Are Geographical Indications a Worthy Quality Signal? A Framework with Endogenous Quality Choice

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Abstract

The paper provides a theoretical framework to analyze the effects of Protected Designation of Origin (PDO) labeling on quality choices and welfare. Our model distinguishes two attributes of goods: gustatory quality, which is a search attribute, and geographical origin, which is a credence attribute. We compare equilibria with no label, "non-binding labeling" (i.e. when no requirement on production methods is binding to get the PDO label) and "binding labeling". We find that the PDO good is not necessarily the high-quality good. When it is, the introduction of non-binding labeling causes a decrease in quality. Restrictions on production methods are warranted to maintain the quality level of the labelable good, but they adversely affect the PDO firm.

1. Introduction

Are geographical indications (GIs) worthy quality signals for agri-food products? Does origin labeling convey relevant information and encourage quality improvement? Or is it mainly a means for agri-food chains to capture undue rents? These questions have been and remain conflicting among countries and among producer and consumer groups. The mere existence of a label certifying the place of origin of a product can suggest to consumers that localization confers some qualities to this product. If no pre-established link exists between quality and territory, and if producers granted with a GI do not undertake genuine efforts to improve quality, then origin labeling may well be considered as false advertising. In this case, GIs may relax competition intensity and provide rents to producers inside the geographical area without benefiting consumers.

On the opposite, GIs are likely to be warranted if natural factors and accumulated know-how in the place of origin do confer some specific quality attributes to products, if reputation provided by GIs helps producers to improve their quality, or if consumers wish to defend for itself the fact that production took place in a given area with given methods of production.

These issues may be illustrated with the example of the European Union (EU) rules on Protected Designation of Origin (PDO), which are one type of GIs (EU Regulation 2081/92). This regulation stipulates that PDO labeling may be granted to a product originating from a specific region, and "*the quality or characteristics of which are essentially or exclusively due to a particular geographical environment with its inherent natural and human factors, and the production, processing and preparation of which take place in the defined geographical area*". The preambule of this Regulation states that PDO protection is beneficial both for consumers and producers: for consumers, by giving them information regarding the origin of products and by making available high-quality products with guarantees as to the method of production and origin; for producers, by helping securing higher incomes in return for a genuine effort to improve quality, and by retaining rural population in less-favored or remote areas.

In practice, this legal framework allows a lot of flexibility on production and processing rules, and PDOs are very heterogeneous with this respect. For example, for some cheeses, production rules define authorized animal breeds, limit animal spatial density and forbid use of silage in animal feed, while other cheeses protected by PDO show no restriction on these criteria. Traditional versus industrial aspects of cheese processing as well as maturing length also vary widely between cheeses. These criteria may also change across time. For example, EU regulation 828/2003 modifies the geographical area and/or production/processing rules for sixteen PDOs, with criteria strengthened or decreased depending on cases. These examples suggest that PDO labeling is quite independent from restrictiveness of production/processing rules and therefore from quality

efforts. As to the link between product characteristics and inherent natural and human factors supposedly required in the Regulation, it is in effect hard to prove. While it has been questioned by some stakeholders, especially for processed products where particular attributes of raw agricultural products may be partially destroyed during the processing stage, some technology studies tend to prove that it may exist and be preserved at least through some of the possible transformation techniques.

Although a number of papers have recently discussed issues about GIs, only few have yet framed them into a theoretical model. More generally, the relevant economic literature to study GIs and PDOs is that on information asymmetry, quality signaling and firm reputation (Lucatelli 2000, Josling 2005).

One article that indeed provides many interesting insights for the issue of PDO is that of Crampes and Hollander (1995) on denomination or appellation standards. This article builds on a stylized fact about harmonization of the standard for gold in the EU, which has led France to diminish the number of karats that a metal has to contain in order to be called "gold". The authors examine how relaxing this standard affects different producers and consumers. They model the appellation standard as certifying that quality is at least equal to a given threshold. They adopt a vertical differentiation framework where consumers value the intrinsic quality level of the good they consume as well as the presence of a label on this good, and where a high-quality firm in the standard competes with a low-quality firm outside the standard. They show that relaxing the denomination standard benefits high-quality producers.

Zago and Pick (2004) study similar issues in a paper precisely about PDO, but comparing situations with and without standard rather than considering variations in the standard level. Their framework is different, in that it considers a credence good produced under two exogenous quality levels (a high level that may possibly be labeled as PDO, and a low one), with initial perfect

competition in both regions, and with PDO label introduction potentially conferring market power to PDO producers (land restriction or monopolistic price determination). The PDO label provides consumers with information. The regulation introduces the emergence of two distinct qualities. The consequences are that consumers and high quality producers are better off while producers of the quality commodity are worse off.

In connection with this literature, this paper aims at contributing to the understanding of PDO effects. Contrarily to the studies quoted above, and in line with our stylized facts from European PDO regulation, we do not assume a priori that the PDO region produces the highest quality level. Rather, we start from assumptions on potential links between quality and territory for consumers, from which we derive relative quality levels inside and outside the region with PDO labeling. We compare equilibria with no label and with a PDO label, distinguishing two cases: the PDO label only guarantees the origin of the product, and requirements on production methods are non-binding ("non-binding labeling"); or producers have to maintain their initial production methods, thereby guaranteeing that the initial quality level is maintained, as labeling is introduced ("binding labeling").

2. Theoretical framework

We adopt a model that draws on standard features of the vertical differentiation literature (Mussa and Rosen 1978, Cremer and Thisse 1994, Lambertini 1996). We consider two goods. The first one may pretend to PDO labeling. For concision, we refer to it as the "labelable" good; and we refer to its production region as the "PDO region". We denote this good by *a* (where *a* stands for "appellation"). The other good, the "non- labelable good", good *b*, is produced in a region where no PDO labeling is possible (the "non-PDO region"). We assume that there exists one producer in each region.

Implementation of the label

The PDO label certifies a product that originates from a given region and fulfills production requirements specified in the PDO regulation. Depending on products, these specifications may induce or not an effective constraint. In our model, we consider successively two alternative ways in which the PDO label is implemented. In the case of "non-binding labeling", this label is granted to the producer of the PDO area whatever its quality level (there may exist specification requirements, but they induce no effective production constraint). In the case of "binding labeling", this producer obtains the PDO label only if its quality is above a given threshold (an assumption analogous to that of Crampes and Hollander, 1995, who view "denomination standards" as standards imposing a minimum quality level). We always assume costless labeling.

Attributes of goods

We distinguish two attributes of goods: gustatory quality and geographic origin. Gustatory quality of good *i* is a one-dimensional continuous vertical attribute labeled by q_i (the higher q_i, the higher the quality of good *i*). In the usual classification of search, experience or credence attributes (Nelson 1970, Darby and Karni 1973), taste is typically an experience attribute, known after purchase. However, for a product purchased repeatedly, which is the usual case with food products, consumers have an idea of its taste before purchase (as long as this taste is stable enough in time). In our one-period model, we account for this by treating this gustatory quality attribute as a search attribute (detected before purchase) and we leave out any informational problem related to this gustatory quality. By contrast, we assume that the attribute of geographic origin is a credence attribute, which can be revealed only by public labeling.[1] We denote it by an indicator number:

[1] In this, we adopt a more realistic assumption than that of Zago and Pick, who consider quality as credence attribute for simplification matters. Crampes and Hollander do not consider the effects of the introduction of a standard, but only of a change in the restrictiveness of a standard already in place, and therefore leave out informational problems from their model.

$$(1)\ \text{Ind(origin)} = \begin{cases} 1 & \text{for the labelable good,} \\ 0 & \text{for the non-labelable good.} \end{cases}$$

We define an indicator number that will be useful in our definition of the utility function:

$$(2)\ \text{Ind(label)} = \begin{cases} 1 & \text{for the labelable good if it is labeled as PDO,} \\ 0 & \text{otherwise.} \end{cases}$$

Consumers

Consumers purchase a single unit of one of the two goods, or nothing. Their utility is additive in the two attributes of the good. Consumers differ in the intensity of their preference for gustatory quality, measured by a parameter θ distributed uniformly on the interval $[\underline{\theta}, \overline{\theta}]$. They have identical preferences for regional origin, measured by a parameter *r* (the same for all consumers). This formulation is consistent with the observed fact that usually consumers are willing to pay more for products with a geographical indication.[2]

We consider two alternative assumptions on consumer utility, depending on whether consumers value the origin of good *a* only if this good is actually labeled, or value the origin of this good for itself. Accordingly, utility derived from a positive consumption of one of the two goods is given by:

$$(3)\ \begin{cases} U = \theta\, q_i + r\ \text{Ind(label)} & \text{if consumers care for the label (assumption A1)} \\ U = \theta\, q_i + r\ \text{Ind(origin)} & \text{if consumers care for the origin (assumption A2)} \end{cases}$$

Under assumption A1, consumers value the origin of the labelable good only if this good is actually labeled. Under assumption A2, consumers value the origin of good *a* per se. It is analogous

[2] Loureiro and McCluskey (2000) found that Spanish consumers were willing to pay a premium for fresh meat products with a Protected Geographical Identification label. The label is "Galician Veal" which is regulated by the European Union. Umberger et al. (2003) found a similar result for country-of-origin labeling of beef. Chicago and Denver consumers were surveyed. They were willing to pay a 19% premium for steak labeled "guaranteed USA: Born and raised in the US".

to the formulation of Crampes and Hollander (1995), who assume in their article on gold labeling that consumers derive utility from two characteristics of jewellery, identification as gold jewellery by a label and gold content. Assumption A2 is more in line with the model of Zago and Pick, who view the label only as a means to disclose information on the origin of the good, but on which consumers do not attach a utility per se.

Producers

We assume that there exists one producer in each region. By doing so, we leave out one aspect of PDOs that has received attention in the literature, i.e. the fact that PDO labeling may help producers of the PDO region to cartelize and exercise market power (Marette, Crespi and Schiavina 1999; Zago and Pick 2004). We do so in order to focus on quality issues. In addition, for tractability reasons, we focus on the case where production costs are identical in both regions. We assume that fixed costs of production are zero, while variable costs of production are constant in quantity (x_i) and quadratic in quality (q_i):

(4) $C_i(x_i, q_i) = x_i\, t\, q_i^2$

where t is the cost parameter, the same for both qualities.

Firms compete in two stages. In the first stage, they simultaneously choose their quality levels. In the second stage, they simultaneously determine prices.

Resolution for a covered market

To be able to get to analytical solutions in our model, we choose to study only the case where the market is covered. Except for the addition of our constant preference parameter for origin r, our model is equivalent to that of Cremer and Thisse (1994) and Lambertini (1996). We assume that $\overline{\theta} = \underline{\theta} + 1$ and restrict the analysis to the case where $\underline{\theta}$ is sufficiently high so that the market is

covered.[3]

3. No PDO labeling

We analyze here the equilibrium in the case where the product origin is not signaled by a PDO label. If consumers care for the label (assumption A1), in the absence of labeling, they get no utility from the origin attribute even if they consume the labelable good. Therefore, the utility of consuming good *i* is θq_i. We then obtain the standard results of the literature (Cremer and Thisse 1994, Lambertini 1996). If consumers care for the origin (assumption A2), they value by *r* the consumption of the labelable good. However, they can distinguish goods in terms of their gustatory quality but not in terms of their origin. Given that the origin of the good is a credence attribute, consumers make expectations as to the origin of the good they buy. Because two goods are marketed, they expect that the probability that the good they consume comes from the PDO region is one half, therefore Ind(*origin*) is equal to ½ and the utility from consuming good *i* is $U = \theta q_i + r/2$. The difference in our two assumptions on consumer utility does not affect demand functions; therefore equilibrium is the same, except for consumer surplus which is different with these two assumptions.

There exists two possible duopoly configurations, one in which the PDO firm produces the high-quality good and one in which it produces the low-quality good. To solve the model, we determine the equilibria in which both firms are active for both configurations. Then, we calculate conditions on parameters for these duopoly equilibria to arise with a covered market. Condition 1 ensures that the market is covered. Our results are summarized in Proposition 1 and described in

[3] Cremer and Thisse (1994) and Lambertini (1996) are able to solve their model analytically. With a similar framework, Motta (1993) analyzes the case of an uncovered market. In terms of our model's parameters, he assumes that $\underline{\theta}$ is equal to zero, and has to choose a numerical value for $\overline{\theta}$ in order to solve the model.

Table 1, with indexes *H* and *L* denoting respectively the high and the low quality.

Condition 1. $\underline{\theta} > \frac{5}{4}$.

Proposition 1: *Assume that condition 1 holds. Without labeling, there exist two duopoly equilibria generated by switching the role of both firms (depending on whether the labelable good is the high-quality or the low-quality good). In equilibrium, both firms sell the same quantities and obtain the same profit. Consumer surplus is lower if consumers care for the label than if they care for the origin. Other equilibrium values are the same whether consumers care for the label or the origin.*

Insert Table 1.

4. Non-binding PDO labeling

We now turn to the equilibrium with labeling. The PDO label is a signal of origin and fulfillment of production specifications. For now, we assume that these production specifications are not binding, so that the PDO label only signals the origin. By definition, Ind(origin) and Ind(label) are both equal to one if the labelable good is actually labeled. In this case, utility functions are identical whether consumers care for the label or for the origin: the utility from consuming the labeled good is $\theta q_a + r$, while the utility from consuming the non-labeled good is θq_b. We assume that conditions 2 are fulfilled:

Conditions 2. (a) $16\,t\,r < 9$

(b) $\underline{\theta}^2 > 1 + \left(\frac{9 - 16\,t\,r}{12}\right)^2$

These conditions are used in proposition 2 to ensure that in equilibrium both firms are active (condition 2a) and the market is covered (condition 2b.) (All proofs are given in the appendix.) Equilibrium values are described in Table 2.

Proposition 2. *Assume that conditions 2 hold. With non-binding labeling, two duopoly equilibria may emerge, depending on whether the labeled good is the high-quality or the low-quality good. Equilibrium quantities for each good, the degree of differentiation, the average quality, profit levels and consumer surplus are identical in these two equilibria.*

Insert Table 2.

The PDO label is a signal of origin and know-how, but does not impose a quality standard (as is the case for Label Rouge for example). Under the assumptions of our model, the firm producing the labelable good may be either the low-quality or the high-quality producer, both before and after the introduction of a PDO label with no effective constraint on production requirements. In addition, profits of each firm and consumer surplus are the same whatever which of these two possible equilibria emerges – i.e., both firms, and consumers in aggregate, are indifferent between both situations (labelable good as high quality or low quality good). Therefore, in this context, the PDO label is not a signal of "high quality". If we assume that no quality efforts are associated with labeling, we obtain that there is a priori no reason for the PDO region to provide a higher or a lower quality than the non-PDO region. This is in contrast with usual assumptions of the literature that the PDO good is necessarily a high-quality good (Zago and Pick 2004). This is also in contrast with the Preamble of the European PDO regulation, which, as mentioned in the introduction, associates a notion of high quality to PDO.

Proposition 3. *Assume that conditions 2 hold. If the labelable good is the high-quality good, the introduction of non-binding labeling increases the price difference and lowers quality levels and prices. If the labelable good is the low-quality good, the introduction of labeling decreases the price difference and increases quality levels and prices.*

Figure 1 illustrates the results of Proposition 3 in terms of shifts in first-stage reaction functions, which give how one firm determines its best quality level, given the quality level chosen

by the other firm (the analytical expressions of these reaction functions are given in the appendix). The equilibria lie in regions where both reaction functions are upward-sloping, i.e. there exists strategic complementarity between qualities. If the labelable good is the high-quality good ($q_a > q_b$), the introduction of labeling causes both reaction functions to shift in, and the equilibrium to take place with lower qualities for both goods. On the contrary, if the labelable good is the low-quality good ($q_a < q_b$), the introduction of labeling causes both reaction functions to shift out, and the equilibrium to take place with higher qualities for both goods.

Insert figure 1.

Further intuition on these results can be gained by defining a new variable, the "gustatory quality equivalent" of the labeled good, q_a'. We assume that given equilibrium values of prices and of quality level of the non-labeled good, consumers of the labeled good get the same total surplus from consuming the labeled good, valuing its gustatory quality at its equilibrium level plus the origin, than they would get from consuming a good with gustatory quality only, but at a higher level q_a'. Letting D_a denote the segment of θ on which the labelable good is consumed, q_a' is implicitly defined by: $\int_{Da} \theta q_a' d\theta = \int_{Da} (\theta q_a + r) d\theta$.

Insert figure 2.

Figure 2 pictures the levels of quality and quality equivalents. In both possible configurations (high or low quality for the labelable good), as labeling is introduced, the quality gap remains unchanged ($|q_a^{NB} - q_b^{NB}| = |q_a^0 - q_b^0|$) and the quality equivalent of the labeled good is higher than its quality ($q_a'^{NB} > q_a^{NB}$). As a result, the quality gap defined with the quality equivalent increases if the labelable good is the high-quality good ($q_a'^{NB} - q_b^{NB} > q_a^0 - q_b^0$), therefore relaxing price competition between both varieties and leading to an increase in the price difference. If the labelable good is the low-quality good, the opposite result is obtained (q_b^{NB} -

$q_a'^{NB} < q_b^0 - q_a^0$), therefore price competition intensifies and the price difference is reduced as labeling is introduced.

In our framework where consumers value the origin of the good, or the fact that this good is labeled as PDO, the label introduction actually leads to lowering gustatory qualities when the PDO good is the high-quality good. This result of our model, here again, is in contradiction with the preamble of the European PDO regulation, which views PDO as encouraging quality improvement for producers.

Proposition 4: *Assume that conditions 2 hold. The introduction of non-binding labeling causes the profit of the non-PDO firm to decrease and the profit of the PDO firm to increase. Consumers' surplus increases if consumers care for the label; while it decreases if consumers care for the origin. Total welfare increases.*

Labeling increases the utility provided by the labelable good without changing its production cost function. Therefore, we obtain the intuitive result that the profit of the PDO firm increases while the profit of the non-PDO firm decreases with the introduction of the PDO label. This result is similar to the one obtained by Zago and Pick (2004). However, our results on how labeling affects consumer surplus are different from theirs. Zago and Pick assume that the labelable good is the high-quality good, with quality levels exogenous and unknown in the absence of labeling. In their model, PDO labeling causes consumer surplus to increase by removing imperfect information on quality levels. Our assumption that consumers care for the origin is analogous to that of Zago and Pick: with no labeling, consumers make expectations as to the relative proportions of quantities of each good and therefore affect an average utility on origin for any good they consume. In our model, asymmetric information exists only for the origin, not for the gustatory quality. The introduction of PDO labeling removes the asymmetric information on the origin, and lowers the qualities of both products. Contrarily to the model of Zago and Pick, the consumer surplus

decreases with labeling introduction. The result is different with our assumption that consumers care for the label. In this case, prior to labeling, they do not affect any utility on any good because of its origin. Then, their surplus increases with labeling introduction. With both alternative assumptions, labeling increases total profit and total welfare.

5. Binding PDO Labeling

PDO certification guarantees the fulfillment of requirements on production methods, but not output quality. We study here the extreme case where all production practices have to be maintained at least to their initial level as the PDO label is introduced, thereby assuring that at least the initial quality level is obtained. In this particular case, the PDO specifications on production methods are equivalent to a minimum quality requirement. Therefore, in this section, we assume that the PDO firm gets the PDO label only if its quality level is at least the quality of the no-label case. We study the case where the labelable good is the high-quality good, because it is the only case where the minimum quality requirement is binding. (From proposition 3, the introduction of non-binding labeling would then induce a decrease in the quality level of the labelable good; whereas if the labelable good is the low-quality good its quality increases as non-binding labeling is introduced).

Below, we use conditions 3 to ensure that in equilibrium both firms are active (condition 3a) and the market is covered (condition 3b):

Conditions 3. (a) $64\,t\,r < 81$

(b) $8[8\,t\,r(\bar{\theta}-1)+3\bar{\theta}(\bar{\theta}-2)(\sqrt{81+192\,tr}-6\bar{\theta})]>81(\bar{\theta}-1)$

Our results are described in table 3.

Insert table 3.

Proposition 5 compares the situation where the PDO label is associated with a minimum quality requirement ("binding labeling") to the situation where PDO specifications on production methods induce no effective production constraint (the non-binding labeling studied in section 4).

Proposition 5. *Assume that the labelable good is the high-quality good and that conditions 3 hold. Both quality levels are higher and the degree of differentiation is smaller with binding labeling than with non-binding labeling. The PDO firm obtains a smaller profit with binding labeling than with non-binding labeling. When the intensity of preferences for the origin is small enough ($r < 9/24t$), the non-PDO firm obtains a higher profit with binding labeling than with non-binding labeling; otherwise, comparison of profit levels is indeterminate. Consumer surplus and total welfare are lower with binding labeling than with non-binding labeling.*

The results of Proposition 5 can be compared to the results of Crampes and Hollander (1995). These authors study the effects of a relaxation in a denomination standard that is already in place. Considering the opposite effect of a strengthening of a denomination standard, they obtain that an increase in the minimum quality requirement associated with the standard causes the profit of the firm that meets the standard to decrease. This result is similar to our result that the PDO firm obtains a smaller profit when it maximizes profits under a minimum quality constraint than when it is free to choose whatever quality level it wants to produce, and conforms to the intuition. They obtain that all consumers lose from a strengthening in the standard; we have the analogous result that in aggregate consumer surplus is smaller if production requirements for the PDO label are binding. Our results differ on profits of the firm that does not meet the standard. They obtain that this profit necessarily increases with a strengthening of the standard. Our results are less clearcut: we can conclude and obtain the same result as they do only if the intensity of preferences for the origin is small. Our results also differ on total welfare. We obtain that total welfare decreases with the introduction of binding production constraints. They find the same marginal effects only if the

standard is not severe, but the opposite result with a severe standard.

Proposition 6 compares the equilibrium with binding labeling to the equilibrium with no label.

Proposition 6. *Assume that the labelable good is the high-quality good and that conditions 3 hold. The introduction of binding labeling causes the quality of the non-labelable good to decrease, while the quality of the labelable good is maintained to its initial level. The price of the labelable good increases, whereas the price of the non labelable good decreases. The profit of the PDO firm increases and the profit of the non-PDO firm decreases, with total profit increasing. The consumers are better off if they care for the origin, they are worse off if they care for the label.*

The quality of the labelable good is the same with and without the PDO label because of production requirements associated with the label (as pictured on figure 3).

Insert figure 3.

As the label is introduced, the labelled good benefits from willingness to pay for the attribute of origin, therefore its price increases although its quality is unchanged. The introduction of binding labeling causes the quality of the non labelable good to decrease and therefore the degree of differentiation to increase. As a result, the non-labelable good faces a price decrease. The results we obtain for the consumer surplus are similar to those obtained in proposition 5 when comparing the binding and non-binding labeling equilibria. Analytically it is no possible to conclude on the evolution of the total welfare.

6. Conclusion

This paper gives the first step of a study aimed at analyzing the effects of PDO labeling when no a priori assumption is made on relative quality levels in the PDO and non-PDO regions. Thus far, the analysis is restricted to the simple case considered in the paper (one firm per region,

identical cost functions for both firms, Mussa-Rosen type vertical differentiation framework with a covered market and with an attribute of preference for the good produced in the PDO region).

Interestingly, we find that when quality is determined endogenously in the model, it is a priori not possible to determine whether the PDO region will produce the high-quality or the low-quality good, and each of these two possible situations yields identical profits for both firms and identical total consumer welfare. Assume that the regulator authorizes PDO labeling without imposing restrictions on methods of production and thereby on the quality level. Then, if the labelable good is the high-quality good, the firm producing this good gets no incentive for quality and labeling causes its quality level to decrease. When PDO labeling is already in place, the PDO firm loses if a binding minimum quality requirement is made mandatory to keep the label. Yet, we observe real-world situations where associations of PDO producers take initiatives to strengthen their production requirements, which is in contradiction with the results of our model. One possible interpretation in line with our results would be that these producers could seek to improve their product image but introduce new production methods that are actually not binding.

Future research could extend this work in several directions. It could be relevant to consider an alternative assumption on preferences, where the higher the quality level, the more consumers value the geographic origin, with for example $U = (\alpha\, a + \beta)\, q_i$. Our current formulation assumes identical variable cost functions in both regions. Actually, the cost of producing a given level of quality may be lower or higher in the PDO region than in the outside region, depending on whether the quality level is intrinsically linked to the place of origin through natural and human factors, whether general production conditions are harder in the PDO region, and which of these effects dominates. The assumption of identical variable cost functions for both regions has been maintained here for simplicity reasons, but extensions of this work could consider the case where these cost functions differ.

References

Bureau J.C., Marette S., Schiavina A. 1998. “Non-tariff Trade Barriers and Consumers’ Information : The Case of the EU-US Trade Dispute over Beef.” *European Review of Agricultural Economics 25:437-462.*

Crampes C., Hollander A. 1995. “How many Karats is Gold: Welfare Effects of Easing a Denomination Standard.” *Journal of Regulatory Economics* 7:131-143.

Cremer H., Thisse J.F. 1994. “Commodity Taxation in a Differentiated Oligopoly.” *International Economic Review* 35:613-633.

Darby M., Karni E. (1973). “Free Competition and the Optimal Amount of Fraud. ” *Journal of Law and Economics* 16:67-88.

Josling T. 2005. “What's in a Name? The Economics, Law and Politics of Geographical Indications for Foods and Beverages.” Paper presented to the Institute for International Integration Studies, Trinity College, Dublin, November 11, 2005.

Lambertini L. 1996. “Choosing Roles in a Duopoly for Endogenously Differentiated Products.” Australian Economic Papers 35, 205-224.

Loureiro, M.L. & McCluskey, J. (2000) - Assessing Consumer Response to Protected Geographical Identification Labeling, *Agribusiness*, 16, 3, 309-320.

Loureiro M.L. and UmbergerW.J. “Assessing Preferences for Country-of-Origin Labeled Products”. Journal of Agricultural and Applied Economics. 37(1) April 2005:49-63.

Lucatelli S. (2000). “Appellations of Origin and Geographical Indications in OECD Member Countries: Economic and Legal Implications.” OCDE, Directorate for food, agriculture and fisheries, trade directorate, 73 p.

Mussa M., Rosen S. (1978). Monopoly and Product Quality. Journal of Economic Theory 18, 301-317.

Marette S., Crespi J.M., Schiavina A. (1999). "The role of common labelling in a context of asymmetric information." *European Review of Agricultural Economics* 26:167-178.

Motta M. 1993. "Endogenous Quality Choice: Price vs Quantity Competition." *Journal of Industrial Economics* 41:113-132.

Nelson P. 1970. "Information and Consumer Behavior." *Journal of Political Economy* 78:311-329.

Ronnen U. 1991. "Minimum Quality Standards, Fixed Costs, and Competition." *Rand Journal of Economics* 22:490-504.

Umberger, W.J., D.M. Feuz, C.R. Calkins and B.M. Sitz. "Country-of-Origin Labeling of Beef Products: U.S. Consumers Perceptions." Journal of Food Distribution Research. 34: 103-116. November 2003.

Zago A.M., Pick D. 2004. "Labeling Policies in Food Markets: Private Incentives, Public Intervention, and Welfare Effects." *Journal of Agricultural and Resource Economics* 29:150-165.

Appendix

Demand functions are given by:

$x_a = \bar{\theta} - \tilde{\theta}$ and $x_b = \tilde{\theta} - \underline{\theta}$ in the case where $q_a > q_b$,

$x_a = \tilde{\theta} - \underline{\theta}$ and $x_b = \bar{\theta} - \tilde{\theta}$ in the case where $q_a < q_b$,

with $\tilde{\theta} = \dfrac{p_a - p_b - r}{q_a - q_b}$.

Profit functions are $\pi_i = x_i(p_i - t\, q_i^2)$, $i = a, b$.

For each of the two possible cases ($q_a > q_b$ and $q_a < q_b$), the equilibrium is solved by backward induction. Solving the second stage of the game gives equilibrium prices p_a and p_b as functions of exogenous parameters t, r and $\overline{\theta}$ and quality levels q_a and q_b. In each of the two cases, when solving the first stage of the game, we find that 5 couples of quality levels may qualify for first-order conditions. Out of these 5 couples, we are able to eliminate one couple that does not satisfy the condition on the relative levels of q_a and q_b and to eliminate three other couples that do not satisfy the second-order condition of profit maximization at the first stage of the game. We are then left with one couple of quality levels in each case. This couple satisfies the second order condition of profit maximization at the first stage of the game under condition 2a.

The next stage is to determine the conditions under which the duopoly solution emerges with a covered market. In the case where $q_a > q_b$, we need: (1) $\underline{\theta} < \tilde{\theta} < \overline{\theta}$, which is always fulfilled if condition 1a holds, and (2) $\frac{p_b}{q_b} < \underline{\theta}$, which is equivalent to condition 2b. In the same way, in the case where $q_a < q_b$, we need: (1) $\underline{\theta} < \tilde{\theta} < \overline{\theta}$, which is always fulfilled if condition 2a holds, and (2) $\frac{p_a - r}{q_a} < \underline{\theta}$, which is equivalent to condition 2b.

At least, total consumer surplus is given by:

$$\int_{\underline{\theta}}^{\tilde{\theta}} (\theta q_b - p_b) d\theta + \int_{\tilde{\theta}}^{\overline{\theta}} (r + \theta q_a - p_a) d\theta \text{ if } q_a > q_b,$$

$$\int_{\underline{\theta}}^{\tilde{\theta}} (r + \theta q_a - p_a) d\theta + \int_{\tilde{\theta}}^{\overline{\theta}} (\theta q_b - p_b) d\theta \text{ if } q_a < q_b.$$

At the second stage of the game, we have:

$$\text{If } q_a > q_b, \begin{cases} p_a^*(p_b, q_a, q_b, r) = \frac{1}{2}\left(p_b + q_a{}^2 t + r + (q_a - q_b)\overline{\theta} \right) \\ p_b^*(p_a, q_a, q_b, r) = \frac{1}{2}\left(p_a + q_b{}^2 t - r - (q_a - q_b)\underline{\theta} \right) \end{cases}$$

If $q_a < q_b$, $\begin{cases} p_a^*(p_b, q_a, q_b, r) = \frac{1}{2}\left(p_b + q_a{}^2 t + r + (q_a - q_b)\underline{\theta} \right) \\ p_b^*(p_a, q_a, q_b, r) = \frac{1}{2}\left(p_a + q_b{}^2 t - r - (q_a - q_b)\overline{\theta} \right) \end{cases}$

At the first stage of the game, we obtain the following reaction functions:

If $q_a > q_b$, $\begin{cases} q_a^*(q_b, r) = \dfrac{\overline{\theta} + 1 + 4q_b t + \sqrt{(\overline{\theta} + 1 - 2q_b t)^2 - 12tr}}{6t} \\ q_b^*(q_a, r) = \dfrac{\overline{\theta} - 2 + 4q_a t - \sqrt{(2q_a t + 2 - \overline{\theta})^2 + 12tr}}{6t} \end{cases}$

If $q_a < q_b$, $\begin{cases} q_a^*(q_b, r) = \dfrac{\overline{\theta} - 2 + 4q_b t - \sqrt{(2q_b t + 2 - \overline{\theta})^2 - 12tr}}{6t} \\ q_b^*(q_a, r) = \dfrac{\overline{\theta} + 1 + 4q_a t + \sqrt{(\overline{\theta} + 1 - 2q_a t)^2 + 12tr}}{6t} \end{cases}$

In the case where $r = 0$, they simplify to:

If $q_a > q_b$, $\begin{cases} q_a^*(q_b) = \dfrac{\overline{\theta} + 1 + q_b t}{3t} \\ q_b^*(q_a) = \dfrac{\overline{\theta} - 2 + q_a t}{3t} \end{cases}$

If $q_a < q_b$, $\begin{cases} q_a^*(q_b) = \dfrac{\overline{\theta} - 2 + q_b t}{3t} \\ q_b^*(q_a) = \dfrac{\overline{\theta} + 1 + q_a t}{3t} \end{cases}$.

Table 1. Equilibrium in the absence of PDO labeling

q_h^0	$\frac{4\bar{\theta}+1}{8t}$	
q_l^0	$\frac{4\bar{\theta}-5}{8t}$	
Degree of Differentiation $q_h^0 - q_l^0$	$\frac{3}{4t}$	
$x_h^0 = x_l^0$	$\frac{1}{2}$	
Average Quality	$\frac{2\bar{\theta}-1}{4t}$	
p_h^0	$\frac{\left(4\bar{\theta}+1\right)^2+24}{64t}$	
p_l^0	$\frac{\left(4\bar{\theta}-5\right)^2+24}{64t}$	
$\tilde{\theta}^0$	$\bar{\theta}-\frac{1}{2}$	
Consumer Surplus	$CS_{A1}^0 = \frac{16\bar{\theta}(\bar{\theta}-1)-23}{64t}$	$CS_{A2}^0 = CS_{A1}^0 + \frac{r}{2}$
Profit $\prod_h^0 = \prod_l^0$	$\frac{3}{16t}$	
Total Profit $\prod^0$	$\frac{3}{8t}$	
Total Welfare	$W_{A1}^0 = \frac{16\bar{\theta}(\bar{\theta}-1)+1}{64t}$	$W_{A2}^0 = W_{A1}^0 + \frac{r}{2}$

Note: The superscript 0 denotes equilibrium values in the absence of labeling. CS_{A1}^0 and CS_{A2}^0 denote the consumer surplus in the absence of labeling respectively under assumption A1 and under assumption A2.

Table 2. Duopoly Equilibria With Non-Binding Labeling

	$q_a > q_b$	$q_a < q_b$
q_a^{NB}	$q_h^0 - \frac{2}{3}r$	$q_l^0 + \frac{2}{3}r$
q_b^{NB}	$q_l^0 - \frac{2}{3}r$	$q_h^0 + \frac{2}{3}r$
Degree of Differentiation	$\frac{3}{4t}$	$\frac{3}{4t}$
Average Quality	$\frac{2\overline{\theta} - 1}{4t}$	
x_a^{NB}	$\frac{1}{2} + \frac{8}{9}tr$	
x_b^{NB}	$\frac{1}{2} - \frac{8}{9}tr$	
p_a^{NB}	$p_h^0 - \frac{r}{18}\underbrace{\left(12\overline{\theta} - 8rt - 9\right)}_{>0 \text{ (from conditions 2)}}$	$p_l^0 + \frac{r}{18}\underbrace{\left(12\overline{\theta} + 8rt - 3\right)}_{>0 \text{ (from conditions 2)}}$
p_b^{NB}	$p_l^0 - \frac{r}{18}\underbrace{\left(12\overline{\theta} - 8rt - 3\right)}_{>0 \text{ (from conditions 2)}}$	$p_h^0 + \frac{r}{18}\underbrace{\left(12\overline{\theta} + 8rt - 9\right)}_{>0 \text{ (from conditions 2)}}$
Price Difference	$p_h^0 - p_l^0 + \frac{r}{3}$	$p_h^0 - p_l^0 - \frac{r}{3}$
$\tilde{\theta}^{NB}$	$\tilde{\theta}_0 - \frac{8}{9}tr$	$\tilde{\theta}_0 + \frac{8}{9}tr$
Consumer Surplus CS^{NB}	$CS_{A1}^0 + \frac{r}{54}(27 - 8tr) = CS_{A2}^0 - \frac{4r}{27}$	
Profit a $\prod_a^{NB}$	$\frac{(9 + 16tr)^2}{432t}$	
Profit b $\prod_b^{NB}$	$\frac{(9 - 16tr)^2}{432t}$	
Total Profit $\prod^{NB}$	$\prod^0 + \frac{32tr^2}{27}$	
Total Welfare W^{NB}	$W_{A1}^0 + \frac{r}{2} + \frac{28tr^2}{27} = W_{A2}^0 + \frac{28tr^2}{27}$	

Note : The subscript NB denotes equilibrium values with non-binding PDO labeling.

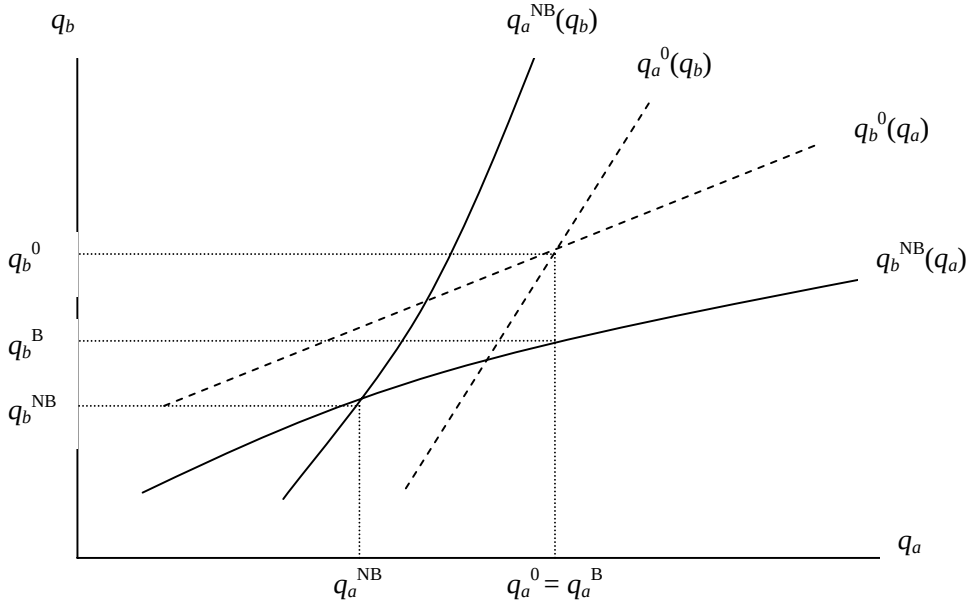
Table 3. Duopoly Equilibrium with Binding PDO Label, with $q_a > q_b$ and $q_a^B = q_h^0$

q_a^B	q_h^0
q_b^B	$\frac{4\bar{\theta}-5}{8t} + \frac{9-\sqrt{81+192rt}}{24t} > q_b^{NB}$
Degree of Differentiation	$\frac{3}{4t}+\frac{\sqrt{81+192rt}-9}{24t}$
x_a^B	$\frac{1}{6}\sqrt{9+\frac{64tr}{3}}$
x_b^B	$1-\frac{1}{6}\sqrt{9+\frac{64tr}{3}}$
Average Quality	$\bar{Q}^B = \frac{64t\alpha - 3(3+\sqrt{81+192t\alpha})+72\bar{\beta}}{144\,t} > \bar{Q}^{NB} = \bar{Q}^0$
p_a^B	$\frac{256tr+3(39+4\sqrt{81+192tr}+24\bar{\theta}(1+2\bar{\theta})}{576t}$
p_b^B	$\frac{-64tr+3(75+8\sqrt{81+192tr}-8(6+\sqrt{81+192tr}-6\bar{\theta})\bar{\theta})}{576t}$
$\tilde{\theta}^B$	$\bar{\theta}-\frac{\sqrt{81+192\,t\,r}}{18}$
Consumer Surplus CS^B	$CS_{A1}^0+\frac{81(9-\sqrt{81+192t\,r})-64t\,r(18+\sqrt{81+192tr})}{5184t}$
Total profit $\prod_a^B$	$\frac{\sqrt{81+192\,t\,r}\,(3(9+\sqrt{81+192\,t\,r})+64\,t\,r)}{5184\,t}$
Total profit $\prod_b^B$	$\frac{(18-\sqrt{81+192\,t\,r})\,(3(9+\sqrt{81+192\,t\,r})-64\,t\,r)}{2592\,t}$
Total profit	$\frac{64\,t\,r(\sqrt{81+192\,t\,r}-9)+27(\sqrt{81+192\,t\,r})+9)}{1296\,t}$
Total Welfare	$\frac{64\,t\,r(5\sqrt{81+192\,t\,r}-18)+27(\sqrt{81+192\,t\,r}-6+48\theta(\theta-1))}{5184\,t}$

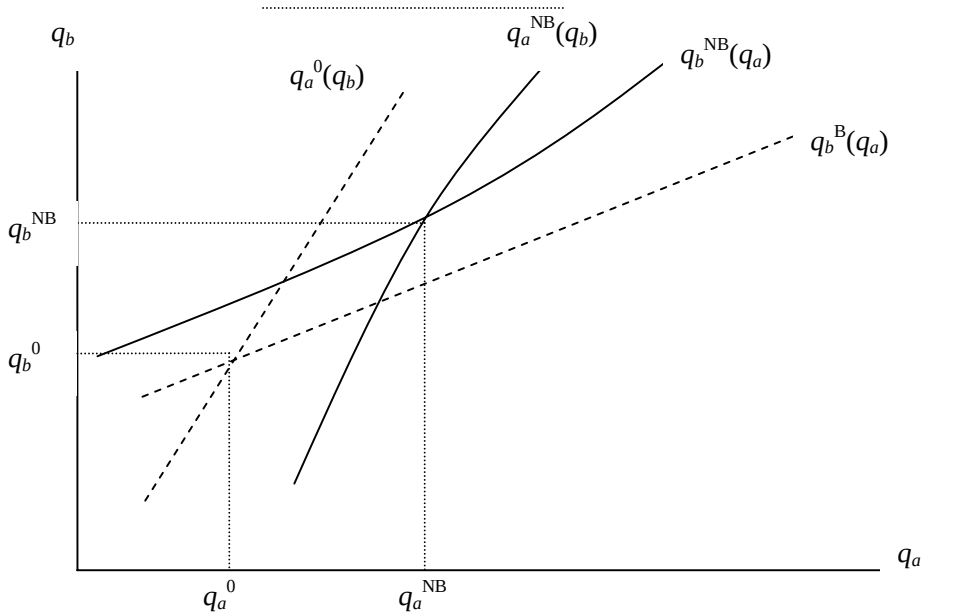
Note : The superscript B designates the equilibrium with binding PDO labeling.

Figure 1. Equilibrium in the quality space.

If $q_a > q_b$



If $q_a < q_b$



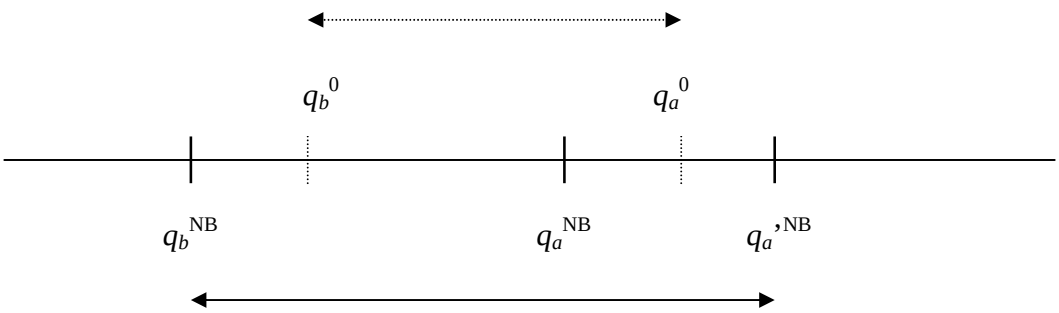
Reaction functions: with no labeling: $q_i^0(q_j)$; with non-binding labeling: $q_i^{NB}(q_j)$

Equilibrium values: with no labeling: q_i^0; with non-binding labeling: q_i^{NB}; with binding labeling: q_i^B

Figure 2. Quality and average perceived quality with no labeling and with non-binding labeling

If $q_a > q_b$

$$q_b^{NB} < q_b^{0} < q_a^{NB} < q_a^{0} < q_a^{,NB}$$



If $q_a < q_b$

$$q_a^{0} < q_a^{NB} < q_a^{,NB} < q_b^{0} < q_b^{NB}$$

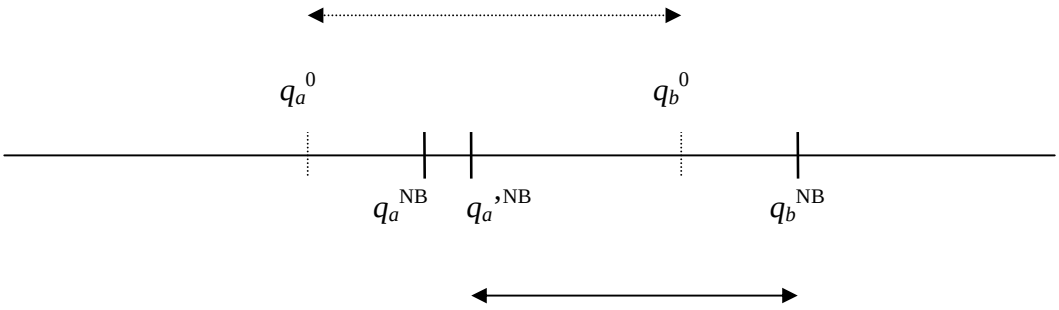


Figure 3. Quality levels and degree of differentiation in the duopoly equilibria in which the labelable good is the high-quality good