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Résumé: Cet article propose d'associer la certification d'origine à une barrière non tarifaire dans les échanges internationaux. En effet, la certification d'origine se traduit souvent à la fois par une restriction quantitative et par une subvention implicite de la qualité. On considère le modèle canonique de concurrence internationale dans lequel une firme domestique et une firme étrangère se concurrencent pour la vente de leur produit sur le marché domestique. Dans ce cadre, on montre comment l'adoption de la certification peut permettre à la firme domestique de se positionner en leader de qualité. Si au contraire elle offre le bien de qualité plus faible, le surplus des consommateurs peut être amélioré.

Abstract: This paper put forward the opinion that the certification of origin constitutes another type of non-tariff barrier. Indeed, certification of origin often combines both a quantity restriction and a sort of quality cost subsidy. We consider the canonical model of strategic trade policy, whereby two firms are located respectively in the home country and in a foreign country and are competing on the domestic market. In this framework, we show how certification can allow the domestic firm to position itself as a high quality producer. If, however, the certified firm offers the low quality good, then consumers' surplus may be improved.

Mots clés : Marque, Certification d'origine, Barrière non tarifaire, Commerce international

Key Words : Brand, Certification of Origin, Non tariff Barrier, International Trade

Classification JEL: F12, F13

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1 Introduction

International trade literature has devoted a great deal of attention to the effects of various instruments of trade policy and, in particular, to non-tariff barriers (NTB). Among these NTBs, the most frequently encountered and studied are export subsidies, import quotas, voluntary export restraints (VERs) and technical barriers to trade.In this paper, we put forward the opinion that the certification of origin constitutes another type of NTB. Indeed, principally in the agro-food sector, the certification of origin systems are usually based on the respect of production rules, mainly yield restrictions, as well as the definition of territorial limits outside of which a producer cannot benefit from the official certification[1]. Taking for granted that the certification of origin restrains the quantities produced and commercialized, it may operate like a VER or an import quota, in the context of international trade where some countries resort to certification of origin while others do not. However, the certification of origin is not a classical VER. First, unlike with a VER, it is the domestic firm which is here hurt by the quantity restrictions, whereas a voluntary export restraint is a quota on trade imposed by the foreign country at the request (in general) of the domestic country. Moreover, more often than not (and particularly in the agro-food sector), a certification of origin provides a certain level of reputation or a guarantee of quality. The certification of origin is thus also a kind of cost

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[1]For instance, in the wine-growing sector it is not rare that these certifications of origin specify, in addition, a limitation of the production of grapes (as is the case of the French "Appellations d'Origine Contrôlées" labeling, or more generally the European "Quality Wines Produced in a Determined Region"). This is also found for cheeses with the definition of the breed of animal designated to produce the milk. It is the same for the quality labels in the meat sector which very severely restrict the producers on the number of animals per hectare that they have and these restrictions are often much more costly than investments in fixed or variable costs to satisfy production specification requirements.

The other pole in the production system and the marketing of the agro-food sector (and especially for wine) is that which can be observed today in newly exporting countries such as the United States, Australia, or Chile. Here it concerns a more industrialized form of wine growing based on a simplified identification of the product variety (for example the type of vine) and on private brands. The often significant promotional investments are essentially associated with these brands (as an example, the Gallo firm in the United States has the biggest advertising budget of the entire profession with 30 billion dollars invested each year, see Bastien (1997)).

subsidy that modifies a firm's quality investments and in turn the quantity of the product offered. Thus, a partial but nonetheless relevant interpretation is that certification of origin may constitute a new type of NTB combining both a quantity restriction and a sort of quality cost subsidy.

This interpretation is rather original, since in the literature certification schemes are usually regarded as quality labels used by the State as a mean to correct market failures which are induced by the consumers' lack of information about a products' quality. Most of the theoretical works in this field compare the effectiveness of private and/or public signals with respect to information revelation from the point of view of public economics (Shapiro (1983)). In contrast, even though we agree that information revelation is an important issue, our analysis does not hinge on this factor.

Our approach to the problem falls within the framework of the international trade literature. Our work is related to recent papers on international trade, which largely focus on the analysis of the effects of quantitative restraints such as import quotas or voluntary export restraints. More precisely, our model is close to the works of Krishna (1990), Das and Donnenfeld (1987), Herguera Kujal and Petrakis (2000)[2], who analyze the impact of import quota imposition or voluntary export restrictions on quality choice in an international competition setting. We consider the canonical model of strategic trade policy, whereby two firms are located respectively in the home country and in a foreign country and are competing on the domestic market.

The main questions we ask in this paper are : under which conditions would the domestic producer voluntarily choose certification ? To what extent will the certification strategy benefit or on the contrary hurt consumers surplus?

We assume that only the domestic firm can opt for certification, since a labeling organism exists in the home country and not in the foreign country[3]. The under study game is thus the following: once the domestic firm has taken its decision about certification (i.e., whether it is certified or not), the two rivals first choose their qualities and then

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[2]See also Boccard and Wauthy (2000).

[3]According to footnote 1, this assumption is realistic especially in the wine sector with the competition between the european system of certification and the newly exporting countries (see also Chambolle and Giraud-Héraud (2003)).

compete in quantities. In our paper, the certification of origin has, through the quantity restriction, a direct impact on quantities exchanged, and an indirect impact on firms' quality choice. Furthermore, the reputation resulting from the certification has a direct impact on products' qualities. In this framework, we show how certification can allow the domestic firm to position itself as a high quality producer. If, however, the certified firm offers the low quality good, then consumers' surplus may be improved, this equilibrium corresponding to a lower product differentiation and thus a fiercer competition.

The next section presents the general assumptions of our model. In section 2, we also develop the benchmark model where the domestic firm refuses certification. We then identify the conditions for equilibrium under which the domestic firm chooses to adopt the certification of origin while its rival is not certified in section 3. This is followed by section 4, which compares the results in terms of individual profitability for the domestic firm, qualities of goods delivered on the market and consumers' surplus. Section 5 concludes.

2 The model

2.1 Supply

Let us consider the canonical model of strategic trade policy, where two firms are located respectively in the home country and in a foreign country and are competing on the domestic market. The firms offer goods differing in quality on the domestic market of a normalized size as 1. As we have already mentioned, for historical or cultural reasons, there exists in the domestic country an institution controlling the certification of origin process from its definition to its attribution while the foreign country does not have such an institution. Thus, in our model, only the domestic firm can adopt the certification. We will relax this assumption in section 6.

If the domestic firm becomes certified, it commits itself to limiting its production to a level z in exchange for the certification. In return for the restriction in capacity z to which it assents, the certified firm benefits immediately from a minimal quality level s ($s \geq 0$). This exogenous s parameter reflects here the consumer satisfaction with such

a certification system. If the domestic firm is not certified, then it chooses a traditional brand strategy. A brand firm is then free to supply all the demand, but has no advantage for quality at the start. Whatever the chosen strategy be, the firms can make investments to improve their quality in relation to their initial quality (respectively, s for a certified firm or 0 for a brand firm). These investments can represent technical innovation costs allowing for the objective improvement of the quality of the goods, as well as costs of brand promotion which contribute to improving the image and the reputation of the product. In these two examples, the entailed expenses are most often independent from the quantities produced, we therefore assume that a firm having adopted the brand strategy and wishes to reach a quality k has a fixed cost for quality[4]:

$$F(k) = \frac{1}{2}k^2 \tag{1}$$

If a firm adheres to a certification system, the investment cost spent to reach a quality level $k > s$ is :

$$F(k) = \frac{1}{2}(k - s)^2 \tag{2}$$

As shown in the figure 1 below, the amounts invested to reach a given quality level k are given for each type of firm.
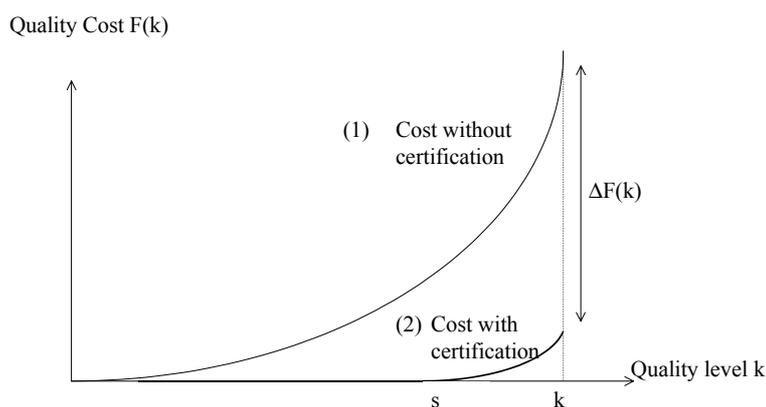

Figure 1: Cost structure with and without certification

[4]Differing from the other form of quality costs, namely variable costs (see for example Motta (1993).

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The two curves (1) and (2) in figure 1 correspond respectively to the two strategies which the domestic firm can adopt. For any quality level k, the brand strategy is more expensive than the certification strategy in terms of investment spendings, the compensation being that the producer is limited in the quantity put on the market. The marginal cost of quality improvement is equally less when the firm is certified. This is an important assumption of our model. The main explanation lying behind this assumption is that there are synergies between both types of investments: the promotion and reputation of the brand, investments are relatively less costly when combined with a certification of origin, which constitutes a kind of official quality guarantee[5].

2.2 Demand

Consumers are distinguished by a taste parameter θ which expresses the intensity of an individual's preferences for quality. The one dimensional parameter θ is uniformly distributed over an interval $[0, 1]$. We assume that each consumer buy zero or one unity of goods. The surplus $S_j(\theta)$ that an individual with the taste parameter θ redeems from quality k_j good's purchase, is given as: $S_j(\theta) = \theta k_j - p_j$, $j = l, h$. This formulation comes from Mussa and Rosen (1978) and expresses the surplus of the consumer as the difference between a reservation price and the purchase price p_j. The relationship between the reservation price and the quality is linear and depends on the taste parameter θ. Thus the quality k_j, sold at price p_j cannot be bought by a type θ consumer except insofar as $S_j(\theta) > 0$, so that the market is not totally covered by incumbent firms. Of course, we assume that consumers know perfectly the quality of the good, this latter being made up of both intrinsic quality and reputation.

The consumption of each good depends on the qualities offered and on the prices set on the market. In the same way, when two products of qualities k_l and k_h, with $k_l < k_h$, prices when quantities q_l and q_h of each quality good are sold are written:

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[5]Another physical explanation could be that a certified firm respecting a capacity constraint will get a better raw material and thus will reach a better quality of food product through a given level of research and technological investments.

$$\left| \begin{array}{l} p_l = k_l \left(1 - q_h - q_l\right) \\ p_h = k_h - k_l q_l - k_h q_h \end{array} \right. \tag{3}$$

Thus, the general expression of profit realized by a quality k_i good producer is:

$$\pi_i = p_i \left(q_i, q_{j \neq i}\right) q_i - F\left(k_i\right) \text{ where } i = l, h \tag{4}$$

where $F\left(k_i\right)$ is respectively defined by (2) or (1) according to whether the domestic firm is certified or not.

2.3   The benchmark model

The case where the domestic firm has not adopted the certification system, namely the free trade situation, can be represented by a two stage game where the firms first realize their investments in quality and then compete in quantity in the absence of capacity constraints. The equilibrium qualities, quantities and profits of this game were obtained by Motta (1993) and are given in Table 1. The exponent b reminds us that we are in the particular free trade case where both firms have a "brand" strategy.

Table 1 : Perfect equilibrium of the duopoly

$k_l^b = 0.09$	$k_h^b = 0.252$
$q_l^b = 0.275$	$q_h^b = 0.451$
$\pi_l^b = 0.0027$	$\pi_h^b = 0.0195$

The consumers' surplus and the welfare (sum of the surpluses of consumers and producers) respectively denoted SC^b and W^b are : $SC^b \simeq 0.0402,\quad W^b \simeq 0.0624$. At the equilibrium, the product differentiation level is measured by $\mu^b = \dfrac{k_l^b}{k_h^b} \simeq 0.357$. Furthermore, the quantity of high quality goods produced is greater than the quantity of goods offered on the low quality segment[6]. Since the firms are perfectly symmetrical

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[6]However, if we introduce the variable quality costs, these costs would lead to a lower quantity of high quality goods, whose production becomes relatively more expensive, being put on the market in relation to low quality goods. Consequently, the surplus of the consumers is always higher with a fixed quality cost rather than a variable cost. Indeed, the latter is maximal when all the quantity produced is placed on the high quality market.

at the start, two perfect equilibria exist: one for which a firm offers the low quality good and one for which the same firm offers the high quality one. The high quality good producer's profit is always higher than that of the low quality good producer but each firm has only a probability $\frac{1}{2}$ to be the high quality good producer.

3 Certification

In this section, the domestic firm is certified while the other adopts a brand strategy. We first characterize both types of equilibria, where the certified (domestic) firm is the lower (section 3.1) and the higher (section 3.2) quality good producer. Then we find out the conditions for having each type of equilibrium (section 3.3).

3.1 The domestic firm offers the low quality good

We denote cb the situation of competition between a certified (domestic) firm c offering the low quality good and a foreign firm competing with its brand b offering the high quality good. At the second stage, the objectives for the two firms differ here since the certified firm must respect the production capacity restriction z in order to benefit from a certified quality level s. We assume that the parameter s remains inferior to the level of the high quality good in the free trade case $s \in \left[0, \frac{1}{4}\right]$ (given that $k_h^b = 0, 252$)[7]. Furthermore, we assume that the capacity restriction is always compelling, by considering that $z \in \left[0, \frac{1}{4}\right]$. This condition is enough to insure that the certified firm will always be ex post restricted whether it be of high quality or low quality. The firms choose their quantities for each pair of qualities (k_l, k_h) by maximising their profits π_l^{cb} and π_h^{cb}. The quantities chosen at the equilibrium are:

$$
\left|
\begin{aligned}
q_l^{cb} &= z \\
q_h^{cb} &= \frac{(1 - \mu z)}{2}
\end{aligned}
\right.
\tag{5}
$$

The qualities are chosen by the firms to maximize their respective profits. By replacing the equilibrium quantities above and after a few analytical calculations, we define

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[7]In fact, as we will show, as soon as s is above $\dfrac{1}{4}$, results are constant whatever the value of z.

equilibria of type cb for all of the parameter values (z, s). These perfect equilibria, when they exist are characterised by the following (5), (6) and (7):

$$\left| \begin{array}{l} k_l^{cb} = \dfrac{\mu^{cb}\left(1 - z^2\mu^{cb^2}\right)}{4} \\[2ex] k_h^{cb} = \dfrac{\left(1 - z^2\mu^{cb^2}\right)}{4} \end{array} \right. \tag{6}$$

where μ^{cb} is the solution to the equation :

$$s = s^{cb}(z, \mu) = \tfrac{1}{4}\left[\left(1 - 4z^2\right)\mu - z^2\mu^3 - 2z\left(1 - 2z\right)\right] \tag{7}$$

However, a first glance at $s^{cb}(z, \mu)$ properties is meaningful. Whatever $\mu \in [0, 1]$ and $z \in \left[0, \frac{1}{4}\right]$, $s^{cb}(z, \mu)$ is a strictly increasing function in μ and decreasing in z. Consequently, at a given level of certification s, μ^{cb} decreases when the capacity restriction becomes more restrictive (z decreases). In other words, the differentiation of product rises when the capacity restriction becomes stricter while keeping the right to an unchanged level of certification s. Indeed, the brand firm which produces high quality goods is then prompted to increase its quality whereas the certified firm is influenced to reduce its quality. This effect of the capacity restriction is somehow a wealth-effect, since the potential profits of the certified firm decrease when z decreases, whereas those of the competing brand firm increase[8] boosting its investments.

Now considering the level of capacity restriction z as fixed, the domestic producer is always encouraged to increase its quality whereas its foreign competitor decreases it when certification level s increases; thus the differentiation of products decreases. In fact, the more the certification level increases the more the domestic firm can reach a high quality for a smaller investment. On the other hand, s dissuades the foreign firm from investing in quality. This is a paradoxical effect because when s increases, the certified firm increases its quality, with the result that the high quality firm could, in order to maintain a sufficient product differentiation, also have incentives to raise its

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[8]These results agree with Herguera et al.(2000), who examined the impact of an import quota on the quality choices of the two firms.

quality level. This result, as we will show in the section 4.2, also results from interesting strategic effects between firms.

3.2 The domestic firm offers the high quality good

We now turn to determining the bc equilibrium for which the domestic firm offers the high quality good. The quantity produced by the high quality certified firm is limited by the capacity restriction. The equilibrium quantities are:

$$\left| \begin{array}{l} q_l^{bc} = \dfrac{(1-z)}{2} \\ q_h^{bc} = z \end{array} \right. \tag{8}$$

We notice that the quantity equilibrium does not depend on the quality levels k_l and k_h chosen by the firms when the high quality is restricted by z. By replacing the equilibrium quantities above, maximizing the profits leads to the following qualities:

$$\left| \begin{array}{l} k_l^{bc} = \dfrac{(1-z)^2}{4} \\ k_h^{bc} = s + (1-z)\,z \end{array} \right. \tag{9}$$

In this situation, we easily show that with s fixed, when z decreases the product differentiation is lowered. More precisely, the quality chosen by the certified firm is lower whereas the quality chosen by the brand firm increases. Once again these results are connected to a wealth-effect and agree with those of Herguera and al (2000). Furthermore, with a fixed capacity constraint, an increase of the certification level s allows the certified firm to improve its quality without involving any change in the quality of its rival. The differentiation of the products therefore increases. There again, we would expect that, facing an increase in the domestic firm's quality, the brand foreign competitor would reduce its investment in quality. This paradoxical effect directly ensues from the independence between the quantities and the qualities of the chosen equilibrium.

3.3 Conditions for existence of equilibrium

We are able to prove the existence and to characterize all the equilibria of the game in which the domestic firm chooses the certification namely to determine the condition for

having a cb and a bc type equilibria. In order to prove the existence of these equilibria, it is necessary to verify that one of the two firms doesn't have any interest in deviating by leapfrogging in qualities[9]. Contrary to the cases studied in the preceding section, the two equilibria no longer always appear simultaneously. Hence, for certain parameter values, only one perfect equilibrium exists, whereas, for the intermediary values of z and s, the two equilibria co-exist. The following proposition reviews the situation on these results:

Proposition 1: A certification system being defined by a pair of parameters (z, s) $\in \left[0, \frac{1}{4}\right]^2$, there exist two functions $f(z)$ and $g(z)$ both decreasing in z with $f(z) > g(z)$ and such that:

* when $s > f(z)$, the bc equilibrium is the only sub-game perfect equilibrium.

* when $s < g(z)$, the cb equilibrium is the only sub-game perfect equilibrium.

* when $g(z) \leq s \leq f(z)$, both sub-game perfect equilibria cb and bc exist.

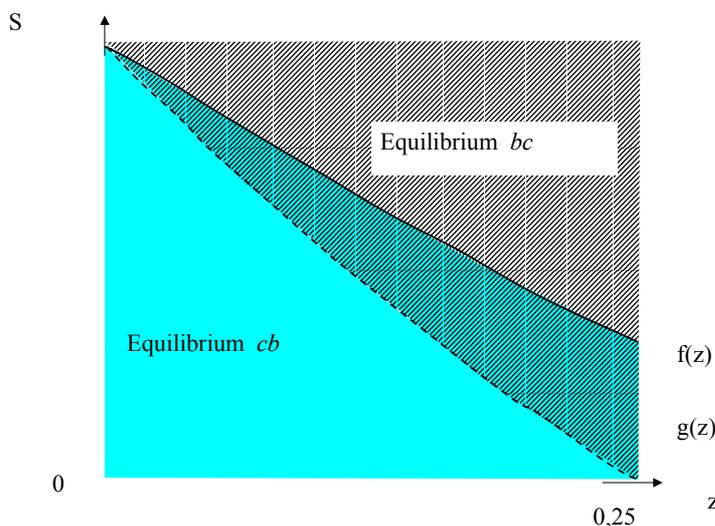The following figure illustrates proposition 1 in plan (z, s) :

Figure 2: Configuration of cb and bc equilibria

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[9]By "leapfrogging" we mean that one producer choosing its quality so as to maximize its profit of "the lower" (resp.higher) quality producer may have an interest in investing in a higher (resp. lower) quality level than its rival.

In the above figure, when $s > f(z)$, the only equilibrium which emerges is the one where the domestic firm produces the high quality good. Indeed, assume we are in an equilibrium situation where the domestic firm offers the low quality good, and let us considere that s becomes higher than $f(z)$: the quality granted to the certification system s is high enough compared to a less compelling capacity restriction, so that it becomes too expensive for the foreign firm to offer the highest quality. It is then in its interest to leapfrog with low quality, that is, to offer an inferior quality than that of its competitor. Inversely, assume we are in an equilibrium situation where the domestic firm offers the high quality good, when s becomes inferior to $g(z)$, the capacity restriction the domestic firm has to respect is relatively strong in relation to the level of quality s guaranteed by the certification system, so that the foreign firm has an incentive to produce a higher quality than the certified firm.

As mentioned in section 2.3, standard duopoly models of vertical differentiation exhibit two perfect equilibria in pure strategies. We showed here that the choice of an appropriate certification system (z, s) can lead to select a single perfect equilibrium. Nonetheless, being the producer of the high quality good is not a guarantee for obtaining the best profit. The reason why being the high quality producer is not a guarantee for making the best profit is that a capacity restriction z less than $\frac{1}{4}$ is much more restrictive for a high quality firm which, in the absence of a capacity restriction, would offer a greater quantity of the good, than for a low quality firm. Therefore, the choice of a particular certification system (z, s) can also insure the best profit for the domestic firm but not necessarily in implementing the bc type equilibrium. However, an unappropriate choice (z, s) may also impede the domestic firm to realize a better profit than that of its competitor, or to position itself as the high quality producer while it would be profitable.

4 Comparative statics: certification vs. free trade

We now compare the profits granted to the domestic firm in case it certifies with those of free trade. We first determine the conditions under which the domestic firm chooses the certification. In the following sub-section we point out the influence of the domestic firm certification on consumers' surplus.

4.1 Certification and profits

Even if a certification system exists, the request for certification is here a matter of a private decision on the part of the producer. We are looking for conditions based on the (z, s) parameters under which adherence to a certification system would be profitable for the domestic firm given that its foreign rival has a brand strategy.

Proposition 2: There exist a function $\phi(z)$ such that, when $s > Max\left[\phi(z), f(z)\right]$, the domestic firm adopts certification and thus always offers the high quality good. There exist a function $\varphi(z)$ such that, when $\varphi(z) < s < f(z)$, the domestic firm adopts certification and thus may be the high or the low quality producer (each with a $\frac{1}{2}$ probability). When $s < Max\left[\phi(z), f(z)\right]$ or $s < Min\left[f(z), \varphi(z)\right]$ then, the domestic producer prefers a brand strategy.

As represented in figure 3, we can distinguish three types of answers depending on the level of the parameters (z, s).
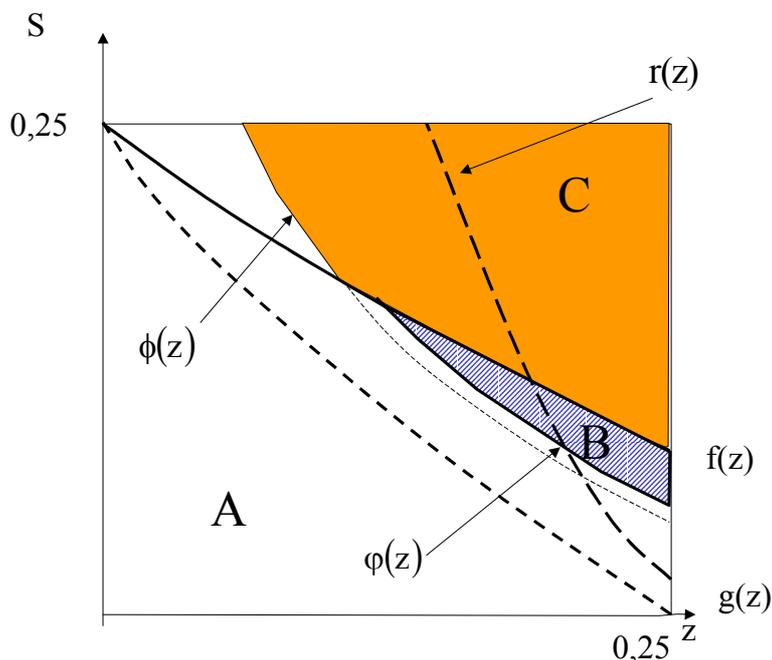

Figure 3: Domestic firm's certification strategy

The three regions **A**, **B** and **C** are delimited by functions $\varphi(z)$ and $\phi(z)$. In zone **A**, the certification system is too unfavorable and thus the domestic firm never finds it

profitable to certify. Indeed, if s is too low the domestic firm will never agree to respect a capacity restriction associated with certification. On the contrary, in area **C**, the domestic firm adopts certification. In this case, choosing a brand strategy, the domestic firm could be the high or the low quality producer (each with a probability $\frac{1}{2}$) whereas choosing the certification, the domestic firm is sure to be the high quality good producer. This effect reinforces the profitability of the certification strategy. However, in region **B**, the domestic firm once again finds the certification strategy profitable while he may be the low quality producer at equilibrium with a probability $\frac{1}{2}$. It thus appears that an equilibrium where the domestic firm chooses the certification strategy and offers the low quality product may arise.

4.2   Certification and consumers' surplus

We now study the influence of the domestic firm certification on consumers' surplus. Larger quantities and better qualities of course benefit the consumers. We obtain the following proposition:

Proposition 3: When the domestic firm chooses certification and offers the high quality good ($s \geq g(z)$), the consumers' surplus is always weakened in comparison with the free trade level. On the other hand, when the domestic firm chooses the certification and offers the low quality good ($s \leq f(z)$), there exists a function $r(z) \leq f(z)$ such that, if $r(z) \leq s \leq f(z)$, the consumers' surplus increases in comparison with the free trade level.

The consumers' surplus reaches its maximum when the entire quantity is allocated on the high quality market. Finally, when the quantity allocated on the high quality good market is restricted by the certification system, the capacity restriction is relatively more prejudicial to consumers than when it restricts the quantity allocated on the low quality good market. This negative effect related to quantities always prevails even over an improvement of the quality induced by certification.

Let us now analyze the different effects that may explain the second part of the proposition. There are both quality and quantity effects. First, the quantity of low quality good is reduced and on the contrary, the quantity of high quality good increases.

As we mentionned, at a given total quantity, this new allocation of quantities benefits to the consumer's surplus. Nevertheless, the capacity restriction leads to a global drop in total quantities of products sold on the market which hurts the consumer surplus. When the domestic firm chooses certification and offers the low quality good, the domestic firm benefits from the certification system and thus has a higher incentive to invest in quality. Thus the quality level of the low quality good is higher thanks to certification. On the contrary, because the domestic firm is constrained in quantity, the foreign firm has a smaller incentive to invest in quality since the capacity provokes a rigidity in terms of the loss of demand incured in case of a lessening of quality[10]. Thus the quality level of the high quality good decreases thanks to certification. Finally, when $r(z) \leq s \leq f(z)$, the product differentiation is small and the positive effect due to the increase in the quality level of the low quality product prevails over the damaging effects of both the capacity restriction and the lowering in quality of the high quality product. The consumers' surplus is therefore improved. This result according to which the consumers' surplus may be higher than in free trade, when the domestic firm chooses the certification and offers the low quality good was unexpected.

5   Conclusion

This paper has proposed a formalization of the certification as a non-tariff barrier. In our model, we have assumed that the certification system is exogenous from the producer's point of view, and we have analyzed its implications in terms of profit for the domestic firm that adopts it as well as its implication with products' quality and consumers surplus. We have shown how a certification system based on a quantitative restriction and initially designed in order to promote the quality of products and to protect consumers, may be a weapon in international trade when the rival country uses a traditional brand strategy. In particular, we show how the adoption of certification may be used by a domestic firm to select the equilibrium simply for individual profit improvement prospects which may be in contradiction with its initial objectives of products' quality upgrading.

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[10]Indeed, when the foreign firm's quality lessens, the consumers who would like to turn to the low quality good cannot do so because the quantity offered is restricted.

In reality, it appears throughout the model that the only way to improve the consumers' surplus is to promote an equilibrium which is not too restrictive on the quantitative level such that the certified firm positions itself on the low quality segment. This equilibrium corresponds paradoxically to a situation where the products are slightly differentiated (the high quality good has a worse quality, and the low quality good a better quality) in relation to that which would prevail at free trade.

Concerning extensions, we beleive that similar results could also be obtained when firms compete in price. In particular, Boccard and Wauthy (2000) showed in a Bertrand competition model, that imposing a quota on a foreign firm could allow the domestic firm to select the equilibrium and become a leader in quality. More interesting, we have approached a new game where at the first stage both the domestic and the foreign firms could choose to adopt the certification. The analysis was led assuming that in the two countries the certification system (z, s) were identical. Nonetheless, we couldn't provide a whole analytical solution giving the equilibrium configuration of that game. However, we were able to prove[11] that there exists some certifications systems (z, s), such that the only equilibrium of the game is asymetric: one producer chooses the certification while its rival chooses a brand strategy. This result comforts us in the opinion that the situation analysed in this paper may be endogenized.

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[11]See the last part of the appendix.

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6 Appendix

Characterisation of cb equilibrium

First we demonstrate that $s^{cb}(z,\mu)$ define by (7) is encreasing in μ and decreasing in z. We have $\dfrac{\partial s^{cb}(z,\mu)}{\partial \mu} = (1 - 4z^2) - 3z^2\mu^2$ which is decreasing in z. For $z = \frac{1}{4}$, $\dfrac{\partial s^{cb}\left(\frac{1}{4},\mu\right)}{\partial \mu} = \frac{3}{4}\left(1 - \frac{1}{4}\mu\right) > 0$. So $\dfrac{\partial s^{cb}(z,\mu)}{\partial \mu} > 0$ whatever $\mu \in [0,1]$. In the same way, $\dfrac{\partial s^{cb}(z,\mu)}{\partial z} = z\left(4 - 4\mu - \mu^3\right) - 1$ which is strictly descreasing in μ. $\dfrac{\partial s^{cb}(z,0)}{\partial z} < 0$ since $z < \frac{1}{4}$, so $\dfrac{\partial s(z,\mu)}{\partial z} < 0$, whatever $\mu \in [0,1]$ and $z \in \left[0, \frac{1}{4}\right]$.

Second, we demonstrate that $s = s^{cb}(z,\mu)$ defines a unique $\mu \in [0,1]$ for all given (z,s). In order to simplify this technical analysis, we can take a dual problem giving the value of s for given values of $(z,\mu) \in [0, \frac{1}{4}] \times [0,1]$. Note that for all $z \in [0, \frac{1}{4}]$ we have $s^{cb}(z,0) < 0$ and $0 < s^{cb}(z,1) < \frac{1}{4}$. Hence, since $s^{cb}(z,\mu)$ is encreasing in μ, there always exists a unique $\widehat{\mu}(z) \in]0,1[$ such that for all $\mu \in [\widehat{\mu}(z),1]$, there exists a unique s such that $s = s^{cb}(z,\mu)$.

This argument demonstrates that for all $z \in [0, \frac{1}{4}]$ and for all $s \in [0, s^{cb}(z,1)]$, there exists a unique $\mu \in [0,1]$ such that $s \in [0, s^{cb}(z,\mu)]$. Then, we note that $s^{cb}(z,1)$ tends towards $\frac{1}{4}$ as z tends towards 0. Hence, for all $(z,s) \in [0, \frac{1}{4}] \times [0, \frac{1}{4}]$, there exists a unique μ such that $s = s^{cb}(z,\mu)$.

Equilibrium profits

Using (5) and (6) we show that, at the cb equilibrium, the profits are given by $\pi_h^{cb} = \dfrac{k_h^{cb}}{4}\left(1 - \mu^{cb}z\right)^2 - \dfrac{(k_h^{cb})^2}{2}$ and $\pi_l^{cb} = \dfrac{k_l^{cb}}{2}z[1 - z(2 - \mu)] - \dfrac{\left(k_l^{cb} - s\right)^2}{2}$.

Using (8) and (9) we show that, at the bc equilibrium, the profits are given by $\pi_h^{bc} = \dfrac{1}{8}z(1 - z)(8s - 1 + 6z - 5z^2)$ and $\pi_l^{bc} = \dfrac{1}{32}(1 - z)^4$.

Existence of cb equilibrium

For the cb equilibrium, there is leapfrog from the brand firm if and only if there exists $k_0 < k_l^{cb}$ such that $\pi_h^{leap}(k_0) > \pi_h^{cb}$ where $\pi_h^{leap}(k_0)$ is the equilibrium profit in the subgame quantity competition.

To define the leapfrog profit $\pi_h^{leap}(k_0)$ we need to find the leapfrog quantity q_h^{leap} and the optimal quality $k_0 = k_h^{leap}$ of leapfrog. Since the brand firm becomes the lower quality producer, we fall in a situation of type bc. Then $q_h^{leap} = q_l^{bc} = \frac{(1-z)}{2}$, $k_h^{leap} = k_l^{bc} = \frac{(1-z)^2}{4}$ and $\pi_h^{leap}(k_h^{leap}) = \pi_l^{bc} = \frac{(1-z)^4}{32}$. Now, let $C_1(z,\mu)$ be such that:

$$C_1(z,\mu) = (1-z)^4 - (1-\mu z)^2 \, (1+\mu z) \, (1-3\mu z)$$

When μ^{cb} is the solution of (7), we have $\pi_h^{leap}(k_h^{leap}) > \pi_h^{cb}$ if and only if $C_1(z, \mu^{cb}) > 0$. $C_1(z, \mu)$ is a function defined and continuous over $]0, \frac{1}{4}[\times]0,1[$ and is differentiable with respect to μ. Moreover, we have $\frac{\partial C_1(z,\mu)}{\partial \mu} = 4z(1-z\mu)(1-3z^2\mu^2)$. Since $z^2\mu^2 < \frac{1}{3}$ ($z < \frac{1}{4}$ and $\mu < 1$), we have $\frac{\partial C_1(z,\mu)}{\partial \mu} > 0$. Thus, for all $z_0 \in]0, \frac{1}{4}[$, $C_1(z_0, \mu)$ increases in μ. We also have $C_1(z_0, 0) = (1-z_0)^4 - 1 < 0$ and $C_1(z_0, 1) = 4z_0(1-z_0)^2 > 0$. Hence, for all $z_0 \in]0, \frac{1}{4}[$, there exists a unique $\mu_0 \in]0,1[$ such that $C_1(z_0, \mu_0) = 0$. Given the implicit function theorem, there exists a function $\mu(z)$ define in the neighbourhood of (z_0, μ_0) such that $\mu(z_0) = \mu_0$ and $C_1(z, \mu(z)) = 0$. Moreover, we have:

$$\mu'(z) = -\frac{\frac{\partial C_1(z,\mu)}{\partial z}[z,\mu(z)]}{\frac{\partial C_1(z,\mu)}{\partial \alpha}[z,\mu(z)]}$$

Denote $\psi(z,\mu) = \frac{\partial C_1(z,\mu)}{\partial z} = -4(1-z)^3 + 4\mu(1-z\mu)(1-3z^2\mu^2)$. We can easily prove that $\psi(z, \mu)$ increases as z and μ increase. Therefore we have $\psi(z, \mu(z)) < 0$ and then $\mu'(z) > 0$ for all z. Thus, $\mu(z)$ increases as z increases.

Therefore, we have $\pi_h^{leap} > \pi_h^{cb}$ if and only if $\mu^{cb} > \mu(z)$. Since μ^{cb} is such that $s = s^{cb}(z,\mu)$, and $s^{cb}(z,\mu)$ increases in μ, we have $\pi_h^{leap} > \pi_h^{cb}$ if and only if $s > f(z)$ with $f(z) = s^{cb}(z, \mu(z))$. We have the following derivative of f with respect to z:

$$f'(z) = \tfrac{1}{4}[-2 + 8z - 8z\mu(z) - 2z\mu^3(z) + (1 - 4z^2 - 3z^2\mu^2(z))\mu'(z)] < 0$$

Moreover, with the arguments given above with the implicit theorem, we have $0 < f(z) < s^{cb}(z, 1)$ (since $\mu_0 = \mu(z_0)$ is such that $0 < \mu_0 < 1$).

Consider now the leapfrog from the certified firm. This kind of leapfrog could emerge if and only if there exists $k_1 > k_h^{cb}$ such that $\pi_l^{leap}(k_1) > \pi_l^{cb}$ where $\pi_l^{leap}(k_1)$ is the equilibrium profit in the quantity competition, given the qualities k_1 and $k_h^{cb} = \frac{1-z^2\mu^2}{4}$ (with $\mu = \mu^{cb}$). Then we have the following leapfrog profit for the certified firm:

$$\pi_l^{leap}(k_1) = z(1-z)(k_1 - \tfrac{k_h^{cb}}{2}) - \tfrac{1}{2}(k_1 - s)^2$$

Therefore $k_l^{leap} = s + z(1-z)$ defines the potential optimal quality of leafrog (according to the first order condition of maximisation of $\pi_l^{leap}(k_1)$). According to $\mu = \mu^{cb}$, we obtain the leapfrog profit:

$$\pi_l^{leap}(k_l^{leap}) = z(1-z)[s + \tfrac{1}{2}z(1-z) - \tfrac{1}{8}(1 - z^2\mu^2)]$$

Let $C_2(z, \mu)$ be such that:

$$C_2(z, \mu) = (1 + 3\mu^2 + \mu^4)z^2 - (4 + 4\mu - \mu^2 + \mu^3)z^2 + (2 - \mu^2)z - (1 - \mu)$$

After some calculations, we show that the condition $\pi_l^{leap}(k_l^{leap}) > \pi_l^{cm}$ is equivalent to $C_2(z, \mu^{cb}) > 0$.

Now, we can demonstrate that $C_1(z, \mu^{cb}) > 0$ implies $C_2(z, \mu^{cb}) > 0$ for all $z \in]0, \tfrac{1}{4}[$. First, we can verify that $C_1(z, \mu)$ and $C_2(z, \mu)$ decrease in μ over $]0, 1[$. For all $z \in]0, \tfrac{1}{4}[$, we have $C_1(z, 0) < 0$ and $C_1(z, 1) > 0$. Thus, for all $z \in]0, \tfrac{1}{4}[$ there exists $\mu_1 \in]0, 1[$ such that $C_1(z, \mu) > 0$ if and only if $\mu > \mu_1$. On the other hand, for all $z \in]0, \tfrac{1}{4}[$ we have $C_2(z, 0) < 0$ while $C_2(z, 1) > 0$ if and only if $z < z_0$ with $z_0 = \dfrac{2 - \sqrt{2}}{4} \simeq .14$. Thus, for all $z \geq z_0$ we have $C_2(z, \mu) \leq 0$ and for all $z < z_0$, there exists $\mu_2 \in]0, 1[$ such that $C_2(z, \mu) > 0$ if and only if $\mu > \mu_2$. In this case, one can verify $\mu_2 > \mu_1$ and the result given above is demonstrate.

Existence of bc equilibrium

For the bc equilibrium, there is leapfrog from the brand firm if there exists $k_1 > k_h^{bc}$ such that $\pi_l^{leap}(k_1) > \pi_l^{bc}$ where $\pi_l^{leap}(k_1)$ is the equilibrium profit in the subgame quantity competition (given k_h^{bc} for the law quality and k_1 for the high quality one).

Let $A = z[s + z(1 - z)]$. The leapfrogging quantity q_1 is such that $q_1 = \dfrac{1}{2k_1}(k_1 - A)$ and we have $p_1 = \dfrac{1}{2}(k_1 - A)$. We then have to maximize $\pi_1 = \dfrac{1}{4k_1}(k_1 - A)^2 - \dfrac{1}{2}k_1^2$. Thus, $\dfrac{\partial \pi_1}{\partial k_1} > 0$ if and only if $\Gamma(A, k_1) = k_1^2(1 - 4k_1) - A^2 > 0$. For a given value of A, $\Gamma(A, k_1)$ is maximized for $k_1 = \dfrac{1}{6}$ and we have $\Gamma(A, 0) < 0$ while $\lim\limits_{k_1 \to +\infty} \Gamma(A, k_1) = -\infty$. Now, we have $\Gamma(A, k_h^{bc}) = \dfrac{A^2}{z^2}[(1 - z)(1 - 3z) - 4s]$. Thus, if $s > \dfrac{1}{4}(1 - z)(1 - 3z)$ we have $\Gamma(A, k_h^{bc}) < 0$ while $k_h^{bc} > \tfrac{1}{6}$ (since $s > \dfrac{1}{4}(1 - z)(1 - 3z)$). Thus there is no leapfrog from the brand firm. On the other hand, for $s = 0$, we have $\Gamma(A, k_h^{bc}) > 0$. So $\dfrac{\partial \pi_1}{\partial k_1}(k_h^{bc}) > 0$ and there is always leapfrog from the brand firm.

There is leapfrog from the certified firm if there exists $k_0 < k_l^{bc}$ such that $\pi_h^{leap}(k_0) > \pi_h^{bc}$ where $\pi_h^{leap}(k_0)$ is the equilibrium profit in the subgame quantity equilibrium (given $k_l^{bc} = \dfrac{(1 - z)^2}{4}$ for the high quality and k_0 for the law quality). In this subgame quantity

equilibrium, we have $q_0 = z$ and $q_1 = \frac{1}{2}(1 - \frac{k_0}{k_1}z)$. Therefore the price of the law quality is such that $p_0 = k_0(\frac{1}{2} - z + \frac{k_0}{2k_1}z)$ and the profit $\pi_0 = p_0 q_0 - \frac{1}{2}(k_0 - s)^2$ is maximized for $k_0^{leap} = \frac{(1-z)^2[2s + z(1-2z)]}{2(1+z)(1-3z)}$. One can verifie that $k_0^{leap} > k_l^{bc} = \frac{(1-z)^2}{4}$ if and only if $s > \frac{1}{4}(1-z)(1-3z)$. So, if $s > \frac{1}{4}(1-z)(1-3z)$ there is no leapfrog both for brand quality and certified quality. Hence $g(z)$ exists and $g(z) < \frac{1}{4}(1-z)(1-3z)$. Moreover, there is always no leapfrof if $s > \frac{1}{4} - \frac{13}{16}z$. One can also verify that $f(0) = \frac{1}{4}$ and that $f'(z) < -\frac{13}{16}$. Therefore $f(z) > g(z)$.

Certification and profits

If the domestic firm chooses the brand strategy, its expected profit is $\pi^{bb} \simeq 0.0111$.

When $s > f(z)$, the domestic firm gets a better profit through certification if $\pi_h^{bc} > \pi^{bb}$ if and only if :

$$s > \phi(z) = \tfrac{0.0111}{z(1-z)} + \tfrac{1}{8}(5z^2 - 6z + 1)$$

When $s < g(z)$, the domestic firm never improves its profit through certification. We cannot demonstrate this point in a simple way. Nevertheless, taking into account that $g(z) \leq \frac{1}{4}(1 - 4z + 3z^2)$ and using *mathematica* one can verify that π_l^{cb} is a strictly increasing function in s over $[0, \frac{1}{4}(1 - 4z + 3z^2)]$. Using (7), and taking $s = \frac{1}{4}(1 - 4z + 3z^2)$, we infer the equilibrium value of $z^*(\mu)$ and we maximise π_l^{cb} with $z = z^*(\mu)$ and $s = s^{cb}(z, \mu)$. The maximum value of π_l^{cb} is obtained for $\mu^* = 0,7433$ and then we have $\pi_l^{cb} \simeq 0,0090 < \pi^{bb}$.

When $g(z) < s < f(z)$, the domestic firm strictly improves its profit through certification if $\varphi(z) < s < f(z)$ where $\varphi(z) = s^{cb}(z, \widehat{\mu}(z))$ with $\widehat{\mu}(z)$ solution of $\frac{1}{2}\pi_l^{cb}(z, \mu) + \frac{1}{2}\pi_h^{bc}(z, \mu) - \pi^{bb} = 0$. Then we verify that $\varphi(z)$ is decreasing in z and that $\varphi(0.1) > f(0.1)$ while $\varphi(0.25) < f(0.25)$. Thus, there exists (z, s) such that $\varphi(z) < s < f(z)$. We also check that $\varphi(z) > g(z)$ since $g(z) < \frac{1}{4}(1 - 4z + 3z^2)$.

Consumers' surplus

The general expression of surplus with two qualities is $SC(k_l, k_h, q_l, q_h) = \frac{1}{2}[k_l q_l^2 + k_h q_h^2 + 2k_l q_l q_h]$. Then, for the equilibriums cb and bc, we have:

$$SC^{cb} = \tfrac{1}{8}(1 - z^2\mu^2)(\tfrac{1}{4} + \tfrac{1}{2}\mu z + \mu z^2 - \tfrac{3}{4}\mu^2 z^2)$$

$$SC^{bc} = \frac{1}{2}\left(\frac{(1-z)^4}{16} + \frac{z(1-z)^3}{4} + z^3(1-z) + sz^2\right)$$

Comparing SC^{cb} with $SC^b \simeq 0.0402$ (Motta (1993)), we first define $\mu^\times$ such that if $\mu \geq \mu^\times$, then $SC^{cb} \geq SC^b$. Since parameters (z,s) have to respect the equilibrium condition (7), we have $\mu \geq \mu^\times(z)$ if and only if $s \geq r(z)$ with $r(z) = s^{cb}(z, \mu^\times(z))$ decreasing in z. Once again, drawing $r(z)$ show us that when z is high enough, $\varphi(z) \leq r(z) \leq f(z)$.

Comparing SC^{bc} with SC^b, we easily obtain the following condition: $SC^{bc} \geq SC^b$ if $s \geq r'(z)$ with $r'(z) < 0$, thus whatever $(z,s) \in \left[0, \frac{1}{2}\right]^2$ we get $SC^b > SC^{bc}$.

Extension

If the two firms adopt certification (we denote this situation cc), they are constrained by z. Thus, we infer equilibrium qualities : $k_l^{cc} = (1-2z)z + s$ and $k_h^{cc} = (1-z)z + s$. Equilibrium profits are thus: $\pi_l^{cc} = \frac{1}{2}z(1-2z)(2s + z(1-2z))$ and $\pi_h^{cc} = \frac{1}{2}z(s(2-4z) + z - z^2(4-5z))$. Since there are two equilibrium, the expected profit of one firm who chooses to certify when its rival is certified is: $\pi^{cc} = \frac{1}{2}\pi_l^{cc} + \frac{1}{2}\pi_h^{cc} = \frac{1}{4}z(s(4-8z) + z(2 - z(8-9z)))$.

Let us now assume that $s > f(z)$. Comparing π^{bb} to π_l^{bc}, we show that, there exists $P_1(z)$ such that if $s > P_1(z)$, the firm best response when its rival adopts the brand strategy is the certification strategy. Comparing π^{cc} with π_l^{bc}, one can verify also that there exists $P_1'(z)$ such that if $s > P_1'(z)$, the firm best response when its rival adopts the certification is the certification strategy. Thus if $P_1(z) < s < P_1'(z)$, the firm best response when its rival is certified is to adopt a brand strategy (since $s < P_1'(z)$) and the rival's best response when this firm chooses a brand strategy is to remain certified (since $s > P_1(z)$). Since when $z < 0,131$, $P_1(z) < P_1'(z)$, there exists a subgame perfect equilibrium where one of the two firms chooses to certify while the other prefers the brand strategy.

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