Pareto-improving import tariffs *

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Abstract

We study the role of import tariffs model when the quality of imported products is not observable. We consider a two-country model where Foreign consumers do not observe the quality of Home products. Home exporters use price to signal the quality of their products. We show that when the Foreign country imposes an import tariff, its welfare can rise. This result is driven by the ability of the tariff to reduce a signalling distortion. More surprisingly, a Foreign import tariff can also raise welfare in the Home country. We go on to examine the robustness of our results when quality is endogenous and when firms have alternate signalling devices.

KEYWORDS : Quality uncertainty, incomplete information, import tariff, signalling.

JEL CLASSIFICATION : D83, F10, F19, L15.

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1 Introduction

Uncertainty about product quality is an endemic problem in trade. It is often not possible to assess the true quality of a product before one has consumed it. This problem of incomplete information becomes more severe when products are traded across international boundaries. In such situations, the problem becomes one of asymmetric information, whereby consumers have more information about products sold by domestic firms relative to foreign firms.[1]

It is well known that incomplete information usually leads to a welfare loss relative to a full information world. In an international trade context, both consumers in the importing country and firms in the exporting country could lose due to information frictions. This has prompted researchers to examine various policies that could alleviate this problem. In this paper, we examine one such policy – import tariffs. To the best of our knowledge, ours is the first paper that studies the role of import tariffs when there is uncertainty about the *quality of imported products*.

We add quality uncertainty to a canonical model of trade with CES preference, monopolistic competition and a representative firm. There are two countries - Home and Foreign. The Home country has two types of firms – firms selling low quality products (L firms) and those selling high quality products (H firms).[2] Quality of a firm is unknown *ex-ante*; it is revealed once a firm has paid a sunk cost and entered the industry. The Foreign country has only one kind of firm. The Home firms can serve not only the domestic market, but also the Foreign market by paying a fixed exporting cost. Foreign firms only serve the domestic market. In this setup, we consider a policy experiment whereby the Foreign government imposes an import tariff that leads to selection – only the H firms from Home continue to export.

In Section 2, we solve the frictionless benchmark. To focus on the ability of tariffs to correct a distortion arising from incomplete information, we assume that the entire tariff revenue is used up in administering tariff collection. This ensures that under free entry, there is no change in Foreign welfare due to the tariff. When entry is restricted, the tariff does, however, reduce Foreign welfare due to fewer and more expensive imported varieties. The tariff also lowers welfare at Home – through lower profits under restricted entry and lower number of firms under

[1] In a highly influential paper, Rauch (1999) showed that proximity, common language and colonial ties are more important for differentiated products than for products traded on organized exchanges, suggesting a role for information in facilitating trade. Other papers to provide evidence of informational asymmetry in international trade, although not necessarily about product quality, include Gould (1994), Head and Ries (1998), Rauch and Trindade (2002), Portes and Rey (2005), Allen (2014) and Steinwender (2014).

[2] Recent research has shown that even within narrowly defined sectors, firms produce and export goods of different quality (Verhoogen, 2008; Kugler and Verhoogen, 2012; Hallak and Sivadasan, 2013).

free entry.

In Section 3, we analyze the pricing behaviour of Home firms under incomplete information. We consider the simplest form of asymmetry – quality of a product is perfectly observed in the domestic market, but not in the export market. Given the static nature of the model, firms try to signal their quality through price. In order to solve the model, we use the notion of perfect Bayesian equilibrium (PBE). We study both separating and pooling equilibrium. In a separating equilibrium, the L firms always charge their first-best (frictionless) price, but the H firms do not. In particular, the H firms charge a price that is strictly higher than their first-best price. The inefficiency arises due to incentive compatibility – the H firms have to charge an "excessively" high price to discourage L firms from mimicking them. A standard drawback of PBE is the multiplicity of equilibria owing to the flexibility in choosing off-the-equilibrium beliefs. We apply the intuitive criterion of Cho and Kreps (Cho and Kreps, 1987) to narrow down the set of reasonable equilibria. The intuitive criterion eliminates all pooling and all but one separating equilibria.

We examine the effect of an import tariff imposed by the Foreign government on Foreign and Home welfare in Section 4. First, we consider an equilibrium under restricted entry. By construction, the tariff leads to selection – only the H firms export. The absence of L firms from the export market means that the H firms no longer need to set an inefficiently high price to signal quality. This has a positive effect on Foreign welfare. At the same time, by shutting out the L firms, the tariff reduces the number of varieties available to Foreign consumers – a negative effect on welfare. We derive the conditions under which the former effect dominates and Foreign welfare goes up under restricted entry. Under free entry, Foreign welfare remains unchanged just as in the complete information benchmark.

The import tariff affects Home welfare through a completely different channel – profits. A modest tariff, by eliminating the need to signal quality, brings the price charged by the H firms in the Foreign market closer to the first-best price, causing profit to rise. At the same time, it lowers the export profit of the L firms to zero. We derive the conditions under which the former effect dominates and Home welfare goes up under restricted entry. Hence, under restricted entry, welfare could go up at Home and in the Foreign country – a Pareto improvement. Under free entry, the aggregate profits are driven down to zero. But Home consumers have more available varieties, resulting in higher welfare.

Our model is admittedly stylized. To examine the robustness of the welfare improvement result, we consider two extensions in Section 5. First, we allow Home firms to choose their quality. In this setup, incomplete information creates additional distortions. Nevertheless, there

exists a range of import tariffs that cause welfare to go up in both countries. Next, we allow firms to signal quality by incurring an additional expenditure. In this scenario, the price charged by the H firms under free trade coincides with the first-best. A tariff, in this case, lowers Foreign welfare under restricted entry. But by eliminating the need to send a costly signal, the tariff could still raise Home profit and welfare, with and without free entry.

Our welfare result is an application of the general theory of the second best (Lipsey and Lancaster, 1956). A version of the theory states that when there is a distortion in a market, the optimal policy could very well diverge from the first-best. The distortion in our model is the higher than normal price charged by the H firms to signal quality. That firms can signal quality through higher prices has been well recognized in the literature (Bagwell and Riordan, 1991). Although it is hard to say whether a firm is charging more than its first-best price, evidence does suggest that higher quality firms tend to charge higher prices (Gerstner, 1985). Furthermore, there is experimental evidence suggesting that consumers infer higher quality when they see higher price, a key requirement for separation in our model (Monroe, 1973).

Related literature: One of the first papers to study optimal policy when the quality of domestic products is not perfectly observable to foreign consumers was Mayer (1984). In his dynamic model, consumers learn the quality of imported products over time; as information increases, so does price. If all domestic firms enter the export market, the price they can command would be high enough for exports to be profitable. But each exporter is too small to affect learning. Consequently, if the initial price facing each exporter is too low, none of them export. An externality arises because each exporter fails to internalize the effect its entry will have on the price faced by all exporters. The externality in our paper arises from the L firms' failure to internalize the effect of their entry on H firms' price and subsequent welfare.

Firms in Mayer's model do not choose their price. Bagwell and Staiger (1989) study a similar problem where firms use price to signal their quality in the export market. In their model, informed consumers do not demand the low quality product. Consequently, a separating equilibrium is one where only the high quality firms export. In such an equilibrium, the high quality firms need to earn a profit in the second period (and beyond) to cover their losses in the first period. Incomplete information lowers welfare in the export market when the presence of the low quality firms results in the high quality firms being forced out of the export market. In contrast, love of variety in our model ensures that both types of firms export under free trade. The lower welfare in the export market results from the high quality firms charging a price that is too high.

Raff and Kim (1999) study optimal policy in a dynamic, duopoly model with asymmetric information about product quality. The possibility of having a low quality product causes the high quality firms to choose a price that is higher than their first-best price in the export market. A subsidy by the exporting country reduces this price and brings it closer to the first-best. Therefore, the policy in their paper directly tackles the distortion arising from asymmetric information. In our paper, on the other hand, the policy affects the distortion indirectly by altering the probability that different types of firms export. In a related paper, Chisik (2003) studies the determination of quality when foreign consumers receive noisy signals about quality. In his paper, firms signal quality not through prices but by incurring an additional expenditure. He shows how a country's reputation for producing poor quality can become self-fulfilling and examines the effectiveness of different policies in improving reputation.

Perhaps the paper that is closest to ours is Grossman and Horn (1988). Unlike the papers mentioned above, this paper considers the use of import tariff by a country where the domestic firms have different qualities that are not observed by local consumers. The firms signal quality through investment in capacity. The existence of a separating equilibrium, where the low quality firms do not operate, depends on two objects – the costly signal of the high quality firms and competition from imports. Import tariffs, by eliminating import competition, cause the high quality firms to raise their investment to signal quality. This results in a welfare loss. In Grossman and Horn's model, the quality of imported products is perfectly observed. So, in a sense, they examine a scenario that is the exact opposite of what we consider.

2 The Model

We consider the canonical monopolistic competition model of Krugman (1980). There are two countries, Home and Foreign, which are symmetric in terms of their preference, technology and endowments. We begin by laying down the preference of consumers and technology available to the producers. An asterisk (*) is used to denote all Foreign variables.

Preference : Consumers have CES preference over varieties:

$$U = \Big[\int_{\Omega} q(i) c(i)^{1-\frac{1}{\sigma}} di \Big]^{\frac{\sigma}{\sigma-1}},$$

where $i \in \Omega$ indexes a variety that is available to consumers in a country, while $c(i)$ and $q(i)$ are consumption and quality of variety i. The above preference implies the following demand

for variety i:

$$c(i) = q(i)^{\sigma} p(i)^{-\sigma} Y / P^{1-\sigma},$$

where Y is aggregate income and P, the ideal price index, is given by

$$P = \Big[\int_{\Omega} q(i)^{\sigma} p(i)^{1-\sigma} di \Big]^{\frac{1}{1-\sigma}}.$$

Technology : Labour is the only factor of production. A potential entrant needs to hire S workers to enter the industry, and draws a quality after entry. Without incurring any additional fixed cost, a firm can also produce a new variety. We make the simplifying assumption that there is only one quality available in the Foreign country, q^*, (so there is no scope for quality uncertainty). In the Home country, quality can be of two types – low (q_L) and high (q_H). The exogenous probability of drawing quality q_H is η. Henceforth, we use i to index quality. To produce a unit of a variety with quality $q_i (i = L, H)$, a firm requires q_i workers. Finally, a fraction δ of incumbent firms exit every period. Hence, in the steady-state, there is a steady flow of firms into and out of the industry.[3]

Exporting : A Home firm can also export to the Foreign market, while Foreign firms only serve the domestic market.[4] The Foreign government could impose an ad-valorem import tariff of τ. For simplicity, we assume away with all other ad-valorem trade costs. Exporting also entails hiring a fixed number of workers, f_L and f_H, for L and H firms respectively, where $f_L \geq f_H$. As we discuss in detail later, a key element of our analysis is selection of H firms into exporting. The potentially different fixed exporting cost is a simple, albeit unconventional, way to ensure this.

We start by solving for the full information benchmark. The equilibrium price of a q_i firm at Home selling domestically is

$$\tilde{p_i} = \frac{\sigma}{\sigma - 1} w q_i,$$

where w denotes nominal wage. When the import tariff is in place, a Home firm charges $\tau \tilde{p_i}$ in the export market. We assume that the wage is the same across countries and set it as the

[3] If the set of incumbents do not change, over time their quality might be revealed and the problem that we study in this paper might disappear. This assumption ensures that there are always new firms whose quality is not initially known to Foreign consumers.

[4] This assumption can be justified by introducing an outside good that trades freely. This good allows countries to balance trade. Introducing this sector will not affect any of the results in the paper and hence we leave it out for the sake of parsimony.

numéraire.[5] A Home firm's profit at Home is then given by

$$\pi_i^{Home}(\tilde{p}_i; q_i) = \frac{\alpha q_i Y}{\sigma P^{1-\sigma}},$$

while its profits in the Foreign market is

$$\pi_i(\tau\tilde{p}_i; q_i) = \tau^{1-\sigma}\frac{\alpha q_i Y^*}{\sigma (P^*)^{1-\sigma}} - f_i,$$

where $\alpha = [\sigma/(\sigma-1)]^{1-\sigma}$ is a constant, P and P^* are the Home and Foreign price indices respectively, while Y and Y^* are the Home and Foreign aggregate income respectively. The argument q_i in the profit function is the product quality that consumers *believe* the firm has. In a full information world, this would of course be the actual quality of the product; under incomplete information however, the two could be different. Similar expressions obtain for $\tilde{p}^*$ and $\pi^*(\tilde{p}^*; q^*)$, the equilibrium price and profit of Foreign firms in the Foreign market respectively. Then $\pi_H(\tau\tilde{p}_H; q_H) > \pi_L(\tau\tilde{p}_L; q_L)$. An implication is that if L firms find it profitable to export, so will the H firms.

Foreign country : We focus on the scenario where both types of Home firms export under free trade (i.e., $\tau = 1$).[6] Define $Q = \eta q_H + (1-\eta)q_L$ as the expected quality of a Home firm. The restricted-entry full information price index in the Foreign country, P^*_{RE}, is given by

$$(P^*_{RE})^{1-\sigma} = \alpha M^* q^* + \alpha M Q, \tag{1}$$

where M and M^* are the equilibrium measure of firms in the Home and Foreign countries respectively. Under restricted entry, aggregate income in a country is the sum of total variable labor costs and total profits:

$$Y^*_{RE} = (N - M^* S) + M^* \pi^*(\tilde{p}^*; q^*), \tag{2}$$

where N is the size of the labour force in both countries.

Under free entry, Foreign firms enter the industry until their profit, $\pi^*(\tilde{p}^*; q^*) = \frac{\alpha q^* Y^*}{\sigma (P^*_{LR})^{1-\sigma}}$, equals the sunk entry cost S. As a result, in an equilibrium with free-entry, aggregate income

[5] This would be true if the outside good sector has the same technology in both countries.

[6] As we shall see in the next section, a scenario where only the H firms export under free trade is not interesting in the context of our model.

equals total wage bill. The free-entry Foreign price index is then given by

$$(P^*_{FE})^{1-\sigma} = \frac{\alpha q^* N}{\sigma S}, \tag{3}$$

while aggregate income is

$$Y^*_{FE} = N. \tag{4}$$

Note that welfare in this model is captured by aggregate real income.

Next, consider a scenario where the Foreign government levies an import tariff ($\tau > 1$) such that only the H firms in the Home country find it profitable to export. The Foreign price index under restricted entry is then given by

$$(\hat{P}^*_{RE})^{1-\sigma} = \alpha \hat{M}^* q^* + \tau^{1-\sigma} \alpha \hat{M} \eta q_H, \tag{5}$$

where *hat* is used to denote variables when there is a tariff. Under restricted entry, the measure of firms in both countries is fixed. Hence, the restricted-entry price index following the imposition of a tariff is given by (5) with $\hat{M} = M$ and $\hat{M}^* = M^*$. Comparing (1) with (5), we can conclude that $\hat{P}^*_{RE} > P^*_{RE}$.

We also make the simplifying assumption that the revenue generated from the collection of tariffs is used up in administering the tariff regime. Following the imposition of the tariff, it is then clear from (2) that short-run aggregate income changes only due to a change in the profit of Foreign firms. But these profits, in turn, depend on aggregate income. So, an import tariff leads to a simultaneous change in Foreign firms' profits and aggregate income. How does this translate into welfare? The following lemma proves a useful result:

Lemma 1. *Y^*_{RE}/P^*_{RE} is decreasing in P^*_{RE}.*

Under restricted entry, aggregate real income falls with the price index. The above lemma, combined with the result that the Foreign price index is higher under the tariff, allows us to evaluate the effect of the tariff on welfare under restricted entry. With free entry, aggregate income is pinned down by the size of the labour force (see (4)). As a result, the free-entry price index is given by (3); there is no change in either aggregate income or price index under free-entry due to the import tariff. Accordingly, we can state the following observation:

Observation 1: *An import tariff τ that forces Home L firms out of the export market reduces Foreign welfare under restricted entry and keeps it unchanged under free entry.*

Under restricted entry, an increase in import tariffs has no effect on the measure of firms

in either country. So the only way it affects the Foreign price index is through its effect on the final price of available Home varieties, which rises, and the measure of available Home varieties, which falls. Fewer Home varieties and their higher prices raises the profit of Foreign firms in the absence of entry. Nevertheless, aggregate income rises at a slower rate than the price index, causing welfare to fall. The higher profits of the Foreign firms triggers entry. At the same time, the measure of Home varieties changes too. In equilibrium, entry by Foreign firms *exactly* balances the change in the price and measure of imported varieties, keeping the Foreign price index unchanged.

Home country : Recall that the Home market is served only by Home firms. The restricted-entry Home price index is then given by

$$P_{RE}^{1-\sigma} = \alpha MQ, \tag{6}$$

while aggregate income is

$$Y_{RE} = (N - MS) + ME[\pi], \tag{7}$$

where $E[\pi] = \eta\pi_H(.) + (1-\eta)\pi_L(.)$ is the expected profit of Home firms.

Under free entry, Home aggregate income is pinned done by N as before. Hence, the free entry condition implies that

$$\frac{\alpha QN}{\sigma P_{FE}^{1-\sigma}} + \left[\frac{\alpha QN}{\sigma (P_{FE}^{*})^{1-\sigma}} - f\right] = S. \tag{8}$$

where $f = \eta f_H + (1-\eta) f_L$. The first and second terms on the LHS of the above equation denote expected profits at Home and Foreign respectively.

After imposition of the tariff, the restricted-entry Home price index, $\hat{P}_{RE}$, continues to solve (6). Because the measure of firms do not change, the restricted-entry Home price index remains unchanged due to the tariff. At the same time, $E[\pi]$ declines because both $\pi_H(.)$ and $\pi_L(.)$ fall (with the latter falling to zero). Hence, Home aggregate income and welfare falls under restricted entry.

As the tariff leads to a selection of the H firms into exporting, free entry implies

$$\frac{\alpha QN}{\sigma \hat{P}_{FE}^{1-\sigma}} + \eta\left[\tau^{1-\sigma}\frac{\alpha q_H N}{\sigma (\hat{P}_{FE}^{*})^{1-\sigma}} - f_H\right] = S. \tag{9}$$

It is straightforward to show that conditional on the Home price index (i.e., setting $P_{FE} = \hat{P}_{FE}$),

the left-hand side of (9) is less than the left-hand side of (8). It then follows that $P_{FE} < \hat{P}_{FE}$. At the same time, there is no change in the long-run aggregate income. The next observation follows:

Observation 2: An import tariff τ that forces Home L firms out of the export market reduces Home welfare both under restricted and free entry.

After the imposition of the tariff, the export profits of both H and L firms goes down. Accordingly, for the free entry condition to be satisfied, the measure of Home firms must decline. This raises the price index at Home. There is no change to the price index under restricted entry however, as all Home firms continue to serve the Home market. But aggregate income does fall, thereby reducing welfare.

3 Pricing under Quality Uncertainty

What happens when consumers in a country perfectly observe the quality of the domestic products but not the quality of the imported products? In this section, we examine the pricing behaviour of firms in such a situation. We assume that Home firms use prices to signal the quality of their product in the Foreign market.[7] After observing prices, Foreign consumers form beliefs about the quality of Home varieties, which in turn generates demand. For the rest of this section, by consumers and firms we shall be referring to Foreign consumers and Home firms respectively. Figure 1 shows the timing of the game in the export market:

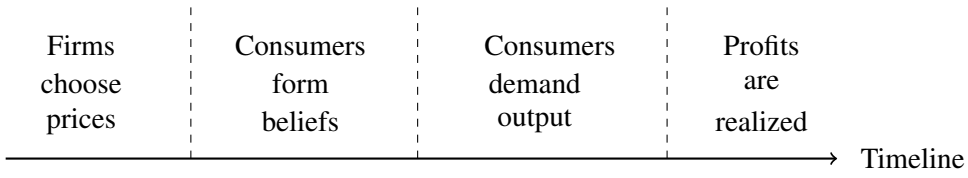


Figure 1: *Timing of the game in the export market*

Given the structure of the problem, we use the concept of a perfect Bayesian equilibrium (PBE). PBE requires a strategy profile for the agents and posterior beliefs about the type of the agents. The strategy for a consumer in this model is to demand a variety, while the strategy for a firm is to choose a price. Let us denote the posterior belief held by the consumers about the quality of a variety by $\mu(q|p)$. Formally,

[7] We assume that guarantees, certifications, etc. are imperfect tools for revealing quality.

Definition 1. *A PBE of the model consists of strategies for the consumers and firms, and posterior beliefs such that:*
(a) Consumers maximize utility,
(b) Firms maximize profits,
(c) $\mu(q|p)$ is formed from the prior distribution of quality using Bayes' rule whenever possible.

Let the quality expected by consumers on observing a price p be denoted by q_E. The profit of a i firm charging p is then given by

$$\pi_i(p; q_E) = (p - q_i) q_E^{\sigma} p^{-\sigma} \frac{Y^*}{(P^*)^{1-\sigma}} - f_i,$$

where the aggregate price index under incomplete information, P^*, is usually different from that under full information. We shall be exploiting two useful properties of the iso-profit curves:

PROPERTY 1 (CONVEXITY): The iso-profit curves are globally convex in prices as long as price exceeds marginal cost.

PROPERTY 2 (SINGLE-CROSSING): At a given (p, q_E), the slope of the iso-profit curve of the L firm is greater than that of the H firm.

An implication of property 1 is that corresponding to any expected quality level q_E, there are at most two price levels which generate the same profit. Property 2 implies that if both types of firms raise price by the same amount, and this results in the expected quality to go up by the same amount, the profit of the H firm goes up (or down) more (or less) than the profit of the L firm. What this essentially means is that signalling through higher prices is more "costly" for the L firm. Observe that *conditional* on q_E, profit is still maximized for $p_i = \tilde{p}_i$ – a higher q_E simply acts as a demand shifter that increases the profit levels at all prices.

In this paper, we focus only on pure strategy equilibria. Before analyzing the effect of an import tariff, we consider the class of separating and pooling equilibria under free trade. As is well known, an issue with equilibria under incomplete information is their multiplicity. Therefore, we apply notions of equilibrium refinement to narrow down the equilibrium set.

3.1 Separating equilibrium

A separating equilibrium is charaterized by two prices, p_L and p_H, charged by the L and H firms respectively such that foreign consumers, upon observing $p_L(p_H)$, believe that the firm is of quality L(H). These prices must satisfy two conditions – *individual rationality (IR)* and

incentive compatibility (IC). IR implies that both types of firms should want to export, i.e., $\pi_L(p_L; q_L) > f_L$ and $\pi_H(p_H; q_H) > f_H$. The necessary conditions for the individual rationality constraints to hold are $p_L > q_L$ and $p_H > q_H$ (price is greater than marginal cost). IC, on the other hand, requires that L firms must not want to mimic H firms and similarly for H firms, i.e., $\pi_L(p_L; q_L) > \pi_L(p_H; q_H)$ and $\pi_H(p_H; q_H) > \pi_H(p_L; q_L)$.

As the following lemma shows, the price for L firms under a separating equilibrium is unique :

Lemma 2. *In a separating equilibrium,* $p_L = \tilde{p}_L$.

Even when consumers do not observe the quality of their product, L firms continue to charge their first-best price. Intuitively, a lack of information cannot hurt low quality firms because these firms do not need to signal their low quality. But the same is not true for the H firms. The following lemma proves a result that is central to our analysis.

Lemma 3. $\pi_L(\tilde{p}_H; q_H) > \pi_L(\tilde{p}_L; q_L)$.

Lemma 3 says that by mimicking a H firm, the L firm can actually get more than its first-best profit. In other words, if consumers assign beliefs $\mu(q_E = q_H | p = \tilde{p}_H) = 1$, the L firms will deviate and mimic H firms. Hence, in a separating equilibrium, *H firms will no longer be able to charge their first-best price*.

Let p_1 be the price such that $\pi_L(p_1; q_H) = \pi_L(\tilde{p}_L; q_L)$, i.e., p_1 makes a L firm indifferent between signalling that it is indeed a L firm and mimicking a H firm. Property 1 of the iso-profit curves then implies that there must be exactly two values for p_1, one less than $\tilde{p}_L$ and the other greater than $\tilde{p}_L$. Similarly, define p_2 as the price satisfying $\pi_H(p_2; q_H) = \pi_H(\tilde{p}_L; q_L)$, i.e., p_2 makes a H firm indifferent between signalling that it is indeed a H firm and mimicking a L firm. As before, there are two values for p_2, one less than $\tilde{p}_L$ and the other greater than $\tilde{p}_L$. The following lemma provides a uniqueness result:

Lemma 4. *Incentive compatibility of both types implies that* p_1 *and* p_2 *are unique with* $\tilde{p}_L < p_1 < p_2$.

The above lemma exploits the single-crossing property of the profit function. It implies that if beliefs are such that $\mu(q_E = q_H | p < p_1) = 1$, a L firm will always mimic a H firm. Similarly, if beliefs are such that $\mu(q_E = q_H | p > p_2) = 1$, a H firm will always mimic a L firm. Hence, in a separating equilibrium, we must have $p_1 \leq p_H \leq p_2$. The next lemma proves an important property of p_1:

Lemma 5. $p_1 > \tilde{p}_H$.

Lemma 5 implies that for the IC of the L firms to be satisfied, the H firms must charge a price that is higher than their first-best price. Thus, incomplete information not only results in lower profit for the H firms, but by raising the final price, lowers the utility of consumers as well.

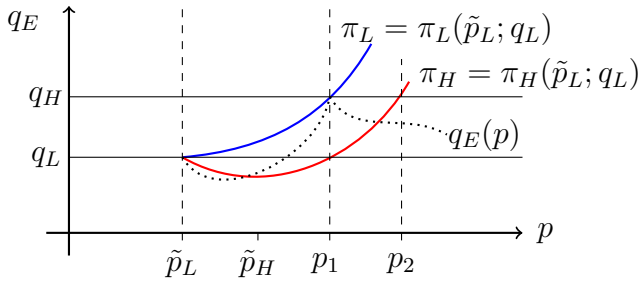


Figure 2: *A separating equilibrium*

The two bounds for p_H, p_1 and p_2, are shown in Figure 2. The flexibility in choosing off-the-equilibrium beliefs implies that any price between p_1 and p_2 can be sustained in equilibrium as the price charged by H firms. A possible equilibrium belief is shown by the dotted, black line in Figure 2. Of course, as we discuss in Section 3.3, not all of these beliefs are *reasonable*. This allows us to narrow down the set of equilibria considerably.

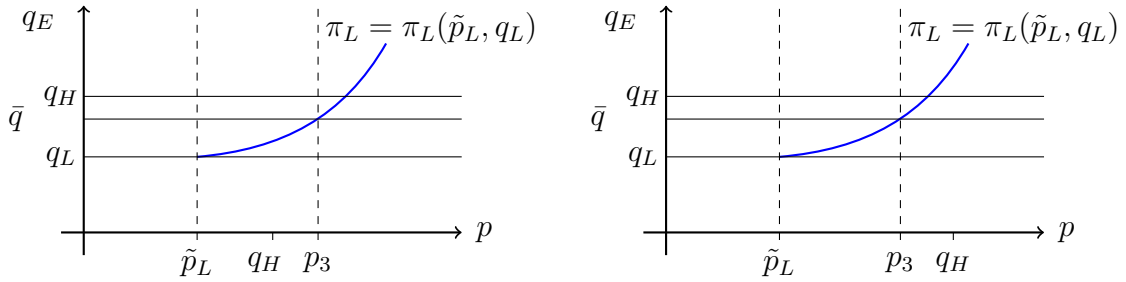
To summarize, when there are information frictions, L firms charge the first-best price in the export market while H firms charge a price that is higher than their first-best. As we show in the next section, the presence of this distortion creates a situation where a government intervention in the form of import tariffs could potentially raise welfare.

3.2 Pooling equilibrium

A pooling equilibrium is characterized by a unique price $\bar{p}$ that is charged by both L and H firms in the foreign market. For this price to be sustained in equilibrium, consumers must also believe that the expected quality q_E is equal to $\bar{q} = \eta q_H + (1 - \eta) q_L$.

Now, a necessary condition for IR is that $\bar{p} \geq q_H$. Observe that L firms can always charge a price of $\tilde{p}_L$ and earn their first-best profits. Let us define p_3 such that $\pi_L(p_3; \bar{q}) = \pi_L(\tilde{p}_L; q_L)$, i.e., p_3 makes a L firm indifferent between choosing the pooling equilibrium price and the first-best price. Using a similar argument as before, it can be shown that p_3 is greater than $\tilde{p}_L$. Observe that if beliefs are such that $\mu(q_E = \bar{q} | p > p_3) = 1$, a L firm will always choose $\tilde{p}_L$. Any pooling equilibrium must therefore have a price that is bounded above by p_3. Combined

with the individual rationality condition, this constraint presents us with two scenarios as shown in Figure 3.



(a) *Pooling equilibrium may exist* **(b)** *Pooling equilibrium does not exist*

Figure 3: *Pooling equilibrium*

When $q_H > p_3$, a pooling equilibrium does not exist. Otherwise, a pooling equilibrium may exist, depending on what the fixed costs of exporting are. As before, there are a large number of beliefs that can sustain the price $\bar{p}$ in equilibrium. The reasonableness of such beliefs is discussed next.

3.3 Equilibrium refinement

Models with incomplete information feature a multiplicity of separating and pooling equilibria owing to the flexibility allowed by PBE in choosing off-the-equilibrium beliefs (Fudenberg and Tirole, 1991). This is true in our model as well. But not all such beliefs are reasonable. To see this, let us consider a separating equilibrium. Assume that foreign consumers have the following beliefs: $\mu(q = q_H | p = p_e) = 1$ and $\mu(q < q_H | p \neq p_e) = 1$ where the price p_e is shown in Figure 4. Suppose foreign consumers observe a price $p_e - \epsilon$. How would they update their belief?

According to the refinement proposed by Cho and Kreps (1987), the consumers should be able to reason as follows: If a H firm deviates from p_e and charges a price $p_e - \epsilon$, then there is a *possibility* that his profit might go up in the event that consumers still believe that he is a H firm. But if a L firm deviates from $\tilde{p}_L$ and charges $p_e - \epsilon$, then his profits will always go down, no matter what off-the-equilibrium beliefs are. This is because at any price above p_1, the profit of the L firm is strictly less than his equilibrium profit even if consumers believe that he has quality q_H. This suggests that the belief $\mu(q < q_H | p \neq p_e) = 1$ is *not intuitive*. When observing a price like $p_e - \epsilon$, consumers should still believe that the firm is H type. But then, a H firm should deviate from p_e. In fact, one can see that any price for a H firm that is greater

than p_1 cannot be part of an equilibrium strategy if one uses the intuitive criterion of Cho and Kreps (1987). The only price that survives the equilibrium refinement is $p_H = p_1$.

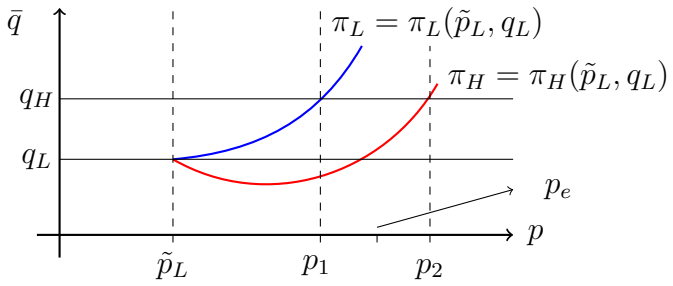


Figure 4: *A separating equilibrium*

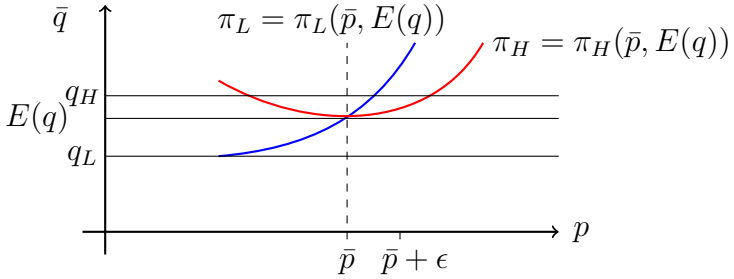


Figure 5: *A pooling equilibrium*

Next consider any pooling equilibrium price, $\bar{p}$, as shown in Figure 5. The single-crossing property implies that we can always find a price $\bar{p} + \epsilon$ such that $\pi_L(\bar{p} + \epsilon, q_H) < \pi_L(\bar{p}, \bar{q})$ but $\pi_H(\bar{p} + \epsilon, q_H) > \pi_H(\bar{p}, \bar{q})$. This suggests that a L firm will never deviate from $\bar{p}$, no matter what consumers' off-the-equilibrium beliefs are, while a H firm could deviate. Accordingly, if consumers see a firm deviating to $\bar{p} + \epsilon$, they should believe that this is a H firm. Because this is true for any $\bar{p}$, the intuitive criterion rules out all pooling equilibria. This allows us to state the following result:

Proposition 1. *The unique equilibrium that satisfies the Cho and Kreps' intuitive criterion has the L firms charging $\tilde{p}_L$ and the H firms charging p_1.*

The unique price p_1 solves $\pi_L(p_1; q_H) = \pi_L(\tilde{p}_L; q_L)$. Simplifying, p_1 is defined implicitly by the following equation:

$$ap_1^{\sigma} - p_1 + q_L = 0.$$

where $a = \frac{\alpha}{\sigma} q_L q_H^{-\sigma}$. Because in equilibrium, p_1 must always be greater than $\tilde{p}_H$, the first-best

price of the H firms, the ratio $p_1/\tilde{p}_H$ could be thought of as a measure of inefficiency created by incomplete information. The following lemma characterizes this inefficiency:

Lemma 6. *$p_1/\tilde{p}_H$ is decreasing in q_L.*

The first-best price charged by the H firms is independent of the quality of L firms. This is a consequence of CES preferences, whereby, the price is completely pinned down by the marginal cost of production. But under incomplete information, the H firm's optimal price becomes a function of q_L. In particular, lower is q_L, higher is p_1, i.e., higher is the distortion. Intuitively, lower is q_L, the higher is the profit of the L firm from deviating to a given price charged by H firms (because q_L is the L firm's marginal cost of production). Accordingly, to make the L firm indifferent between charging its first-best price and deviating, the H firm has to charge a higher price.

4 Welfare under import tariff

In this section, we study what happens when the Foreign country imposes an import tariff. In particular, we consider the interesting scenario where a tariff leads to selection: only H firms from Home export.

4.1 Selection

What import tariff can lead to this selection? Under full information, this tariff τ must satisfy (a) $\pi_L(\tau\tilde{p}_L; q_L) < f_L$ and (b) $\pi_H(\tau\tilde{p}_H; q_H) > f_H$. Under asymmetric information, however, we need a condition that is stronger than (a). This is because, in an equilibrium where only H firms export, these firms will charge their first-best price $\tau\tilde{p}_H$. A modified version of Lemma 3 then allows us to complete the argument:

Lemma 3′. $\pi_L(\tau\tilde{p}_H; q_H) > \pi_L(\tau\tilde{p}_L; q_L)$.

The above lemma states that if H firms charge $\tau\tilde{p}_H$, the L firms have an incentive to mimic them, unless it violates their individual rationality constraint. Hence, instead of condition (a), we need condition (a′) $\pi_L(\tau\tilde{p}_H; q_H) < f_L$ for there to be selection in exporting. Notice, however, that $\pi_L(\tau\tilde{p}_H; q_H) > \pi_H(\tau\tilde{p}_H; q_H)$. This is simply because when L firms mimic H firms, they have a lower cost of production but enjoy the same price and demand as the H firms. Hence, to ensure that there is selection, we need the difference $f_L - f_H$ to be large enough.

Note that differential fixed costs, with the cost being higher for L firms, is not essential for generating selection. An alternative model that can generate selection is a two period model where quality is unobserved in period one but fully revealed in period two. In such a scenario, even if L firms, by mimicking the H firms, earn higher profits than H firms in period one, they would earn lower profits in period two. Then, under certain conditions on discount rates, the present discounted value of profits for L firms would be lower than the corresponding profits of H firms. The bottomline is that selection can be obtained in a number of alternative models: our main results do not depend on the exact detail of these models. The next lemma provides a sufficient condition for selection:

Lemma 7. *If* $\pi_H(\tilde{p}_H; q_H) - f_H > \pi_L(\tilde{p}_L; q_L) - f_L > 0$*, then there exists* τ *such that* $\pi_H(\tau\tilde{p}_H; q_H) - f_H > 0 > \pi_L(\tau\tilde{p}_L; q_L) - f_L$.

Holding everything else constant, as one increases τ starting from $\tau = 1$ (no tariffs), eventually there will be selection. Everything else may not be constant, however. In particular, if the Foreign price index changes due to a change in τ, profits of the exporting firms will be affected. But as we show below, the imposition of the import tariff that causes selection reduces the Foreign price index in the short run (under certain conditions) while keeping it unchanged in the long run. Hence, the general equilibrium effects of the import tariff re-enforce the result that tariffs reduce export profits of Home firms. We can then conclude that under certain conditions, there exists τ that can lead to selection of H firms into exporting. The following lemma obtains the range for τ that guarantees selection:

Lemma 8. *The* τ *that causes selection must satisfy* $\tau_L < \tau < \tau_H$ *where* $\tau_L = (\frac{Sq_H}{f_L q^*})^{\frac{1}{\sigma-1}}[\sigma - (\sigma-1)\frac{q_L}{q_H}]^{\frac{1}{\sigma-1}}$ *and* $\tau_H = (\frac{Sq_H}{f_H q^*})^{\frac{1}{\sigma-1}}$.

4.2 Foreign country

In order to analyze the effect of the import tariff on welfare, we first need to compute welfare in the absence of tariffs. Without tariffs, all Home firms export. In this case, the restricted-entry Foreign price index is given by

$$(P^*_{RE})^{1-\sigma} = \alpha M^* q^* + M[\eta q_H^\sigma p_1^{1-\sigma} + (1-\eta) q_L^\sigma \tilde{p}_L^{1-\sigma}]. \tag{10}$$

The first term on the right-hand side is the Foreign component of the price index, while the second term is the Home component. Following the imposition of the import tariff, there is no

change in the measure of firms, be it Foreign or Home, under restricted entry. Therefore, if the imposition of the import tariff causes selection, the Foreign price index, $\hat{P}^*_{RE}$, will be given by

$$(\hat{P}^*_{RE})^{1-\sigma} = \alpha M^* q^* + M\eta q_H^\sigma (\tau \tilde{p}_H)^{1-\sigma}. \tag{11}$$

Comparing (10) with (11), one can show that $\hat{P}^*_{RE}$ is less than P^*_{RE} if the following is true

$$\begin{aligned}\tau &< \left(\frac{1-\eta}{\eta}(\frac{q_L}{q_H})^\sigma \tilde{p}_L^{1-\sigma} + p_1^{1-\sigma}\right)^{\frac{1}{1-\sigma}} / \tilde{p}_H \\ &= \tau(\eta)\end{aligned}$$

The imposition of the import tariff has two opposing effects on the price index under restricted entry. On the one hand, there is a reduction in available varieties due to the exclusion of L firms. This tends to raise the price index. On the other hand, the final price of the H firms could *potentially* be lower, even with the additional tariffs. The following lemma provides for the condition under which the above inequality holds.

Lemma 9. *For η large, there exists $\tau(\eta)$ such that $\hat{P}^*_{RE} < P^*_{RE}$ whenever $\tau < \tau(\eta)$.*

Lemma 9 suggests that when η is large, the Foreign government can impose an import tariff and lower the Foreign price index. Using Lemma 1, we can then conclude that the tariff raises Foreign welfare. The key element driving this result is the price distortion of H firms when all Home firms export and the removal of this distortion when L firms stop exporting. When η is large, the loss in welfare due to the exclusion of the L firms from the export market is small. In such a case, it is possible to find an import tariff such that the final price of the H firms even with the tariff is less than their distorted price under signalling. In fact, as Lemma 9 states, for a large η it is possible to find an import tariff such that the gain from the removal of the H firm's price distortion actually outweighs the loss from reduced variety.

In Figure 6, we examine the range of τ, as a function of η, that generates gains for the Foreign country under restricted entry. The two solid lines correspond to the upper and lower bounds for τ such that there is selection into exporting. These bounds depend on the fixed costs of exporting, which in turn, must ensure that the individual rationality constraints are satisfied in the absence of tariffs. For a given η, if τ lies below the lower bound τ_L, both types of firms continue to export, while if τ lies above the upper bound τ_H, none of the firms export. The dashed line corresponds to $\tau(\eta)$, the maximum value for τ that ensures gains from the imposition of the tariff. Notice that for η less than around 0.9, there does not exist a τ such that both conditions for welfare gains are satisfied. At the same time, for η greater than around 0.98,

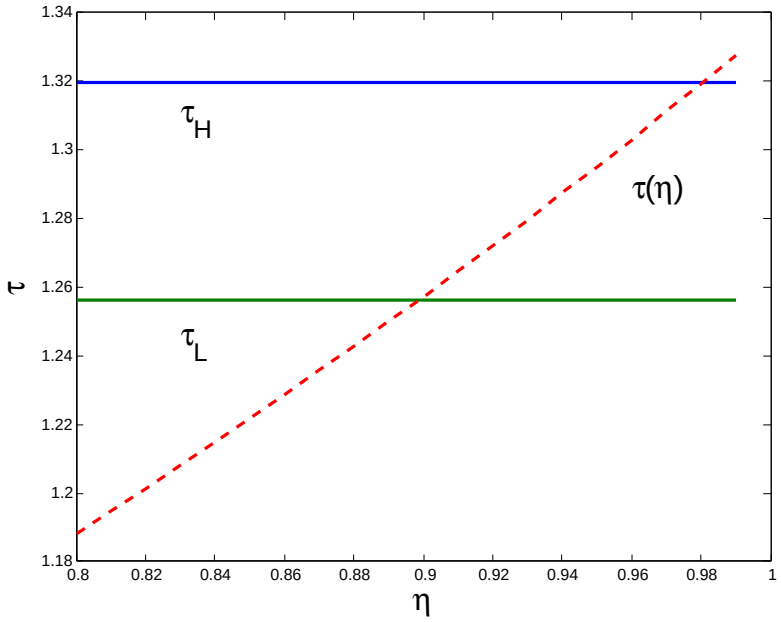


Figure 6: *Range of τ as a function of η, under which Foreign gains*

a sufficient condition for welfare gains is that τ leads to selection. Furthermore, the individual rationality constraints in the absence of tariffs are satisfied for the chosen parameter values.

When there is free entry, the measure of Foreign firms will adjust. Because the actions of the Foreign firms are not modified by incomplete information, the free entry conditions in the absence, as well as the presence of tariffs are given by (3). It then follows that the free-entry price index in the Foreign country remains unchanged due to the tariff. As in the full information scenario, any change in the price index due to a change in the price or measure of Home varieties is *exactly* compensated by the entry (or exit) of Foreign varieties. In fact, we can state a much stronger result: any policy instrument that only affects the behaviour of Home exporters keeps Foreign welfare unchanged in an equilibrium with free entry. We are, of course, assuming that there are no direct costs/benefits arising from the policy. We summarize in the following proposition:

Proposition 2. *For η large, the Foreign government can impose an import tariff that raises Foreign welfare under restricted entry while keeping it unchanged under free entry.*

4.3 Home country

In the absence of tariffs, both types of Home firms export. The L firms charge the same price in both markets but could earn different profits owing to possibly different price indices in the two markets. The H firms, however, charge different prices in the two markets. The free-entry condition is then given by

$$\eta[\pi_H^{Home}(\tilde{p}_H;q_H)+\pi_H(p_1;q_H)-f_L]+(1-\eta)[\pi_L^{Home}(\tilde{p}_H;q_L)+\pi_L(\tilde{p}_H;q_L)-f_H]=S.$$

where $\pi_i^{Home}(.,.)$ refers to the profits of the i firm in the Home market before the imposition of the tariff. Manipulating the above equation, we get the following:

$$\frac{\alpha QN}{\sigma P_{FE}^{1-\sigma}}+\Psi_1=S, \tag{12}$$

where $\Psi_1=\eta[\pi_H(p_1;q_H)-f_L]+(1-\eta)[\pi_L(\tilde{p}_L;q_L)-f_H]$.

After tariffs are imposed, L firms only expect to serve the Home market. The H firms charge the first-best price in both the markets, although the price in the Foreign market is higher by τ. The free-entry condition then becomes

$$\eta[\hat{\pi}_H^{Home}(\tilde{p}_H;q_H)+\hat{\pi}_H(\tau\tilde{p}_H;q_H)-f]+(1-\eta)\hat{\pi}_L^{Home}(\tilde{p}_L;q_L)=S,$$

which can be re-written as

$$\frac{\alpha QN}{\sigma \hat{P}_{FE}^{1-\sigma}}+\Psi_2=S, \tag{13}$$

where $\Psi_2=\eta[\hat{\pi}_H(\tau\tilde{p}_H;q_H)-f]$. Comparing (12) and (13), one can see that $\hat{P}_{FE}<P_{FE}$ if $\Psi_1<\Psi_2$. Manipulating, the condition under which $\hat{P}_{FE}<P_{FE}$ is

$$\begin{aligned}\tau &< \Big[\sigma(p_1-q_H)q_H^{\sigma-1}p_1^{-\sigma}+\frac{1-\eta}{\eta}\Big(\frac{q_L}{q_H}-\frac{\alpha f q^*}{Sq_H}\Big)\Big]^{\frac{1}{1-\sigma}},\\ &= \tau'(\eta).\end{aligned}$$

The following lemma, which is similar to Lemma 9, provides the condition under which the above inequality holds.

Lemma 10. *For η large, there exists $\tau'(\eta)$ such that $\hat{P}_{FE}<P_{FE}$ whenever $\tau<\tau'(\eta)$.*

Lemma 10 therefore suggests that when η is large, the Foreign government can impose an import tariff and raise *Home* welfare under free entry. As before, the key element driving this

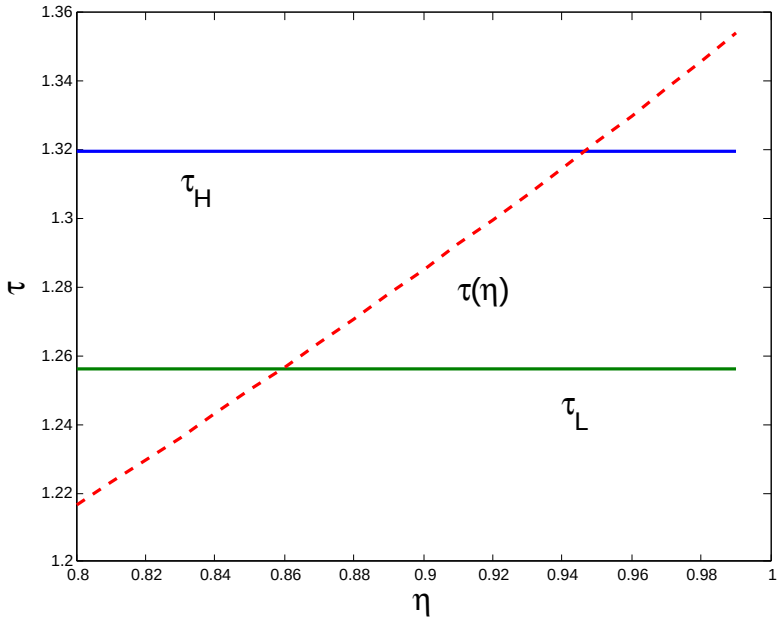


Figure 7: *Range of τ as a function of η, under which Home gains*

result is the price distortion of H firms when all Home firms export and the removal of this distortion when L firms stop exporting. But the underlying mechanism for this welfare gain at Home is different from that at Foreign. The correction of the price distortion could raise the ex-post profits of H firms. At the same time, the ex-post profits of the L firms decline because they are shut out from the export market. As Lemma 10 suggests, it is possible to find an import tariff such that the ex-ante profits of a potential entrant at Home actually rises, triggering entry. This, in turn, raises the number of available varieties in the Home country. A the same time, the free-entry aggregate income at Home is unaffected by the tariff. Figure 7 shows the range of τ for which the Home country gains.

Recall that the Home country is served only by Home firms. Accordingly, the price index under restricted entry is pinned down by the measure of Home firms which does not change (see (6)). At the same time, the tariff that raises welfare under free entry also increases profits at Home when entry is not allowed. We summarize in the following proposition:

Proposition 3. *For η large, the Foreign government can impose an import tariff that raises Home welfare under restricted, as well as free entry.*

4.4 Discussion

It is a standard practice, at least in international trade, to focus on steady-state equilibria with free entry. As our analysis of the Foreign country shows, the effect of an import tariff under restricted entry could be quite different from that under free entry. Note that our notion of restricted and free entry are similar to notions of short and long run typically used in the literature. Hence, our model suggests that if the Foreign country gains from trade during the entire transition, focussing on the long-run effect of an import tariff would generate normative implications that are not quite accurate. A similar point has been made recently by Alessandria et al. (2014). They show that following a cut in import tariff, consumption overshoots its steady-state level resulting in welfare gains that are larger than the long-run change in welfare.

That the import tariff can generate short-run gains in the country that imposes it, as well as its trading partner is significant for two reasons. First, decisions to impose import tariffs are typically political. In countries where governments are democratically elected every few years, policymakers have a vested interest in implementing policies that generate short-run gains. In such a scenario, it is unlikely that a policy that inflicts a loss in the short-run would be adopted by a government, even if this policy generates long-run gains. In our model, this conflict does not always exist. Second, unilateral imposition of tariff by a country might invite retaliation from its trading partner. In such a situation, the country may no longer gain from the tariff Johnson (1953). The underlying premise of this assertion is that a unilateral tariff harms the trading partner. But as we illustrate, in an incomplete information world, a unilateral tariff could raise the welfare of both countries, thereby eliminating the possibility of a trade war.[8]

In proving our results, we have made some simplifying assumptions - that (1) the tax revenues "melt away", (2) the wages are exogenous and (3) Foreign firms only serve the domestic market. First, it can be shown that when tariff revenues are positive, the Foreign country can raise its welfare under free entry by imposing a small import tariff. This is the familiar profit-shifting argument for tariffs in models of imperfect competition. Second, with endogenous wages, an import tariff could reduce Home wage and thereby improve the Foreign terms-of-trade. By assuming that the tax revenues do not increase domestic nominal income and wages are exogenous, we shut down the two traditional channels of welfare gains. This allows us to isolate the effect of tariffs on welfare in the presence of a price distortion. And finally, the assumption that Foreign firms do not export allows us to derive a simple closed-form expres-

[8]Of course, in our model, the Foreign firms do not export to the Home country. Hence, import tariff is not a relevant policy for the Home government. But even if Foreign firms could export, the conclusions would remain unchanged.

sion for the Foreign price index under free entry. This index is independent of the import tariff because the tariff does not directly affect the profitability of domestic firms. As a result, when computing the change in welfare due to the tariff, one only needs to keep track of nominal income - a very convenient feature. Having Foreign firms export would complicate the analysis without altering any of the key results.

5 Extensions

In this section, we relax some of the assumptions of our benchmark model and examine whether the imposition of import tariffs by the Foreign government can still raise welfare in both countries. We consider two extensions: (i) endogenous quality of Home firms, and (ii) the possibility of Home firms to use alternative signalling devices.

5.1 Endogenous quality

In this section, we drop the assumption that Home firms are endowed with a quality. Rather, upon entry, firms draw an ability a where $a \in [a_L, a_H]$. We assume that the probability of drawing ability a_H is η. Production of an unit of the product with quality q by a i firm requires a marginal cost of q and a fixed cost of q^γ/a_i. Firms can sell products of different quality in different markets. Given the technology, the first-best choice of quality of firm i in the export market is

$$\tilde{q}_i = \left(\frac{\alpha a_i N}{\sigma\gamma(P^*)^{1-\sigma}}\right)^{\frac{1}{\gamma-1}}.$$

while the price charged is $\tilde{p}_i = (\sigma/(\sigma-1))\tilde{q}_i$. When $\gamma > 1$, quality is increasing in any factor that raises demand or reduces the fixed cost of producing quality.

Under a separating equilibrium, the L firms will continue to charge the first-best price, $\tilde{p}_L$ and choose the first-best quality, $\tilde{q}_L$. Observe that Lemma 3 is true for any two types of firms with different quality levels. Hence, it is true when firms endogenously choose different quality for their products. In other words, in a separating equilibrium where both L and H firms export, the H firms can no longer charge their first-best price, $\tilde{p}_H$. Because the choice of quality depends on the price that a firm can charge, the quality of a H firm in such an equilibrium could diverge from $\tilde{q}_H$. The optimum price and quality of the H firm, denoted by p_1 and q_1, must satisfy the

following two equations:

$$q_1 = \left(\frac{\alpha a_i N}{\sigma\gamma(P^*)^{1-\sigma}}\right)^{\frac{1}{\gamma-1}} \left[\frac{\alpha p_1^\sigma}{\sigma q_1^\sigma} \frac{q_1}{\sigma p_1 - (\sigma+1)q_1}\right]^{\frac{1}{1-\gamma}},$$
$$0 = \frac{\alpha}{\sigma} q_L q_1^{-\sigma} p_1^\sigma - p_1 + t q_L.$$

The first equation is the first-order condition when a H firm maximizes its profit with respect to quality, conditional on the price being p_1. The second equation solves for p_1 (the price that makes a L firm indifferent between charging its first-best price and deviating) conditional on the quality chosen by the H firm being q_1. It can be shown that when the H firm charges its first-best price, $q_1 = \tilde{q}_H$. Hence, with information frictions, the quality chosen by the H firm will usually diverge from the first-best as well.

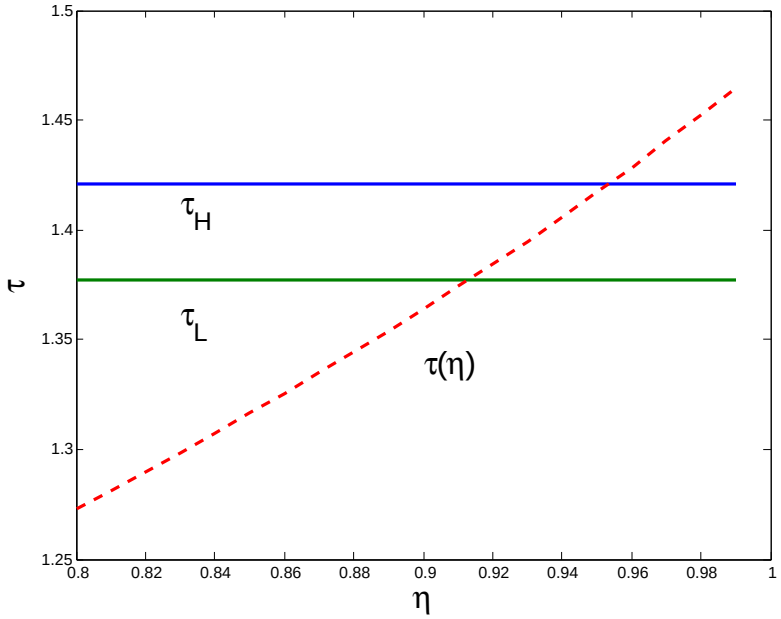


Figure 8: *Range of τ as a function of η, under which Foreign gains*

In this scenario, an import tariff addresses two distortions: a price and a quality distortion. Of course, the tariff itself distorts the H firm's choice of quality. What matters for welfare is then whether the new distortion is more or less than the existing distortion. Recall that Foreign welfare under restricted entry depends only on the price index. The condition under which

welfare in the Foreign country goes up due to the tariff is

$$\begin{aligned}\tau &< \Big(\frac{1-\eta}{\eta}\big(\frac{\tilde{q}_L}{\tilde{q}_H}\big)^{\sigma}\tilde{p}_L^{1-\sigma} + \big(\frac{q_1}{\tilde{q}_H}\big)^{\sigma}p_1^{1-\sigma}\Big)^{\frac{1}{1-\sigma}}/\tilde{p}_H \\ &= \tau(\eta).\end{aligned}$$

Unlike the previous case however, it is not possible to derive conditions under which a $\tau(\eta)$ exists that would ensure a welfare gain. This is because q_1 is different from $\tilde{q}_H$ and the sign of $q_1 = \tilde{q}_H$ cannot be determined analytically. Figure 8 shows the range of τ corresponding to different values of η that lead to an increase in welfare in the Foreign country. In Figure 9, we examine how q_1 diverges from $\tilde{q}_H$, and how the post-tariff choice of quality compares with q_1 and $\tilde{q}_H$ for a range of τ that ensures selection and welfare gains. We make the following observations: (a) For the chosen parameter values, $q_1 > \tilde{q}_H$; information frictions cause the H firms to not only choose a higher price than the first-best, but also a higher quality relative to the first-best. (b) There exists a range of import tariffs that raise Foreign welfare under restricted entry, despite causing quality of H firms to fall below the first-best levels.

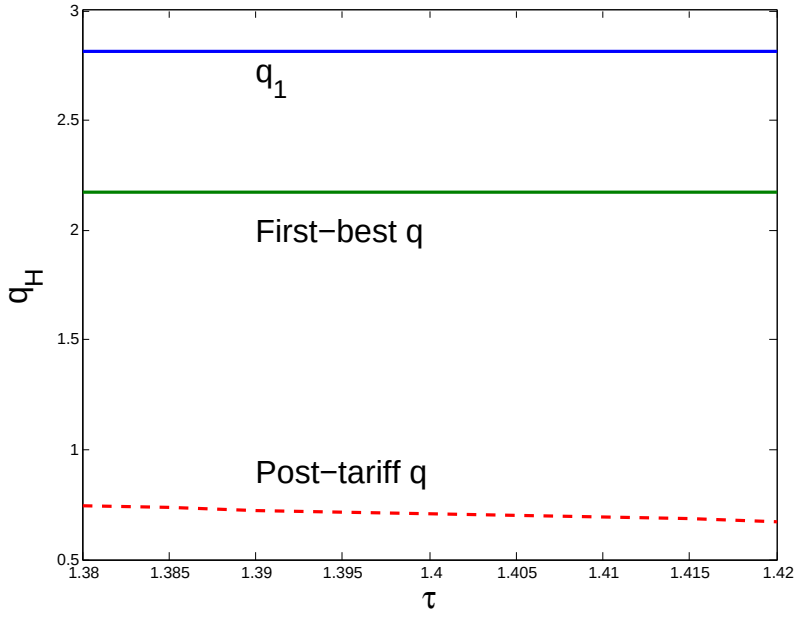


Figure 9: *Comparing quality chosen with and without tariffs*

In a similar fashion, it can be shown that there exists a range of τ for which profits of Home firms go up under restricted entry, while the measure of Home firms rises under free entry. To

summarize, even with endogenous quality, our main result continues to hold: an import tariff by the Foreign country can raise Foreign welfare under restricted entry and Home welfare under both restricted and free entry.

5.2 Alternative signalling devices

In this section, we allow the possibility for firms to use a costly signal other than price. In particular, we assume that by spending an amount E, firms influence consumers' beliefs. One can think of E as expenditure on advertisement. To be consistent with the analysis so far, first we consider an equilibrium where both types of firms export, while only H firms incur E to signal high quality. Then we consider an equilibrium where the imposition of the import tariff leads to a selection of only the H firms into exporting. Finally, we compare welfare across these two equilibria.

In a separating equilibrium where both L and H firms export but only the H firms use the quality signal, both types of firms charge their first-best price. As before, when H firms charge their first-best price, L firms can mimic H firms and earn higher variable profits. Incentive compatibility then requires that $\pi_L(\tilde{p}_H; q_H) - E < \pi_L(\tilde{p}_L; q_L)$. This creates a lower bound for E that must be satisfied for the equilibrium to exist. At the same time, for the H firms to export, one must have $\pi_H(\tilde{p}_H; q_H) - E - f_H > 0$. This creates an upper bound for E. If the imposition of the import tariff leads to selection, the H firms no longer need to use the costly signal. The conditions for selection under tariff are the same as in Section 4.1.

Under restricted entry, the Foreign price index – when both types of firms export – is given by (10), with p_1 replaced by $\tilde{p}_H$, while when only H firms export, it is given by (11). It follows that the imposition of the tariff now reduces the Foreign price index, and using Lemma 1, welfare. As before, the imposition of the tariff has no effect on Foreign welfare under free entry.

Using a similar analysis as in Section 4, it can be shown that the free-entry condition at Home without tariffs is

$$\frac{\alpha Q N}{\sigma P_{RE}^{1-\sigma}} + \Psi_1 = S, \tag{14}$$

where $\Psi_1 = \eta[\pi_H(\tilde{p}_H; q_H) - f_H - E] + (1-\eta)[\pi_L(\tilde{p}_L; q_L) - f_L]$ while the same condition after the imposition of tariffs is

$$\frac{\alpha Q N}{\sigma \hat{P}_{RE}^{1-\sigma}} + \Psi_2 = S, \tag{15}$$

where $\Psi_2 = \eta[\hat{\pi}_H(\tau\tilde{p}_H; q_H) - f_H]$. Comparing (14) and (15), one can see that $\hat{P}_{RE} < P_{RE}$

if $\Psi_1 < \Psi_2$. As before, one can derive the condition under which the measure of Home firms goes up under free entry. This is also the condition under which profits go up under restricted entry. In particular, it can be shown that for η large enough, there exists a value of τ equal to $\tau(\eta)$, such that $\hat{P}_{RE} < P_{RE}$ whenever $\tau < \tau(\eta)$.

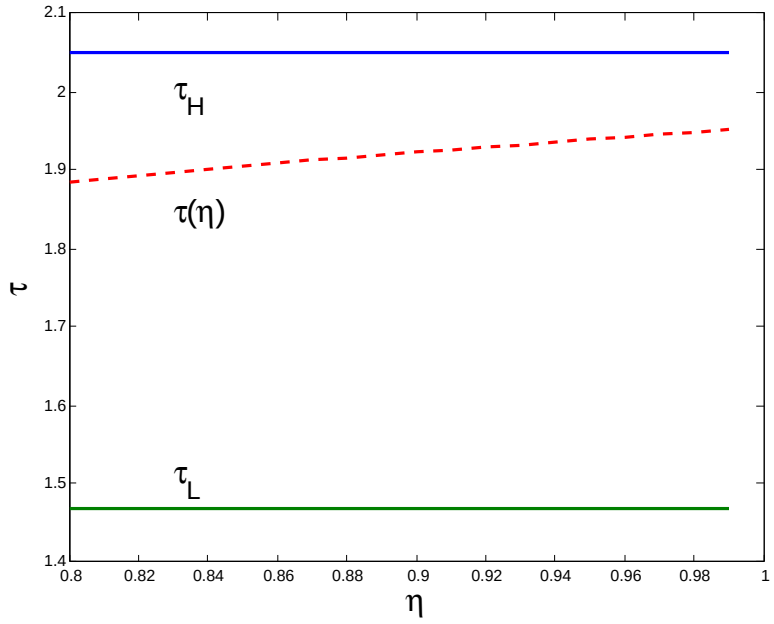


Figure 10: *Range of τ as a function of η under which Home gains*

Figure 10 shows the range of τ as a function of η that satisfies the conditions for welfare gains, as well as selection (both into exporting and using the quality signal). As before, the two solid lines correspond to the upper and lower bounds for τ that ensure selection into exporting while the dashed line represents $\tau(\eta)$. As long as τ lies below $\tau(\eta)$ but above τ_L, the tariff causes selection and raises welfare.

The effect on Foreign welfare under restricted entry in this alternate signalling scenario differs from the scenario where firms use price signals. When firms use prices as signals, the H firms end up choosing a price that is too high. If the import tariff leads to selection, the price charged by the H firms falls, provided the tariff is not too high. This is the source of welfare gains for Foreign consumers. When H firms use the alternate signalling device, there is no effect on the price charged. In this case, when an import tariff causes selection, the H firms could potentially gain because they no longer have to spend the extra amount E to signal their quality. But the Foreign consumers do not gain from the tariff. In fact, they lose because the

price charged by the H firms actually rises (and also because they consume fewer varieties).

To summarize, when firms can use an alternate signalling device such as advertisement to signal their quality, an import tariff reduces Foreign welfare under restricted entry but could raise Home welfare under both restricted and free entry.

6 Conclusion

In this paper, we have examined the effect of an import tariff imposed by a Foreign country on the welfare of both the Home and Foreign country. We have shown that an import tariff could raise Foreign welfare when entry of firms is restricted while keeping it unchanged under free entry. The import tariff could also raise Home welfare under both restricted and free entry. Therefore, the import tariff could be Pareto-improving. The positive effect on welfare arises due to the ability of the tariff to correct a distortion due to information friction. Most of the results continue to hold when we allow firms to choose quality and when firms have access to alternate signalling device.

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Appendix

Proof of Lemma 1. Short-run income in the Foreign country is given by

$$Y^*_{RE} = (N - M^*S) + M^*\pi^*(\tilde{p}^*, q^*).$$

Now, aggregate profit of Foreign firms is

$$M^*\pi^*(\tilde{p}^*, q^*) = M^*\frac{\alpha q^*}{\sigma(P^*_{RE})^{1-\sigma}}Y^*_{RE},$$

where we have used the result that $\tilde{p}^* = \frac{\sigma}{\sigma-1}q^*$. Replacing the value of Y^*_{RE} in the above equation and re-arranging, we have

$$M^*\pi^*(\tilde{p}^*, q^*) = \frac{M^*\frac{\alpha q^*}{\sigma}}{(P^*_{RE})^{1-\sigma} - M^*\frac{\alpha q^*}{\sigma}}(N - M^*S)$$

Replacing aggregate profit in the expression for short-run real income then yields

$$Y^*_{RE} = \frac{1}{1 - \frac{\alpha q^*}{\sigma(P^*_{RE})^{1-\sigma}}}$$

One can then show that,

$$\begin{aligned}\frac{d\ln Y^*_{RE}}{d\ln P^*_{RE}} &= \frac{\frac{\alpha q^*}{(P^*_{RE})^{1-\sigma}} - \frac{\alpha q^*}{\sigma(P^*_{RE})^{1-\sigma}}}{1 - \frac{\alpha q^*}{\sigma(P^*_{RE})^{1-\sigma}}},\\ &< 1,\end{aligned}$$

where the second line follows from the fact that $\alpha q^* = (q^*)^\sigma(\tilde{p}^*)^{1-\sigma} < (P^*_{RE})^{1-\sigma}$. Therefore, Y^*_{RE}/P^*_{RE} is decreasing in P^*_{RE}. □

Proof of Lemma 2. We prove by contradiction. Let there be a price $p' \neq \tilde{p}_L$ that L firms charge in equilibrium. When $p = p'$, $\bar{q} = q_L$, i.e., on observing a price of p', consumers must believe that the firm is of type L. If a L firm deviates and charges $p = \tilde{p}_L$, its profit goes up. This is because $\bar{q}$ is bounded below by q_L, and $\tilde{p}_L$ maximizes the profit of a L firm irrespective of what $\bar{q}$ is. □

Proof of Lemma 3. Notice that

$$\begin{aligned}\pi_L(\tilde{p}_H; q_H) &= q_H^{\sigma}\Big(\sigma - (\sigma-1)\frac{q_L}{q_H}\Big)\frac{\alpha Y^*}{(P^*)^{1-\sigma}} \\ &> q_L^{\sigma}\frac{\alpha Y^*}{(P^*)^{1-\sigma}}\end{aligned}$$

where the inequality follows from the fact that $q_L/q_H < 1$. But the expression on the second line is nothing but $\pi_L(\tilde{p}_L; q_L)$. □

Proof of Lemma 4. Let the two values of p_1 be denoted by p_1^a and p_1^b with $p_1^b < \tilde{p}_H < p_1^b$. Similarly, let the two values of p_2 be denoted by p_2^a and p_2^b with $p_2^b < \tilde{p}_H < p_2^b$. Property 2 implies that at $(\tilde{p}_H, q_L)$, $\frac{dq}{dp}|_{\pi_L} > \frac{dq}{dp}|_{\pi_H}$. This suggests that $\pi_H(p_2^b; q_H) = \pi_H(\tilde{p}_H, q_L)$ but $\pi_L(p_2^b; q_H) > \pi_L(\tilde{p}_H, q_L)$. Because $\pi_L(p_1^b; q_H) = \pi_L(\tilde{p}_H, q_L)$ and $\frac{d\pi_L}{dp} < 0$ for $p < \tilde{p}_L$, it must be the case that $p_1^b < p_2^b$. Similarly, it can be shown that $p_1^a < p_2^a$. Now, IC for the L firm implies that $p_H \leq p_1^b$ and $p_H \geq p_1^a$, while IC for the H firm implies that $p_2^b \leq p_H \leq p_2^a$. Therefore, for the IC of both firms to be satisfied, we must have $p_1^a \leq p_H \leq p_2^a$. That is, p_1 and p_2 are unique. □

Proof of Lemma 5. $\pi_L(p, q)$ is maximized at $p = \tilde{p}_L$ for any q. In particular, $\pi_L(p, q_H)$ is maximized at $p = \tilde{p}_L$. Concavity of the profit function then implies that $\frac{\partial \pi_L(p, q_H)}{\partial p} < 0$ for $p > \tilde{p}_L$. Now,

$$\begin{aligned}\pi_L(p_1, q_H) &= \pi_L(\tilde{p}_L; q_L) \\ &< \pi_L(\tilde{p}_H; q_H).\end{aligned}$$

It then follows that $p_1 > \tilde{p}_H$. □

Proof of Lemma 6. Recall that p_1 solves

$$\frac{\alpha}{\sigma} q_L q_H^{-\sigma} p_1^{\sigma} - p_1 + q_L = 0.$$

Differentiating with respect to q_L, we have

$$\frac{dp_1}{dq_L} = \Big(1 + \frac{\alpha}{\sigma} q_H^{-\sigma} p_1^{\sigma}\Big) / \Big(1 - \alpha q_H^{-\sigma} p_1^{\sigma-1} q_L\Big).$$

The denominator equals $[-(\sigma-1)p_1 - \sigma q_L]/p_1$ which is negative because $p_1 > \tilde{p}_H > \tilde{p}_L$. Therefore, $\frac{dp_1}{dq_L} < 0$. □

Proof of Lemma 7. Let τ' be the value of τ that satisfies $\pi_L(\tau'\tilde{p}_L, q_L) - f_L = 0$. Solving, we have $\tau' = \frac{f_L (P^*)^{1-\sigma}}{\alpha q_L Y^*}$. At $\tau = \tau'$,

$$\begin{aligned} \pi_H(\tau'\tilde{p}_H, q_H) - f_H &= \frac{q_H}{q_L} f_L - f_H, \\ &> 0. \end{aligned}$$

The second line follows from $f_L \geq f_H$ and $q_H > q_L$. Because profits are monotone decreasing in τ, by continuity we can find a τ that is close to τ' such that $\pi_H(\tau'\tilde{p}_H, q_H) - f_H > 0 > \pi_L(\tau'\tilde{p}_L, q_L) - f_L$. □

Proof of Lemma 8. For selection, we must have

$$\begin{aligned} \Big[\sigma - (\sigma-1)\frac{q_L}{q_H}\Big] \tau^{1-\sigma} q_H \frac{\alpha Y^*}{\sigma (P^*)^{1-\sigma}} &< f_L, \\ \tau^{1-\sigma} q_H \frac{\alpha Y^*}{\sigma (P^*)^{1-\sigma}} &> f_H. \end{aligned}$$

In equilibrium, we have $\frac{\alpha Y^*}{\sigma (P^*)^{1-\sigma}} = \frac{S}{q^*}$. Replacing and re-arranging, we have

$$\Big[\sigma - (\sigma-1)\frac{q_L}{q_H}\Big]^{\frac{1}{\sigma-1}} \Big(\frac{S q_H}{f_L q^*}\Big)^{\frac{1}{\sigma-1}} < \tau < \Big(\frac{S q_H}{f_H q^*}\Big)^{\frac{1}{\sigma-1}}.$$

□

Proof of Lemma 9. For the tariff to raise welfare in the Home country, we must have

$$\tau < \Big(\frac{1-\eta}{\eta} \xi^{\sigma} \tilde{p}_L^{1-\sigma} + p_1^{1-\sigma}\Big)^{\frac{1}{1-\sigma}} / \tilde{p}_H.$$

When $\eta \to 1$, the right-hand side of the above equation, $\tau(\eta)$, converges to $\frac{p_1}{\tilde{p}_H}$. Because $p_1 > \tilde{p}_H$, $\tau(\eta) > 1$. Hence, there exists a range of τ such that $1 < \tau < \tau(\eta)$. □

Proof of Lemma 10. For the tariff to raise welfare in the Home country, we must have

$$\tau < \Big[\sigma(p_1 - q_H)q_H^{\sigma-1}p_1^{-\sigma} + \frac{1-\eta}{\eta}\Big(\frac{q_L}{q_H} - \frac{\alpha f q^*}{S q_H}\Big)\Big]^{\frac{1}{1-\sigma}}.$$

When $\eta \to 1$, the right-hand side of the above equation, $\tau'(\eta)$, converges to $[\frac{p_1^\sigma}{\sigma(p_1-q_H)q_H^{\sigma-1}}]^{\frac{1}{\sigma-1}}$. Now, we know that $\pi_H(\tilde{p}_H; q_H) > \pi_H(p_1; q_H)$. This implies

$$\frac{1}{\sigma}q_H > (p_1 - q_H)q_H^\sigma p_1^{-\sigma}.$$

Re-arranging, we get

$$\frac{p_1^\sigma}{\sigma(p_1 - q_H)q_H^{\sigma-1}} > 1.$$

Hence, there exists a range of τ such that $1 < \tau < \tau'(\eta)$. □