

Quality Choice, Competition and Vertical Relationship in a Market of Protected Designation of Origin

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Abstract

Protected Designation of Origin (PDO) is a public label that is used by the European Union as a tool to sustain the competitiveness and the profitability of agricultural sector and in particular to maintain rural activity in less favored areas. However, in PDO supply chain, many farmers deal with relatively few processing firms. In this framework, it is not clear that producers under such protective policy would have incentive to adopt costly measures to improve their product qualities and accept the restrictions on their production practices. Taking into account the vertical structure of the PDO supply chain, we develop a model of oligopoly and oligopsony competition to investigate the conditions under which PDO producers set high quality requirements on the production of the agricultural input. We find that even if raising quality does not imply additional willingness to pay from consumers, there is still scope for the PDO producers to choose a higher level of quality than the minimum quality standard. The outcome depends on the demand and technology characteristics, which will affect the oligopoly and oligopsony power of processors. In particular, farmers will prefer a higher quality standard than processors when the demand for PDO market is inelastic and the increase in quality generates an additional reduction in farmers' return to scale.

1 Introduction

Following the successive reforms of the Common Agricultural Policy and the loss in competitiveness on world markets, agricultural production is stagnating or decreasing in many European countries. In line with these reforms, the European Union has developed a quality labeling policy that aims at valorize and protect agricultural and food products (European Commission, 1996). High quality reputation is expected to sustain the competitiveness and the profitability of the agricultural sector and in particular to maintain rural activity in less favored areas. Different quality labels have been introduced since 1992 (European-Commission (1996)) for geographical indications (GI), including mainly: Protected Designations of Origin (PDO) and Protected Geographical Indications (PGI). An important issue for public authorities is to evaluate whether these quality labels can effectively limit the decline in agricultural activity.

This question has attracted increasing interests in recent literature. The benefits of developing GI labels for producers and consumers has been widely analyzed. It is shown that public label may be an efficient tool (Moschini et al. (2008)) to signal the quality of agricultural products. However, cost arises both for certifying the GI product (Marette and Crespi (2003)) and for producers to meet the quality specification (Bouamra-Mechemache and Chaaban (2010a), Bouamra-Mechemache and Chaaban (2010b)). Thus the producers' incentive for labeling depends on the trade-off between the return they can get from the label and the extra costs they have to incur to certify their products.

Most of the registered PDO products are processed commodities (cheese, oil, meat, etc.), that requires the use of agricultural product. The PDO quality specification relies on the quality and origin of both the agricultural product and the final consumption good. Thus both farmers and processing firms are involved in the certification process. The PDO label certifies the final processed commodity. By providing signals to the characteristics of the PDO product, the label may add value to the whole production chain. However, in order to be certified, farmers, who provides the agricultural inputs for the PDO, should comply with the production technology requirements which are specified in the label regulation. These production specifications may involve additional production costs for farmers. The final decision on technical requirements (which correspond to the label quality standard) will depend on the cost and benefit for farmers and processors and may affect dif-

ferently farmers and processors's profits. In this case, farmers and processors may have conflicting incentive when choosing the quality standard. The decision of the label quality requirements is the outcome of a joint negotiation among farmers and processors, which will depend on how they interact with each other along the vertical supply chain. However, the literature on quality labeling often omits the vertical interaction between farmers and processors. This paper will thus investigate the choice of requirements specified in the label regulation, taking into account the behavior of farmers on the one hand and processors on the other hand.

It is often argued in the literature that farmers/processors involved in the PDO process will design the product specifications so as to indirectly control the total production of PDO and hence get sufficient profits to compensate for the PDO certification cost (Lence et al., 2007, Hayes et al. 2005). The cost and benefit of labeling depend on the degree of competition among processors on the procurement market as well as on the final market. First, the level of oligopsony competition among processing firms will influence the raw input prices and may thus affect farmers' incentives in quality provision. Second, oligopoly competition will influence the final market price and hence affect the value of the labeled good. This will in turn affect firms' incentive to certify the quality of their products (Marette and Crespi, 2003, Langiner and Babcock, 2008). Moreover, the oligopoly and oligopsony power jointly determine firms' mark-up (difference between the final price and the input price), which determines how the label value will be shared among processors and farmers. As a whole, the competition among processors affects not only the value of the labeled product but also the distribution of profits between farmers and processors along the vertical production chain. However, the literature dealing with imperfect competition in agricultural markets (cf. McCorrison, 2002 or Hamilton, 1999) do not address the impact of imperfect competition on producers' quality choice. Therefore, this paper will take into account the potential oligopoly and/or oligopsony power of processors when analyzing the choice of the PDO quality standard.

We develop a model of a PDO supply chain, where farmers provide raw materials to processing firms, who produce the final product. The model takes into account that farmers may have to bear additional cost in order to comply with the quality requirement of the PDO. We show that the farmers' choice of quality may differ from the processors' choice, depending on the demand and technology characteristics of the PDO product. In particular, farmers will prefer a higher quality standard than processors under two con-

ditions. First, the demand for the PDO product should be inelastic enough such that the oligopoly power will lead to a higher price for a small decrease in quantity. Second, when the agricultural input technology exhibits decreasing return to scale, an increase in quality should generate a further reduction in farmers' return to scale, such that a higher quality can be sustained by a higher procurement price while the oligopsonistic processors cannot easily adjust their quantity. We also show that when farmers and processors have conflicting incentive in the choice of PDO quality standard, the equilibrium quality standard is the result from the negotiation between farmers and processors and depends on the relative bargaining power of farmers when negotiating with firms.

The article is organized as follows. The next section presents the PDO supply chain model and the main assumptions. In section 3, we derive the outcome of quantity competition among PDO farmers and processors. Section 4 investigates the individual choice of quality standard and presents the conflicting quality choices between farmers and processors. Section 5 discusses the quality choice with different technology and demand characteristics and the last section discusses conclusions and implications for future research.

2 The PDO supply chain model

We consider the industry structure of a PDO supply chain, where n identical farmers supply raw materials to m identical processors, who produce the final products.

The inverse demand for PDO is denoted by $p(X, \beta)$, where X is the quantity of PDO consumption and $\frac{\partial p}{\partial X} < 0$. While many studies in the literature have shown that PDO products have both the attributes of experience goods and credence goods (Marette et al. (1999)), few works provide the evidence that the consumers are willing to pay for a stringent quality requirement. This attribute of PDO quality cannot be easily observed by consumers. We thus assume that the production of PDO can give an additional premium to processors but that this premium does not change with the level of quality requirement. Hence the demand of the PDO commodity can be written as a function of x only ($p(X)$).

The production of the agricultural input depends on the quality requirement that is regulated by public authority. We denote by $c(q, \beta)$ the farmer's

production cost, where q is the quantity of production and β represents the level and stringency of the quality requirement. We assume that the production cost is an increasing function of the quality level, $c_\beta(q, \beta) > 0$. Furthermore, farmers are assumed to produce at an increasing and convex cost, i.e. $c_q(q, \beta) > 0$ and $c_{qq}(q, \beta) > 0$. We consider a bounded range for quality level β , that is $\beta \in [\underline{\beta}, +\infty)$, where $\underline{\beta}$ corresponds to the minimum quality standard, which is set by the public authority.

Finally farmers (and processors) have to incur certification cost when they decide to engage in the PDO certification scheme. Without loss of generality, we assume that this fixed cost is equal to zero. This assumption will affect the PDO certification choice but not the PDO quantity and quality choice once the PDO label is developed.

Farmers sell their agricultural production to processors given a linear contract. Denoting by w the price of raw input, the profit for farmers is thus:

$$\pi^f = wq - c(q, \beta) \quad (1)$$

Processors use the agricultural input to produce homogeneous final products, which are labeled by the PDO certification. We assume a fixed proportion technology so that the production of one unit of the PDO product requires the use of one unit of raw input. Except the cost of purchasing the raw input, no other cost are required. Hence, the PDO quality requirement affects only farmers' production cost and will not generate direct cost at the processing level. We thus focus on the quality attributes of the input and consider that the quality of the PDO commodity arises from the quality of the agricultural commodity. For example, the quality of PDO olive oil is determined by the quality of olive production (yield per hectare, variety, harvest techniques). Likewise, the quality of PDO cheeses largely depend on the milk characteristics.

Processors compete for the procurement of agricultural input. Denoting by x_i the quantity of final product produced by processor i ($i = 1, 2, \dots, m$), the profit for processor i is given by:

$$\pi_i^p = (p(X) - w) x_i. \quad (2)$$

The PDO certification process follows a three-stage game. In the first stage, the farmer group and the processor group negotiate over the PDO quality β . In the second stage, processors simultaneously decide how much to sell on the downstream market and buy the quantity of input according

to their downstream production decision. Finally, farmers decide how much to supply to processors. The market of the raw material clears through the balance of supply and demand.

The game is solved by backward induction. We first derive the farmers supply condition and then the equilibrium of competition among processors. Next, we investigate the processors and farmers' individual choices of quality, which provide insights into their joint negotiation on quality standard. Finally, we study the demand and supply characteristics, which may affect their decision of quality standard.

3 Quantity decision

3.1 Farmers' supply condition

The farmers' supply decisions depend on their competition behaviors. Providing that farmers are atomic and the processing industry is concentrated, we assume that farmers are price-takers of w . Hence a farmer will produce so as to equalize the raw product price and its marginal cost, i.e. $w = c_q(q, \beta)$. We denote by Q the total quantity of raw material supply. By symmetric assumption, $Q = nq$, which gives the inverse supply function for the aggregate raw material supply:

$$w = c_q\left(\frac{Q}{n}, \beta\right) \quad (3)$$

3.2 Quantity competition among processors

As for processors, we assume that they compete à la Cournot. A processor will choose the quantity of the agricultural input he is going to buy, x_i , anticipating the impact of this decision on the prices of both the final product and the raw input. We denote by $X_{-i} = \sum_{j \neq i} x_j$, the total quantity produced by other processors except producer i . Giving the market clearing condition $Q = X = x_i + X_{-i}$ and the farmers' supply condition (3), the profit maximizing program of processor i can be written as:

$$\max_{x_i} \pi_i^p = \left(p(x_i + X_{-i}) - c_q\left(\frac{x_i + X_{-i}}{n}, \beta\right) \right) x_i.$$

By the symmetry assumption, in equilibrium, we have $x_i = \frac{X}{m}$ for $i = 1, 2, \dots, m$. Hence the first-order condition of the processor' maximization pro-

gram can be written as:

$$p(X) - c_q\left(\frac{X}{n}, \beta\right) + \frac{X}{m} \left(p'(X) - \frac{c_{qq}\left(\frac{X}{n}, \beta\right)}{n} \right) = 0. \quad (4)$$

To ensure the existence and uniqueness of the solution, we assume that the second order condition satisfies: $SOC = \frac{m+1}{m} \left(p'(X) - \frac{c_{qq}\left(\frac{X}{n}, \beta\right)}{n} \right) + \frac{X}{m} \left(p''(X) - \frac{c_{qqq}\left(\frac{X}{n}, \beta\right)}{n^2} \right) < 0$. Note that this condition holds for not too convex demand and not too concave supply functions.

From condition (4), the equilibrium industry quantity is affected by the market power of processors. Providing that $w = c_q\left(\frac{X}{n}, \beta\right)$, the price-cost margin a processor ($p(X) - c_q\left(\frac{X}{n}, \beta\right)$) is determined by two effects, an oligopoly power effect ($\frac{X}{m}p'(X)$) and an oligopsony power effect on the price of the raw input ($-\frac{X}{m}\frac{\partial w}{\partial X}$). Other things being equal, the higher the level of concentration in the processing industry (the smaller m), the larger the market power of processors and hence the larger the industry mark-up (Sexton and Lavoie (2001)). Let $\epsilon_d = -1/\left(\frac{p'X}{p}\right)$ denote the price elasticity of demand for the final product and $\epsilon_s = 1/\left(\frac{c_{qqq}}{c_q}\right)$ the price elasticity of supply for the raw input, then the processors' market power can also be expressed as a form of Lerner index:

$$L \equiv \frac{p - w}{p} = \frac{1}{m} \left(\frac{1}{\epsilon_d} + \frac{w}{p} \frac{1}{\epsilon_s} \right) = \frac{\epsilon_s/\epsilon_d + 1}{m\epsilon_s + 1}. \quad (5)$$

This condition can be seen as the "adjusted" inverse elasticity rule, which takes into account the number of firms as well as upstream competition. To ensure the existence of solution, we must have $\epsilon_d > \frac{1}{m}$. Under this condition, the less elastic the demand of final product and the supply of the raw product, the more processing firms can exercise their oligopoly and oligopsony power (the last term of equation (5) is decreasing in both ϵ_s and ϵ_d).

It should be mentioned that the equilibrium quantity differs from the optimal quality that would have been chosen by a vertically integrated monopoly. In the case of a vertically integrated monopoly, the equilibrium quantity condition is such that processors' marginal revenue is equal to farmers' marginal cost. However, when there is competition among processors on the downstream market, the presence of oligopoly competition tends to reduce the industry mark-up and increase the total quantity compared to the vertically

integrated monopoly case. On the contrary, the presence of oligopsony competition among processors on the upstream market tends to increase the mark-up and thus decrease the total quantity compared to the efficient vertically integrated monopoly quantity level. As a result, the equilibrium quantity depends on the relative magnitude of the oligopoly and oligopsony power effects, which in turn depends on the market demand and supply functions.

3.3 Impact of quality on equilibrium quantity

The level of the quality standard will affect the equilibrium quantity. Using the implicit function theorem, the effect of β on quantity can be derived from equation (4):

$$\frac{dX}{d\beta} = \frac{c_{q\beta} + \frac{q}{m}c_{qq\beta}}{SOC} \quad (6)$$

From equation (6), it follows that the impact of β on X depends both on the PDO farmers' cost structure and on demand characteristics.

The impact of PDO quality will highly depend on the underlying technology requirements. Assume first that an increase in quality induces an increase in farmers' fixed cost but does not affect variable cost of production. A possible specification of such a cost function could be $c(q, \beta) = h(q) + g(\beta)$. This situation occurs for instance when PDO quality standard requires new investment for farmers purchase and install equipments or train works to operate the specific production technology. In this case, β will have no impact on X .

When quality affects the variable cost of PDO production, quantity could be affected because the increase in the quality standard may raise the marginal cost of production, i.e. $c_{q\beta} > 0$. For instance, the PDO technology can be exhibited by a cost function as $c(q, \beta) = h(q) + f(\beta)q + g(\beta)$, which implies that a higher quality β induces a parallel upward shift in the farmers' supply curve. This cost structure will apply when the PDO quality requirements involve the use of specific input or more extensive techniques (manual harvesting techniques for instance), which may generate an increase in cost of each production unit.

In addition, an increase in β can also affect the shape of the marginal cost. A higher quality may generate an increase in the marginal cost that is higher for larger production quantity i.e. $c_{qq\beta} > 0$. This occurs when PDO requirements restrict production capacity. For instance, PDO requirements on

cheese may impose some restriction on the land space devoted to cow breeding and PDO requirements on olive oil imposes minimum area for growing the olive trees. In this situation, the more stringent the requirements are, the more difficult it is to increase the production. Depending on whether β affects or not the elasticity of supply, cost functions such as $c(q, \beta) = f(\beta)q^{(\frac{1}{\epsilon_s}+1)}$ or $c(q, \beta) = q^{\frac{1}{\epsilon_s(\beta)}+1}$ with $\epsilon_s'(\beta) < 0$ fits this technology structure. Note that when the supply is inelastic such that $\epsilon_s < 1$, the production technology reflects a decreasing return to scale. In the following sections, we will assume that the technology of production is such that $c_{q\beta} > 0$ and $c_{qq\beta} \geq 0$ so that $\frac{dX}{d\beta} < 0$.

The way quality will affect the equilibrium quantity also depends on the characteristics of the demand for the final product. We can show that, other things being equal, the more elastic the demand is, the larger the effect of β on X , i.e. $\frac{d}{d\epsilon_d}|\frac{dX}{d\beta}| > 0$. This suggests that if producers want to use quality requirements to control the total quantity of output, this tool will be less effective when the demand is inelastic. In the next section, we analyze more specifically the strategic choice of quality for farmers and processors.

4 Choice of quality

If quality is a strategic choice of a fully vertically integrated supply chain, where processors compete neither in the upstream market nor in the downstream market, then choosing a higher quality standard will only affect the cost of production. Hence the efficient quality, which leads to the maximum industry profit, will be chosen at its minimum level $\underline{\beta}$. In this section, we investigate the individual choice of quality and focus on the condition under which the individual choice of farmers and/or processors differ from the efficient quality level.

4.1 Processors' quality choice

We first derive the effect of quality requirements on the profit of processing firms. Quality will affect directly profit through its impact on cost and indirectly by changing the quantity:

$$\frac{dm\pi^p}{d\beta} = \underbrace{-Xc_{q\beta}}_{-} - \underbrace{(m-1)(p-w)}_{+} \frac{dX}{d\beta} \quad (7)$$

The first term in equation (7), $(-Xc_{q\beta})$, can be rewritten as $X\frac{\partial w}{\partial\beta}$. This effect is negative suggesting that an increase in β directly raise the processors' procurement cost. The second term represents the quantity adjustment. Indeed, from a processor's point of view, quality standard can serve as a device to correct the quantity distortion due to the intensity of competition among processors. Providing that $\frac{dX}{d\beta} < 0$, processors will have the incentive to set a higher quality standard so as to constraint the quantity level and restore the monopoly and monopsony power. The optimal quality for processors will then result from the trade-off between the rise in the procurement price and the increase in the processing industry mark-up. If the impact on the procurement price offsets the positive impact on profit, then processors have no incentive to deviate from the efficient quality level. Otherwise, they will have an incentive to increase the PDO standard.

To better assess the incentive of firms to deviate from the minimum quality standard, we now focus on the impact of β on the mark up term in equation (7). Using equation (4), this term can be rewritten as $-\frac{m-1}{m}\left(\frac{p}{\epsilon_d} + \frac{w}{\epsilon_s}\right)\frac{dX}{d\beta}$. Thus, the positive effect of quality on profit is a function of both supply and demand elasticities. If the demand for the PDO product is inelastic, a reduction in quantity will induce a large increase in the price-cost margin and processing firms will have the incentive to impose a high quality standard. However, from condition (6), we can show that $\frac{d}{d\epsilon_d}\left|\frac{dX}{d\beta}\right| > 0$. When demand becomes more inelastic, the impact of the quality standard on the reduction in quantity is thus more limited and processors' choice of quality becomes ambiguous.

4.2 Farmers' quality choice

As for processing firms, farmers may also find more profitable to deviate from the efficient quality level of a vertically integrated PDO supply chain. The impact of the quality standard level on their profit is given by:

$$\frac{dn\pi^f}{d\beta} = \underbrace{-nc_\beta}_{-} + \underbrace{Xc_{q\beta}}_{+} + \underbrace{\frac{dX}{d\beta}qc_{qq}}_{-}$$

The first two terms captures respectively the negative effect of β on the total production cost and the positive effect on farmer's marginal cost and hence on the agricultural input price. It can be easily shown that the joint effect is

positive if $\frac{\partial^2 AC}{\partial q \partial \beta} > 0$, where $AC = \frac{c(q, \beta)}{q}$ denotes the farmer's average cost of production. In this case, an increase β will induce a further increase of the average cost with quantity. Note the increment of the average cost reflects the extent to which the farmer's production return decreases if he wants to expand the production. As a result, if raising quality standard leads to a further reduction in the farmer's return to scale, it is more likely that the positive price effect dominates the direct cost effect.

The third term ($\frac{dX}{d\beta} q c_{qq}$) captures the negative effect of β on quantity. Note that $\frac{dX}{d\beta}$ will depend on the magnitude of the demand elasticity. If the demand of final product is inelastic, the negative quantity effect will be reduced, making it more likely for farmers to choose a higher quality standard. As a whole, the final outcome on the individual decision of farmers will depend on the PDO production technology as well as demand characteristics.

4.3 Negotiation on quality choice

In general, producers have an incentive to provide a high quality because they benefit from a positive willingness to pay for the quality product. However in our framework, the incentive to increase quality standard is not a result of this benefit but comes from the ability of producers to influence prices through cost and quantity adjustments when increasing quality. The above analysis suggests that either processors and/or farmers may choose a quality that is higher than the minimum quality standard. They may have conflicting interests when deciding the final level of the quality standard. We examine more precisely this case using linear demand and supply functions, i.e. $p(X) = a - bX$ and $c(q, \beta) = \frac{\beta}{2}q^2$.¹

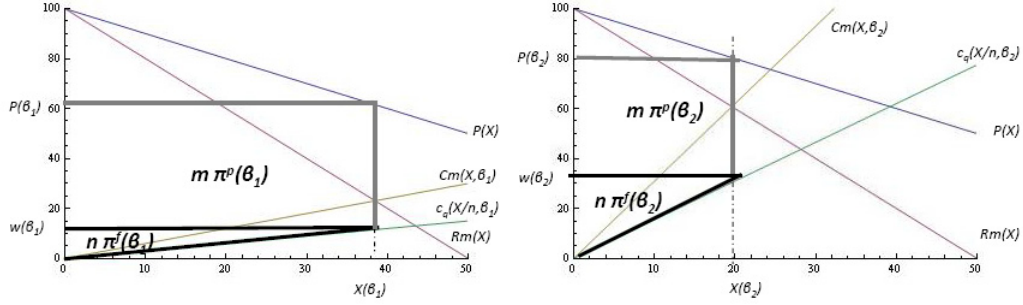
Using equations (1), (2) and (4), we derive the following equilibrium quantity $X^e(\beta)$ and profit for processors $\pi^{pe}(\beta)$ and farmers $\pi^{fe}(\beta)$:

$$X^e(\beta) = \frac{amn}{(1+m)(bn+\beta)} \quad \pi^{pe}(\beta) = \frac{a^2mn}{(1+m)^2(bn+\beta)} \quad \pi^{fe}(\beta) = \frac{a^2m^2n\beta}{2(1+m)^2(bn+\beta)^2}.$$

It follows that processors would choose the minimum quality level while farmers will choose a higher quality, $\beta^f = nb$. To ensure the interior solution, we assume that $\underline{\beta} < nb$. The conflict between farmers and processors for the choice of quality is shown in Figure 1.

¹The cost function can be generalized to be $f(\beta)q^2$, which will not change the result as long as $f'(\beta) > 0$.

Figure 1: Impact of β on equilibrium with linear demand and supply



The figure compares the equilibrium for two quality levels ($\beta_1 < \beta_2$). The equilibrium is given by the intersection between the marginal revenue curve ($Rm(X)$) and the perceived marginal cost curve for processors ($Cm(X)$). The equilibrium profit for farmers and processors are respectively represented by the triangle and rectangle areas. When β increases, the equilibrium quantity decreases from $X(\beta_1)$ to $X(\beta_2)$. Following the decrease in the equilibrium quantity as well as the changes in farmers' supply function, the equilibrium prices of both the agricultural input and the final product increase. The benefit of farmers due to the change in the procurement price dominates the negative effect on quantity. However, for processors, the increase in the final commodity price is offset by the increase in the procurement cost. Note that, when the number of farmers increases, the slope of the supply curve is reduced, which tends to lower the procurement price and reduce farmers' profit. In this case, farmers would prefer a higher quality standard because it will have a positive effect on the procurement price. Note also that when the demand becomes more inelastic (the parameter b in the demand function is large), then farmers will have more incentive to increase the quality standard.

The equilibrium quality is the outcome of the negotiation game between the group of farmers and the group of processors. We abstract from modeling the bargaining process and assume that the negotiation outcome is captured by the Nash bargaining solution. Let λ and $1 - \lambda$ denote respectively the bargaining power of the PDO farmer group and the processor group. If the negotiation fails, both groups can sell their product to the spot market and earn profits, which is normalized to zero. In other words, the disagreement payoffs of both groups are assumed to be zero.² Thus, the Nash bargaining

²This assumption holds if the spot markets for the generic final product and for the

problem is described as follows:

$$\max_{\beta} (m\pi^{fe}(\beta))^{\lambda} (n\pi^{pe}(\beta))^{1-\lambda} \quad (8)$$

Providing that both π^{pe} and π^{fe} are strict concave functions of β , the problem has a unique solution. We denote by β^N the Nash bargaining solution. Solving the problem, we have

$$\beta^N = \lambda bn = \lambda \beta^f.$$

Thus, the negotiation outcome depends on the bargaining power of the farmer group relative to processors as well as the number of farmers and demand elasticity.

5 Quality choice with various technology and demand characteristics

Because the choice of quality standard by farmers and processors depends on the cost and demand function structures, we analyze different specifications of cost and demand functions. Results for the individual choice of quality standard are summarized in Table 1.

Assume first that the demand is perfectly elastic ($p(X) = a$) so that firms cannot exercise oligopoly power. We can then focus only on the oligopsony power effect. Then, with a large range of cost functions, both farmers and processors will have no incentive to choose a higher quality standard. Actually, farmers will benefit from an increase in w but this benefit is more than compensated by the loss in profit due to the decrease in quantity. Similarly, the profit of processors always decreases with β because both the procurement cost and the quantity are reduced.³

raw product are very competitive, so that farmers and processors earn zero profit if they sell their products through the spot market channel.

³However, if the supply elasticity is highly affected by β , we may have a situation where the equilibrium procurement price is decreasing with β . This is the case for the cost function $c(q, \beta) = q^{\mu(\beta)}$ when the processing industry is not too concentrated (m is small) and the price of the final product is not too high (a is small). In this case, processors benefit from a lower procurement cost. This benefit may be higher than the loss in profit due to the quantity effect. As a result, they may choose a higher quality standard.

Table 1: Individual choice of quality with different demand and cost functions

cost function specification	Demand function specification		
	a	$a - bx$	$ax^{-\frac{1}{\epsilon_d}}$
$h(q) + f(\beta)q + g(\beta)$	$\beta^p = \underline{\beta}$ $\beta^f = \underline{\beta}$	$\beta^p = \underline{\beta}$ $\beta^f = \underline{\beta}$	$\beta^p = \underline{\beta}$ $\beta^f = \underline{\beta}$
$f(\beta)q^2$	$\beta^p = \underline{\beta}$ $\beta^f = \underline{\beta}$	$\beta^p = \underline{\beta}$ $\beta^f > \underline{\beta}$	$\beta^p = \begin{cases} \underline{\beta} & \text{if } \epsilon_d < 1 \\ \underline{\beta} & \text{if } \epsilon_d > 1 \end{cases}$ $\beta^f = \beta^p$ (1)
$f(\beta)q^{\frac{1}{\epsilon_s}+1}$	$\beta^p = \underline{\beta}$ $\beta^f = \underline{\beta}$	— (2)	$\beta^p = \begin{cases} \underline{\beta} & \text{if } \epsilon_d < 1 \\ \underline{\beta} & \text{if } \epsilon_d > 1 \end{cases}$ $\beta^f = \beta^p$

(1) When $\epsilon_d = 1$, β has no effect on π^p and π^f .

(2) With the cost function, it is difficult to derive the optimal β for processors or farmers.

Assume now that quality does not affect the slope of farmers' marginal cost function. In this case, $c_{qq\beta} = 0$ and a change in β will have no effect on oligopsony power (difference between the processors' perceived marginal cost and marginal procurement cost) and whatever the demand specification, both processors and farmers will choose the minimum quality standard.

When demand becomes less elastic and β influences the oligopsony power. As shown in section 4, the more inelastic the demand is, the more likely that farmers will prefer a higher quality standard while the effect for processors is ambiguous. In the case of constant elasticity demand and supply, processors will always find it more profitable to choose the minimum quality standard if the demand elasticity is high enough (larger than 1). Otherwise, they will choose a higher one.

6 Concluding remarks

This paper investigates the incentive of farmers and processors to provide high quality product with certification of Protected Designation of Origin. Although conventional wisdom suggests that the PDO quality labeling plays

a positive role to sustain the competitiveness and the profitability of agricultural producers, it is not sure that such policy provides enough incentive for producers to raise their product quality. While the label provides consumers the information about specific quality attributes of the product, it may not reveal the information about the effective quality level of the product. This is especially the case when increasing quality requires the use of costly technology, which may not be easily perceived by consumers. This paper provides a rationale that producers would like to improve their PDO product quality when the level of PDO quality cannot be directly reflected through the market price signal. In this case, the quality standard, which is jointly decided by the PDO farmers and processors in the supply chain, can serve as a device to constrain the quantity of production and hence allow them to cover the high mark-up in the competitive PDO market.

We find that farmers and processors may agree upon a high quality requirement for PDO production, depending on the demand and production technology characteristics which will affect the oligopoly and oligopsony power of firms. Farmers prefer a higher quality standard than processors when the demand for PDO market is inelastic and the increase in quality generates an additional reduction in farmers' return to scale. This situation occurs when the increase in quality implies a higher increase in the average production cost when quantities are large. Our results also suggest that the higher the number of farmers, the more likely they will choose a higher quality standard. This creates conflicting interests between farmers and processors. It turns out, that the quality standard will finally depend on their relative bargaining power when negotiating over the production requirements.

Our results have some implications for public regulation. The PDO labels are often implemented in the less favored regions such as mountain areas, where the production often exhibits decreasing return to scale. Our results suggest that in these regions, raising quality standard may benefit farmers because under decreasing return to scale, increasing quality will lead to an increase in the farm gate price. This positive effect of quality on farmers' profit more than compensates the losses generated by the incremental cost and quantity reduction due to a higher quality standard. It follows that a public regulation that stipulates high quality standard may benefit farmers in less favored areas at the expense of processors that would rather prefer a low quality.

Our results also provide some insight on anti-trust regulation. Cases of output control have been investigated by anti-trust authorities particularly

in France and in Italy (Lence et al. (2007)). When quality is used as a device to control supply, it may not affect consumers if a change in quality does not affect the consumption of the PDO product. However, it may enhance farmers' profit especially for farmers in less favored areas. In this situation, providing that farmers' income is one of the main objective of the EU PDO policy, the potential benefits from the implementation of high quality requirements that may indirectly limit supply quantity should be considered.

The paper has some limitations: first, it does not take into account the competition from the producers outside the PDO region. The analysis can then be extended by introducing the competition of non certified producers and taking into account the substitution between PDO and non-PDO certified products. Second, it will be worthwhile to analyze what would be the actual benefit to improve the PDO quality for consumers when the quality requirements of the label directly influence the willingness to pay for consumers. In this case, it will be more likely that PDO producers have more incentive to raise their quality. Further works can be devoted to the welfare analysis taking into account the consumers' actual benefit from the PDO quality improvement.

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