic firm, by choosing a higher quality than its rival's, can induce the government to provide a subsidy high enough such that it will cover the entire market by selling its good at a zero price. Thus, the foreign firm, anticipating the government's optimal subsidy to the domestic firm's output, stays out of the market. A similar reasoning applies when the foreign firm is the low quality producer under free trade. Again, the optimal time consistent subsidy results in the foreign firm exiting the market and the domestic firm becoming a heavily subsidized monopolist. In both cases the domestic monopolist will produce a much higher quality than the qualities offered in the market under free trade. As the domestic monopolist covers the entire market under time consistent subsidies, consumer surplus is higher than under free trade. On the other hand, quality costs are much higher than under free trade. As a result, total domestic welfare is lower (effectively, zero) under time consistent subsidies than under free trade. Consequently, precommitment subsidies lead always to a higher level of welfare than time consistent subsidies. Under the government's commitment to a subsidy scenario, the foreign and the domestic firm compete by offering their vertically differentiated goods in the market. Thus, the market structure is similar to the free trade case, but with the firms offering different levels of quality. While under the time consistent subsidies scenario, there is no competition in the market, as the domestic firm can strategically induce an (ex-post optimal) high subsidy on its output that will lead the foreign firm to exit the market in the first stage. The domestic firm is thus transformed to a heavily subsidized monopolist. These results are summarized in the following proposition.

Proposition 3.1. *The optimal subsidy for a non-commital government is* $\overline{k}^* = \frac{(s_1-s_2)s_2}{2s_1}\overline{\theta}$ *if the domestic firm is the low quality producer, and* $\overline{k}^* = (s_1 - s_2)\overline{\theta}$ *if it is the high quality producer. The foreign firm, anticipating the government's optimal subsidy, will stay out of the market independently if it is the high, or low, quality producer under free trade. As a result, the domestic firm becomes a subsidized monopolist and selects a quality* $s_d^* = \overline{\theta}^2$ *which sells at a zero price to all consumers in the market. Total welfare under time consistent subsidies equals zero and is lower than under both free trade and precommitment subsidies.*

We first analyze the case where the foreign firm is the high quality producer and the domestic firm the low quality producer under free trade. We then consider the opposite case.

(i) UFT-high quality foreign firm

We first consider the price selection stage. Let the per-unit of domestic output subsidy be $\bar{k}$. Define $k = \frac{\bar{k}}{\bar{\theta}}$. Then the profits of the firms are, $\pi_1 = p_1 x_1(p_1, p_2) - \frac{s_1^2}{2}$ and $\pi_2 = (p_2 + k\bar{\theta}) x_2(p_1, p_2) - \frac{s_2^2}{2}$. From the first order conditions the best reply functions for the foreign and the domestic firm are obtained. Solving these we get the equilibrium prices,

$$p_1^* = \frac{s_1(2s_1 - 2s_2 - k)}{4s_1 - s_2}\bar{\theta}; \quad p_2^* = \frac{s_1 s_2 - 2ks_1 - s_2^2}{4s_1 - s_2}\bar{\theta} \tag{3.1}$$

and the equilibrium profits, $\pi_1^* = \frac{p_1^{*2}}{s_1 - s_2} - \frac{s_1^2}{2}$ and $\pi_2^* = \frac{s_1(p_2^* + k\bar{\theta})^2}{s_2(s_1 - s_2)} - \frac{s_2^2}{2}$. From (3.1), if the subsidy is large enough, the domestic firm's price becomes negative. To avoid this, we shall restrict attention to subsidies such that $p_2^* \geq 0$, that is, $k \leq \frac{s_2(s_1 - s_2)}{2s_1}$. In the second stage, the government selects the subsidy that maximizes total domestic welfare, given the quality choice of the foreign and the domestic firm. Total domestic welfare is the sum of consumer surplus and domestic firm's profits minus the expenditures on subsidies ($k\bar{\theta}x_2^*$). Using (??), (3.1) and (??), we get,

$$TW = \frac{s_1(s_1^2 s_2 + 2ks_1 s_2 + s_1 s_2^2 - 2s_2^3 - k^2 s_1 - 2ks_2^2)}{2s_2(s_1 - s_2)(4s_1 - s_2)}\bar{\theta}^2 - \frac{s_2^2}{2} \tag{3.2}$$

It can be checked that TW is increasing in k for all $k \leq \frac{s_2(s_1 - s_2)}{2s_1}$; thus the optimal subsidy is $\bar{k}^* = \frac{(s_1 - s_2)s_2}{2s_1}\bar{\theta}$. Note from (3.1)that, as a result of the optimal subsidy, the domestic firm sets a zero price in the subsequent stage, while the foreign firm's price is $p_1^* = \frac{s_1 - s_2}{2}\bar{\theta}$. It can be checked that $x_1^* = x_2^* = \frac{1}{2}\bar{\theta}$; thus, $\pi_1^* = \frac{s_1 - s_2}{4}\bar{\theta}^2 - \frac{s_1^2}{2}$ and $\pi_2^* = \frac{s_2(s_1 - s_2)}{4s_1}\bar{\theta}^2 - \frac{s_2^2}{2}$. Finally, in the first stage the domestic and the foreign firm select their qualities to maximize profits. From the first order conditions, we obtain that $s_1^* = 0.25\bar{\theta}^2$ and $s_2^* = 0.08333\bar{\theta}^2$. As a result, the domestic and the foreign firm share the entire domestic market and obtain the same profits, $\pi_1^* = \pi_2^* = 0.010417\bar{\theta}^4$. The question is whether this can be sustained as an equilibrium outcome. The answer is no. To see this, suppose that the domestic firm decides to choose a higher quality than its rival. In other words, given that the foreign firm has chosen $s_l = s_1^* = 0.25\bar{\theta}^2$, does the domestic firm have incentive to leapfrog its rival and produce a higher quality $s_h > s_l$? If so, the optimal ex-post subsidy, $\bar{k}^* = (s_h - s_l)\bar{\theta}$, will result in both firms setting a price equal to zero. The high quality domestic firm thus covers the entire market and

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can make profits equal to $\frac{1}{2}\overline{\theta}^4$ by selecting a quality $s_h = \overline{\theta}^2$ (for details see below case (ii)). Hence, the domestic firm has always incentive to leapfrog its rival and become the higher quality producer. In fact, it becomes a subsidized monopolist in the market, as the foreign firm decides to stay out to avoid the sunk costs of quality (its price equals zero).

(ii) **UFT-low quality foreign firm**

In the last stage, firms select their prices. The profit functions for the domestic and foreign firm are now, $\pi_1 = (p_1 + k\overline{\theta})x_1(p_1, p_2) - \frac{s_1^2}{2}$ and $\pi_2 = p_2 x_2(p_1, p_2) - \frac{s_2^2}{2}$, respectively. From the first order conditions we obtain the equilibrium prices in the final stage,

$$p_1^* = \frac{2s_1(s_1 - s_2 - k)}{4s_1 - s_2}\overline{\theta}; \quad p_2^* = \frac{s_2(s_1 - s_2 - k)}{4s_1 - s_2}\overline{\theta} \tag{3.3}$$

and the equilibrium profits are, $\pi_1^* = \frac{(p_1^* + k\overline{\theta})^2}{s_1 - s_2} - \frac{s_1^2}{2}$ and $\pi_2^* = \frac{s_1 p_2^{*2}}{s_2(s_1 - s_2)} - \frac{s_2^2}{2}$.

In the second stage, the government selects a subsidy that maximizes total welfare which is now given by,

$$TW = \frac{s_1(3s_1^2 - 3s_1 s_2 - k^2 + 2ks_1 - 2ks_2)}{2(4s_1 - s_2)(s_1 - s_2)}\overline{\theta}^2 - \frac{s_1^2}{2} \tag{3.4}$$

¿From the first order condition the optimal time consistent subsidy, $\overline{k}^* = (s_1 - s_2)\overline{\theta}$, is obtained. Note from (3.3) that the optimal subsidy leads both the foreign and the domestic firm to set a zero price in the subsequent stage. As a result, the foreign firm's profits are negative for any $s_1, s_2 > 0$. The foreign firm, anticipating the government's optimal policy, will never enter the market (i.e. $s_2 = 0$) and the domestic firm will be transformed to a subsidized monopolist. In particular, as $p_1^* = 0$ and $k^* = s_1 - s_2$, $\pi_1^* = s_1\overline{\theta}^2 - \frac{s_1^2}{2}$. Therefore, the domestic firm will select $s_1^* = \overline{\theta}^2$, and as a result, $k^* = \overline{\theta}^2$, $x^* = \overline{\theta}$, $\pi_1^* = \frac{1}{2}\overline{\theta}^4$, $CS = \frac{1}{2}\overline{\theta}^4$ and $TW = 0$. The domestic monopolist induces a high subsidy on its output by choosing a high quality. As the price is zero, the whole market is covered by the monopolist. The monopolist obtains high profits, consumers also enjoy a high surplus, but total domestic welfare is zero due to the government's expenditures on subsidies.

Finally, total domestic welfare under time consistent subsidies is lower than under free trade. Under free trade total welfare is positive ($0.04475\overline{\theta}^4$, and $0.06766\overline{\theta}^4$, when the foreign firm is the low, and high quality producer, respectively), while under time consistent subsidies total welfare is zero. Further, it is easy to see that

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any small subsidy under precommitment gives a positive total welfare. Thus, the government prefers to precommit if its policy tool is to subsidize the domestic firm.
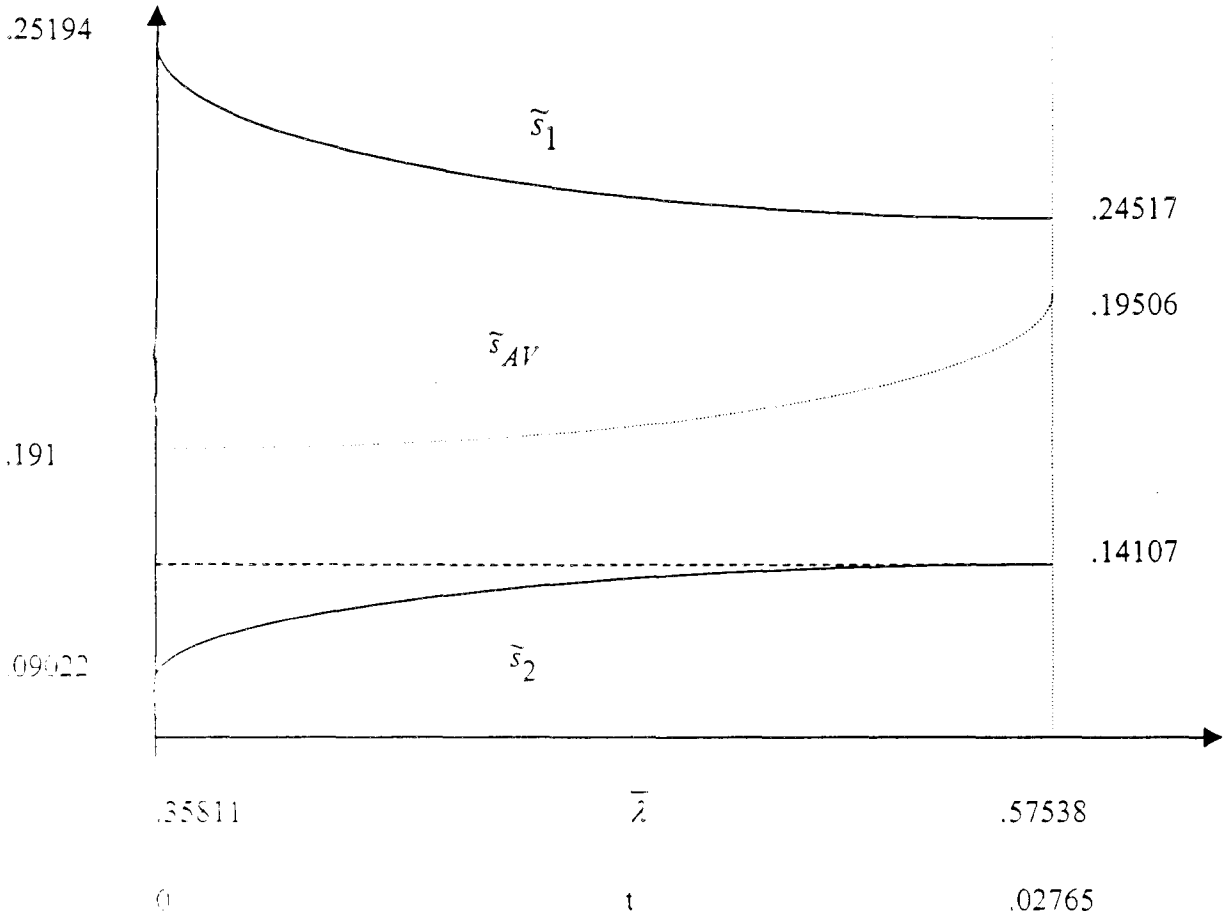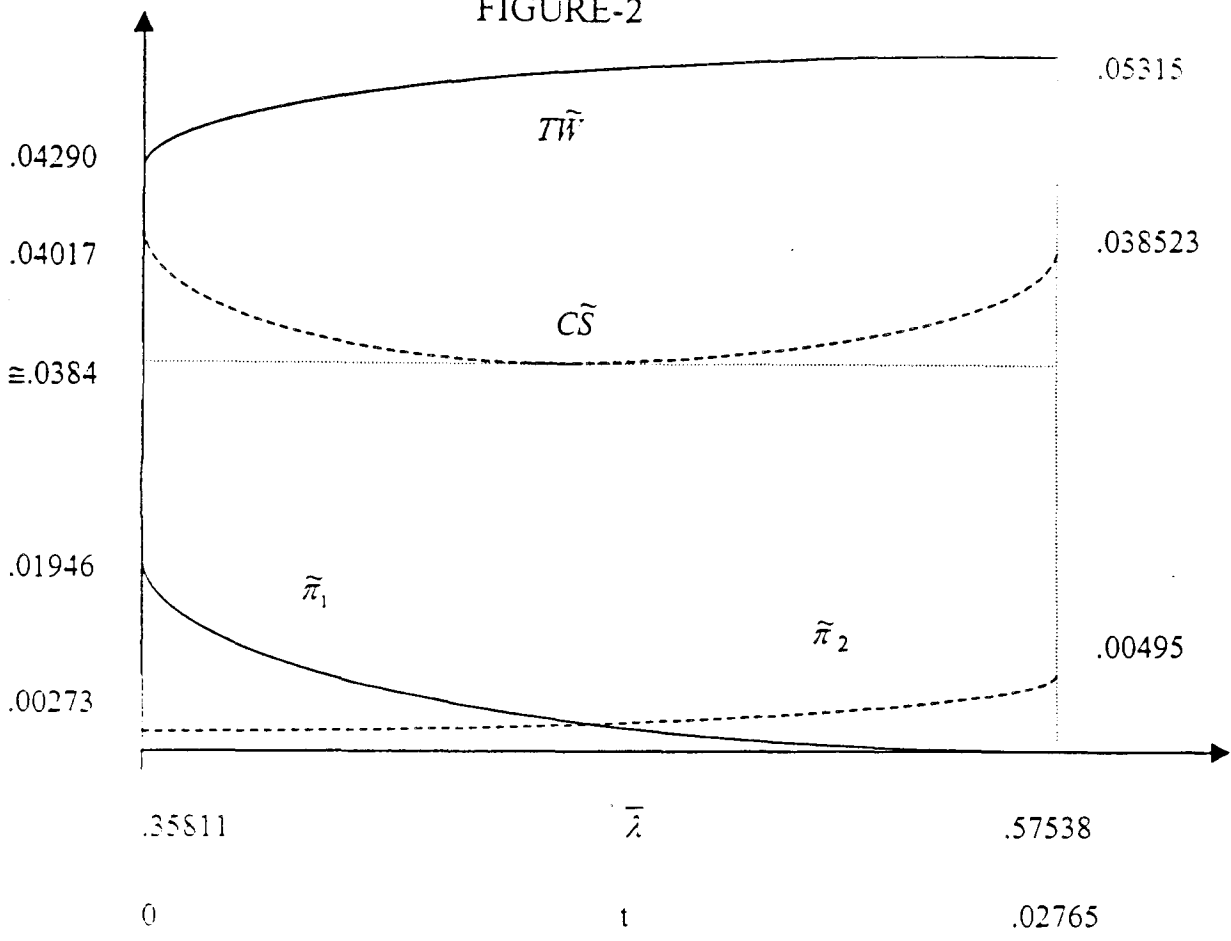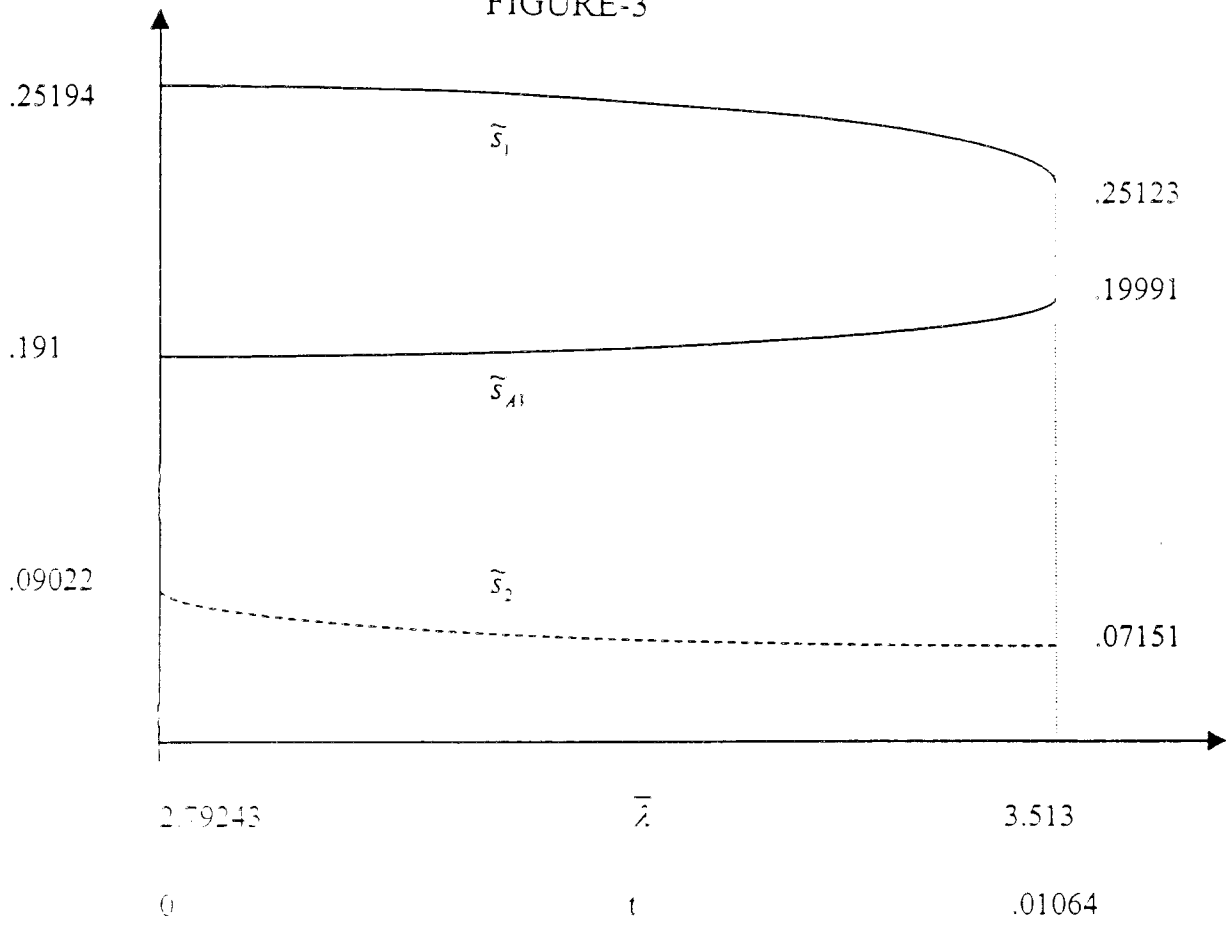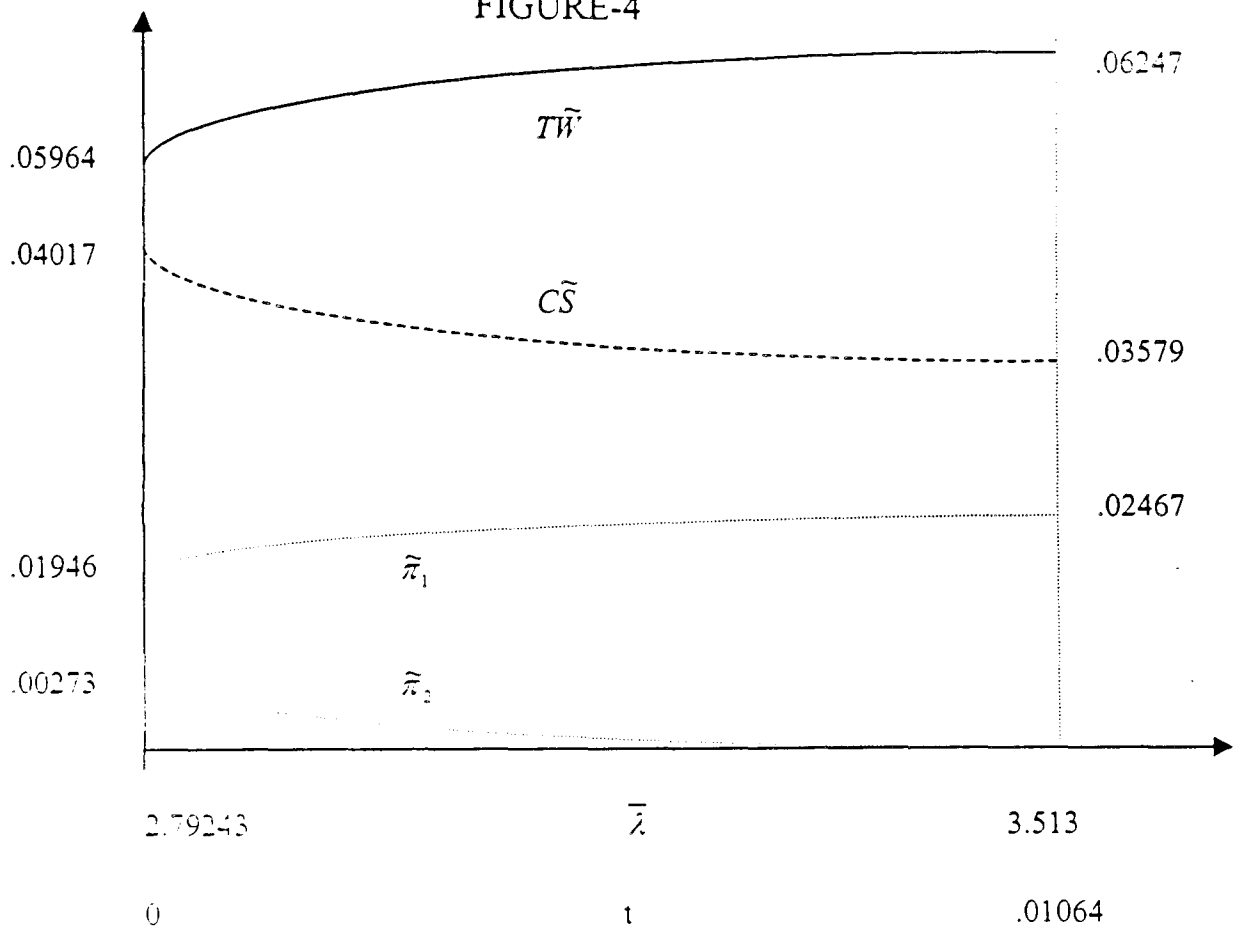
FIGURE-1

FIGURE-2

FIGURE-3

FIGURE-4

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