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INTERNATIONAL STRATEGIC CHOICE OF MINIMUM QUALITY STANDARDS AND WELFARE

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International Strategic Choice of Minimum Quality Standards and Welfare

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Abstract

We study the influence of minimum quality standards in a two-region partial-equilibrium model of vertical product differentiation and trade. Three alternative standard setting arrangements are considered: Full Harmonization, National Treatment and Mutual Recognition. The analysis integrates the choice of a particular standard setting alternative by governments into the model. We provide a set of sufficient conditions for which Mutual Recognition emerges as one regulatory alternative that always improves welfare in both regions when compared to the case without regulation. We show that Mutual Recognition, being the default procedure if governments do not reach a unanimous decision, is the only possible equilibrium of the game.

JEL Classifications: F12, F13, L13
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1. Introduction

In spite of the ongoing efforts to implement the directives on harmonization of standards put forth in the EU Commission's (1985) White paper, support for the harmonization of standards, especially minimum standards concerning product quality, safety, or environmental protection, varies considerably within the EU. The opposition to full harmonization of standards is in general based on the common belief that these standards, when binding for less advanced national industries but not for more advanced national industries, lead to increased market share for the latter. Moreover, some of the economically weaker members in the EU would only agree to the Common Market program in exchange for massive subsidy promises[1].

The EU currently adopts three alternative ways of handling standards. These arrangements are: Full Harmonization, FH, where uniform standards are set centrally for all member countries; Mutual Recognition, MR, where national governments set standards for their own industries and recognize the adequacy of each others' standards; and National Treatment, NT, where national governments apply national standards to any product sold within their country. This gives rise to questions about the relative effects of different standard setting procedures and in particular about the possibility to regulate standards in such a way that the economically weaker regions do not take welfare losses. This paper will address some of these questions.

The model to be developed below will represent some stylized facts about economic asymmetries within the EU. More precisely, two regions will be considered, labelled core and periphery, respectively[2]. The core will be characterized by a larger market, higher per-capita income, and lower cost of producing or developing products of a certain level of quality. Industry structure will be duopolistic. Regional governments, as members of an interregional council, either unanimously choose one of three alternative standard setting procedures or a default procedure takes effect.

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[1]See, for example, Franzmeyer (1989), p. 313.

2 Following, for example, Smith and Venables (1988) or Venables (1990), we could identify France, Germany, Italy and Great Britain as the core, and the rest of the EU as periphery.

In both the fields of industrial organization and of international trade, there are fairly large bodies of literature focusing on product quality[3]. Some of this literature investigates the effects of minimum quality standards[4]. Ronnen (1991) uses Shaked and Sutton's framework to demonstrate cases where quality standards improve welfare. He concludes that there exists a binding minimum quality standard such that all consumers are weakly better off, both firms have positive profits, and total welfare is increased. However, since there is only one market, there is no scope for strategic government interaction in this model. For example, Boom (1995) studies the effects of the adoption of minimum quality standards for two (identical) countries with segmented markets and compares the equilibria with uniform or asymmetric quality standards. The author shows that consumer's surplus and qualities are higher in both countries if no firm is forced out of the country's market with the higher minimum quality standard. Hansen and Nielsen (2006) study instead a two-country model in which two firms provide goods horizontally and vertically differentiated with partially integrated markets (i.e. there exist some positive finite trade costs). Assuming that all consumers have the same willingness to pay, fully covered markets and size asymmetry between countries, the authors show that, ceteris paribus, the high quality producer will appear in the country with the larger market. In addition, they show that market integration tends to increase the provision of the low quality and decrease the provision of the high quality; in this sense, market integration has effects similar to the introduction of a minimum quality standard. Our model extends Lutz (2000) with which shares a few features. The author compares two standard setting arrangements in a two-region pure vertical differentiation model. He shows that Mutual Recognition is the optimal standard setting procedure when the two countries have firms with small cost differentials; otherwise, a fully harmonized standard that drives the inefficient producer out of the markets will

[3] E.g., Leland (1979), Gabszewicz and Thisse (1979), Shaked and Sutton (1982), Shapiro (1983), Motta (1993), Johnson/Myatt (2003).

4 E.g., Ronnen (1991), Crampes and Hollander (1992), Ecchia/Lambertini (1997), Constatatos/Perrakis (1998), Scarpa (1998), Valletti (2000), Pezzino (2006), Besanko/Donnenfeld/White (1988), Das/Donnenfeld (1989), Copeland (1992), Jinji/Toshimitsu (2004).

be optimal. In contrast to our model, the aforementioned paper does not consider the setting arrangement we called National Treatment (with and without entry deterrence) and assumes identical market size and average income in the two countries. In this paper, when we describe the equilibrium under National Treatment with deterred entry we consider the case in which the non-cooperative choice of national standard by regional governments makes not profitable for the low quality producer to enter the richer and larger market. This case should not be confused with the model described by Lambertini and Scarpa (1999) and (2006). The authors analyze the introduction of a minimum quality standard in a single-market vertically differentiated duopoly à la Ronnen (1991). In contrast to most contributions in the literature, relaxing the assumption that the high quality firm might decrease its quality provision after the adoption of a standard in order to strategically deter entrance of the low quality provider, they show that an equilibrium with deterred entry exists for any combination of parameters and it would be always selected be the risk dominance criterion. In our model, instead, the low quality provider at most will be driven out of one regional market (the one in which the high quality producer is located) because of the welfare maximising decision of the government of the larger and richer region and not due to the strategic predatory behaviour of the competitor.

Our paper initially describes a general model and provides a set of sufficient conditions that let MR emerge as the only equilibrium of a game in which, first, regional governments strategically choose the standard setting arrangements and the quality standards and, then, firms compete in qualities. Secondly, the paper presents a specific model that satisfies the conditions that produce the results mentioned above. The particular model employed extends the framework of Ronnen (1991) for the two-country case, i.e. it is a partial-equilibrium model of vertical product differentiation and trade.

We study a four-stage game in pure strategies. In the first stage, both regional governments, as members of an interregional council, announce one choice out of three alternative standard setting

procedures. If the two announcements coincide the particular procedure will be applied, otherwise the default procedure, MR, takes effect. The governments' role in the second stage depends on the first-stage outcome. In the third stage of the game, firms simultaneously determine quality to be produced unless a standard is binding. In the fourth stage, firms compete in prices, given qualities. We look for Subgame Perfect Nash Equilibria by the method of backwards induction.

Mutual Recognition emerges as one regulatory alternative that always improves welfare in both regions when compared to the case without regulation. Since the foreign region always prefers Mutual Recognition over all other available alternatives and this is the default in the first stage of the game, this is also the only possible equilibrium outcome of the game. If the domestic firm has a sufficiently large cost advantage, then the domestic region will also prefer Mutual Recognition over all available alternatives.

The reminder of the paper is structured as follows. Section 2 describes a general model and provides a set of conditions that produce our main results. Section 3 presents a specific model of pure vertical differentiation satisfying the conditions described in section 2. Section 4 concludes.

2. The general model

In this section we present our argument in general form. Two regions belong to an interregional federation. Each region has a regional government and one representative in an interregional council. Moreover, there are two firms each located in a different region. The two firms produce the same product, differentiated only by quality. They compete in qualities in the long run and in prices in the short run. Before quality competition takes places, governments can decide whether to introduce minimum quality standards, MQS, on production and choose the type of standard setting arrangement. In particular, we consider three different setting arrangements: under Full Harmonization, FH, a council maximizes the sum of regional welfares by setting one uniform

standard[5]; under Mutual Recognition, MR, regional governments maximize regional social welfare by noncooperatively setting regional producer standards; finally, under national Treatment, NT, governments maximize regional social welfare by noncooperatively setting regional standards. If the two announcements coincide the particular procedure will be applied, otherwise the default procedure, MR, takes effect.

Even if firms and regions were identical, qualities offered in an unregulated equilibrium would not be identical (choosing different qualities the two firms can ensure non negative profits and overcome the Bertrand Paradox). In what follows, we show that, if a set of sufficient conditions is satisfied, the regional government in which the low quality producer operates will always prefer to set a standard according to the MR setting procedure; consequently, MR will be the only standard setting procedure adopted in the long run equilibrium.

Throughout the paper we use the following notation. The two regions are denoted by $r = C, P$, whereas the two respective firms are denoted by $i = c, p$. Anticipating equilibrium prices produced by the competition in the short run (that in this section we will not model) each firm chooses the provide quality s_i to maximise profits, given by $\Pi_i\left(s_c, s_p\right) = R_i\left(s_c, s_p\right) - k_i\left(s_i\right)$, where $R_i\left(s_c, s_p\right)$ represents the revenues of firm i and $k_i\left(s_i\right)$ is the quality-dependent cost function. Variable production costs are assumed equal to zero. Consumers in each region obtain surplus from purchasing either of the two products offered in their regional market. Consumer surplus in region r is denoted by CS_r. Regional welfare is given by $W_r = \Pi_i + CS_r$ and global (interregional) welfare by $W = W_C + W_P$. CS_{Cn} indicates the surplus of consumers in region C when firm p does not enter the market.

[5]Maximizing the sum of regional welfares can be seen as the outcome of Nash-Bargaining between both governments in the Council.

In this paper we will concentrate on the case in which, if the market is not regulated, in equilibrium $s_c > s_p$. This case arises naturally if firms' costs of providing quality are sufficiently different. Suppose the simple case where $k_c(s_c) = b_c k(s_c)$ and $k_p(s_p) = b_p k(s_p)$. If b_p is sufficiently high relative to b_c the only remaining pure-strategy equilibrium would be given by $s_c > s_p$. Another way to ensure a unique equilibrium where $s_c > s_p$ is to make the somewhat plausible assumption that firm p faces a technological constraint of the form $s_p \leq s_p^{\max}$ (in other words, $k_p(s_p)$ is infinite for all $s_p > s_p^{\max}$), where $s_p^{\max}$ is smaller than the highest quality level the firm p can select without inducing firm c to select a quality that would make it the low quality provider in the market. In addition, we will assume that consumers located in region C have a higher willingness to pay for quality than the agents located in region P.

The following set of assumptions is sufficient to ensure our results.

Assumptions

1) $\partial R_c / \partial s_p < 0$, $\partial R_p / \partial s_c > 0$, $\partial^2 R_i / \partial s_i^2 < 0$, $\partial^2 R_c / \partial s_c \partial s_p > 0$, $\partial k_i / \partial s_i > 0$ and $\partial^2 k_i / \partial s_i^2 > 0$

2) $\partial CS_r / \partial s_r > 0$, $\partial CS_r / \partial s_z > 0$ and $\partial^2 CS_r / \partial s_r \partial s_z > 0$, $\partial^2 CS_r / \partial s_r^2 \leq 0$

3) $\partial R_c / \partial s_p + \partial CS_c / \partial s_p > 0$, $\partial CS_c / \partial s_c \geq \partial CS_{cn} / \partial s_c$ and

$$\partial CS_C / \partial s_c \geq \partial^2 CS_C / \partial s_c \partial s_p - \int_{x_0}^{s_p} \partial^2 W_C / \partial s_c \partial s_p dx.$$

Assumption 1) ensures that useful concavity properties hold for profit maximization. In addition, it guaranties that at the unregulated equilibrium $ds_c / ds_p > 0$, i.e. s_p is treated as a strategic complement by the high quality firm (it is also true that $ds_p / ds_c > 0$).

Assumption 2) says that consumer surplus increases when either of the two qualities in the market increases. Marginal consumer surplus in each region is also increasing in the quality chosen by the firm located in the other region. This assumption implies also that qualities chosen in (any) unregulated equilibrium are socially insufficient.

Assumption 3) requires that an increase in the low quality has a positive aggregate effect on revenues of the high quality provider and on the surplus of consumers located in the same region. This is not a trivial assumption, since intuitively $\partial R_c / \partial s_p$ might be negative: an increase in the low quality for a given s_c increases the level of competition in the short run, producing a negative effect of firm c revenues. We are assuming that the positive effect on consumers' surplus more than offsets the possible loss in revenues. In addition, assumption 3) says that marginal consumer surplus in the high quality region is higher when both qualities are offered in the market. The last condition included in Assumption 3) (as it will be clear later on) ensures that $\partial W_C / \partial s_c$ remains positive when s_c is held at the FH level and s_p is decreased.

Assumptions 1)-3) describe in general terms a market (formed by two segmented markets) in which competition in the short run is fierce enough to justify the positive slope of the quality best response function of the high quality provider in the unregulated market. An intuition is that if low quality increases, the products in the market are more similar and the high quality provider find profitable to increase its quality to (at least partially) restore the degree of differentiation. Moreover, in such a market consumers value quality and their surplus increases when either quality in the market is increased.

2.1. Full Harmonization, FH

Lemma 1 describes the effect of the introduction of a MQS under a FH setting procedure.

Lemma 1

Moving from no regulation to FH will strictly increase both qualities, total welfare, and core welfare.

Proof

Remember that in the unregulated equilibrium $s_c > s_p$. Therefore, the harmonized standard will be binding only for the low quality in the market, i.e. s_p.

Increase of both qualities follows directly from the positive sign of $ds_c / ds_p > 0$. Total welfare increases with the introduction of a harmonized standard if the following equation is positive:

$$\frac{dW}{ds_p} = \frac{dW_P}{ds_p} + \frac{dW_C}{ds_p} = \frac{\partial \Pi_p}{\partial s_p} + \frac{\P\ CS_P}{\P\ s_p} + \frac{ds_c}{ds_p}\left\{\frac{\P\ R_p}{\P\ s_c} + \frac{\P\ CS_P}{\P\ s_c}\right\} + \frac{ds_c}{ds_p}\left\{\frac{\partial \Pi_c}{\partial s_c} + \frac{\P\ CS_C}{\P\ s_c}\right\} + \frac{\P\ R_c}{\P\ s_p} + \frac{\P\ CS_C}{\P\ s_p} \tag{1}$$

Equation (1) is indeed positive at the unregulated equilibrium, since marginal profits are equal to zero for both firms, $\partial R_c / \partial s_p + \partial CS_c / \partial s_p > 0$ according to assumption 2) and the remaining terms are positive. Q.E.D.

In addition, note two important properties regarding the profits of the low quality firm. First, in the unregulated equilibrium the following equation is positive:

$$\frac{d\Pi_p}{ds_p} = \frac{\partial \Pi_p}{\partial s_p} + \frac{\P\ R_p}{\P\ s_c}\frac{ds_c}{ds_p} \tag{2}$$

implying that a harmonized standard that marginally increases s_p would have initially a positive effect on firm *p*'s profits[6]. However, we can show that in the FH equilibrium, profits for the low quality firm become negative. This result can be seen using the information embodied in equation (1). First, note that the zero-profit cost condition for firm *p* is say $k_p^0 = R_p$. According to equation (1) at FH:

$$\frac{\partial k_p}{\partial s_p} > \frac{\partial R_p}{\partial s_p} + \frac{\partial CS_p}{\partial s_p} + \frac{\partial CS_C}{\partial s_p} + \frac{\partial R_C}{\partial s_p}$$

Thus, given the convexity property of the cost function, at FH $k_p > k_p^0$.

Even if initially an increase in s_p has a positive effect on firm *p*'s profits, the equilibrium reached under FH requires a level of s_p so high that revenues can not cover the quality-dependent costs. Intuitively, such a result can be explained by the structure of the FH procedure itself. As we have already pointed out, in the unregulated equilibrium both qualities are socially insufficient. To increase welfare, however, the interregional council can only impose a standard on s_p and, indirectly, increase s_c. Doing so, the council imposes a standard so high that firm *p* makes a loss.

2.2. Mutual Recognition, MR

Let us now consider MR standard setting procedure in order to be able to compare the results to FH. Under MR each regional government maximises its own regional welfare setting a standard for the regional firm. The first order conditions for the solution of the problem under MR are given by:

[6] Reminiscent of the result shown in Ronnen (1991), when the standard is sufficiently close to the quality chosen in the unregulated equilibrium, the low quality firm earns higher profits due to the quality commitment imposed by the standard.

(3) $$\frac{d}{ds_p} W_P = \frac{\partial \Pi_p}{\partial s_p} + \frac{\partial CS_P}{\partial s_p}$$

(4) $$\frac{d}{ds_c} W_C = \frac{\partial \Pi_c}{\partial s_c} + \frac{\partial CS_C}{\partial s_c}$$

In the unregulated equilibrium both conditions are clearly greater than zero, implying that the standard best responses are located everywhere above firms' unrestricted quality best response.

Before comparing FH and MR, let us consider first a benchmark quality equilibrium.

Global social optimality can be achieved if the interregional council could maximize global welfare choosing both qualities provided in the market. Such a socially optimal solution will be the benchmark, BM, to which we will compare the equilibria under the various standard setting procedures considered.

Lemma 2 compares the quality solution under FH and MR to the socially optimal solution, BM.

<u>Lemma 2</u>

Define a benchmark as the result of maximizing the sum of regional welfares, W, with respect to both qualities subject to subsequent price competition.

a) At FH, $\partial W_C / \partial s_c = \partial CS_C / \partial s_c > 0$. *Any horizontal move to the left (any reduction in* s_p *without reducing* s_c*) will always leave* $\partial W_C / \partial s_c > 0$.

b) Compared to the benchmark, FH will result in s_c *being too low and* s_p *being too high.*

c) Compared to the benchmark, MR will result in both qualities being too low.

Proof

a) At FH, $\partial W_C / \partial s_c = \partial CS_C / \partial s_c > 0$. Let $s_c\big|_{MR}$ and $s_c\big|_{FH}$ be s_c at the Mutual Recognition solution and the Full Harmonization solution, respectively. Given assumption 3), we know that a reduction in s_p without reducing s_c will always leave $\partial W_C / \partial s_c > 0$, i.e. $s_h\big|_{MR} > s_h\big|_{FH}$ must hold.

b) Under FH, $\partial W / \partial s_c = \partial CS_C / \partial s_c + \partial R_p / \partial s_c + \partial CS_P / \partial s_c > 0$ and $\partial W / \partial s_p = -\left(ds_c / ds_p\right)\left(\partial CS_C / \partial s_c + \partial R_p / \partial s_c + \partial CS_P / \partial s_c\right) < 0$ hold since the RHS of equation (1) is equal to zero. Hold s_c constant at the FH level and decrease s_p until $\partial W / \partial s_p = 0$. At this point, $\partial W / \partial s_c = \partial W_C / \partial s_c + \partial R_p / \partial s_c + \partial CS_P / \partial s_c > 0$ by part a). It follows that s_c is too low. Hold s_p constant at the FH level. Then for any s_c, $\partial W / \partial s_p < 0$ holds. It follows that s_p is too high.

c) Under MR, $\partial W / \partial s_c = \partial R_p / \partial s_c + \partial CS_P / \partial s_c > 0$ and $\partial W / \partial s_p = \partial CS_C / \partial s_p + \partial R_c / \partial s_p > 0$ hold since the RHS of equations (3) and (4) are equal to zero. Q.E.D.

The result in lemma 2 can be intuitively explained by the structure of the two setting arrangements considered. Given the assumptions of the model, we know that qualities in the unregulated equilibrium are socially insufficient. Under FH, as we mentioned earlier, the council maximises global welfare only through directly affecting s_p that, in the end, will be excessive compared to BM. s_c will increase, but not sufficiently compared to BM. Under MR a standard is imposed on both qualities provided in the market. However, since each government selects the standard to maximise only own regional welfare, the standards produce socially insufficient quality levels (however higher than in the unregulated equilibrium).

We are now in condition to describe the welfare effect of a move from FH to MR. Proposition 1 summarizes the results.

Proposition 1

Moving from FH to MR will strictly increase high quality, decrease low quality, and increase W_p.

Proof

The results with respect to qualities follow from Lemma 2. Suppose that a uniform standard was set at the optimal FH level. In this case, the RHS of equation (1) is equal to zero and firm c chooses its quality by equating its marginal revenue and marginal cost. This implies that the RHS of equation (3) is less than zero, whereas the RHS of equation (4) is greater than zero. It follows that a gradual reduction of s_p down to the point where the RHS of equation (3) equals zero will increase peripheral welfare and decrease core welfare (by marginal properties of revenues and consumer surplus). At this point, the peripheral region is on its standard best response, but the core region is below its standard best response. The RHS of equation (4) will still be equal to $\partial CS_C / \partial s_c > 0$. Consequently, core welfare can be increased by raising s_c which, in turn, will further increases peripheral welfare. Peripheral welfare is unambiguously increased, whereas core welfare is decreased by the reduction in s_p and increased by the increase in s_c. The lower the peripheral cost disadvantage the less will s_p be decreased relative to the increase in s_c. Q.E.D.

Moving from FH to MR has a positive effect on W_P. First, MR requires firm p to provide a lower quality and, consequently, allows it not to make a loss (the increase in profits more than offsets the decrease in CS_P for the lower s_p). In addition, MR requires a higher level of s_c, producing a second positive effect on W_P.Whether the increase in s_c can be welfare improving for region C only depends on the cost function of firm c. If it is not too costly to increase quality, the increase in s_c (and the following increase in consumer surplus) and the decrease in s_p (and the

following increase in Π_C) can more than offset the negative effect produced on CS_C by the decrease in s_p and the negative effect on Π_C produced by the increase in s_c and costs.

2.3. National Treatment, NT

We can now analyse the case in which each government noncooperatively and simultaneously sets consumer standards for the respective region and apply them to all imports, i.e. the standard setting procedure of National Treatment, NT. With both firms entering in both markets, each regional standard can only be binding, if at all, for the low quality firm, i.e. firm *p*. If government *C* sets a standard sufficiently high, it can deter entry by firm *p* and the standard will be binding only for firm *c*. Moving from NT with accommodated entry to NT with deterred entry involves an increase of s_c and a decrease to zero of s_p in the *C* market. It follows that the government of region *C* prefers to deter entry of firm *p* only if it can benefit from a cost advantage sufficiently large.

2.3.1 National Treatment where the Low Quality Firm Enters Both Markets

The government of region *C* has the greater incentive to set a high standard because of its consumers' greater willingness to pay for high quality and firm *c*'s cost advantage. Hence, only the standard chosen by government *C* will be binding. Firm *p* will only enter market *C* if its profit from providing the higher quality in both markets is greater than or equal to its profit from providing the lower quality in market *P* only.

Consequently, government *C* will set a standard such that firm *p*' s profits when entry is accommodated just equal profits when entry is deterred. Denote the minimum profit required for entry as $\Pi_p^{\min}$. The following inequality is a binding constraint on government *C*'s objective function

(5) $$\Pi_p \geq \Pi_p^{\min}$$

Region P government would also like to increase s_p along firm c's quality best response, but not as much as region C government. W_P reaches a unique maximum along c's quality best response somewhere between the unregulated quality equilibrium and the FH solution. Region P government can affect the binding quality standard only through measures affecting firm p's profits when entry is deterred, i.e. $\Pi_p^{\min}$. If firm p's profits with deterred entry are lower than with accommodated entry at the W_P maximizing point on firm c's quality best response, government P sets its standard to Π_p with deterred entry. Region P government also needs to find the point on firm c's quality best response when entry is accommodated where W_P is maximized, say MF. Let an added subscript n denote non-entry variables.

Let firm c's marginal quality best response when entry is deterred be denoted by $ds_c / ds_p \big|_n$. Government P needs to calculate firm p's maximum profit when entry is deterred. Differentiating the appropriate objective function with respect to s_p yields equation (6).

$$\frac{d\Pi_{pn}}{ds_p} = \left(\frac{\partial R_{pn}}{\partial s_p} - \frac{\partial k_p}{\partial s_p}\right) + \frac{ds_c}{ds_p}\Big|_n \frac{\partial R_{pn}}{\partial s_c} \tag{6}$$

Differentiating the W_P with respect to s_p yields equation (7).

$$\frac{dW_P}{ds_p} = \frac{\partial \Pi_p}{\partial s_p} + \frac{\partial CS_P}{\partial s_p} + \frac{ds_c}{ds_p}\left\{\frac{\partial R_p}{\partial s_c} + \frac{\partial CS_P}{\partial s_c}\right\} \tag{7}$$

Differentiating government C's objective function with respect to s_p yields equation (8).

$$\frac{dW_C}{ds_p} = \frac{ds_c}{ds_p}\left\{\frac{\partial \Pi_c}{\partial s_c} + \frac{\partial CS_C}{\partial s_c}\right\} + \frac{\partial R_c}{\partial s_p} + \frac{\partial CS_C}{\partial s_p} \tag{8}$$

Since firm c is on its quality best response, the RHS of equation (8) will be positive.

Consequently, the equilibrium under NT with accommodated entry can be calculated by maximizing W_C along firm c's quality best response subject to inequality (5).

Lemma 3 describes the solution of government P's problem under NT with accommodated entry.

<u>Lemma 3</u>

Under National Treatment (with accommodated entry), government P will calculate Π_p *at the* W_P *maximum along firm c's quality best response, say* $\Pi_P\big|_{MF}$. *It will then set a standard such that* $\Pi_p\big|_{FH} < \Pi_{pn} < \Pi_p\big|_{MF}$.

Proof

By equations (7) and (8), W_C along firm c's quality best response is steadily increasing in s_p, whereas W_P is maximized at a point, say MF, where s_p is higher then in the unregulated equilibrium and lower than in under FH. At MF, Π_p is nonnegative and decreasing in s_p. Furthermore, Π_p is negative at FH. Region P government sets a standard such that Π_{pn} are as close as possible to profits with accommodated entry at MF, $\Pi_p\big|_{MF}$. It can choose a standard such that Π_p with deterred entry are positive. Q.E.D.

Proposition 2 describes a move from the equilibrium under NT with accommodated entry to MR. Again, we show that region P is strictly better off moving to MR. Moving to MR requires a decreases in s_p, with the following decrease in costs for firm p and an increase in W_p. Government C calls for a higher level of s_c, increasing W_p further.

Proposition 2

Moving from NT (with accommodated entry) to MR will strictly increase s_c *while* s_p *may increase or decrease.* W_P *strictly increases.*

Proof

b) At NT, the RHS of equation (7) is less than or equal to zero. Hence, the RHS of equation (3) is less than zero. Decreasing s_p until the RHS of equation (3) equals zero while holding s_c constant will increase W_P while decreasing W_C. At this point, region P is on its standard best response, but region C is below its standard best response. The rest of the proof is analogous to the proof of Proposition 1. Q.E.D.

2.3.2. National Treatment: Low Quality Firm's Entry into the Core Market is Deterred

If firm c' s cost advantage is large enough, then region C government prefers to set its regional standard under NT so high that firm p' s entry is deterred. The increase in W_C due to increased s_c more than offsets the welfare loss due to the unavailability of the product of firm p. The problem faced by regional governments is similar to the case of MR. However, W_C does not include consumer surplus derived from the consumption of the product provided by firm p and W_P does not include profits derived from selling to region C. It can be shown that concavity properties of the governments' objective functions hold, ensuring that welfare maximization problems have unique solutions. Differentiating W_P with respect to s_p yields equation (9).

(9) $$\frac{dW_{Pn}}{ds_p} = \frac{\partial \Pi_{pn}}{\partial s_p} + \frac{\partial CS_P}{\partial s_p}$$

Differentiating W_C function with respect to s_c yields equation (10).

(10) $$\frac{dW_C}{ds_c} = \frac{\partial \Pi_c}{\partial s_c} + \frac{\partial CS_{Cn}}{\partial s_c}$$

Proposition 3 compares NT with deterred entry to MR and shows once more that region P is better off moving to MR. Under NT with deterred entry qualities provided are socially too low. In region C the increase in s_c necessary to deter firm p's entry is not enough to offset the lack in the market of the low quality good. Moving to MR increases Π_p and the increases in qualities has a positive effect on W_P.

<u>Proposition 3</u>

Moving from National Treatment (with deterred entry) to Mutual Recognition will strictly increase both qualities and both regions' welfare.

Proof

Note that $\partial R_{pn} / \partial s_p < \partial R_p / \partial s_p$ and $\partial CS_{Cn} / \partial s_c < \partial CS_C / \partial s_c$. Comparing equations (3) and (4) with equations (9) and (10) shows then that regional standard best responses under NT (with deterred entry) must lie everywhere below the standard best responses under MR. The quality result follows. A move from NT (with deterred entry) to MR without adjusting qualities and standards would strictly increase both regions' welfare by allowing firm p' s product to be sold in region C. Given that qualities are too low, under NT the RHS of both equations (3) and (4) are positive. It follows that a gradual increase of s_p up to the point where the RHS of equation (3) equals zero will increase both regions' welfare. At this point, region P is on its standard best response, but region C is below its standard best response. The rest of the proof is analogous to the proof of Proposition 3. Q.E.D.

Given the results describes in proposition 1-3 we can analyse governments' setting procedure choice. Governments have to choose one regulatory regime in the interregional council. This regime is either chosen by unanimous vote or a default rule, namely applying MR. Since region P government always prefers the default rule MR, this is the only possible outcome. Note that even

with a different default rule, MR would remain a long run equilibrium as long as a firm c could benefits from a sufficiently large cost advantage.

3. Vertical Differentiation

In this section we study a specific model of duopolistic competition with endogenous quality choice and show that it satisfies the assumptions proposed in section 2. The model is a two-region extension of the model studied in Ronnen (1991). In addition, we assume that the two competitors in the market and the two regions that form the market are not symmetric. In particular, the model includes the following assumptions.

- There are two separate regions, denoted by $r = C, P$.

- In each region is located a firm. Firms are denoted by $i = c, p$. Each firm produces a single variety of a quality-differentiated product. Products are differentiated on the basis of a single attribute, "quality", $s_j \geq 0$, $j = h, l$. When the qualities provided differ, we refer to them as "high" (h) quality and "low" (l) quality, respectively. Both firms have constant marginal cost (equal to zero) in quantity produced. However, they have to incur a fixed "cost of providing quality", k_i, before entering into production; in particular, $k_i = b_i s_j^2$, $b_i > 0$. Firm c has a technological advantage in developing quality, i.e. $b_c < b_p$.

- Each firm's problem is the maximization of the profit function:

(11) $$\Pi_i = p_{Cj} q_{Cj} + p_{Pj} q_{Pj} - k_i$$

where q_{rj} is the demand of good j in region r.

- The two product markets are regionally segmented. The product qualities are known to all consumers. Each consumer may purchase at most one unit of a product of either high or low quality. We assume consumers have identical ordinal preferences across regions and differ only in their incomes. In particular, consumers can be ordered according to an "income parameter" t,

where t is uniformly distributed over its support. In region C a mass $T \geq 2$ of consumers are uniformly distributed on the interval [0, T], whereas a unit mass of consumers in the periphery region is uniformly distributed on the interval [0, 1][7].

The utility of the generic consumer z who lives in region r and buys one unit of the good produced by firm i at price p_{rj} and quality s_j is given by:

(12) $$U_{rz} = \begin{cases} t_{rz} s_j - p_{rj} & \text{if one unit one good if purchased} \\ 0 & \text{otherwise} \end{cases}$$

The marginal willingness to pay for quality of the consumers located in region r respectively indifferent to buy a product of either quality and indifferent to buy a product of low quality or not to buy at all are given by:

(13) $$t_{rh} = \frac{p_{rh} - p_{rl}}{s_h - s_l} \text{ and } t_{rl} = \frac{p_{rl}}{s_l}$$

Given the assumption regarding consumers' preferences, firms' market shares are given by:

(14) $$\begin{aligned} q_{Ch} &= T - t_{Ch} & q_{Ph} &= 1 - t_{Ph} \\ q_{Cl} &= t_{Ch} - t_{Cl} & q_{Pl} &= t_{Ph} - t_{Pl} \end{aligned}$$

We study a four-stage game in pure strategies. In the first stage, both regional governments, as members of an interregional council, announce one choice out of three alternative standard setting procedures. If the two announcements coincide the particular procedure will be applied, otherwise the default procedure, MR, takes effect. The governments' role in the second stage depends on the first-stage outcome. In the third stage of the game, firms simultaneously determine quality to be produced unless a standard is binding. In the fourth stage, firms compete in prices, given qualities. We look for Subgame Perfect Nash Equilibria by the method of backwards induction.

[7]This also implies that region C has higher per capita income than region P.

In the last stage of the game, each firm will have two first order conditions for price choice, obtained by setting the partial derivatives of profit with respect to own prices in either market equal to zero, since markets are segmented. Solving these two equations simultaneously for the firm's own prices yields the price reaction function for each firm.

Solving all four reaction functions simultaneously yields the following equilibrium prices:

$$p_{Ch} = \frac{2Ts_h(-s_h + s_l)}{-4s_h + s_l} \qquad p_{Cl} = \frac{T(s_h - s_l)s_l}{4s_h - s_l}$$

(15)

$$p_{Ph} = \frac{2s_h(-s_h + s_l)}{-4s_h + s_l} \qquad p_{Pl} = \frac{(s_h - s_l)s_l}{4s_h - s_l}$$

It can be shown that the second order conditions for profit maximizations and consumers' positive-demand conditions are satisfied.

Let us consider briefly the unregulated equilibrium.

To derive the firms' quality best responses, we need to investigate each firm's profit function, given the other firm's quality choice, and taking into account that both firms choose equilibrium prices. This profit function will be a composite function, consisting of a segment where the firm is the low-quality producer and another segment where the firm is the high-quality producer. Firm i's profit as a function of own quality, s_j, is then given by:

$$\Pi_i = -(b_i s_j^2) + \frac{5s_j s_d(-s_j + s_d)}{(s_j - 4s_d)^2} \quad \text{for all } s_j \le s_d;$$

(16)

$$-(b_i s_j^2) + \frac{20s_j^2(s_j - s_d)}{(-4s_j + s_d)^2} \quad \text{for all } s_j \ge s_d;$$

$$i = c,p;\ j=h,l;\ d \neq j.$$

The market equilibria in pure strategies without government intervention are simply given by the intersections of the quality best responses. Generally, there will be two pure-strategy equilibria.

As we did in section 2, we want to concentrate on asymmetric pure-strategy equilibria where the low-cost firm (i.e. the firm located in the Core region) provides high quality. From now on then:

$s_c = s_h$ and $s_p = s_l$ Therefore, defining $R_c = p_{Ch}q_{Ch} + p_{Ph}q_{Ph}$ and $R_p = p_{Cl}q_{Cl} + p_{Pl}q_{Pl}$, from now on:

$$\Pi_h = \Pi_c = R_c - b_c s_c^2 \qquad (17)$$
$$\Pi_l = \Pi_p = R_p - b_p s_p^2$$

where R_r represents the revenue function of the firm located in region *r*.

Equations (18) through (21) describe properties of the total revenue function for both markets. These properties satisfy assumption 1.

$$(18)\ \frac{\partial R_c}{\partial s_c} = \frac{4s_c\left(1+T^2\right)\left(4s_c^2 - 3s_c s_p + 2s_p^2\right)}{\left(4s_c - s_p\right)^3} > 0 \qquad \frac{\partial R_c}{\partial s_p} = -\frac{4s_c^2\left(1+T^2\right)\left(2s_c + s_p\right)}{\left(4s_c - s_p\right)^3} < 0$$

$$(19)\ \frac{\partial R_p}{\partial s_p} = \frac{s_c^2\left(1+T^2\right)\left(4s_c - 7s_p\right)}{\left(4s_c - s_p\right)^3} > 0 \text{ if } s_c > \frac{7s_p}{4} \qquad \frac{\partial R_p}{\partial s_c} = \frac{s_p^2\left(1+T^2\right)\left(2s_c + s_p\right)}{\left(4s_c - s_p\right)^3} > 0$$

$$(20)\ \frac{\partial^2 R_c}{\partial s_c^2} = -\frac{8s_p^2\left(1+T^2\right)\left(5s_c + s_p\right)}{\left(-4s_c + s_p\right)^4} < 0 \qquad \frac{\partial^2 R_c}{\partial s_c \partial s_p} = \frac{8s_c s_p\left(1+T^2\right)\left(5s_c + s_p\right)}{\left(-4s_c + s_p\right)^4} > 0$$

$$(21)\ \frac{\partial^2 R_p}{\partial s_p^2} = -\frac{2s_c^2\left(1+T^2\right)\left(8s_c + 7s_p\right)}{\left(-4s_c + s_p\right)^4} < 0 \qquad \frac{\partial^2 R_p}{\partial s_p \partial s_c} = \frac{2s_c s_p\left(1+T^2\right)\left(8s_c + 7s_p\right)}{\left(-4s_c + s_p\right)^4} > 0$$

If no standard is adopted, in stage three firms maximize profits choosing qualities that solve first order conditions.

Applying the implicit function theorem to the first-order conditions, we can derive the slopes of both reaction functions:

$$(22) \qquad \frac{ds_c}{ds_p} = \frac{\left(1/2b_c\right)\partial^2 R_c / \partial s_c \partial s_p}{1 - \left(1/2b_c\right)\partial^2 R_c / \partial s_c^2}$$

$$(23) \qquad \frac{ds_p}{ds_c} = \frac{\left(1/2b_p\right)\partial^2 R_p / \partial s_p \partial s_c}{1 - \left(1/2b_p\right)\partial^2 R_p / \partial s_p^2}$$

It can be shown that $0 < ds_i / ds_d < 1$. Qualities are strategic complements for both firms.

Consumer surplus in each region are given by:

$$CS_C = \int_{t_{Ch}}^{T} \left(t\, s_c - p_{Ch}\right) dt + \int_{t_{Cl}}^{t_{Ch}} \left(t\, s_p - p_{Cl}\right) dt$$

(24)

$$CS_P = \int_{t_{Ph}}^{1} \left(t\, s_c - p_{Ph}\right) dt + \int_{t_{Pl}}^{t_{Ph}} \left(t\, s_p - p_{Pl}\right) dt$$

The following properties of consumer surplus in either region satisfy the requirements of assumption 2.

(25) $$\frac{\partial CS_C}{\partial s_c} = T^2 \frac{\partial CS_P}{\partial s_c} = T^2 \frac{s_c\left(4s_c - 7s_p\right)\left(2s_c + s_p\right)}{\left(-4s_c + s_p\right)^3}$$

(26) $$\frac{\partial CS_C}{\partial s_p} = T^2 \frac{\partial CS_P}{\partial s_p} = T^2 \frac{s_c^{\,2}\left(28s_c + 5s_p\right)}{2\left(4s_c - s_p\right)^3} > 0$$

(27) $$\frac{\partial^2}{\partial s_c^{\,2}} CS_C = T^2 \frac{\partial^2}{\partial s_c^{\,2}} CS_P = T^2 \frac{s_p^{\,2}(52s_c + 5s_p)}{(-4s_c + s_p)^4} > 0$$

(28) $$\frac{\partial^2}{\partial s_p \partial s_c} CS_C = 4 \frac{\partial^2}{\partial s_p \partial s_c} CS_P = -\frac{4s_c s_p (52s_c + 5s_p)}{(-4s_c + s_p)^4} < 0$$

The expression in equation (25) is strictly positive for any pair of qualities chosen in a market equilibrium, since a market equilibrium requires the low-quality firm's marginal revenue to be positive, which is only the case if $s_p < 4s_c / 7$.

Note, in addition, that $\partial CS_C / \partial s_p + \partial R_c / \partial s_p > 0$, as required by assumption 3.

As required by assumption 3, it can also be shown that at FH, $\partial W_C / \partial s_c = \partial CS_C / \partial s_c > 0$ and that a reduction in s_p without reducing s_c will always leave $\partial W_C / \partial s_c > 0$.

In the previous section we have shown that a move from FH to MR involves a decrease in s_p and an increase in s_c. The latter move increases both regions' welfare, but the former has a negative

effect on core welfare. This suggests that the peripheral region will prefer MR to FH, but the core region may not. In fact, the core region's preference depends on relative cost. If firm c's cost advantage is large, MR will lead to higher core welfare. The core region will prefer MR rather than FH if $b_c < g(b_p)$, where $g(b_p)$ describes combinations of cost parameters where regional core welfare is identical under FH and MR. It can be shown that $g(b_p) > 0$, $\partial g(b_p)/\partial b_p > 0$, $\lim_{b_p \to \infty} g(b_p) > 0$.

In the previous section, in addition, we argued that the core government prefers to deter entry of the peripheral firm if the core cost advantage is sufficiently large. Let $NTn(b_c, b_p)$ and $NTe(b_c, b_p)$ be the quality equilibria as functions of cost parameters under NT with deterred entry and NT with accommodated entry, respectively. The core region will prefer NT with deterred entry if $b_c < h(b_p)$, where $h(b_p)$ describes combinations of cost parameters where regional core welfare under NT with deterred entry equals welfare under NT with accommodated entry. It can be shown that $h(b_p) > 0$, $\partial h(b_p)/\partial b_p > 0$, $\lim_{b_p \to \infty} h(b_p) > 0$.

Taken together, functions $g(b_p)$ and $h(b_p)$ can be used to distinguish four cases. If the core cost advantage is "large", the core government deters entry under NT and prefers MR over all alternative regulatory regimes. If the core cost advantage is "small", the core government accommodates entry under NT and prefers FH over all alternative regulatory regimes. If core cost advantage is "intermediate", the remaining two cases result.

The effects of alternative regulatory regimes relative to the case without regulation are summarized in Table 1. A decrease (an increase) of a particular variable is denoted by "-" ("+"), whereas the question mark indicates that the direction of the effect could not be determined. It is noteworthy that MR unambiguously increases welfare and consumer surplus in both regions as well as both qualities.

Table 1. Effects of Standards Under Different Regulatory Regimes

	FH	NTe	NTn	MR
W	+	+	?	+
W_C	+	+	?	+
W_P	?	?	?	+
CS_C	+	+	?	+
CS_P	+	+	+	+
? $_c$	-	-	?	-
? $_p$	-	-	-	-
S_c	+	+	+	+
S_p	+	+	?	+

In the first stage of the game, governments choose one regulatory regime in the Council. This regime is either chosen by unanimous vote or a default rule, namely applying Mutual recognition, takes effect. Since the peripheral government always prefers the default rule MR, this is the only possible outcome of this game. Note that even with a different default rule, MR would remain a Nash equilibrium as long as $b_c < g\left(b_p\right)$.

6. Conclusions

Support for the harmonization of standards, especially minimum standards concerning product quality, safety, or environmental protection, varies considerably within the EU.

The EU currently adopts three alternative ways of handling standards. These arrangements are: Full Harmonization, Mutual Recognition, and National Treatment. The objective of our paper has been to shed some light on some questions about the relative effects of different standard setting

procedures and in particular about the possibility to regulate standards in such a way that the economically weaker regions do not take welfare losses. Specifically, the paper has extended Ronnen (1991) model studying the introduction of MQS in an asymmetric two-region model with segmented markets. The strategic choice of standard setting arrangements by the two region governments has been studied.

The paper has shown that concerns about adverse consequences of minimum quality standards might not be entirely valid. Whether a particular region will gain or lose from the introduction of a standard setting procedure depends on the procedure chosen. Within the framework of this model, welfare of the "peripheral" region will always be largest under MR. This leads to MR being the sole equilibrium outcome since it is the default procedure. In particular, this could indicate that the economically weaker members in the EU could be better off resisting the harmonization of product standards in the Council of Ministers of the EU. The "core" region's welfare will be largest under MR if its industry has a large cost advantage. This could indicate that MR of standards is more likely to prevail for industries with large cost differences.

To conclude, it is worth to notice that our paper produces some insights that can be related to the broad issue of global standards and globalisation. The paper provides some reasonable conditions to ensure the no existence of an equilibrium with Full Harmonization. In this sense, the model gives theoretical support to the growing belief[8] that global agreement on standards is unlikely to be achieved and that regional standards should be a more probable outcome. In addition, literature on globalisation interestingly stresses the increasing importance of firm-based standards[9] (e.g. a uniform quality standard requirements that must be followed by all of a firm's facilities around the world, even if these firm-based standards exceed the requirements of local and national regulations). In our opinion, extending the model to allow multinational firms to compete globally and to set internal quality standards could be an interesting topic for future research.

[8] See Thompson (2005).
[9] See, for example, Angel and Rock (2005).

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