

WORKING PAPERS IN ECONOMICS

INCENTIVES, PROTECTION AND
TIME CONSISTENCY

by

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ABSTRACT

Given symmetric information, it is assumed that the optimal policy for a policy maker is to commit to future removal of tariff protection as this provides the firm with a greater incentive to undertake cost reducing effort than otherwise. This policy is shown to be time inconsistent and as a result less cost reducing effort is undertaken than in the credible commitment solution. The introduction of asymmetric information weakens this last result as it allows the policy maker to credibly commit to at least some removal of tariff protection. As a consequence, the expected value of the policy maker's objective function may be greater under asymmetric information than symmetric information.

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1. Introduction

Tariff protection is often introduced on a temporary basis so that an industry can profitably produce what the policy maker views as the optimal amount of output, given current costs at home and abroad. This protection is given on the understanding that it will be removed in the future as this gives the industry an incentive to undertake cost reducing investment or effort so as to be internationally competitive in the future.¹ Nevertheless, costs are often not reduced and temporary protection is renewed again and again, eventually taking on the appearance of permanent protection.²

One reason for the failure of industries to reduce costs is that the future removal of tariff protection is time inconsistent. If it is optimal for the policy maker to give tariff protection today, with today's costs, then it will be optimal for the policy maker to give protection tomorrow if costs tomorrow are the same as they are today. The time inconsistency of future tariff removal weakens the incentive that the industry has to undertake cost reducing investment or effort because it knows that if costs are not reduced, then tariff protection will be renewed. As a result, less cost reducing investment or effort is undertaken than the policy maker desires with the consequence that future costs are often not reduced by enough for an industry to profitably produce what the policy maker views as the optimal amount of output, given costs, unless tariff protection is renewed.

Two recent papers analyse this time inconsistency problem. Matsuyama (1990) constructs an infinite horizon, perfect information game of timing and demonstrates that the subgame perfect equilibrium that supports temporary protection is not renegotiation-proof, that is, it is time inconsistent. Tornell (1991) constructs a two period, perfect information

¹ This paper concentrates on the incentive effects of temporary protection [Matsuyama (1990)] rather than the traditional infant industry argument for temporary protection which is technologically based [Kemp 1960].

² Yamamura (1986) documents that the Japanese aluminium, chemical, and steel industries received temporary assistance in 1978 that was renewed in 1983 after these industries failed to adjust. In Australia, the passenger motor vehicle industry and the textile, clothing, and footwear industries were the recipients of renewed protection over a period extending from the 1950's to the present [Woodland (1991)].

model in which a policy maker has a target level of employment and can use investment-contingent subsidies to induce the firm to undertake investment and achieve the target level of employment. He demonstrates that what he calls the “made to measure” subsidy does not eliminate the time inconsistency of tariff removal.³

This paper extends the work of Matsuyama and Tornell by adding uncertainty and asymmetric information to the analysis. Uncertainty is introduced by assuming that more cost reducing effort (investment) increases the probability of reduced future costs while asymmetric information is introduced by assuming that the amount of effort undertaken and costs are private information not available to the policy maker.

The two period model is outlined in Section 2 and 3. A single domestic firm, which is a price taker on the world market, chooses period 1 effort to maximise the present value of its profit stream. In period 1, it is assumed that it is optimal for the policy maker to give the firm tariff protection while committing to the removal of this protection in period 2. This future tariff removal provides the firm with an incentive to undertake more cost reducing effort than otherwise.

In Section 4, this policy is shown to be time inconsistent because if period 2 costs are not reduced, it is optimal to have tariff protection in period 2. As a result, less cost reducing effort is undertaken in period 1 and more output is produced in period 2 (when costs are not reduced) than is optimal under credible commitment. It is also shown that the time consistency of tariff removal can not be resurrected via effort-contingent subsidies.

Asymmetric information is introduced in Section 5 by assuming that the policy maker is unable to observe firm effort or costs.⁴ In these circumstances, regardless of its costs, the firm has an incentive to represent itself as having high costs in order to receive tariff protection. Applying the ‘Revelation Principle’ [Myerson (1979)] allows the policy maker’s

³ In a different setting, Staiger and Tabellini (1987) analyse the time inconsistency of optimal trade policies.

⁴ This paper makes no attempt to solve the hidden action (moral hazard) problem as it is assumed that the only policy instrument available to the policy maker is an import tariff. Wright (1990) and (1991) deals with the hidden action problem in a learning-by-doing framework.

period 2 problem to be written as a maximization problem with incentive compatibility constraints. It is shown that the solution to this problem is a separating solution in which it is optimal (i) for a high cost firm to choose a protection package characterised not only by a tariff rate, but also a restriction which states that if this package is chosen, then the firm can not produce more output than is optimal for a firm with high costs and (ii) for a low cost firm to choose a protection package characterised only by a tariff rate.

Section 6 demonstrates that more cost reducing effort may be undertaken with asymmetric information than symmetric information. As a result, the expected value of the policy maker’s objective function may be greater with asymmetric information than symmetric information. Asymmetric information allows the policy maker to credibly commit to the removal of at least some tariff protection and this increases the expected value of the policy maker’s objective function. Some concluding remarks are made in Section 7.

2. Model Structure

2.1. The Firm

A single domestic firm which takes the world price as given faces a two period problem. In period 1, the firm chooses period 1 output and cost reducing effort to maximise the present value of its profit stream. The common discount factor of the firm and the policy maker is given by δ . Although the cost reducing effort (or expenditure) is undertaken in period 1 it is assumed that its effects are not realised until period 2. In period 2, given the effects of period 1 cost reducing effort, the firm chooses output to maximise period 2 profit.

The world price is given by p^w in each period. In period 1, the firm’s cost function is given by $c_1(q_1)$, where $c_1'(q_1) > 0$ and $c_1''(q_1) > 0$. In period 2, for simplicity, the firm’s cost function is assumed to be

$$c_2(q_2, \theta) = c_1(q_2) - \theta \cdot \alpha \cdot q_2, \quad (2.1)$$

where

$$\theta = \begin{cases} 1, & \text{with probability } \rho(e); \\ 0, & \text{with probability } (1 - \rho(e)), \end{cases} \quad (2.2)$$

and $\alpha > 0$, $\rho'(e) > 0$, $\rho''(e) < 0$, $\rho(e) = 0$ if $e = 0$, and $\rho(e) < 1 \forall e$. The conditions on $\rho(e)$ capture the idea that more cost reducing effort increases the probability of reducing costs, though at a decreasing rate. An implication of (2.1) and (2.2) is that there are only two cost states, high cost ($\theta = 0$) and low cost ($\theta = 1$). Finally, the cost of cost reducing effort is given by $v(e)$, where $v'(e) > 0$ and $v''(e) > 0$.

2.2. The Policy Maker

In each period, the objective function of the policy maker is assumed to be $B(q^p, q^c)$, where q^p is the quantity produced by the firm and q^c is the quantity consumed by domestic consumers. It is assumed in this very partial equilibrium analysis that $q^c > q^p$ so that the good in question is an importable. It is further assumed that $B(q^p, q^c)$ is a strictly concave function which is increasing in both arguments. The inclusion of q^c in the policy maker's objective function is fairly standard, however, the inclusion of q^p warrants some discussion. q^p is included to capture the idea that the policy maker is concerned with the size of the industry (in this case, the size of a firm) because the industry has some positive externalities associated with it or the industry's size is important politically.

It is assumed that the only policy instrument available to the policy maker is tariff protection which takes the form of an *ad valorem* tariff at rates t_1 and t_2 in periods 1 and 2 respectively. Given p^w and the firm's cost function in each period, it is clear that the profit maximising output of the firm is an increasing function of the tariff in each period and that the function obtained in period 2 depends on the cost state θ . Let these profit maximising output functions be given by $q_1^p(t_1)$ and $q_2^p(t_2, \theta)$.

On the consumption side it is assumed that the domestic demand curve is downward sloping so the quantity consumed is the same decreasing function of the tariff in each period. Let this function be given by $q^c(t)$.

The profit maximising output functions and $q^c(t)$ determine the combinations of q^p and q^c which are feasible for the policy maker in each period, given the policy maker can only affect q^p and q^c via a tariff. Substituting these functions into the objective function of the policy maker gives feasible values of the objective function as a function of t_1 in period 1 and t_2 and θ in period 2. Let the resulting functions be given by $B_1(t_1)$ and $B_2(t_2, \theta)$. To distinguish low cost and high cost states more easily let $B_2(t_2, \theta = 1)$ be denoted by $B_2^L(t_2^L)$ and let $B_2(t_2, \theta = 0)$ be denoted by $B_2^H(t_2^H) = B_1(t_1)$. It is assumed that $B_2^L(t_2^L)$ reaches its maximum at $t_2^L = 0$ and that $B_2^H(t_2^H)$ reaches its maximum at $t_2^H = \bar{t}^H > 0$. This captures the idea that no protection is necessary in period 2 if the low cost state occurs, and seems consistent with tariff reduction programmes. It is assumed that $B_2^H(t_2^H) = B_1(t_1)$ is a strictly increasing function for $t_2^H < \bar{t}^H$ and a strictly decreasing function for $t_2^H > \bar{t}^H$. It is also assumed that $B_2^L(t_2^L)$ is a strictly decreasing function for $t_2^L > 0$. Finally, for a given t_2 , $B_2^L(t_2) > B_2^H(t_2)$ because firm output is greater in the low cost state than the high cost state.

3. Credible Commitment and Symmetric Information

In this section, it is assumed that the firm's effort and costs are publicly observable so there is symmetric information. It is also assumed that the policy maker can credibly commit in period 1 to a level of protection in period 2. Finally, in the spirit of tariff reduction programmes, it is assumed that it is optimal for the policy maker to commit in period 1 to the removal of protection in period 2, but to keep the period 1 tariff at its optimal level. Although a zero tariff is not optimal in period 2 if the high cost state occurs, the policy maker is prepared to accept this cost in order to provide the firm with a greater incentive to undertake cost reducing effort in period 1.

In period 2, given p^w , $c_2(q_2, \theta)$, and the ability of the policy maker to credibly commit to the removal of period 2 protection, the firm chooses q_2 to maximise period 2 profit. Let the solution to this problem be either \bar{q}_2^H ($\theta = 0$) or \bar{q}_2^L ($\theta = 1$) and let the maximised profit

associated with these outputs be either $\bar{\Pi}_2^H$ or $\bar{\Pi}_2^L$.

In period 1, the firm chooses q_1 and e to maximise the present value of its profit stream. The choice of q_1 is trivially obtained by equating marginal revenue to marginal cost, that is,

$$p^w \cdot (1 + i^H) - c_1'(q_1) = 0, \quad (3.1)$$

while the choice of e is obtained from the following first order condition

$$\delta \cdot \rho'(e) \cdot (\bar{\Pi}_2^L - \bar{\Pi}_2^H) - v'(e) = 0. \quad (3.2)$$

Let the solution of this condition be given by \bar{e} .

4. Non-credible Commitment and Symmetric Information

In this section it is assumed that the policy maker can not credibly commit in period 1 to remove protection in period 2, rather, in period 2 the policy maker does whatever is optimal given cost conditions in period 2. In these circumstances, if the high cost state arises, the policy maker will find it optimal to set the tariff at its optimal level, \bar{i}^H . Given this tariff, let the firm's choice of q_2 be given by \bar{q}_2^H and let the maximised profit associated with this output be given by $\bar{\Pi}_2^H$, where $\bar{q}_2^H > \bar{q}_2^L$ and $\bar{\Pi}_2^H > \bar{\Pi}_2^L$. If the low cost state arises the optimal tariff is zero so that output is \bar{q}_2^L .

In period 1, the choice of e is obtained from a similar condition to (3.2) except $\bar{\Pi}_2^H$ is replaced by $\bar{\Pi}_2^L$. Let the solution to this condition be given by \bar{e} . As $\bar{\Pi}_2^H > \bar{\Pi}_2^L$, it is clear from (3.2) that $\bar{e} > \bar{e}$. These results are summarised in Proposition 1.

Proposition 1: *Given the assumptions regarding $B_2(t_2, \theta)$, removal of tariff protection in period 2 is not time consistent. Less cost reducing effort is undertaken in period 1 and more output is produced in the high cost state of period 2 than is optimal under credible commitment.*

Effort \bar{e} can be induced from the firm by an effort-contingent subsidy. The addition of a per-unit effort-contingent subsidy of s changes the firm's period 1 problem to

$$\max_{q_1, e} p^w \cdot (1 + i^H) \cdot q_1 - c_1(q_1) + \delta(\rho(e) \cdot \bar{\Pi}_2^L + (1 - \rho(e)) \cdot \bar{\Pi}_2^H) + s \cdot e - v(e). \quad (4.1)$$

The relevant first order condition for the choice of e is

$$\delta \cdot \rho'(e) \cdot (\bar{\Pi}_2^L - \bar{\Pi}_2^H) + s - v'(e) = 0. \quad (4.2)$$

By comparing (4.2) with (3.2) it is clear that if $s = \delta \cdot \rho'(e) \cdot (\bar{\Pi}_2^H - \bar{\Pi}_2^L)$ calculated at \bar{e} , then the period 1 solution without credible commitment but with an effort-contingent subsidy involves \bar{q}_1 and \bar{e} . Nevertheless, if the high cost state occurs in period 2, then tariff protection of \bar{i}^H will be given.

This result is summarised in Proposition 2.

Proposition 2: *The removal of tariff protection in period 2 is not time consistent even if an effort-contingent per-unit subsidy is used to induce \bar{e} .*

Proposition 2 is significant because Tornell (1991) demonstrates, in a somewhat different two period model, that the investment(effort)-contingent subsidy which induces the firm to undertake the optimal amount of investment in the face of what he calls the "renewal-of-protection" function, also makes removal of tariff protection time consistent.⁵ Tornell's result disappears if uncertainty is introduced into his model in a similar manner as it is introduced in this paper.

5. Non-credible Commitment and Assymmetric Information

In this section it is assumed that the policy maker can not observe firm cost reducing effort nor firm costs. Therefore, it can not pay effort-contingent subsidies, nor offer

⁵ Tornell, however, does demonstrate that what he calls the "made to measure" investment-contingent subsidy is time inconsistent.

protection contingent on the cost state. However, it will do whatever is optimal in each period given the information it possesses. This latter requirement (time consistency) means that the policy maker's problem must be solved backwards.

5.1. Period 2

In period 2, the policy maker must choose the degree of tariff protection to maximise its objective function. However, the policy maker does not know the firm's costs, they are proprietary to the firm. In these circumstances, the symmetric information solution in which the high cost firm was given tariff \bar{t}^H and the low cost firm was given no protection may not maximise expected welfare because the low cost firm has an incentive to represent itself as having high costs so that it receives tariff protection.

Application of the Revelation Principle [Myerson (1979)] allows the policy maker's problem to be written as a maximisation problem in which there are incentive compatibility constraints and the solution involves a menu of two protection packages, one intended for a high cost firm and the other intended for a low cost firm. It is assumed that the protection package intended for the high cost firm specifies a tariff as well as the restriction that output can be no greater than that which is optimal for a high cost firm. The protection package intended for the low cost firm just specifies a tariff. The two packages are respectively given by

$$(t_2^H, q_2^H(t_2^H)) \quad \text{and} \quad (t_2^L), \quad (5.1)$$

where $q_2^H(t_2^H)$ is the profit maximising output of a high cost firm given tariff t_2^H .

The policy maker's problem can now be written as

$$\max_{t_2^H, t_2^L} \rho \cdot B_2^L(t_2^L) + (1 - \rho) \cdot B_2^H(t_2^H), \quad (5.2)$$

subject to

$$\Pi^{L,L}(t_2^L) \geq \Pi^{H,L}(t_2^H) \quad (5.3)$$

and

$$q_2^H = q_2^H(t_2^H), \quad (5.4)$$

where ρ is the probability the policy maker attaches to the firm being low cost and $\Pi^{i,j}(t_2^i)$; $i, j = H, L$ is the maximised profit of a firm with costs j when it chooses the package intended for the firm with costs i . The incentive compatibility (self-selection) constraint (5.3) ensures that a low cost firm chooses the protection package intended for the low cost firm.⁶

It is clear given the assumptions regarding cost functions that $\Pi^{L,L}$ and $\Pi^{H,H}$ are strictly increasing functions of t_2^L and t_2^H respectively. For $t_2^L = t_2^H$ it is also clear that $\Pi^{L,L} > \Pi^{H,L} > \Pi^{H,H}$ and that

$$\frac{d\Pi^{L,L}(t_2^L)}{dt_2^L} > \frac{d\Pi^{H,H}(t_2^H)}{dt_2^H} \quad (5.5)$$

as $q_2^L > q_2^H$. Although $\frac{d\Pi^{H,L}(t_2^H)}{dt_2^H} > \frac{d\Pi^{H,H}(t_2^H)}{dt_2^H}$ because of the cost saving on extra output, the relationship between $\frac{d\Pi^{L,L}(t_2^L)}{dt_2^L}$ and $\frac{d\Pi^{H,L}(t_2^H)}{dt_2^H}$ at $t_2^L = t_2^H$ is ambiguous.

The symmetric information solution occurs where $B_2^L(t_2^L)$ and $B_2^H(t_2^H)$ attain their maximums, that is, at $t_2^L = 0$ and $t_2^H = \bar{t}^H$. If $\Pi^{L,L}(0) \geq \Pi^{H,L}(\bar{t}^H)$, then incentive compatibility constraint (5.3) does not bind at the symmetric information solution. In this case, if the policy maker offers the symmetric information protection packages, with the additional restriction that the output of a firm choosing the package intended for a high cost firm can be no greater than that which is optimal for a high cost firm, then each type of firm will choose the package intended for it and the symmetric information solution is attainable. On the other hand, if $\Pi^{L,L}(0) < \Pi^{H,L}(\bar{t}^H)$, then both types of firm will choose the package intended for the high cost firm and the symmetric information solution is not attainable. For the remainder of this section it is assumed that the incentive compatibility constraint is binding.

⁶ There is no participation constraint as both high and low cost firms are assumed to make positive profit when no tariff protection is offered.

Proposition 3: *Pooling, in which both types of firm are offered the same protection package, is not a solution to the policy maker's problem.*

Proof: First consider the case in which both firms are offered a protection package of the form $(t_2^H, q_2^H(t_2^H))$. Regardless of firm type, the policy maker obtains $B_2^H(t_2^H)$. This pooling package is dominated by the pooling package (\bar{t}_2^H) , which does not restrict output to the profit maximising level of the high cost firm, because $B_2^H(\bar{t}_2^H)$ is still obtained if the firm is high cost, but $B_2^L(\bar{t}_2^H)$ is obtained if the firm is low cost and $B_2^L(\bar{t}_2^H) > B_2^H(\bar{t}_2^H)$.

Now consider the menu of protection packages $(t_2^H, q_2^H(t_2^H))$; (\bar{t}_2^L) , where $\bar{t}_2^L = 0$ if $\Pi^{H,L}(t_2^H) < \Pi^{L,L}(0)$, and $\bar{t}_2^L > 0$ otherwise and is obtained from the incentive compatibility constraint $\Pi^{H,L}(t_2^H) = \Pi^{L,L}(\bar{t}_2^L)$. The low cost firm chooses package (\bar{t}_2^L) and the high cost firm chooses package $(t_2^H, q_2^H(t_2^H))$. $\Pi^{L,L}(t_2^L)$ and $\Pi^{H,L}(t_2^H)$ are both strictly increasing functions and $\Pi^{L,L}(t_2^L) > \Pi^{H,L}(t_2^H)$ at $t_2^L = t_2^H$, so $\bar{t}_2^L < t_2^H$. Since $\bar{t}_2^L < t_2^H$ and $B_2^L(t_2^L)$ is a strictly decreasing function with a maximum at $t_2^L = 0$, it must be the case that $B_2^L(\bar{t}_2^L) > B_2^L(t_2^H)$. Therefore, the menu of protection packages given above dominates the pooling package (t_2^H) . (Q.E.D.)

Proposition 3 states that any solution to the policy maker's problem must involve the two types of firms being separated in that each chooses a different protection package. The set of protection packages which satisfy incentive compatibility constraint (5.3) is large. However, only a subset of these packages remain after those which are weakly dominated are eliminated. Let \underline{t}_2^H be the solution for t_2^H from $\Pi^{L,L}(0) = \Pi^{H,L}(t_2^H)$ and let \bar{t}_2^L be the solution for t_2^L from $\Pi^{L,L}(t_2^L) = \Pi^{H,L}(\bar{t}_2^H)$.

Proposition 4: *The only separating solutions to the policy maker's problem that remain after those which are weakly dominated are eliminated involve $t_2^H \in [\underline{t}_2^H, \bar{t}_2^H]$ and $t_2^L \in [0, \bar{t}_2^L]$, where the t_2^L which is paired with t_2^H is obtained from the incentive compatibility constraint $\Pi^{L,L}(t_2^L) = \Pi^{H,L}(t_2^H)$.*

Proof: (i) Consider $t_2^H > \bar{t}_2^H$. As \bar{t}_2^H maximises $B_2^H(t_2^H)$, then $B_2^H(\bar{t}_2^H) > B_2^H(t_2^H)$. From

the incentive compatibility constraint the t_2^L which is associated with t_2^H is greater than \bar{t}_2^L . As $B_2^L(t_2^L)$ is a strictly decreasing function that achieves its maximum at $t_2^L = 0$, then $B_2^L(\bar{t}_2^L) > B_2^L(t_2^L)$. That is, any separating solution involving $t_2^H > \bar{t}_2^H$ is strictly dominated by the separating solution involving \bar{t}_2^H . (ii) Consider $t_2^H < \underline{t}_2^H$. As $\underline{t}_2^H < \bar{t}_2^H$ and $B_2^H(t_2^H)$ is a strictly increasing function for $t_2^H < \bar{t}_2^H$, then $B_2^H(\underline{t}_2^H) > B_2^H(t_2^H)$. From the incentive compatibility constraint the t_2^L associated with t_2^H is the same as that associated with \underline{t}_2^H , namely, $t_2^L = 0$. Therefore, any separating solution involving $t_2^H < \underline{t}_2^H$ is weakly dominated by the separating solution involving \underline{t}_2^H . (Q.E.D.)

From the set of separating solutions that survive weak domination, the one that maximises expected welfare is chosen by the policy maker. Clearly, this choice depends on ρ . The greater is the probability that the policy maker attaches to the firm being low cost, the less weight it attaches to distortions from the high cost symmetric information solution and the more weight it attaches to distortions from the low cost symmetric information solution. Therefore, the greater is ρ , the greater is t_2^L and the smaller is t_2^H in the optimal separating solution. Let $(\hat{t}_2^H, \hat{q}_2^H = q_2^H(\hat{t}_2^H))$ and (\hat{t}_2^L) be the protection packages in the optimal separating solution and let \hat{q}_2^L be the profit maximising output of a low cost firm given \hat{t}_2^L . Let maximised profit in the optimal separating solution be given by $\hat{\Pi}^{L,L}$ and $\hat{\Pi}^{H,H}$ for the low and high cost firm respectively.

To date, nothing has been said about how ρ is formed. In keeping with the style of this paper, it seems appropriate to assume that in forming ρ the policy maker knows the firm's problem, the firm knows the policy maker's problem, and the policy maker knows the firm knows this etc. etc., that is, both the policy maker's and the firm's problems are common knowledge.

Given this assumption, for the policy maker to assess probability ρ^0 to the firm being low cost, it must believe that in period 1 the firm undertook effort e^0 , where $e^0 = \rho^{-1}(\rho^0)$. For the policy maker to believe the firm undertook e^0 in period 1, the policy maker must

believe that the firm believed a separating solution would be offered in period 2 in which the difference between the profit of a low and high cost firm would be Π^{D^0} , where Π^{D^0} is obtained from first order condition $\delta \cdot \rho'(e^0) \cdot (\Pi^D) - v'(e^0) = 0$. In turn, for the policy maker to believe that the firm believes the separating solution that involves Π^{D^0} will be offered in period 2, the policy maker must believe that the firm believes that the policy maker believes that the probability of the firm being low cost is ρ^* , where ρ^* leads the policy maker to choose the separating solution involving Π^{D^0} . So, given the assumption of common knowledge, if the policy maker assesses probability ρ^0 to the firm being low cost, then it must believe that the firm believes the policy maker believes the firm is low cost with probability ρ^* .

Can ρ^0 and ρ^* differ? This depends on the following question. Is it reasonable for the policy maker to believe that the firm believes the policy maker believes ρ^* , when this set of beliefs leads the policy maker to believe something else, namely ρ^0 ? If the answer to this question is yes, then any ρ can be supported by some set of beliefs. However, if the answer is no, then $\rho^0 = \rho^*$ and using a fixed point theorem it is shown in Appendix 1 that there is only one such ρ^0 .

5.2. Period 1

Regardless of the answer to the preceding question, given the firm's period 1 beliefs that the probability assessment of the policy maker in period 2 is ρ , the firm's choice of effort in period 1 is obtained from the following first order condition

$$\delta \cdot \rho'(e) \cdot \Pi^D(\rho) - v'(e) = 0. \quad (5.6)$$

Let the solution of this condition be given by \bar{e} .

6. Comparison of Results

Sections 3, 4, and 5 provide the following ordering of tariffs

$$0 \leq \hat{t}_2^L < \hat{t}_2^H \leq \bar{t}^H. \quad (6.1)$$

These can be used to order outputs as firm output is an increasing function of the tariff.

This yields

$$\bar{q}_2^H < \hat{q}_2^H \leq \hat{q}_2^L \quad (6.2)$$

and

$$\bar{q}_2^L \leq \hat{q}_2^L. \quad (6.3)$$

Firm profit is also an increasing function of the tariff which provides the following ordering of cost reducing effort

$$\bar{e} > \hat{e} \quad (6.4)$$

and

$$\hat{e} > \bar{e}. \quad (6.5)$$

The latter inequality follows because $\hat{t}_2^L \geq 0$ and $\hat{t}_2^H \leq \bar{t}^H$. The ordering of \bar{e} and \hat{e} is ambiguous.

Proposition 5: *Where commitment to tariff removal in period 2 is not credible, the period 1 expected value of the policy maker's objective function may be greater with asymmetric information than symmetric information.*

Proof: By assumption, the period 2 policy maker's objective function is maximised by setting $t_2^L = 0$ and $t_2^H = \bar{t}^H$. Therefore, from (6.1) it follows, in each cost state, that the value of the policy maker's period 2 objective function can be no greater with asymmetric information than with symmetric information. However, it follows from (6.5) that the probability of the low cost state being obtained is greater with asymmetric information than symmetric information. Therefore, the expected value of the policy maker's objective function may be greater with asymmetric information than symmetric information. (Q.E.D.)

Proposition 5 can be understood once it is realised that the asymmetry of information allows the policy maker to credibly commit in period 1 to the removal of at least some

tariff protection in period 2. As the optimal policy of the policy maker is to commit in period 1 to the removal of all tariff protection in period 2, the asymmetry of information may increase the expected value of the policy maker's objective function.

7. Conclusion

This paper has extended the work of Tornell (1991) and Matsuyama (1990) on the time inconsistency of tariff removal programmes by adding uncertainty and asymmetric information to the discussion. The addition of uncertainty was found to make tariff removal time inconsistent even in the presence of period 1 effort(investment)-contingent subsidies. This strengthens the result of Tornell (1991) who found that what he called the 'made-to-measure' subsidy was time inconsistent, though there was what he called an oversubsidization rate that made tariff removal time consistent.

The addition of asymmetric information concerning firm effort and costs was found to make at least some tariff removal time consistent, though complete removal of tariff protection was time inconsistent. This suggests that arguments concerning the time inconsistency of tariff removal programmes may not be robust to differing assumptions about private information. The time consistency of at least some tariff protection led to the interesting proposition that the expected value of the policy maker's objective function may be greater under asymmetric information than symmetric information.

Finally it should be noted that the argument that asymmetric information allows at least some tariff removal to be time consistent relies on the ability of the policy maker to credibly commit, in period 2, to a menu of protection packages. That is, after the firm has chosen a protection package and so revealed its costs, the policy maker is assumed not to be able to then offer the firm another protection package even if it makes the firm and the policy maker better off. This is a little unsatisfactory as one could argue that the inability to commit to tariff removal has to some extent been overcome by assuming an ability to commit to a menu of protection packages. However, there is a difference between

the two cases as tariff removal involves a commitment in period 1 to an event in period 2, whereas the menu of protection packages involves a commitment in period 2 to an event in period 2. To the author the latter seems less stringent, though to be completely consistent renegotiation of protection packages which are chosen from a menu of such packages should be explicitly modelled. This is a rich area of future research.

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APPENDIX 1

Proof that a unique $\rho^0 = \rho^*$ exists.

Given ρ^* , the firm believes that in period 2 it will be offered the menu of protection packages such that the difference between the profit of a low and high cost firm is Π^{D^0} . As a result it undertakes e^0 in period 1. If the policy maker believes ρ^* then the policy maker believes that the firm undertook e^0 in period 1 and so the policy maker's assessment concerning the probability of the firm being low cost is $\rho^0 = \rho(e^0)$. To prove that there exists at least one $\rho^0 = \rho^*$ Brouwer's Fixed Point Theorem is used. $\rho^* \in [0, 1]$ and $\rho^0 \in [0, 1]$ are both compact, convex sets. $\rho^0 = \rho\left(e^0\left(\Pi^{D^0}(\rho^*)\right)\right)$ is a continuous function as $\Pi^{L,L}(t_2^L)$ and $\Pi^{H,L}(t_2^H)$ are continuous functions. This continuous function maps from $[0,1]$ into $[0,1]$ so by Brouwer's Fixed point theorem there is a fixed point $\rho^* = \rho(\rho^*)$. Now $\Pi^{D^0}(\rho^*)$ is a strictly decreasing function because $\frac{d\Pi^{H,L}(t_2^H)}{dt_2^H} > \frac{d\Pi^{H,H}(t_2^H)}{dt_2^H}$, so $\rho(\rho^*)$ is a strictly decreasing function. This means that there is a unique fixed point. (Q.E.D.)

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