Tariff and quota equivalence in the presence of asymmetric information

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Abstract

This paper investigates the equivalence of optimal import tariffs and quotas in a Cournot duopoly model when firms have more information about demand than the domestic government. I consider a screening model in which the government offers the domestic firm different contracts from which to choose. I show that the availability and cost of obtaining correct information from the firm depends upon the choice of trade policy instrument. Asymmetric information thus destroys the equivalence of tariffs and quotas, which prevails under complete information, and has a profound impact on how government, firms, and consumers rank different trade policy instruments.

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1. Introduction

Despite considerable trade liberalization since the establishment of GATT in 1948, countries all over the world still impose often severe restrictions on trade. Among the most common of these trade restrictions are tariffs and quantitative import restrictions such as quotas. The fact that governments employ a wide range

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of trade policy instruments at any given point in time suggests that they view different trade policy instruments as imperfect substitutes. This is not surprising because GATT imposes different restrictions on different import barriers. An understanding of the equivalence of various import restrictions is thus important in evaluating national trade policies and guiding international efforts to liberalize trade.

In this paper, I examine how asymmetric information influences the equivalence of specific import tariffs and quotas. Investigating the role of asymmetric information is important because in assessing the market situation and deciding upon the appropriate trade policy, governments often rely upon information provided by domestic industries. However, the interests of government and industry lobbies rarely coincide, so the government has to carefully assess how and at what cost it can extract the correct information from the firms.

I consider a home market Cournot duopoly in which a domestic firm and a foreign firm sell homogeneous goods. Using a duopoly set-up is advantageous because firstly, principal-agent models usually restrict attention to a small number of agents, and secondly, it allows me to obtain simple expressions for the optimal import restrictions by assuming constant marginal cost. The Cournot assumption is useful because Hwang and Mai (1988) show that tariffs and quotas are equivalent under Cournot duopoly and complete information, so any non-equivalence encountered in this paper must be due to asymmetric information. While the firms know whether demand is high or low next period, the government only knows the distribution of demand. In order to extract demand information from the domestic firm, the government screens the firm by offering take-it-or-leave-it menus of import protection. These menus consist of either an import restriction, or an import barrier plus a ‘price’ for obtaining it. The scenario with a price for protection is similar to the set-up in screening models of monopolistic price discrimination as discussed in Mussa and Rosen (1978) and Maskin and Riley (1984).

The equivalence of tariffs and quotas has attracted considerable attention in the literature. Models of perfect competition and complete information predict that tariffs and quotas are perfect substitutes. Fishelson and Flatters (1975) showed, however, that tariffs and quotas are normally not equivalent when the government faces demand or supply uncertainty. Uncertainty is quite different from asymmetric information because, in the case of uncertainty, the government has no means to obtain the desired information from better-informed parties. Therefore, the government cannot distinguish between different uncertain outcomes and has to resort to uniform import restrictions. In contrast, under asymmetric information the government may be able to induce firms to reveal their information.

Models of asymmetric information have recently been introduced into the international trade literature, but have been mostly limited to variations of the well-known Brander–Spencer model of optimal export subsidies. See, for example, Collie and Hviid (1993), Qiu (1994), Brainard and Martimort (1996, 1997), and Maggi (1999). Notable exceptions are Collie and Hviid (1994) and Kolev and
Prusa (1999a), who investigate the impact of asymmetric information on optimal tariffs against a foreign monopolist. In another paper, Kolev and Prusa (1999b) use a duopoly framework to show that the threat of cost-based antidumping measures can induce the foreign firm to use voluntary export restraints in order to signal low efficiency and discourage antidumping complaints. Even though cost-based antidumping would raise welfare under complete information, asymmetric information makes it an undesirable trade policy. All these papers show that results derived for the complete information case can be diametrically different in an economic environment with asymmetric information. I complement this earlier work by demonstrating the large impact asymmetric information has on the equivalence of import restrictions.

The remainder of the paper is organized as follows: I start by presenting the complete information solution in Section 2. Asymmetric information is introduced in Section 3. The case in which the government is not allowed to sell protection is examined in Section 3.1. Section 3.2 investigates the model when a price for protection can be used as an additional policy instrument. Section 4 concludes. All required proofs are in Appendix A.

2. Import tariff vs. quota under certainty

Consider a partial equilibrium model of a home market Cournot duopoly in which a domestic firm (firm 1) and a foreign firm (firm 2) sell homogeneous goods. In this section, I assume that firms and government know whether demand next period will be high or low. For brevity, I call a firm facing high demand ‘high demand firm’ or ‘high type’. A firm facing low demand is referred to as ‘low demand firm’ or ‘low type’.

For simplicity, I assume a linear model specification. Inverse demand is linear of the form $p = a - bx$, where $x$ denotes market demand and $p$ market price. Firm $i$’s cost function is specified as $cx_i$, where $i \in \{1, 2\}$, $x_i$ denotes firm $i$’s output level, $c$ is constant marginal cost, which is identical for both firms, and $c < a$. These assumptions are sufficient but not necessary to derive the major results of this paper. Their main purpose is to ensure simple closed form solutions.

The domestic government uses trade policy to maximize its objective function. The foreign firm’s marginal cost can be increased by a specific import tariff $t$. Alternatively, its sales quantity can be restricted by an import quota $q$. As is common in the equivalence literature, the government is not allowed to use combinations of the two alternative policy instruments. The government offers the domestic firm an import tariff or an import quota either free of charge or it sells import protection to the firm. For brevity, I refer to the first case as the ‘costless protection’ case because the domestic firm receives protection for free. The second case is called the ‘costly protection’ case because here the domestic firm has to pay for protection. To specify the governmental objective function, I use the
standard assumption that the government maximizes the sum of consumer surplus, the domestic firm’s profit, and governmental revenues.

We are now in a position to calculate the optimal import restrictions. Starting with an import tariff, consider the costless protection case first. The government chooses $t$ to maximize the sum of consumer surplus $CS(t) = (2a - 2c - t)^2/18b$, the domestic firm’s profit $\Pi(t) = (a - c + t)^2/9b$, and tariff revenue $TR(t) = t((a - c - 2t)/3b)$. The optimal import tariff is easily calculated as

$$t_{opt} = \frac{a - c}{3},$$

where ‘inf’ stands for complete information. The government’s objective function in the case of costly protection is $CS(t) + \Pi_{tN}(t) - y' + TR(t) + y'$, where $\Pi_{tN}(t)$ is the domestic firm’s profit before subtraction of a protection price and $y'$ denotes the protection price. Clearly, $y'$ cancels out in the governmental welfare function. This implies that the optimal protection price is indeterminate, while the optimal tariff $t_{opt}$, where ‘S’ as in ‘sale’ denotes costly protection, equals $t_{inf}$.

Turning to the quota case, first notice that modeling the quota revenue is somewhat arbitrary. From extracting the foreign firm’s entire profit to not extracting any quota revenue, anything is feasible. To construct a useful baseline case, I model the quota revenue such that the optimal import tariff and quota lead to the same import quantity when there is no demand uncertainty. Then the quota revenue amounts to $QR(q) = q/2(a - bq - c)$. In the costless protection case when the government maximizes the sum of $CS(q) = (a + bq - c)^2/8b$, $\Pi_{tN}(q) = (a - bq - c)^2/4b$, and $QR(q)$, the optimal quota is

$$q_{opt} = \frac{a - c}{9b}.$$  

As in the case of tariffs under costly protection, we also have $q_{S,inf} = q_{inf}$ since the protection price ($y'$) cancels out in the governmental utility function. The optimal protection price is indeterminate.

With these results in hand, we can now compare the optimal trade restrictions. One should be careful in defining equivalence between tariffs and quotas when demand information is asymmetric and a price for protection may be used as an additional policy instrument. In our context, a reasonable definition should distinguish between two types of equivalence: (i) an import tariff and an import quota can be equivalent in terms of market outcome. If an import tariff and an import quota are ‘market outcome equivalent’, they lead to the same sales quantities for firms, and thus to the same market price, consumer surplus, and tariff

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1Here, the subscript N stands for Cournot–Nash.

2Neutralizing or simply ignoring revenue effects has long been a tradition in the equivalence literature. When checking whether tariffs and quotas are equivalent, the import level is often fixed and only price effects are compared.
or quota revenue. Furthermore, governmental utility will be the same. (ii) An import tariff and an import quota can be equivalent in terms of domestic profit. If import tariff and import quota are ‘profit equivalent’, they lead to the same net profit for firm 1. The distinction between market outcome and profit equivalence is necessary because the government may charge a price for protection, thus reducing the domestic firm’s profit. If no protection price is charged, market outcome equivalence implies profit equivalence.

A comparison of the optimal tariff and quota easily establishes that they are market outcome and profit equivalent in the costless protection case. Equivalence also holds when the government charges a price for protection, provided that the government sets \( y' = y^q \) in which case profit equivalence follows from market outcome equivalence. This result is not surprising and reflects the earlier result by Hwang and Mai (1988) for Cournot duopoly.

For subsequent equivalence analysis in an asymmetric information framework, two auxiliary results will prove important. The first result (which follows directly from (1) and (2)) states that although the optimal tariff and quota under complete information are equivalent, an increase in the demand shift parameter \( a \) always leads to a more restrictive tariff, but a more generous quota.

**Lemma 1.** Under complete information, the optimal tariff and the optimal quota are strictly increasing in the demand shift parameter \( a \).

The second result shows that a single-crossing or Spence–Mirrlees condition familiar from principal-agent models holds. Basically, the following lemma says that a high demand firm benefits increasingly more from tighter import protection than a low demand firm.

**Lemma 2.** Let \( a_L \) and \( a_H \) be such that \( a_L < a_H \). Define \( q_{\text{max}}(a) = (a - c)/3b \) as the free trade import quantity where the demand parameter \( a \in [a_L, a_H] \). Let \( t_{\text{min}}(a) = c - a \) be the import subsidy that reduces the domestic firm’s output to 0, and \( t_{\text{max}}(a) = (a - c)/2 \) be the tariff that reduces the foreign firm’s output to 0. Then (i) \( t \mapsto \Pi_{\text{IN}}(t, a_H) - \Pi_{\text{IN}}(t, a_L) \) is strictly increasing for \( t \in [t_{\text{min}}(a_H), t_{\text{max}}(a_H)] \), and (ii) \( q \mapsto \Pi_{\text{IN}}(q, a_H) - \Pi_{\text{IN}}(q, a_L) \) is strictly decreasing for \( q \in [0, q_{\text{max}}(a_H)] \).

In the following, the reader should note that although I discuss asymmetric information about demand, all results I present can be readily extended to asymmetric information about the common technology of the firms, i.e. about the cost parameter \( c \).\(^3\) I focus on the case of asymmetric demand information because demand seems to be far more volatile and thus more difficult to predict for the government.

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\(^3\)Note that in all formulae, \( a \) is accompanied by \(-c\), so derivatives with respect to \( a \) are the same as with respect to \( a - c \).
3. Import protection under asymmetric information

3.1. The costless case

The stage is now set to examine the asymmetric information case. While the firms know the demand next period, the government is uncertain about the realization of the demand parameter \(a\). It assumes that \(a\) takes the value \(a_H\) with probability \(\theta\) and \(a_L\) with probability \(1 - \theta\). Here \(a_L < a_H\) and \(\theta \in (0, 1)\). If the government does not have any means of extracting demand information from the domestic firm, it sets the optimal tariff or quota as if the demand parameter equalled \(\theta a_H + (1 - \theta)a_L\). Thus

\[
t_{unc} = \frac{\theta a_H + (1 - \theta)a_L - c}{3}
\]

and

\[
q_{unc} = \frac{\theta a_H + (1 - \theta)a_L - c}{3b}
\]

are the solutions under uncertainty. These import restrictions are weighted averages \(\theta P_{H,inf} + (1 - \theta)P_{L,inf}\) and \(\theta q_{H,inf} + (1 - \theta)q_{L,inf}\), respectively, of the optimal restrictions for high and low demand under complete information.

I now investigate whether the domestic firm can be induced to reveal its demand information to the government when the only policy instrument at the government’s disposal is a specific import tariff or an import quota. The timing of the game is as follows: the government moves first and offers take-it-or-leave-it menus of import protection from which the domestic firm may choose. Once the import restriction is chosen, the firms set output.

Starting with the tariff case, the government’s screening problem involves maximization of its expected utility by choosing a tariff rate \(t_H\) for the high demand case and a tariff rate \(t_L\) for the low demand case; i.e. it solves

\[
\max \left[ \theta \text{CS}(t_H, a_H) + \Pi_{IN}(t_H, a_H) + \text{TR}(t_H, a_H) \right]
\]

\[
+ (1 - \theta) \left[ \text{CS}(t_L, a_L) + \Pi_{IN}(t_L, a_L) + \text{TR}(t_L, a_L) \right].
\]

This maximization problem is subject to several constraints. If firm 1 is to reveal its demand information, it must be true that this revelation does not make it any worse off than if it kept the information to itself. If the firm did not reveal \(a\), the government would set \(t = t_{unc}\). Therefore, the participation constraints for high and low demand, respectively, are

\[(PC_H): \Pi_{IN}(a_H, a_H) \geq \Pi_{IN}(t_{unc}, a_H), \quad (PC_L): \Pi_{IN}(a_L, a_L) \geq \Pi_{IN}(t_{unc}, a_L).\]

Furthermore, for the government to obtain the correct information, it must not pay for firm 1 to lie about the true state of the world in order to receive the tariff meant for the alternative state. This leads to

\[(IC_H): \Pi_{IN}(t_H, a_H) \leq \Pi_{IN}(t_L, a_H), \quad (IC_L): \Pi_{IN}(t_L, a_L) \leq \Pi_{IN}(t_H, a_L)\]

as the incentive constraints.
Since \( t_{L,\text{inf}} < t_{\text{unc}} \), PC limits out \( t_{L} = t_{L,\text{inf}} \). The IC constraints are even more restrictive. As \( H_{t}(t, a) \) is strictly increasing in \( t \), it is not possible to achieve any solution in which \( t_{L} < t_{H} \), since this would violate IC\(_{L} \). The low demand firm would want to claim high demand in order to obtain a higher import tariff. In particular, this rules out the complete information solution because \( t_{H} < t_{L} \). In fact, it is not possible to offer any set of differing tariffs because even if \( t_{H} < t_{L} \) were true, this tariff structure would violate IC\(_{H} \). This means that \( t_{\text{asy}} = t_{H,\text{asy}} = t_{\text{asy}} \); i.e. the government only offers a single tariff rate. The government’s optimization problem thus turns into the maximization problem under uncertainty; namely,

\[
\max_{t} \left[ \theta \left( CS(t, a_{H}) + \Pi_{t}(t, a_{H}) + TR(t, a_{H}) \right) + (1 - \theta) \left( CS(t, a_{L}) + \Pi_{t}(t, a_{L}) + TR(t, a_{L}) \right) \right].
\]

The solution to this optimization problem is

\[
t_{\text{asy}} = t_{\text{unc}} = \frac{\theta a_{H} + (1 - \theta) a_{L} - c}{3}.
\]

Now suppose that the only policy instrument available to the government is an import quota. The government’s screening problem is

\[
\max_{q_{H}, q_{L}} \left[ \left( H_{t}(q_{H}, a_{H}) + \Pi_{t}(q_{H}, a_{H}) + QR(q_{H}, a_{H}) \right) + (1 - \theta) \left( H_{t}(q_{L}, a_{L}) + \Pi_{t}(q_{L}, a_{L}) + QR(q_{L}, a_{L}) \right) \right]
\]

subject to

\[
\begin{align*}
\text{(IC\(_{H}\))}: \Pi_{t}(q_{H}, a_{H}) & \geq \Pi_{t}(q_{L}, a_{H}), \\
\text{(IC\(_{L}\))}: \Pi_{t}(q_{L}, a_{L}) & \geq \Pi_{t}(q_{H}, a_{L}), \\
\text{(PC\(_{H}\))}: \Pi_{t}(q_{H}, a_{H}) & \geq \Pi_{t}(q_{unc}, a_{H}), \\
\text{(PC\(_{L}\))}: \Pi_{t}(q_{L}, a_{L}) & \geq \Pi_{t}(q_{unc}, a_{L}).
\end{align*}
\]

Under complete information, the government wants to offer a higher quota to the firm in case of high demand. But as the firm is interested in more protection, it has an incentive to underreport demand when demand is high, i.e. \( q_{L} < q_{H} \) conflicts with IC\(_{H} \). Similarly, IC\(_{L} \) does not allow for \( q_{H} < q_{L} \). This means that \( q_{H,\text{asy}} = q_{L,\text{asy}} = q_{\text{asy}} \). As in the tariff case, the government’s maximization problem can be rewritten as the maximization problem under uncertainty which is solved by

\[
q_{\text{asy}} = q_{\text{unc}} = \frac{\theta a_{H} + (1 - \theta) a_{L} - c}{4b}.
\]

If the demand parameter were \( \theta a_{H} + (1 - \theta) a_{L} \), the optimal quota and tariff would imply the same import quantity. However, given that the demand parameter is either \( a_{H} \) or \( a_{L} \), the optimal quota and the optimal tariff do not lead to the same import quantity. As the government is not able to extract any information from the domestic firm, the asymmetric information case reduces to the uncertainty model.

For perfect competition, Fishelson and Flatters (1975) demonstrated that under
uncertainty, a tariff and a quota are not equivalent. The same is true in the Cournot model. For \( a = a_H \), \( q_{asy} < q_{H,int} \) and \( t_{asy} < t_{H,int} \). The latter implies that \( x_{2N(t_{asy}, a_H)} > q_{H,int} > q_{asy} \) since \( q_{H,int} = x_{2N(t_{H,int}, a_H)} \). Due to the strict monotonicity of the domestic profit and the consumer surplus in import quantities, it follows that for high demand, consumers are better off when a tariff is employed, while the domestic firm is better off with a quota. For \( a = a_L \), the governmental utility function reaches its maximum at \( q \) and declines symmetrically when imports rise or fall. Since \( x_{2N(t_{asy}, a_H)} - q_{H,int} - (q_{H,int} - q_{asy}) = (1 - \theta)(a_H - a_L) / 9b \) is strictly positive, governmental utility is higher when a quota is employed.

Similarly, when \( a = a_L \), we can show that the consumers and government are better off when a quota is employed, whereas the domestic firm prefers a tariff.

The following proposition summarizes the findings of this section.

**Proposition 1.** In the model with asymmetric information in which the government uses only an import barrier: (i) the government offers a uniform import tariff and import quota which are both increasing in \( \theta \). (ii) The optimal tariff (quota) is a weighted average of \( t_{L,int} \) and \( t_{H,int} \) (\( q_{L,int} \) and \( q_{H,int} \)). (iii) The optimal import tariff and import quota are not market outcome or profit equivalent. Imports are higher (lower) under a tariff than under a quota when demand is high (low). Consumers are thus better off under a tariff (quota) when demand is high (low), whereas firm 1’s profit is lower (higher) under a tariff than under a quota when demand is high (low). Governmental utility under a quota exceeds utility under a tariff. (iv) The complete information solution is infeasible because the low (high) demand firm would misrepresent demand in case of a tariff (quota). Furthermore, the complete information solution would violate the participation constraint for the low (high) demand firm in the tariff (quota) case.

### 3.2. The costly case

When import protection is costly, the government offers contracts which consist of an import restriction \( t \) or \( q \) and a protection price \( y_t \) or \( y_q \), respectively, for it. The protection price \( y \) does not enter the government’s objective function. A higher \( y \) raises the government’s revenues but lowers the domestic firm’s profit in a one-to-one fashion. As the domestic government values these welfare components equally, \( y \) cancels out. But as I will now demonstrate, charging a price for protection may be important in solving the problem of misinformation incentives.

When a tariff is employed, the government solves

\[
\max_{t_{H,int}, t_{L,int}, y_H, y_L} \{ \theta [CS(t_H, a_H) + \Pi_{1N}(t_H, a_H) + TR(t_H, a_H)] + (1 - \theta) [CS(t_L, a_L) + \Pi_{1N}(t_L, a_L) + TR(t_L, a_L)] \}
\]

such that the following participation and incentive compatibility constraints hold:
Selling protection enables the government to implement the complete information tariff levels, which was impossible when protection was offered free of charge. As discussed in Section 3.1, the low demand firm then has an incentive to claim high demand. In the costly protection case, however, the government can increase the relative benefits of claiming low demand using the protection price. Specifically, the government can pay the firm a lump-sum subsidy when demand is low. The fact that \( y'_{L} < 0 \) is necessary can be inferred from the participation constraint for the low demand firm. Since \( t_{\text{unc}} \) is a weighted average of \( t_{L,\text{int}} \) and \( t_{H,\text{inf}} \), it is thus higher than \( t_{L,\text{inf}} \), the government actually has to recompensate the firm for disclosing the correct information when demand is low because the firm would otherwise prefer \( t_{\text{unc}} \) over \( t_{L,\text{int}} \).

With \( PC_{L} \) as an upper bound on \( y'_{L} \) in place, it remains to show that there exists a set of protection prices \( y'_{H} \) for the high demand firm in accordance with the other constraints. Using Lemmas (1) and (2), it can be shown (see proof of Proposition 2) that the set of feasible \( (y'_{L}, y'_{H}) \) that support the complete information tariff levels (or any tariff schedule for which \( t_{L} < t_{\text{unc}} < t_{H} \)) is non-empty and that it can be graphically depicted as in Fig. 1. This figure shows the restrictions placed on \( y'_{L} \) and \( y'_{H} \) by the participation and incentive constraints as contours in \( (y'_{L}, y'_{H}) \)-space that bound the set of feasible protection prices (hatched area). The following proposition states the implementability of the complete information solution and describes the properties of the feasible protection price set.

**Proposition 2.** The complete information tariff schedule \( (t_{L,\text{int}}, t_{H,\text{inf}}) \), or any tariff schedule such that \( t_{L} < t_{\text{unc}} < t_{H} \), is implementable when protection can be sold. The set of feasible protection prices that implement this solution has the following properties.

(i) The upper bound on \( y'_{L} \) follows from \( PC_{L} \); i.e.

\[
y'_{L} \leq \Pi_{IN}(t_{L}, a_{L}) - \Pi_{IN}(t_{\text{unc}}, a_{L}).
\]

(ii) For given \( y'_{L} \), the lower bound on \( y'_{H} \) is determined by \( IC_{L} \); i.e.

\[
y'_{L} + \Pi_{IN}(t_{H}, a_{L}) - \Pi_{IN}(t_{L}, a_{L}) \leq y'_{H}.
\]
Fig. 1. Set of feasible protection prices.

(iii) For \( y_L^i \leq \Pi_{IN}(t_L, a_H) - \Pi_{IN}(t_{unc}, a_H) \), the upper bound on \( y_H^i \) follows from IC\(_H\); i.e.

\[
y_H^i \leq \Pi_{IN}(t_H, a_H) - \Pi_{IN}(t_L, a_H) + y_L^i.
\]

For \( \Pi_{IN}(t_L, a_H) - \Pi_{IN}(t_{unc}, a_H) < y_L^i \leq \Pi_{IN}(t_L, a_L) - \Pi_{IN}(t_{unc}, a_L) \), the upper bound on \( y_H^i \) follows from PC\(_H\); i.e.

\[
y_H^i \leq \Pi_{IN}(t_L, a_H) - \Pi_{IN}(t_{unc}, a_H).
\]

Hence the domestic government is always able to achieve its utility level under complete information. In contrast, the domestic firm’s profit level depends on the chosen protection prices. Clearly, the lower the protection price, the better off is the domestic firm. Since PC\(_L\) and PC\(_H\) provide upper bounds on \( y_L^i \) and \( y_H^i \), the firm obtains at least as high a profit as if it did not reveal the demand information. Compared to the complete information solution, assuming a protection price of zero, the domestic firm benefits from the negative protection price when demand is low. When demand is high, the protection price may be positive in which case the lack of governmental information would be detrimental to the firm.

When a quota is employed, the government solves

\[
\max_{q_H, q_L, y_H, y_L} \left[ \theta \left( CS(q_H, a_H) + \Pi_{IN}(q_H, a_H) + QR(q_H, a_H) \right) \\
+ (1 - \theta) \left( CS(q_L, a_L) + \Pi_{IN}(q_L, a_L) + QR(q_L, a_L) \right) \right]
\]

such that
\[
P_{1N}(q_H, a_H) - y_H^q \geq P_{1N}(q_{unc}, a_H), \quad (PC_H)
\]
\[
P_{1N}(q_L, a_L) - y_L^q \geq P_{1N}(q_{unc}, a_L), \quad (PC_L)
\]
\[
P_{1N}(q_H, a_H) - y_H^q \geq P_{1N}(q_L, a_H) - y_L^q, \quad (IC_H)
\]
\[
P_{1N}(q_L, a_L) - y_L^q \geq P_{1N}(q_H, a_L) - y_H^q \quad (IC_L)
\]

hold. The complete information solution \((q_{L, int}, q_{H, int})\) in (2) is not feasible when protection is offered free of charge. The main reason is that this solution would violate the incentive compatibility constraint for the high type. To remedy this problem, one might try to make the low demand solution less attractive by charging a price \(y_L^q\) for protection (or alternatively by offering a negative \(y_L^q\) to make the high demand solution more attractive) such that the high demand firm is indifferent between the low demand contract and the high demand contract. However, this approach would create a new deviation incentive, this time for the low type. This is a direct consequence of Lemma 2. Proposition 3 formalizes this point. It shows that we cannot have a solution \(q_L < q_H\) in the quota case or \(t_L < t_H\) in the tariff case such that \(IC_H\) and \(IC_L\) hold simultaneously. This is an important result because it emphasizes that it is not possible to offer a level of protection to the low demand firm which exceeds the protection granted to the high demand firm.

**Proposition 3.** (i) \(q_L < q_H\) is incompatible with the incentive compatibility constraints \(IC_H\) and \(IC_L\). (ii) \(t_H < t_L\) is incompatible with the incentive compatibility constraints \(IC_H\) and \(IC_L\).

The intuition behind this result is straightforward: if the government offered the low type a higher protection level and did not charge a protection price, the high type would choose the low type contract. To prevent such a defection by the high type, the government would have to charge the low type a relatively high protection price because by the single-crossing condition, the high type’s advantage from obtaining more protection is high. But on the other hand, the low demand firm does not lose much by choosing the lower protection level of the high type contract. Hence by setting a high \(y_L^q\) to make the high type indifferent between its own contract and the low type contract, the government creates a deviation incentive for the low type.

The complete information solution along with any other solution where \(q_L < q_H\) thus proves to be infeasible in the quota case. Since the governmental utility level decreases as we move away from the complete information solution, it appears best to set a uniform quota somewhere between \(q_{L, int}\) and \(q_{H, int}\). This solution equals \(q_{asy}\) in (4) when protection is offered free of charge; i.e.
To ensure that the incentive compatibility constraints hold, it must be true that the protection price is equal for the high and the low type. Furthermore, the participation constraints imply that the protection prices cannot exceed zero. These findings are summarized in the following proposition.

**Proposition 4.** The government chooses \((q_{\text{asy}}, q_{\text{unc}})\) as the uniform quota schedule even if a protection price is available as additional policy instrument. The set of feasible protection prices fulfills \(y_{H}^{q} = y_{L}^{q} = 0\).

From the consumers’ perspective, a quota is preferable when demand is low because imports are higher and the market price is lower, whereas a tariff is preferable when demand is high. Profit equivalence depends on the choice of the protection price, and without further assumptions nothing more can be said. In order to further investigate profit equivalence, suppose the same \(y_{L}^{q}\) is offered in the quota and in the tariff case. Then the domestic firm prefers a tariff to a quota when facing low demand because imports are lower and \(y_{L}^{q}\) is the same regardless of the chosen import restriction. When demand is high, it prefers a quota as shown in the proof of Proposition 4. The above results are summarized as follows.

**Proposition 5.** Consider the model with asymmetric information about demand. When the government sells protection, the solution is not unique because the protection prices are indeterminate. The complete information tariff levels are obtainable, while in the quota case the complete information solution is not feasible and only a uniform quota can be set. The following non-equivalence results hold: (i) the optimal tariff and quota are not market outcome equivalent. Governmental utility is strictly higher when a tariff is used. Consumers are better off under a tariff (quota) when demand is high (low) because imports are higher. (ii) Profit equivalence crucially depends upon the choice of protection prices. If the government selects the same protection price \(y_{L}^{q}\) in the quota and the tariff case, the tariff is advantageous for the domestic firm when demand is low. When demand is high, firm 1’s profit is higher under a quota.

4. Conclusion

In this paper, I examine systematic differences between optimal import tariffs and quotas in a partial equilibrium setting when firms possess more information.

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\[ q_{\text{asy}} = q_{\text{asy}} = q_{\text{unc}} = \frac{\theta a_{H} + (1 - \theta) a_{L} - c}{9b}. \]
about demand than the domestic government and the government screens the domestic firm for demand information. I assume that a domestic and a foreign firm engage in Cournot competition in the domestic market. The domestic government uses an import tariff or an import quota to maximize the sum of consumer surplus, domestic profit, and governmental revenue. I focus on determining whether optimal tariffs and optimal quotas are equivalent. For this purpose, two kinds of equivalence are defined: market outcome equivalence (identical import quantity, domestic output, market price, consumer surplus, and governmental utility) and profit equivalence (identical domestic profit).

In an asymmetric information framework when the government offers the domestic firm costless import protection, it sets a uniform tariff or quota. The incentive compatibility constraints render it impossible to offer different tariffs or quotas for different realizations of demand. A firm would always be tempted to report the demand level that leads to the more stringent import barrier. A non-equivalence result with respect to market outcome and domestic profit is obtained.

If the domestic government is allowed to sell protection, non-equivalence emerges once more. The only purpose of a protection price is to overcome the misinformation incentive problem since governmental revenue and domestic profit are assigned equal weight in the governmental utility function. The introduction of a protection price as an additional instrument is sufficient to implement the optimal complete information tariffs, but not the complete information quotas. The government thus prefers the tariff over the quota.

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Appendix A. Proofs

Proof of Lemma 2. (i) Differentiating $\Pi_{IN}(t, a_H) - \Pi_{IN}(t, a_L)$ with respect to $t$ yields $2/9b(a_H - a_L) > 0$ for $t \in [t_{\min}(a_L), t_{\max}(a_L)]$. Notice that when $t$ lies in $(t_{\max}(a_L), t_{\max}(a_H))$ or $[t_{\min}(a_H), t_{\min}(a_L)]$, $\Pi_{IN}(t, a_L)$ is constant whereas $\Pi_{IN}(t, a_H)$ is increasing in $t$. (ii) Differentiating $\Pi_{IN}(q, a_H) - \Pi_{IN}(q, a_L)$ with respect to $q$ yields $-1/2(a_H - a_L) < 0$ for $q \in [0, q_{\max}(a_L)]$. Notice that when $q \in [q_{\max}(a_L), q_{\max}(a_H)]$, $\Pi_{IN}(q, a_H)$ is decreasing in $q$ while $\Pi_{IN}(q, a_L)$ is constant.

Proof of Proposition 2. Showing that this proposition holds is equivalent to
proving the accuracy of Fig. 1. To obtain this figure, we first rearrange the incentive and participation constraints so that we can easily plot them in \((y'_{L}, y'_{H})\)-space:

\[
\begin{align*}
\Pi_{IN}(t_{H}, a_{H}) - \Pi_{IN}(t_{unc}, a_{H}) & \geq y'_{H}, \\
\Pi_{IN}(t_{L}, a_{L}) - \Pi_{IN}(t_{unc}, a_{L}) & \geq y'_{L}, \\
\Pi_{IN}(t_{H}, a_{H}) - \Pi_{IN}(t_{L}, a_{H}) + y'_{L} & \geq y'_{H}, \\
y'_{L} & \equiv \Pi_{IN}(t_{H}, a_{L}) - \Pi_{IN}(t_{L}, a_{L}) + y'_{L}.
\end{align*}
\]

When \(PC_{H}\) binds, an upper positive bound on \(y'_{H}\) is obtained since \(t_{unc} < t_{H}\). In Fig. 1, this bound appears as a horizontal line. All solutions satisfying \(PC_{H}\) lie on or below this line. When \(PC_{L}\) binds, an upper negative bound on \(y'_{L}\) is obtained since \(t_{L} < t_{unc}\). In Fig. 1, this bound is depicted by a vertical line. All solutions satisfying \(PC_{L}\) lie on or to the left of this line. When \(IC_{H}\) and \(IC_{L}\) bind, we obtain an upper and lower bound on \(y'_{L}\) as a function of \(y'_{H}\). These bounds appear as parallel lines with unit slope. That \(IC_{L}\) will be the lower line follows from the single-crossing property established in Lemma 2, according to which \(\Pi_{IN}(t_{H}, a_{H}) - \Pi_{IN}(t_{L}, a_{H}) + y'_{L} \equiv y'_{H}\). Any solution satisfying the incentive constraints has to lie on or between the two parallel lines.

In principle, the highest protection price for the low type can either be determined by \(PC_{L}\), or it can be determined by the intersection of \(IC_{L}\) and \(PC_{H}\). To find out which is the case, we have to compare the \(y'_{L}\)-value of the intersection of the \(IC_{L}\) and \(PC_{H}\) contours; i.e. \(y'_{L} = \Pi_{IN}(t_{H}, a_{H}) - \Pi_{IN}(t_{unc}, a_{H}) - \Pi_{IN}(t_{H}, a_{L}) + \Pi_{IN}(t_{L}, a_{L})\), to the maximal \(y'_{L}\)-value determined by \(PC_{L}\). Using the single-crossing result of Lemma 2, we find that the intersection of \(IC_{L}\) and \(PC_{H}\) occurs to the right of \(PC_{L}\). Thus the upper bound for \(y'_{L}\) is determined by \(PC_{L}\) and the lower bound for \(y'_{H}\) is determined exclusively by the binding \(IC_{L}\) constraint. The maximal protection price for the high type can either be exclusively determined by \(IC_{H}\), or it can be first determined by \(IC_{H}\) and then by \(PC_{H}\). A similar argument shows that the intersection of \(IC_{H}\) and \(PC_{H}\) occurs to the left of \(PC_{L}\). Thus the upper bound for \(y'_{H}\) is determined by the binding \(IC_{H}\) constraint until the \(IC_{H}\) and \(PC_{H}\) contours intersect and thereafter by \(PC_{H}\). This establishes the correctness of Fig. 1.

\textbf{Proof of Proposition 3.} (i) If \(IC_{H}\) holds, then \(y'_{H} = \Pi_{IN}(q_{H}, a_{H}) - \Pi_{IN}(q_{L}, a_{H}) + y'_{L} - x\), where \(x \geq 0\). Substituting \(y'_{H}\) into \(IC_{L}\) and rearranging, \(\Pi_{IN}(q_{H}, a_{H}) - \Pi_{IN}(q_{L}, a_{L}) \equiv \Pi_{IN}(q_{L}, a_{H}) - \Pi_{IN}(q_{H}, a_{L}) + x\). But since \(q_{L} < q_{H}\), this contradicts Lemma 2. (ii) Follows by a similar argument.

\textbf{Proof of Proposition 5.} (ii) When demand is low, the profit under the tariff is \(\Pi_{IN}(t_{L, unc}, a_{L}) - y'_{L}\), whereas under the quota it equals \(\Pi_{IN}(q_{unc}, a_{L}) - y'_{L}\). Since
by assumption and \( q_{\text{unc}} > x_{2N}(t_{L,\text{inf}}, a_L) \), the profit under the tariff is higher. To show that profits are higher under the quota when demand is high, it suffices to show that this is the case when the lower bound on \( y^*_H \) is chosen as the protection price in the tariff case, because this is optimal for the domestic firm. Plugging \( y^*_H = y^*_L + \Pi_{1N}(t_{H,\text{inf}}, a_H) - \Pi_{1N}(t_{L,\text{inf}}, a_L) \) into the domestic firm’s profit function, the profit under a tariff equals \( \Pi_{1N}(t_{H,\text{inf}}, a_H) - \Pi_{1N}(t_{L,\text{inf}}, a_L) + \Pi_{1N}(t_{L,\text{inf}}, a_L) - y^*_L \), whereas in the quota case it equals \( \Pi_{1N}(q_{\text{unc}}, a_H) - y^*_L \) since \( y^*_H = y^*_L \) by Proposition 4. By assumption, \( y^*_L = y^*_L \). The difference between firm 1’s profit under the quota and the tariff is thus

\[
\Pi_{1N}(q_{\text{unc}}, a_H) - \Pi_{1N}(t_{H,\text{inf}}, a_H) + \Pi_{1N}(t_{L,\text{inf}}, a_L) - \Pi_{1N}(t_{L,\text{inf}}, a_L).
\]

But \( \Pi_{1N}(q_{\text{unc}}, a_H) - \Pi_{1N}(t_{H,\text{inf}}, a_H) \) and \( \Pi_{1N}(t_{L,\text{inf}}, a_L) - \Pi_{1N}(t_{L,\text{inf}}, a_L) \) are strictly positive since \( x_{2N}(t_{H,\text{inf}}, a_H) > q_{\text{unc}} \) and \( t_{H,\text{inf}} > t_{L,\text{inf}} \). The desired result follows.

References