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MINIMUM QUALITY LEVELS AND IMPORT TARIFFS *

Roberto Hernan[1] and Praveen Kujal[2]

Abstract

In a vertically differentiated duopoly the use of import tariffs by an importing country decreases domestic welfare if import tariffs are chosen once the firms have made their quality decisions. In this paper we propose import tariffs that are contingent on some minimum quality level (MQL) being met. A firm is taxed if it fails to meet these MQL. Import tariffs conditional on fulfilling the MQL are welfare improving over free trade. Investment in quality increases, market coverage goes up and consumer surplus increases. Firm profits decrease relative to free trade under such tariffs.

Keywords: Vertical Differentiation, Import Tariffs, Minimum Quality Standards.

JEL Classification: F12, F13, L13.

[1]R. Hernan, Departamento de Economía, Universidad Carlos III de Madrid; E.mail: rhernan@eco.uc3m.es.
[2]P. Kujal, Departamento de Economía, Universidad Carlos III de Madrid. E.mail: kujal@eco.uc3m.es. Phone: (34) 91 624 9651

1 Introduction:

The adoption of standards is acknowledged by the WTO that recognizes a country´s right to adopt the standards it considers appropriate. Article 20 of the General Agreement on Tariffs and Trade (GATT) allows governments to act on trade in order to protect human, animal or plant life or health, provided they do not discriminate or use this as disguised protectionism. Not surprisingly quality standards have become an integral part of industrial, and international trade, policy around the world. The role of quality standards in trade is highlighted by the debate on increasing globalization. An importing country can simply not allow the imports of a good if it considers that it does not meet the minimum standards set by a country[1]. In this sense standards can act as entry barriers in some markets. A perverse incentive may thus exist among countries to continually "upgrade" standards under the pretext of environmental, health, or other such standards[2].

Authors both in International Trade and Industrial Organization have studied Minimum Quality Standards. In International Trade MQS have been studied by Chiang and Mason (1988), Das and Donnenfeld (1989), and Boom (1995). Chiang and Masson (1988) show that an MQS above the equilibrium quality increases quality and equates domestic salaries to world levels. Domestic welfare increases in this case.Das and Donnenfeld (1989) show that a MQS can decrease domestic welfare of the country imposing it. Similarly, Boom (1995) shows that an importing country has no incentive to impose a MQS slightly above the lowest quality produced in an unregulated market.

In Industrial Organization MQS have been studied by Ronnen (1991), Crampes and Hollander (1995), Ecchia and Lambertini (1997) and Valleti (2000). Ronnen (1991) shows that if the government sets a MQS in some determined range then an equilibrium exists in which both firms stay in the market and domestic welfare increases. This result, however, is shown not to be robust. First, Ronnen (1991) does not analyze the equilibrium of the entire game in the sense that he does not solve for the optimum MQS.The analysis is instead performed for an MQS slightly above the lowest quality in the market. Second, Valleti (2000) shows that if firms compete in quantity then total welfare can decrease. Finally, Ecchia and Lambertini (1997) (extending Crampes and Hollander (1995)) endogenously determine the optimal MQS in a model without sunk costs (of quality). The optimal MQS increases total welfare in their model.

In this paper we first first look at an *optimal MQS* on imports[3]. Extending Ronnen (1991) we first show that domestic welfare goes up if the government

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[1] This is specially true for trade between developed and underdeveloped countries.

[2] The use of differing standards may be justified by present political priorities. One good example along these lines are emission standards as set in the U.S and EU. In the US standards lean more towards blocking smog forming nitrogen oxides and cancer causing particulates (emissions of these kinds mainly arise from diesel engines). While in Europe the emphasis (till now) has been on global warming. As a result diesel technology has flourished in the EU while it is practically noon-existent in the U.S.

[3] Note, except Ecchia and Lambertini (2000) none of the papers above have studied the optimal MQS.

were to only choose an *optimal* MQS, however, the market is then served only by a monopoly[4]. This occurs as the optimal MQS is very high and pushes out the low quality firm from the market. The optimal MQS increases domestic welfare[5] relative to free trade under Cournot competition.[6] We then look at an ex-post import tariff on imports[7]. Firms, anticipating the tariff, decrease investment in quality. This lowers both consumer surplus and welfare. Finally, we propose an ex-post tariff that is contingent upon the minimum quality (MQL) set by the government. Unlike a MQS the MQL allows imports if the quality of the good does not meet the MQL. A firm that meets the MQL is exempt from the import tariff. Contrarily, a firm that does not meet the MQL pays an import tariff. In this sense the import tariff is contingent upon the quality and is time consistent. The advantage[8] of the tariff contingent MQL is that quality improvement is achieved and both the firms still serve the market. Further, the MQL improves welfare over free trade for the importing country.

The government selects its trade policy instrument in two stages. In the first stage, the government announces the MQL that would exempt a firm from paying the tariff. Firms, knowing the MQL, then invest in quality. After firms select quality, the government then chooses its tariff level. The tariff level is defined by the MQL tariff rule that the government announces in the first stage.[9] In this sense the import tariff is conditional on the quality chosen by the firms. MQLs may be interpreted as being less restrictive than Minimum Quality Standards (MQS) as they allow imports below the minimum quality limits. Under a MQL imports are allowed even if the quality of the imported good lies below it. However, a firm failing to meet the MQL pays a tariff.

Facing such an import tariff exporting firms have two options: invest in a quality level that is equal or greater than, or is inferior to, the minimum (knowing that it will then face a subsequent tariff). In such a scenario we analyse the effect of import tariffs chosen by an importing country when the imported good is of a high and a low quality. We show that if the government only sets an ex-post import tariff (set after the firms invest in quality) then the tariff lowers both consumer surplus and welfare. However, if the government were to set a conditional import tariff then domestic welfare goes up. Conditional import tariffs increase consumer surplus, market coverage and total welfare of the importing country.

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[4] Unlike Boom (1995) the importing country does have an incentive to set an MQS. However, it is high enough such that a monopoly is obtained.

[5] Contrary to Valleti (2000) in our model under Cournot competition total welfare goes up under a MQS.

[6] This theoretical result is not realistic. For example, zero emissions maybe optimal, however, this will push all the firms out of the market.

[7] In a third market model Brander and Spencer (1985) show that an importing country has incentives to set an import tariff in response to an export subsidy of the exporting country.

[8] Given that the optimal MQS results in a monopoly serving the market (clearly an unrealistic situation) and that the optimal tariff decreases quality thereby lowering welfare.

[9] The issue of intervention as a strategic choice has been analysed by several authors. Cooper & Riezman (1989), Arvan (1991), Shivakumar (1993) and Hwang & Shulman (1994) model government policy in two stages . In these papers the government first announces the trade policy instrument and later decides on its level.

Setting a MQL the government is able to influence quality investment in a positive manner benefitting domestic consumers. Due to greater commitment power of the government (relative to that of the firm) it is able to positively influence quality investment by the firms. This is the strategic advantage that the government loses if were to choose tariffs that were not conditional on the MQL. The firm is able to counteract the effectiveness of a single intrument, i.e. tariff, by strategically decreasing its quality investment. However, under the conditional tariff the government is able to counteract this negative effect on quality through the MQL.

We further show that outcomes depend upon whether the government is able to set a discriminative, or uniform, conditional tariffs for the, high and low quality, imported goods. If the government were to discriminate and set a different conditional import tariff for the high and low quality firm it would obtain a higher level of welfare. In this case the MQL would be set high enough such that the low quality firm would pay the import tariff thus increasing government revenues. The high quality firm on the other hand produces a quality just equal to the MQL and evades paying the tariff. If the government were to only charge a uniform conditional tariff then it only influences quality investment by the low quality firm. The high quality firm prefers the situation where both the firms pay the import tariff. The uniform tariff is high enough for the low quality firm and relatively low for the high quality firm. The high MQL seriously undermines the competitiveness of the low quality firm. As a result, paying the tariff the high quality firm increases its profits taking advantage of the negative effect the tariff has on its rival.Total welfare achieved under a conditional discrminative, and uniform, tariff is greater than under free trade. Note that, our results show that including variables such as quality (that positively impact consumer surplus) can have an important effect on results.[10]

The paper is organized as follows. In Section 2 we present the model under free trade. Section 3 studies import tariffs. Section 4 studies conditional import tariffs. Section 5 concludes.

2   The model

We study a vertically differentiated industry where a high and low quality firm export to a third market. There is no domestic consumption in the exporting countries. The third country is a pure consumer of the imported goods and has no domestic production. Consumers are uniformly distributed in the importing country and are identified by their taste parametere θ, which is distributed uniformly over the interval $\left[0, \overline{\theta}\right]$, with $\overline{\theta} > 0$. Each consumer has unitary demand for the good. A consumer with parameter θ obtains utility $U = \theta s - p$, if he purchases one unit of the good at price p and quality s. Utility is zero if a consumer does not purchase the good. Note that θ can also be interpreted

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[10] In our model quality investment is a long run variable that allows firms to commit before governments fix their tariff levels. See Grossman (1988), Sutton (1991) and Herguera, Kujal and Petrakis (2000,2002) for a discussion on long and short run competition variables.

as the marginal rate of substitution between income and quality ratio (Tirole, 1989, p. 96).

The high and low quality firm compete in quantities. In the first stage firms invest in quality which is then taken as given in the quantity competition stage. In this sense quality is a long run decision variable. Firms first choose quality and then compete in quantities. The marginal cost of produciton, c, is constant and is independent of costs of quality. The marginal cost of production is set equal to zero without loss of generality. Quality costs are fixed and costs of quality improvement are increasing. This specification captures the characteristics of a (pure) vertical product differentiation model. Shaked and Sutton (1983) define a purely vertically differentiated industry as one in which the costs of quality improvement fall primarily into fixed costs and involve only a modest, or no, increase in unit variable costs. Quality costs borne in the first stage are treated as sunk in the market competition stage. For reasons of tractability we assume that quality costs are quadratic, $s^2/2$,. We solve the game using subgame perfection.

2.1 Quantity competition:

We first determine the demand function faced by the firms. Let θ_{12} be the taste parameter of the consumer that is indifferent between purchasing the high, or low, quality good. Setting, $\theta_{12}s_1 - p_1 = \theta_{12}s_2 - p_2$, we can then write $\theta_{12} = \frac{p_1 - p_2}{s_1 - s_2}$. Similarly, we define θ_{02} as the taste parameter of the consumer that is indifferent between purchasing the low quality good and not purchasing at all. Setting, $\theta_{02}s_2 - p_2 = 0$, we then get $\theta_{02} = \frac{p_2}{s_2}$. Given θ_{12} and θ_{02} we can now determine the demand that each firm faces.

$$
\begin{aligned}
D_1(p_1, p_2, s_1, s_2) &= 1 - \frac{p_1 - p_2}{s_1 - s_2} \\
D_2(p_1, p_2, s_1, s_2) &= \frac{p_1 - p_2}{s_1 - s_2} - \frac{p_2}{s_2}
\end{aligned}
$$

Where $D_1(p_1, p_2, s_1, s_2)$ is the demand faced by the high quality firm and $D_2(p_1, p_2, s_1, s_2)$ is the demand faced by the low quality firm. These then give us the indirect demands:

$$
\begin{aligned}
p_1 &= s_1 - s_1 p_1 - s_2 p_2 & \text{(1a)} \\
p_2 &= s_2 - s_2 p_1 - s_2 p_2 & \text{(1b)}
\end{aligned}
$$

Firms maximize profits. The equilibrium quantities in this stage are given by:

$$
q_1 = \frac{(2s_1 - s_2)\overline{\theta}}{4s_1 - s_2} \tag{2a}
$$

$$
q_2 = \frac{s_1\overline{\theta}}{4s_1 - s_2} \tag{2b}
$$

4

Given quantities [2a] y [2b] firms choose qualitites in the first stage. Maximizing profits with respect to qualities gives us the first order conditions:

$$\frac{\partial \Pi_1}{\partial s_1} = 0; s_1 = \overline{\theta}^2 \frac{16s_1^3 - 12s_1^2 s_2 + 4s_1 s_2^2 - s_2^3}{(4s_1 - s_2)^3} \tag{3a}$$

$$\frac{\partial \Pi_2}{\partial s_2} = 0; s_2 = \overline{\theta}^2 \frac{s_1^2 (4s_1 + s_2)}{(4s_1 - s_2)^3} \tag{3b}$$
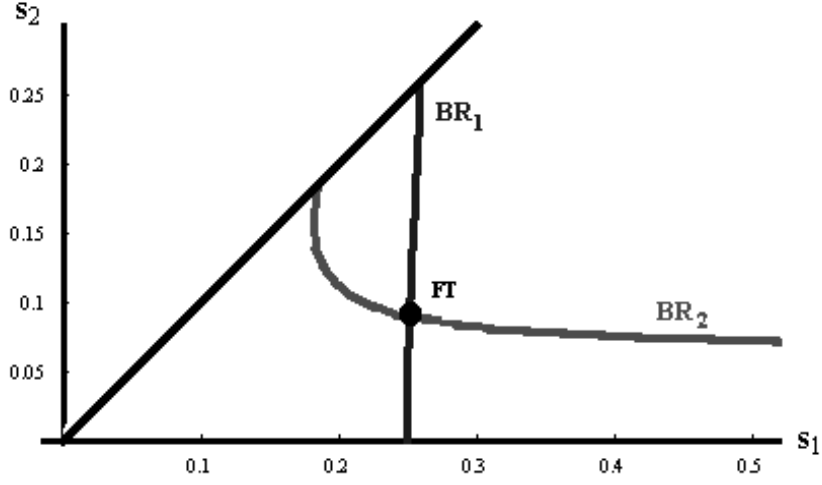

Figure 1: Quality reaction functions under free trade..

The quality reaction functions [3a] y [3b] are described in the figure *1*. The intersection of the reaction function correspond to the Nash equilibrium in quality choices:

$$s_1^* = 0.2519\overline{\theta}^2$$
$$s_2^* = 0.0902\overline{\theta}^2$$

Given qualities one can then write the prices, quantities and profits[11]:

$s_1^{FT} = 0.251942\overline{\theta}^2$	$s_2^{FT} = 0.090223\overline{\theta}^2$	$q_1^{FT} = 0.450834\overline{\theta}$	$q_2^{FT} = 0.274583\overline{\theta}$
$p_1^{FT} = 0.1133584\overline{\theta}^3$	$p_2^{FT} = 0.024774\overline{\theta}^3$	$\Pi_1^{FT} = 0.01947\overline{\theta}^4$	$\Pi_2^{FT} = 0.002732\overline{\theta}^4$

Table 1: Valores de equilibrio bajo libre comercio.

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[11] These are the values that one obtains in the free trade model (see Motta, (1993)).

Consumer surplus if defined by the following expression:

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

Total welfare in this case is defined by the sum of the consumer surplus of the high and low quality consumers, and is given by:

$$CS^{FT} = 0.040174\overline{\theta}^4 \quad SW^{FT} = 0.040174\overline{\theta}^4$$

3 Import tariffs

In a third market Brander and Spencer (1985) model study the trade policy of an importing country when the two exporting countries subsidize exports. They show that for certain demands the import tariff is positive and is welfare improving. We focus only on the import policy of a consuming country with no domestic production. We show that an import tariff imposed by a non-producing import country is welfare decreasing. This occurs as firms anticipating the import tariff optimally respond by lowering quality investment. Decreased quality investment by both the firms lowers average quality resulting in a decline in consumer surplus (and hence total welfare). This result emphasizes the importance of studying the effect of trade policy instruments on long run variables such as quality and the important effect they can have on welfare[12]. The direct positive effect of tariff revenues in this can be counteracted by the effect the tariff has on qualitites.

In this section we introduce the possibility that an importing country imposes tariffs on its imports. The imported goods are of high, and low, quality. Our simple framework allows us to study the effect of an import tariff on quality[13]. We show that an importing country lowers domestic welfare if it imposes import tariffs. Import tariffs are welfare decreasing in our framework due to the effect of tariffs on quality investment. Exporting firms, anticipating the import tariff, invest less in quality. The quality of imported goods as a result declines. This decline in quality lowers consumer surplus. The decline in consumer surplus is greater than tariff revenues and as results in a welfare decline for the importing country. This impact of quality on total welfare is not captured in the horizotal product differentiation models. In our model we show that even though tariff revenues are positive an import tariff can be welfare decreasing due to the fall in the quality of imports. The affect of trade policy instruments on long run variables can give dramatically different results.

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[12] Herguera, Kujal and Petrakis, forthcoming, show that an importing country with a single domestic firm may be more agressive in its trade policies (tariffs) if the domestic firm is low quality. Profit shifting from an agressive policy is greater in this case prompting a high import tariff.

[13] In the following section we extend the analysis by including Minimum Quality Limits.

We consider an import tariff. Facing such a tariff firm profits are:

$$\Pi_i = p_i q_i - t_i q_i - \frac{s_i^2}{2}, \quad i = 1, 2$$

The sequence of moves that we consider is the following. In the first stage firms invest in quality. Given the quality investment the government chooses welfare maximizing import tariffs. Given tariffs and qualities firms compete in quantities in the last stage (see *figure 2*)[14].
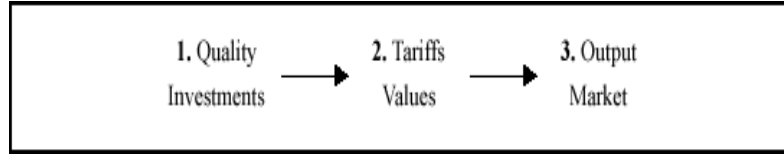

Figure 2: The import tariff game.

As can be seen, in this scenario an import tariff not only impacts short run variables such as quantity, it also affects firm investment in quality. Firms anticipate the ex-post optimal tariff and optimally respond by changing quality investment. The resulting decrease in consumer surplus is greater than the tariff revenues and hence total welfare declines.

In this section we study import tariffs, uniform or discriminative, on both the imported goods. Firm maximize profits and choose quantities. The first order conditions give us the following quantities:

$$q_1 = \frac{2s_1 - s_2 - 2t_1 + t_2}{4s_1 - s_2} \tag{4a}$$

$$q_2 = \frac{s_1 s_2 + t_1 s_2 - 2t_2 s_1}{s_2 (4s_1 - s_2)} \tag{4b}$$

It can be seen from the reaction functions that quantities are decreasing (increasing) in own (other) tariffs. Tariff revenues obtained by the government are the following:

$$R = t_1 q_1 + t_2 q_2 \tag{5}$$

Total domestic welfare is defined as the sum of the consumer surplus and tariff revenues:

$$SW = CS + R \tag{6}$$

We study the possibility that the importing government sets tariffs on both the high and the low quality good. In this case the government has two choices, it can either set a uniform, or discriminatory, tariff on both the goods[15]. We

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[14]This sequence of moves allows us to later study import tariffs conditional on Minimum Quality Limits.

[15]The analysis for tariff only on the low, or high, quality firm can be seen in the appendix.

show that a non-discriminative tariff is welfare improving compared to the discriminative tariff. Welfare under the non-discriminative tariff is lower than under free trade. The single uniform tariff, being higher than the discriminatory *low-quality tariff*, has a greater effect on the low quality firm (than the high quality firm). As a result profits for the low quality firm deciline more and it invests less in quality. Meanwhile, the high quality firm also invests less in quality. Due to the fall in both the qualities, consumer surplus declines and this decline is of a higher magnitude than the import tariff revenues This results in a decline in overall welfare under the non-discriminatory tariff.

The story under a discriminatory tariff is slightly different. The low quality firm now invests more in quality than under the uniform tariff earning greater profits. The high quality firm, however, faces a very high tariff and invests much less in quality earning less than under the uniform tariff. The decline in quality is greater resulting in a greater decline in consumer surplus (relative to the uniform tariff). This decline in consumer surplus is greater than observed under the uniform tariff and dominates the increase in tariff revenues. Total welfare as a result declines relative to the uniform tariff and free trade. One of the interesting results emerging out of this section is that tariff policies increasing in qualities are welfare decreasing[16].

3.0.1 Uniform tariff

The government sets a uniform tariff, t, on all of its imports maximizing total welfare:

$$\max_{t} SW$$

where SW is the total welfare [6] and the tariff paid by each firm is $t_1 = t_2 = t$. From the first order condition we obtain the welfare maximizing import tariff.

$$t = \frac{2s_1 s_2 \left(2s_1 - s_2\right) \overline{\theta}}{12s_1^2 - 5s_1 s_2 + s_2^2} \tag{7}$$

In the first stage firms simultaneously choose qualities. The first order conditions from their maximization problem gives us:

$$s_1 = \frac{432s_1^6 - 540s_1^5 s_2 + 336s_1^4 s_2^2 - 185s_1^3 s_2^3 + 75s_1^2 s_2^4 - 15s_1 s_2^5 + s_2^6}{\left(12s_1^2 - 5s_1 s_2 + s_2^2\right)^3} \tag{8a}$$

$$s_2 = \frac{s_1^2 \left(12s_1^4 - 53s_1^3 s_2 + 33s_1^2 s_2^2 - 9s_1 s_2^3 - s_2^4\right)}{\left(12s_1^2 - 5s_1 s_2 + s_2^2\right)^3} \tag{8b}$$

One can see in the figure (*3*) that the import tariff shifts the reaction functions towards the origin. Both firms reduce quality investment. The shift in the low quality reaction function is greater than the shift in the high quality reaction fucntion. The low quality firm as a result invests much less in quality.

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[16]This contrasts with the fact that most government policies tax the high quality good more than a lower quality good.

The shift of the high quality reaction function is much smaller. The qualty de-
cline for the high quality firm is much less. Profits for the high quality firm are
greater than under free trade as the uniform tariff impacts the low quality firm
negatively making it less competitive. This increases the competitive advanatge
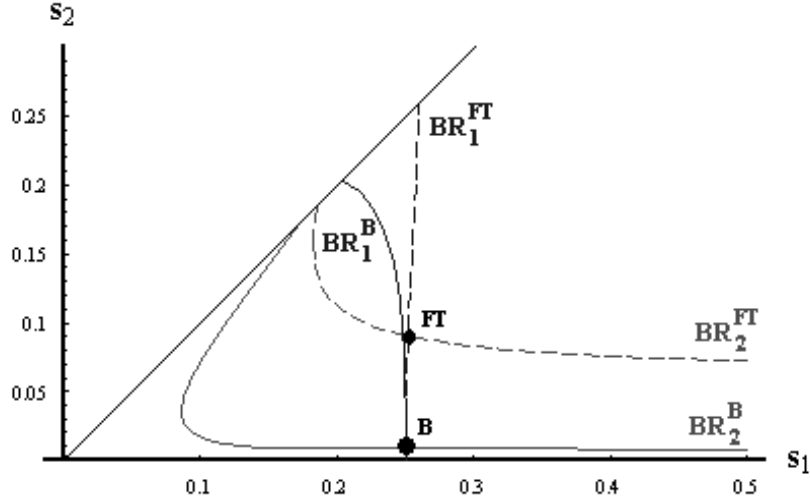of the high quality firm increasing its profits.

Figure 3: Uniform tariff: Quality reaction functions.

Equilibrium quantity, prices, qualities and profits are:

$s_1^B = 0.250001\overline{\theta}^2$	$s_2^B = 0.008327\overline{\theta}^2$	$q_1^B = 0.493011\overline{\theta}$	$q_2^B = 0.087312\overline{\theta}$
$p_1^B = 0.126021\overline{\theta}^3$	$p_2^B = 0.003494\overline{\theta}^3$	$\Pi_1^B = 0.029515\overline{\theta}^4$	$\Pi_2^B = 0.000029\overline{\theta}^4$

Table 2: Equilibrium values under a uniform import tariff.

The welfare maximizing uniform tariff set by the government is $t^B = 0.002767\overline{\theta}^3$ and
total revenues obtained by the government are $R^B = 0.001606\overline{\theta}^4$. Consumer
surplus for the high, and low, quality consumers is $CS_1^B = 0.030741\overline{\theta}^4$ and
$CS_2^B = 0.000032\overline{\theta}^4$, respectively. Total welfare under the uniform tariff is
$SW^B = 0.032379\overline{\theta}^4$.

Both the firms decrease quality investment. The uniform tariff is worse
for the low quality firm. It decreases quality investment by a greater amount
relative to the high quality firm. Output sold by the low quality firm falls due
to the decline in its quality. Given the decrease in quality investment by the
low quality firm, the high quality firm responds optimally and also decreases its
quality investment. Due to increased product differentiation the high quality
firm makes greater profits, selling more output than it did under free trade.

Total output sold declines under the uniform tariff. Compared with free trade total welfare declines under the uniform tariff.

Proposition 1 *Total welfare under a uniform import tariff, $SW^B = 0.032379\overline{\theta}^4$, is smaller than under free trade, $SW^{FT} = 0.040174\overline{\theta}^4$. Total output and consumer surplus decline under the uniform tariff.*

3.0.2 Discriminatory tariffs

In this section we allow the importing government to set a discriminatory tariff on the low, and high, quality firm. The domestic government then maximizes total welfare over the high, and, low quality tariff, t_1, t_2. The goverment maximizes total welfare:

$$\max_{t_1, t_2} SW$$

The solution to the first order conditions gives us the following tariffs.

$$t_1 = \frac{s_1 \left(3s_1 - s_2\right)\overline{\theta}}{9s_1 - s_2} \tag{9a}$$

$$t_2 = \frac{2s_1 s_2 \overline{\theta}}{9s_1 - s_2} \tag{9b}$$

It is easy to see that the tariff on the high quality import is always greater than the tariff on the low quality import. Further, the high quality discriminatory tariff (see [9a]) is always greater than the uniform tariff (see [9a]). Compared to the uniform tariff the low quality firm faces a lower tariff under the discriminatory tariff.

In the first stage firms maximize profits and obtain the following quality reaction function.

$$s_1(s_2) = \frac{81s_1^3 - 27s_1^2 s_2 + 3s_1 s_2^2 - s_2^3}{\left(9s_1 - s_2\right)^3} \tag{10a}$$

$$s_2(s_1) = \frac{4s_1^2 \left(9s_1 + s_2\right)}{\left(9s_1 - s_2\right)^3} \tag{10b}$$

The implicit reaction functions [10a] and [10b], can be seen in the figure *4*.

Under the tariff both the reaction functions shift inwards. The import tariff on the high quality firm being greater its reaction function shifts by a greater amount than under the uniform tariff. Given that the import tariff faced by the low quality firm is smaller its reaction function shifts in by a smaller amount. A discriminatory tariffs favors the low quality and works against the high quality firm. The equilibrium values for quality, output, prices and profits are:

Quality investment, output and profits decline for both the firms relative to free trade. Compared with a uniform tariff quality, quantity and profits for the high quality firm decline. The low quality firm, however, invests more in quality, sells more and increases its profits. The discriminatory low and
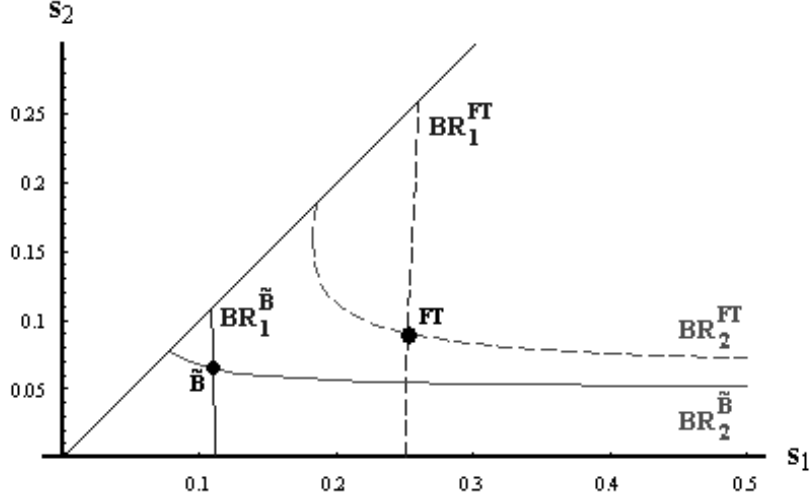
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Figure 4: Discriminatory tariffs.

$s_1^{\tilde{B}} = 0.110822\overline{\theta}^2$	$s_2^{\tilde{B}} = 0.064163\overline{\theta}^2$	$q_1^{\tilde{B}} = 0.287498\overline{\theta}$	$q_2^{\tilde{B}} = 0.237501\overline{\theta}$
$p_1^{\tilde{B}} = 0.063722\overline{\theta}^3$	$p_2^{\tilde{B}} = 0.030477\overline{\theta}^3$	$\Pi_1^{\tilde{B}} = 0.003019\overline{\theta}^4$	$\Pi_2^{\tilde{B}} = 0.001561\overline{\theta}^4$

Table 3: Equilibrium values under a discriminatory import tariff.

high quality tariffs are $t_1 = 0.031861\overline{\theta}^3$ and $t_2 = 0.015239\overline{\theta}^3$, and total tariff revenue accruing to the government is $R = 0.012779\overline{\theta}^4$. Consumer surplus for the high, and low, quality consumers is $CS_1 = 0.008961\overline{\theta}^4$ and $CS_2 = 0.00181\overline{\theta}^4$, respectively. Total welfare under the discriminatory tariff is $SW = 0.02355\overline{\theta}^4$.

Proposition 2 *Compared to free trade, $SW^{FT} = 0.040174\overline{\theta}^4$, total welfare under a discriminatory tariff declines, $SW^{\tilde{B}} = 0.02355\overline{\theta}^4$. Further, total welfare also declines compared to the uniform tariff, $SW^B = 0.032379\overline{\theta}^4$.*

Firms anticipating a discriminatory tariff invest less in quality. Even though tariff revenues increase total welfare declines due to the sharp fall in consumer surplus. A uniform tariff favors the high quality firm while the discriminatry tariff works against the high quality firm. The ability of the government to discriminate in this case works to its detriment and total welfare declines. Of course one needs to keep in mind that with a single instrument the government is targeting both output and quality. Anticipating the tariff the firm is thus able to strategically respond by lowering its quality thus diminishing the effectiveness of the tariff. The negative effect on quality investment in this case negates the increase in tariff revenues.

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4   Conditional tariffs

In the last section we studied the effect of ex-post import tariffs on an importing countries welfare. We saw that any import tariff lowers domestic welfare due to the effect of the tariff on quality invesment. Anticipating the ex-post tariff firms lower quality investment thus resulting in a decline in consumer surplus. This decline is greater than the additional tariff revenues. This result points out the importance of long run variables (such as quality) in determining welfare outcomes. The effect of these variables on welfare can be of a greater magnitude and can lower welfare impacting consumer surplus. If long run variables are negatively affected then ex-post import tariffs can be welfare decreasing (unlike the welfare incresing effect observed in Brander and Spencer (1985)).

One should, however, note that in Brander and Spencer there is one target, i.e. output, and one instrument, i.e. a tariff. In our model this is not the case. Governments can impact both quality and output through the import tariff. Hence a simple comparision of our earlier result to Brander and Spencer (1985) may not be fully justified. A more appropriate government policy may be one that uses two instruments on (its) two target variables, i.e. quality and output. It may be argued that such policy instruments are more appropriate for industries characterised by the presence of both long, and short, run variables.

Keeping this in mind we propose a non-linear policy instrument that can be used by governments in such industries. We propose the use of conditional import tariffs. A conditional import tariff depends on a certain Minimum Quality Limit set by the importing government. If a firm invests above the MQL it is exempt from paying the import tariff, otherwise it pays an import tariff. In our structure Minimum Quality Limits (MQLs) and import tariffs are a pair of possible policy instruments[17] at the governments disposal. Minimum Quality Limits (MQLs) are defined as quality limits set by the government that if unfulfilled result in the good being taxed. In this sense MQLs are less restrictive than Minimum Quality Standards as they permit the sale of the good if the quality is below the limit set by the standard. Our version of MQLs is more flexible than the MQS, goods are taxed if they do not meet the MQL. Further, most industries have quality standards as an integral part of a governments industrial policy. Our use of MQL's is motivated by the fact that a government valuing consumer welfare finds in its own interest to promote quality investment by firms due to their welfare improving effects.

We analyze two types of conditional tariffs. In the first case the government sets a uniform quality conditional tariff (applied to both the firms) on its imports. In the second case we allow the government to discriminate between the firms when setting the conditional tariff. The government in this case can set a different conditional tariff for the high, and low, quality firm. The sequence of moves that we study is the following (see *figure* **??**). The government first sets the MQL. Given the MQL firms then invest in quality. A firm may choose, or not, to meet the MQL. If the firms meet, or exceed, the MQL they pay no

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[17] We only consider these two policy instruments in this paper.

tariffs on their exports. The quality chosen by the firms is of course decided by the tradeoff between the profits gained by the marginal quality increment and the increase in quality costs such that the firm does not pay the import tariff[18].
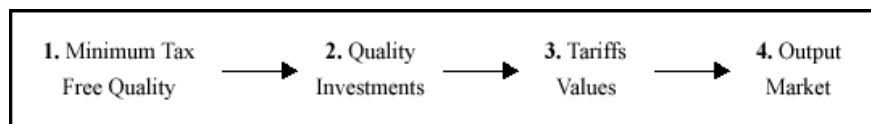

Figure 5: The Conditional Tariff Game.

The government is interested in such a policy as the cost of quality improvement falls only on the exporting countries. An increase in quality in this case implies an increase in the importing countries welfare through the increase in consumer surplus. Looking at it this way the conditional tariff can be interpreted as a mechanism to increase firm investment in quality above the levels observed under free trade. Of course, by choosing its quality investment the firm decides whether it is in its benefit to choose a quality that exempts it from paying the tariff, or not.

In the following section we study such conditional tariffs. First we study a uniform conditional tariff that is the same for both the low and high quality firm. This is followed by the analysis of the discriminative conditional tariff.

4.1   Uniform conditional tariff

The government first announces its MQL. The MQL informs the firms on the minimum quality that exempts their exports from the tariff. Following the announcement of the MQL firms decide on their quality investment. The quality chosen by the firms determines whether they will be subject to the import tariff, or not. After the firms decide on their qualities, the government (observing the qualities) announces the tariff. Finally, the firms compete in quantities.

It is easy to see that if the MQL is at, or less than, the low quality chosen under free trade it has no impact upon the qualities chosen by the firms. Further, if the MQL equals the quality chosen by the low quality firm under free trade tariff revenues are zero. Thus the government is only able to change the qualities and generate tariff revenues if the MQL exceeds the (low) quality chosen under free trade, $s_2^{FT} = 0.090223\bar{\theta}$. If the MQL is slightly above s_2^{FT} the low quality firm has two options. The first is to invest below s_2^{FT} paying the import tariff and the other is to invest above it. If the firm decides to pay the import tariff once more it chooses s_2^{FT}. In the case that the firm invests above s_2^{FT} then it

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[18]Such a separation of government policy has been studied before by several authors in a different context. Cooper y Riezman (1989) study a model in which the government first studies what trade policy instrument to use (subsidies or quotas on exports) and in a later stage decide on the levels. Arvan (1991) and Shivakumar (1993) extend this model and study the effect of choosing its policy before (assuming commitment), or after (assuming no commitment), the firms get to know their true demands.

will always choose the MQL set by the government. Given that total welfare is increasing in quality the government is interested in setting a MQL above s_2^{FT}.
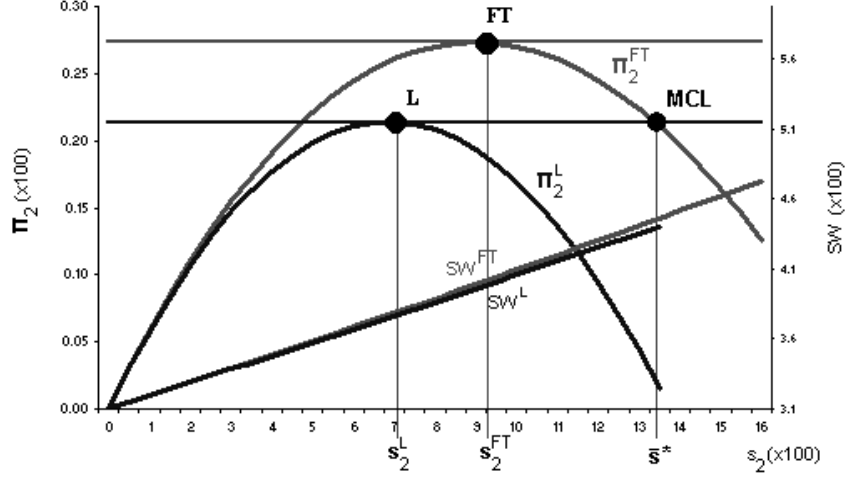

Figure 6: Total welfare and profits under conditional tariff: Low Quality Firm

In *figure (6)* we see the maximimum profits of the low quality firm given the best response of the high quality firm (see [3a] paying no tariff) for quality s_2^{FT}. Beyond s_2^{FT} profits in equilibrium will be smaller if the firm invests more in quality. Contrarily, total welfare (SW^{FT}) increases in low quality (given that no firm pays the tariff and the rival best responding). The low quality firm always sets its quality equal to the MQL (given that it earns greater than setting a lower quality and paying the import tariff). That is,

$$s_2 = \overline{s} \quad if \quad \Pi_2\left(fr_1(\overline{s}; t_1 = t_2 = 0), \overline{s}\right) \geqslant \Pi_2^L$$
$$s_2 = s_2^L \quad otherwise$$

It is interesting to see how the choice of the uniform conditional tariff influences quality choice by the two firms. Looking at the figure we see that any MQL$\leqq s_2^{FT}$ does not affect quality investment for either firm. Further, as neither firms pay the tariff the government does not change the equilibrium from free trade. Thus the government only gains if it sets a MQL above s_2^{FT}. For a MQL above s_2^{FT} we see that the low quality firm still makes greater profits than paying the tariff and staying at point L (on Π_2^{LT}). The low quality firm always chooses the MQL till the point MCL where its profits exactly equal the profits at point L. If the MQL were to be greater than MCL it always chooses point L. The government thus knows that it can only increase low quality in the range $(s_2^{FT}, \overline{s}^*]$.

In figure *6* we can observe that the profits for the low quality firm that meets the MQL and pays the import tariff are represented by the point MCL. This

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point corresponds to a quality level , $s_2 = \overline{s}^* = 0.133885\overline{\theta}^2$, for the low quality firm. In the case that the government sets $\overline{s}^*$ as the MQL the equilibrium values are the following:

$s_1^{\overline{s}} = 0.254011\overline{\theta}^2$	$s_2^{\overline{s}} = 0.133885\overline{\theta}^2$	$q_1^{\overline{s}} = 0.424115\overline{\theta}$	$q_2^{\overline{s}} = 0.287942\overline{\theta}$
$p_1^{\overline{s}} = 0.10773\overline{\theta}^3$	$p_2^{\overline{s}} = 0.038551\overline{\theta}^3$	$\Pi_1^{\overline{s}} = 0.013429\overline{\theta}^4$	$\Pi_2^{\overline{s}} = 0.002138\overline{\theta}^4$

Table 4: Equilibrium values: Uniform conditional tariff.

Given that both the firms invest above the required minimum, neither pays the import tariff. The government thus earns zero tariff revenues. Total consumer (total) surplus in this case is $CS^{\overline{s}} = SW^{\overline{s}} = 0.044745\overline{\theta}^4$. Total welfare obtained under a uniform tariff is greater than under free trade, $SW^{FT} = 0.040174\overline{\theta}^4$.

Lemma 3 *Total welfare under a uniform conditional tariff, $SW^{\overline{s}} = 0.044745\overline{\theta}^4$, is greater than under free trade, $SW^{FT} = 0.040174\overline{\theta}^4$. Neither firm pays the import tariff producing quality at, or above, the MQL.*

Quality investment by both the firms is greater than under free trade. As a result profits for both the firms decline. The government is able to increase quality investment and achieves a higher level of welfare. Even though prices increase and total output declines the increase in quality more than compensates for the increase in the price and the fall in output. Consumer surplus for both, the low and high, quality consumers is greater than under free trade.

If the government sets the MQL above $\overline{s}^*$ the low quality firm prefers to produce the quality s_2^{LT}, paying the import tariff and making greater profits. On the other hand the government has no incentive to set the MQL above $\overline{s}^*$ as it decreases total welfare.

It now interesting to look at the incentives of the high quality firm given that the MQL$>\overline{s}^*$. Profits for the high quality firm are denoted by π_1^{LT} when the low quality firm pays the tariff. Profits for the high quality firm are much higher (π_1^B) if both firms pay the tariff. In any range between B and MCH the high quality firm will always choose a quality slightly below the MQL. Further, knowing that a high tariff works to the detriment of the low quality firm the high quality firm always invests below the MQL in the range $(B, MCH]$ making greater profits. The government, however, never wants both the firms to pay the tariff as its welfare is lower in this case ($SW^B < SW^{LT}$). Knowing that it cannot increase quality investment of the high quality firm above s_1^B, the government, always prefers a MQL in the range $(s_2^{FT}, \overline{s}^*]$.

The results under a uniform conditional tariff are summarized in the following proposition:

Proposition 4 *The government maximizes total welfare choosing a MQL of $\overline{s}^* = 0.133885\overline{\theta}^2$. In equilibrium no firm pays the import tariff. The low quality*
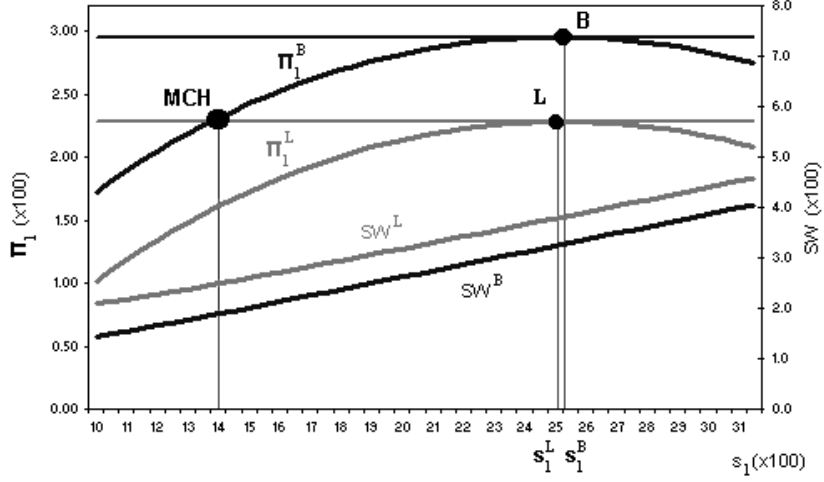
Figure 7: Total welfare and profits for the high quality firm: Uniform conditional tariff.

firm sets its quality (s_2^*) exactly equal to the MQL and the high quality firm produces quality $s_1^{\overline{s}} = 0.254011\overline{\theta}^2$.

4.2   Discriminatory conditional tariff

In this section we look at the possibility that the government sets a different conditional import tariff for both the exporting firms. The advantage of the discriminative conditional tariff is that it allows the government to influence the quality investment of the high quality firm. Knowing that welfare is increasing in high quality, the government chooses a high enough MQL that results in the high quality firm meeting the MQL and not paying the tax. In the case of the discriminatory tariff the high quality firm does not have the incentive to lower its quality investment and pay the import tariff. The incentives for the high quality firm are just the opposite in this case. Under a discriminatory conditional tariff the government chooses a high MQL. In equilibrium the high quality firm invests exactly equal to the MQL and earns less than it would if it were to pay an import tariff. The low quality firm, meanwhile, selects a substantially lower quality (relative to the uniform conditional tariff), selling less and makes less profits. A discriminatory conditional tariff works to the detriment of both the firms.

This is seen in the figure *(8)* below where, π_1^{LT} indicates profits for the high quality firm when only the low quality firm pays the tariff. $\pi_1^{\tilde{B}}$, on the other hand, indicates profits made by the high quality firm when both the firms pay the conditional import tariff. It is thus clear that if the government were to

choose the MQL below s_1^L then it will be non-binding on the high quality firm as it will always choose s_1^L maximizing profits at L. The area to the right of L is thus the region in which the government can increase total welfare (with the high quality firm increasing its quality investment). Noticing that total welfare is increasing in s_1 the government wants the high quality firm to moves down its profit curve (π_1^{LT}). The highest MQL the government will choose is $\widetilde{MCH}$ that leaves the high quality firm indifferent between paying the tariff making $\pi_1^{\widetilde{B}}$ (point $\widetilde{B}$), or not paying the tariff and staying at point $\widetilde{MCH}(=\widetilde{s}^*)$. Under a discriminative tariff the government thus chooses a MQL that coincides with $\widetilde{s}^*(=0.450403\overline{\theta}^2)$ maximizing total welfare.
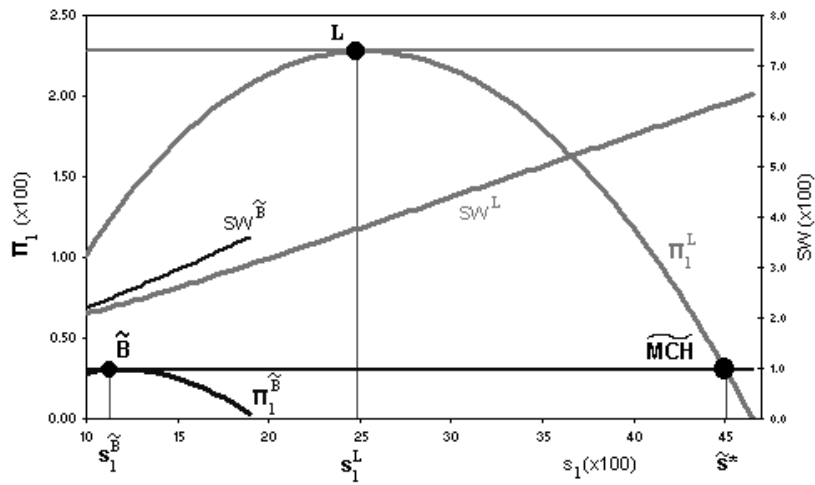

Figure 8: Profits high-quality and total welfare under a discriminative conditional tariff.

Note, however, if both the firms pay the tariff then the welfare obtained by the government is much lower ($SW^{\widetilde{B}} = 0.02355\overline{\theta}^4$ at $\widetilde{s}_1^{\widetilde{B}}$) than if only the low quality firm pays the tariff. Any MQL slightly below $\widetilde{MCH}$ gives the government welfare greater than the case where the high quality firm chooses quality $\widetilde{s}_1^{\widetilde{B}}$.

Proposition 5 *The importing country, setting discriminatory tariffs, increases welfare over free trade (and uniform the conditional tariff) setting a $MQL \geqslant s_1^L$. The welfare maximizing MQL is $\widetilde{s}^* = 0.450403\overline{\theta}^2$ and each firm pays tariff: $t_1 = \frac{s_1(3s_1 - s_2)\overline{\theta}}{9s_1 - s_2}$ y $t_2 = \frac{2s_1 s_2 \overline{\theta}}{9s_1 - s_2}$. Welfare under the discriminatory conditional tariff equals $SW = 0.062528\overline{\theta}^4$.*

The equilibrium values obtained under the discriminatory tariff are summa-

rized in the table below.

$s_1^{\tilde{s}} = 0.450403\overline{\theta}^2$	$s_2^{\tilde{s}} = 0.06562\overline{\theta}^2$	$q_1^{\tilde{s}} = 0.481565\overline{\theta}$	$q_2^{\tilde{s}} = 0.253073\overline{\theta}$
$p_1^{\tilde{s}} = 0.216898\overline{\theta}^3$	$p_2^{\tilde{s}} = 0.017413\overline{\theta}^3$	$\Pi_1^{\tilde{s}} = 0.003019\overline{\theta}^4$	$\Pi_2^{\tilde{s}} = 0.00205\overline{\theta}^4$

Table 5: Equilibrium values under the discriminative conditional tariff.

As can be seen, only the low quality firm pays the import tariff $t_2 = 0.000806\overline{\theta}^3$. Tariff revenues obtained by the government are $R = 0.000204\overline{\theta}^4$ and consumer surplus for the high and low quality consumers, respectively, is $CS_1 = 0.060222\overline{\theta}^4$ y $CS_2 = 0.0021011\overline{\theta}^4$.

The discriminative conditional tariff has important effects on the strategic choice of quality by both the low, and high, quality firm. Both firms earn less profits. The low quality firm decreases quality investment and the high quality firm increases quality investment. Consumer surplus and total welfare under a discriminatory conditional tariff is greater than under any other tariff policy. Under a discriminatory tariff the government is able to affect quality investment by the high quality firm. This ability to affect quality investment of the high quality firm, is not present under the uniform tariff.

5 Conclusion

We have seen that in a vertically differentiated industry a per-unit import tariff, uniform or discriminatory, always lowers total welfare for an importing country. This occurs due to the strategic behaviour of the exporting firm that lowers its quality investment anticipating the tariff. A government loses the strategic advantage of an import tariff due to its inability to control quality investment by the firm. Due to decreased quality investment consumer surplus is lower. This decline is greater than the tariff revenues and hence total welfare declines. This result is important as it indicates that in models where the government targets more than one instrument (not just price, or output) a simple tariff policy may be welfare decreasing. This results suggest that multiple instruments may be much more effective in such environments.

Given that a simple import tariff has a distortionary affect on quality investment by firms we propose a conditional import tariff as an alternative trade policy instrument. The conditional import tariff depends on a certain Minimum Quality Limit (MQL) whereby, any firm failing to meet it pays an import tariff. In this sense, the MQL is a generalized version of the Minimum Quality Standard as it allows sale of a good below a certain minimum threshold (under a MQS this tariff is prohibitive). A firm unable to meet the threshold simply pays the tariff. We show that if the governmet has at its disposal two instruments (a MQL and a conditional import tariff) and two targets (output and quality) then the conditional import tariff can be a welfare improving policy tool in the hands of an importing government.

We study the effect of a conditional import tariff on the welfare of an importing country when firms compete in quantities. We define a conditional tariff as a tariff that depends on a certain minimum quality level being met. If a firm does not meet this minimum it pays an import tariff, otherwise it is exempt. In this manner the government has an instrument for quality (a MQL) and an instrument for output. With such a two-part instrument a government is able to improve domestic welfare. We analyze two different conditional tariffs. First, we study a uniform conditional tariff that is the same for both, high and low quality, firms. Subsequently we study a discriminative tariff. We show that highest welfare is obtained by an importing country under a discriminative conditional tariff. Welfare under a discriminative tariff is higher than under free trade, or a uniform conditional tariff.

The effect on quality chosen by the firms is different under a uniform and a discriminative conditional tariff. A uniform conditional tariff has a detrimental effect on the low quality firm. The high quality firm in this case can lower quality investment thus increasing the competitve presurre on the low quality firm. This clearly works to the detriment of the low quality firm that makes lower profits. The government, however, is unable to affect quality investment by the high quality firm under the uniform conditional tariff. The MQL chosen in equilibrium is such that neither the low, or the high, quality firm pay the conditonal import tariff. The low quality firm chooses a substantially higher level of quality than under free trade. Even though in equilibrium neither firm pays the conditional import tariff total welfare increases due to the increase in consumer surplus (average quality increases).

The MQL set by the government lies in the intermediate range of the qualities chosen by the firms under free trade. The reason is that the high quality firm will never produce a quality greater than it does under free trade. In fact, for a high enough MQL, it is in the interest of the high quality firm to choose a quality level slightly below the MQL provoking a higher tax[19] on the low quality firm[20]. The high import tariff decreases the competitiveness of the low quality firm. This works to the advantage of the high quality firm and it earns greater profits than it would earn otherwise. However, it is not to the advantage of the government to set a high MQL. A high MQL lowers quality investment by both the firms resulting in lower total welfare. The government, as a result, selects an MQL that is somewhere between the qualities chosen by the two firms under free trade.

The story under the discriminative conditional tariff is different. The government is able to affect quality investment by both the firms under the discriminative tariff. Each firm pays a separate tariff, the MQL is high enough such that the quality chosen by the high quality firm is substantially higher than under free trade. The low quality firm, however, invests less in quality. Total domestic welfare of the importing country is greater than under both free

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[19] The import tariff paid by both the firms is greater than when only the low quality firm pays it.

[20] The strategy of reducing its quality investment and paying the tariff is optimal for the high quality firm for a MQL greater than $0.137533\bar{\theta}^2$.

trade and the uniform conditional tariff. The low quality firm pays an import tariff while the high quality firm produces at the MQL (not paying the import tariff). Output sold in the market is higher. Firm profits are, however, much lower than under free trade.

In this paper we have attemped to study the role of quality instruments in a tariff game. We have shown with a single instrument the government is unable to counteract the negative effect of decreased quality investment upon welfare. A simple import tariff in this case is welfare decreasing. Allowing for a quality and output instrument we show that the government can counteract the strategic behaviour of the firms. The importing government achieves increased quality investment that is welfare improving. The role of quality instruments is shown to have important effect on the welfare of the importing country.

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.1 Import tariff:Low quality

In the second stage of the game the government selects an import tariff on the low quality import. Setting $t_1 = 0$, the government maximizing welfare selects a tariff on the low quality import, t_2, given outputs [4a] and [4b]:

$$\max_{t_2} SW$$
$$s.a \quad t_1 = 0$$

The solution to this maximization problem gives us the import tariff on the low quality good:

$$t_2 = \frac{s_2^2 \overline{\theta}}{12s_1 - s_2} \tag{11}$$

Notice that the import tariff is decreasing in high quality (s_1) and increasing in low quality (s_2). It is clear from this that the low quality firm has incentives to lower its investment in quality. Knowing that the low quality firm has incentives to decrease it quality investment, and that investment in quality is costly, the high quality firm also lowers its quality investment. The incentives to alter investment for both the high and low quality firms are clear from the first order condition above.

Given the import tariff [11] firms select qualities in the first stage. The first order condition give us the following quality reaction functions:

$$s_1 = \frac{4\left(108s_1^3 - 27s_1^2 s_2 - s_2^3\right)\overline{\theta}^2}{\left(12s_1 - s_2\right)^3} \tag{12a}$$

$$s_2 = \frac{9s_1^2\left(12s_1 + s_2\right)\overline{\theta}^2}{\left(12s_1 - s_2\right)^3} \tag{12b}$$

A look at the reaction fucntions (*figure 9*) helps us in understanding firm incentives.

The import tariff shifts the reaction curve of the low quality firm inwards. Regardless of the quality offered by the high quality firm the low quality firm invests less in quality (relative to the free trade level of quality investment). The high quality firm responds optimally and also lowers its quality investment. Increasing its quality investment (i.e. increasing product differentiation) is not the optimal response for the high quality firm given that the low quality firm always lowers its quality investment. As a result both firms lower quality invesment in response to an import tariff on the low quality firm.
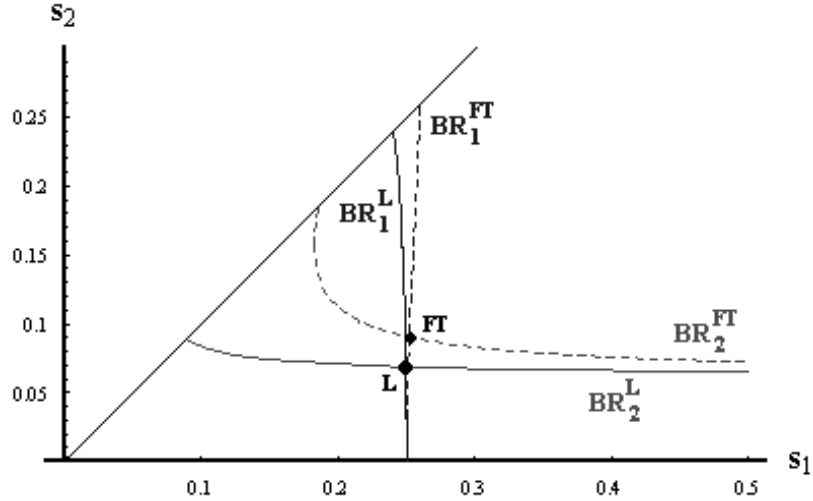

Figure 9: Import tariff on Low Quality Imports

Equilibrium qualities are obtained from equations [12a] and [12b]. Equilibrium output, prices and qualities are presented in the table below:

Given the equilibrium values the import tariff on the low quality good and tariff revenues are $t_2^L = 0.001605\overline{\theta}^3$ and $R^L = 0.000411\overline{\theta}^4$, respectively. Consumer surplus and total welfare are $CS^L = 0.037356\overline{\theta}^4$ and $SW^L = 0.037766\overline{\theta}^4$, respectively.

$s_1^L = 0.249531\overline{\theta}^2$	$s_2^L = 0.068529\overline{\theta}^2$	$q_1^L = 0.464867\overline{\theta}$	$q_2^L = 0.255855\overline{\theta}$
$p_1^L = 0.115999\overline{\theta}^3$	$p_2^L = 0.019138\overline{\theta}^3$	$\Pi_1^L = 0.022791\overline{\theta}^4$	$\Pi_2^L = 0.002138\overline{\theta}^4$

Table 6: Equilibrium quality, output and prices.

Proposition 6 *A tariff on low quality imports lowers total welfare for the importing country, $SW^L = 0.037766\overline{\theta}^4$, relative to free trade $SW^{FT} = 0.040174\overline{\theta}^4$.*

Investment in quality by both the low and high quality firm decrease relative to free trade. The high quality firm increases its profits while the low quality firm decreases its profits relative to free trade. Consumer surplus decreases relative to free trade and the decline is greater than the tariff revenues.

.2 Import tariff:High quality

Given outputs [4a] and [4b] the government sets the tariff on the high quality firm maximizing:

$$\max_{t_1} CS + R$$

$$s.a \quad t_2 = 0$$

From the first order condistions we obtain the tariff:

$$t_1 = \frac{s_1 \left(4s_1 - 3s_2\right)\overline{\theta}}{12s_1 - s_2} \tag{13}$$

In the last stage firms choose qualities maximizing profits. The first prder conditions give us the quality reaction functions:

$$s_1 = \frac{\left(192s_1^3 - 48s_1^2 s_2 + 4s_1 s_2^2 - s_2^3\right)\overline{\theta}^2}{\left(12s_1 - s_2\right)^3} \tag{14a}$$

$$s_2 = \frac{16s_1^2 \left(12s_1 + s_2\right)\overline{\theta}^2}{\left(12s_1 - s_2\right)^3} \tag{14b}$$

The implicit reaction functions [14a] and [14b] can be seen in the figure *10*. As observed before, the import tariff shifts the reaction function of the high quality firm inwards. The high quality firm invests less in quality due to an import tariff. However, unlike what was observed in the case of the low quality tariff, the effect on the rival firm is just the opposite. The low quality firm in this case invests more in quality because competition softens in the quantity stage due to the tariff. An import tariff on the high quality firm thus decreases quality investment by the high, and increases quality investment by the low, quality firm.
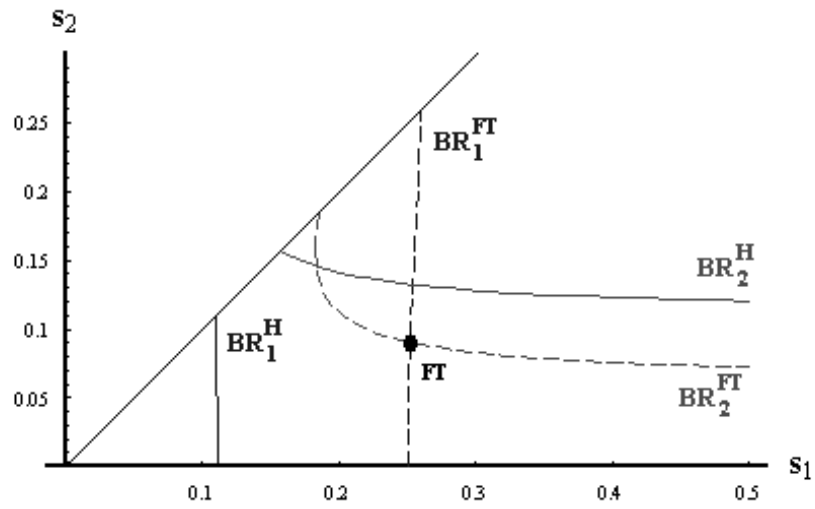
Figure 10: Tariff on the high quality firm.

The ex-post tariff on the high quality firm is very high. Due to the high import tariff equilibria in pure strategies no longer exists. The high quality firm makes negative profits in the presence of the import tariff. This occurs as a high quality exporting firm, facing the high ex-post tariff, has no incentives to sell the high quality good. In this case nor does the low quality firm have an incentives to leapfrog and produce the high quality good as it would then face the same high ex-post tariff. The results are stated in the following proposition:

Proposition 7 *If an importing country set tariffs only on the high quality good then an equilibria in pure strategies does not exists.*