The welfare impact of self-regulation

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Abstract

This paper is concerned with welfare effects of self-regulation. It considers one group of heterogeneous producers modelling incentives they face when collectively deciding about production and trade of a commodity and employing a technology that take into account the trade-off between quality and quantity.

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1 Introduction

Dating from the Great Depression few interventions have survived without reform. A notable exception is regulation of agricultural production through marketing orders. In fruit and vegetable sectors, agricultural producers and handlers have the power to regulate production and trade of single commodities. Marketing orders also regulate markets for milk in US States. In many other parts of the world as well producer groups are granted authority to self-regulate production and trade of many commodities. They decide quality standards, grading schemes, volume controls and marketing and advertising policies.[1]

This form of market organization is not considered a direct support to producers and as such it is allowed under the last WTO agreement. However, many economic analyses are critical towards it. Even though not explicitly permitted under the prevailing regulations, producer groups are accused of exercising market power and reducing consumers' welfare (Jesse, 1979). Particularly scrutinized are policies of output control, condemned as being used solely to increase prices for producers (USDA, 1981; Carman and Pick, 1990).[2]

Some also argue that a subtler form of market power occurs through quality regulation. By imposing stricter quality standards, producer groups reduce output and increase prices (Chambers and Weiss, 1992).[3] It is now well established that with perfect information and observable quality there is no need for government intervention. Regulations in the form of minimum quality standards, for example, limit consumer

[1] The European Union has been providing subsidies in the recent years for the establishment and operations of producer organizations in fruit and vegetable industries. According to the regulation (Council Regulation (EC) No. 2200/96, in the Official Journal of the European Communities No. L297/1 of November 21, 1996), these groups should help supply meet demand, establish and implement quality standards, and introduce environmentally-friendly technologies at the farm level. The presence of producer groups is relevant in other countries too, for example coffee in Colombia, wine in France and Italy, and maple syrup in Canada.

[2] Recently, the Italian Antitrust Authority condemned producer groups for Parmesan cheese and Parma's ham because they imposed individual quantity quotas on members.

[3] There exist the cases of quality standards in fruit and vegetable markets to exclude the production of supposedly lower quality products. For example, wine producers using the *appellation contrôllée* are required to produce within a yield ceiling in order to ensure better quality of grapes and wine. These practices are defended by producers as regulations intended to increase the quality of products, thus benefitting consumers and producers alike (see, e.g., Canali and Boccaletti, 1998).

and producer choices and therefore cannot increase economic welfare (Bockstael, 1984). When there exists uncertainty about quality characteristics of products, however, there is justification for intervention. Quality standards in this latter case could improve social welfare, conditional on the optimal choice of the standard itself.

The potential problem is that a collusive industry may impose too high a standard. In addition, a more concentrated industry would facilitate its implementation, while in a competitive industry, where the standard would be more needed, it would have trouble emerging spontaneously (Bockstael, 1987). Economic theory is still ambiguous regarding the net welfare effects of self-regulating groups. However, in the policy arena these same groups are perceived as an appropriate way to help the agricultural sector without public disbursement of funds and hence resource misallocation (Neff and Plato, 1995).

This paper is concerned with effects of self-regulation in agricultural markets. It considers one group of producers that voluntary decides to regulate production and trade of a single differentiated commodity. It allows for heterogeneous producers considering incentives they face when collectively deciding about production and trade of a commodity. The paper considers the case of more than one choice variable by employing a technology and preference sets that take into account the trade-off between quality and quantity. With a relatively simple model we are able to show whether there is a loss of efficiency due to self-regulation. We are also able to discern whether market structure can affect results and distortions.

Our paper is related to literature on principal-agent problems with hidden information (see, e.g., Guesnerie and Laffont, 1984). Although we use two instruments, quality and quantity, we show that results are similar in nature to those one can obtain considering one instrument. Indeed, using a simple model with two types, we confirm that one can still apply the revelation principle and multidimensional problems have solutions that resemble their single-dimensional counterparts, provided the number of instruments is no greater than the number of types (McAfee and McMillan, 1988). The problem we analyze though is different from the standard principal-agent model with multidimensional instruments because principals and the agents in our game are endogenous, in the sense that the principals the type of agent constituting the majority of agents and depend on Nature's draws. This makes our paper more similar to problems of optimal taxation in public finance.

The next section introduces the simplified model with hidden information and two types of producers: one that is relatively efficient at producing quantity of a particular commodity, while the other is relatively more efficient in producing quality. Section three shows results for the case in which the producer organization (PO) can freely implement an efficient remuneration mechanism and the majority in the group is of quantity-efficient producers. In the fourth section we derive results when the PO is composed of a majority of quality-efficient producers, and in section five we perform a simulation to see whether market power may increase inefficiencies. Section six concludes the paper with limitations of the present research and suggestions for some possible extensions.

2 The model

Consider an agricultural commodity as an **experience good**. A group of farmers has to decide whether or not to form a Producer Organization (PO) with common rules about production and trade of products. The group is made of n heterogeneous producers, some of whom have lower costs for their products. We assume that producers can be of two different types, and each type is denoted by i, with $i = V, H$. For example, in wine production many practitioners in Europe claim that vineyards in valleys and plain areas are relatively more favored in producing large amount of grapes that give wines of reasonable but not excellent quality. On the other hand, the soil and weather conditions in hilly areas seem to be more favorable for high quality wines, even though the quantity of grapes obtained may be relatively lower. By $i = V$ we then denote the quantity-efficient type (V stands for valleys), while by $i = H$ we mean the producers that are more efficient at producing quality (H for hilly areas).[4] For convenience, we assume n is an odd number and $n_H + n_V = n$.

The production technology for different producers can be repre-

[4]Since we are interested in the quantity-quality trade-off, we consider either producers that are efficient at producing quantity but inefficient with quality production (V) or those that vice versa produce efficiently quality attributes but in a limited quantity (H). In other words, we do not consider the case of producers efficient or inefficient at both quantity and quality. This reduction of types should make the analysis simpler without losing the main insights and should be suitable for the situations that are common in agricultural markets.

sented using a technology set in the following way:

$$T_i = \{(\mathbf{x}, q, s) : \mathbf{x} \; can \; produce \; q, s \mid i\},$$

where $\boldsymbol{x} \in \Re_+$ is a vector of inputs that producers choose, $q \in \Re_+$ is the quantity of output, $s \in \Re_+$ is the quality of the output and $i = V, H$. With this representation of the technology we consider a unique commodity and we represent it with a multi-output technology: the first is to be considered the usual scalar measure of the quantity of the commodity, q, while the second, s, is an index of the quality of the commodity produced.[5] This representation is general and without imposing assumptions and restrictions on the technology it allows to capture the main features of the production process.

Producers' choices can be indirectly represented with their cost function:

$$c^i(q, s) = min_{\mathbf{x}}\{\mathbf{wx} : (\mathbf{x}, q, s) \in T_i\},$$

where w is the vector of input prices. Assume type i's cost of production, $c^i(q, s)$, to be twice differentiable, strictly increasing, strictly convex in q, s and without fixed costs. To simplify the analysis we use an additively separable cost function of the type:[6]

$$c^i(q, s) = c^{qi}(q) + c^{si}(s),$$

with $i = V, H$.[7] In addition, we express the different skills of producers with the following.

Assumption 1 (Across Types Ranking). Producers of different types can be ranked according to the following:

$$\begin{aligned} c_q^{qV}(q) &= \frac{\partial c^V(q, s)}{\partial q} < \frac{\partial c^H(q, s)}{\partial q} = c_q^{qH}(q), \qquad \forall q, A1 \qquad (1) \\ c_s^{sV}(s) &= \frac{\partial c(q, s)}{\partial s} > \frac{\partial c^H(q, s)}{\partial s} = c_s^{sH}(s), \qquad \forall s. \end{aligned}$$

[5] For example, we may represent the output of a vineyard in terms of the amount of grapes produced (say in tonnes per acre) and of its quality expressed with the average sugar content (say in degrees *Brix*).

[6] In the remaining of the paper, for convenience we will use the general form $c^i(q, s)$ unless we need to use the speficic functional form $c^{qi}(q) + c^{si}(s)$.

[7] Figure 1, for example, represents the cost planes for the two types of producers when the additive cost structure is quadratic, i.e., $c^i(q, s) = \frac{c^{qi} q_i^2}{2} + \frac{c^{si} s_i^2}{2}$. Note that compared to the case of one choice variable, instead of having the single-crossing property translated into one point of intersection between the two cost curves, we have a unique manifold of intersection between the two cost planes.

This set of conditions, which resembles the single crossing property and that we may call the Across Type Ranking, simply says that the marginal cost of production of quantity q is lower for type V than for type H, while the marginal cost of producing quality s is lower for type H than for type V, other things being equal.

We consider risk-neutral producers whose preferences are separable in income and effort and whose profits for the production of a quantity q of quality s are: $\pi^i = y(q,s) - c(q,s)$, where $y(q,s)$ is the revenue each producer receives from the PO for the amount q of product of quality s. In this paper, we consider only hidden information: each producer has private information about his own type. We assume that the PO can perfectly observe and verify the quantity and quality level provided by each producer.

Given this assumption, the PO can ensure that the payment to the producers should be a function of the output provided, $y(q,s)$. The group though can not observe each producer type. The group or the management may have a prior on the relative number of different producers, and may use this information to optimally design the menu of contracts offered to members.[8]

The PO sells producers' commodity on the market and the price it receives is a function of the total quantity produced and the quality that the consumers expect, which is the average of the quality provided by individual producers. In other words, the revenue for the group is $p(Q,S)Q$, where Q is the aggregate production level for the group, for example $Q = \sum_{i=V}^{H} n_i q^i$, with $i = V, H$ and where q^i represents the quantity produced by type i. $S = S(n_i, s^i, q^i)$ is the average quality for the group: if s^i represents the quality of the good produced by the producer of type i, the average quality from the n producers participating in the PO may be seen, for example, as $S = \sum_{i=V}^{H} \frac{n_i q^i}{Q} s^i$, with $i = V, H$. Note that $p(Q,S)$, the inverse demand, represents the willingness to pay of the consumers, and it has a general form with $p_Q(\cdot) < 0, \quad p_{QQ}(\cdot) \geq 0, \quad p_S(\cdot) > 0$ and $p_{SS}(\cdot) \leq 0$. The aggregate demand is downward sloping in quantity, but less than proportionately, i.e., convex in quantity. It is also increasing in average quality, but less than proportionately, i.e., concave in average quality.

The potential n members meet together to decide whether to form

[8]The group is prevented from using the information to explicitely discriminate among members. In other words, the management can only offer a menu of contracts from which producers can choose, but can not decide which single contract to offer to individual members, even if it is the optimal one for that producer's type.

the PO and how to run it. If the PO is formed, the producers will pool together their production under the collective brand and will receive a price in the market according to the output (quantity and quality level) they provide. In the present setting only one group is allowed to form: if the producers can not agree, the group may not form and each producer faces a competitive market where there is no means to individually signal quality and the profit level is zero.

The group is a *polity* and is governed with majority rule. It is reasonable to think that among the implementable mechanisms each producer independently votes for the one that is the best for himself. Given the assumption about types and technology structure, it is not possible to simply guess which will emerge. It is sensible though to think that the menu of contracts which emerge will be optimal for producers having the majority of the group. The remuneration mechanism that is then decided at the PO's level is the one that is voted by the majority of the producers.

Among the contracts that are implementable, producers have to figure out those that are feasible, i.e., those that satisfy the rationality or participation constraint like the following:

$$y^i - c^i(q^i, s^i) \geq \underline{u}^i,$$

PC_i (2)

which says that each producer participates on a voluntary basis and so must receive at least her reservation utility. In addition, the PO must break-even, that is:

$$p(Q, S)Q - \sum_{i=V}^{H} n_i y^i \geq F.$$

BC(3)$p(Q, S)Q$ is the revenue - net of processing costs - that the PO receives from selling the members' good in the market and is a function of the total quantity Q and average quality S. The aggregate revenues from the products sold in the market minus the payments to the producers must cover the fixed costs F for the Producer Organization.

To find the optimal contract or mechanism one has to take into account the incentives facing different producers. A mechanism in our case is the combination of payments to producers and output (quantity and quality) provided by producers, i.e., (y^i, q^i, s^i). Using the revelation principle (Myerson, 1979) we can focus on direct revelation mechanisms, mechanisms constructed so that it is in each producer's dominant strategy to tell the truth. That is to say, one can design a contract in which producers tell the truth, i.e., it is implementable, provided it is incentive-compatible. Hence, any payment schedule that the producers adopt has to satisfy:

$$y^i - c^i(q^i, s^i) \geq y^j - c^i(q^j, s^j) \tag{4}$$

where i is the true type and j is the reported type. Eq. (4) says that when producers report (q^i, s^i) in exchange for y^i they should be better off reporting their true type. Since we are considering two types, we can restrict attention to a menu in which the number of contracts is equal to two, the number of types. Indeed, there is no need to offer more contracts than agent's types (Fudenberg and Tirole, 1991). In order to find the optimal contract, it is useful to derive some monotonicity in the relative activity levels for each type taking into account the constraint in eq. (4). We can have four possible cases: $q^V \leq q^H$ and $s^V \leq s^H$ (case i); $q^V \geq q^H$ and $s^V \geq s^H$ (case ii); $q^V \geq q^H$ and $s^V \leq s^H$ (case iii); and $q^V \leq q^H$ and $s^V \geq s^H$ (case iv).

Given Incentive Compatibility, $s^H \geq s^V$ implies $q^H \geq q^V$ and hence $y^H \geq y^V$ (case i)); $s^V \geq s^H$ implies that $q^V \geq q^H$ and $y^V \geq y^H$ (case ii)). $q^V \geq q^H$ and $s^V \leq s^H$, (case iii), is incentive-compatible and, in addition, either $y^V \geq y^H$ (case iii/a) if $c^i(q^V, s^V) \geq c^i(q^H, s^H)$, $i = V, H$; or $y^V \leq y^H$ (case iii/b) if $c^i(q^V, s^V) \leq c^i(q^H, s^H)$, $i = V, H$. The last case, case iv), $q^V \leq q^H$ and $s^V \geq s^H$, does not satisfy both incentive-compatible constraints.

Proof: See Appendix 1.

Intuitively, each type is efficient at producing one of the two activities and should produce more of it and less of the other[9]. But she can also decide (or can be offered) otherwise and the lemma distinguishes between the four possibilities. When one type is offered or decides to pick the activity at which she is relatively less efficient at an higher level, she must do so also with the other activity at which she is more efficienct, and thus produce more of both. Accordingly, she would receive an higher payment. This is the only way to have an incentive compatible contract, and this is what would happen with cases i) and ii).

Another possibility is for each type to pick more of the activity at which she is more efficient and less of the other. This would be

[9]By more we in fact mean no-less; by less, we mean no-more.

incentive-compatible, with the relative magnitude of the payments depending on technology conditions. When quantity is relatively more expensive to produce, case iii/a), then the valley type producing more of it should be paid more than the other type. The opposite is when quality is relatively more costly, case iii/b). The last case is when both types choose a higher level of the activity at which they are less efficient, a contract which would not be incentive-compatible.

3 The solution of the game with a quantity-efficient majority

In this section, we derive the optimal mechanism for the first scenario, when Nature draws $n_V > n_H$ and so the majority is of quantity-efficient producers, like for example in prevalently valley areas in the case of grapes for wine production. In this case the majority of the votes goes to the optimal menu of contracts selected by quantity-efficient types, that is the program that has the objective of maximizing their profits (π^V) and is subject to the constraints that each producer‘s participation is on a voluntary basis, that each type should pick the mechanism intended for her, and that the PO must break even:

$$(PO) \qquad \max_{y^i, q^i, s^i} \left\{ y^V - c^V(q^V, s^V) \right\}$$

$$\begin{aligned} s.t. \qquad (IC_V) \quad y^V - c^V(q^V, s^V) &\geq y^H - c^V(q^H, s^H), \\ (IC_H) \quad y^H - c^H(q^H, s^H) &\geq y^V - c^H(q^V, s^V), \\ (PC_i) \quad y^i - c^i(q^i, s^i) &\geq \underline{u}^i, \\ (BC) \quad p(Q, S)Q - \sum_{i=V}^{H} n_i y^i &\geq F, \quad i = V, H. \end{aligned} \qquad (5)$$

(PO) is the maximand and represents the profits of the producer that is in the drawn majority. (IC_H) and (IC_V) are the incentive compatible constraints: since the management can not verify the producers' cost of production, the PO must offer a payment y based on the observable output (q and s) to induce each producer to select himself and pick the mechanism designed for him. (PC_i) are the participation or rationality constraints of the two types. Outside opportunities are denoted by $\underline{u}^i$. (BC) is the break-even constraint: the net aggregate revenues minus the payments to the producers should cover the fixed costs F.

Note that this problem is different from the standard mechanism design problem with two types mainly because in this setting the objective is to maximize the profit of one type, notably the one in the majority, while in the standard setting the objective function is concerned with the principal's welfare. In other words, in this problem the principal is endogenous and coincides with one of the agents of the standard setting. In addition, an adjunct feature in this model is the budget constraint.[10] It corresponds to a problem of optimal taxation with a weighted utility function, and exactly to the two polar cases in which all weight is given to one of the two types.

The above problem can be decomposed into two steps:

$$\max_{q^i,s^i}\left\{\max_{y^i}\left\{y^V \mid IC_i, PC_i, BC\right\} - c^V(q^V, s^V)\right\}, \tag{6}$$

in which the management (on majority's behalf) first chooses the remuneration or payment scheme that maximizes the total payments to type V while satisfying all the constraints, and then finds the efficient level of output (quantity and quality) to provide for each type.[11] First note that the budget constraint must be binding.

At the optimum of the first stage, the budget constraint (BC) is binding.

Proof: Using arguments similar to those of Weymark (1986) and Chambers (1997), suppose that at the optimum the budget constraint (BC) is not binding. Increase payments to both types, y^V and y^H, by the same small amount. All constraints remain satisfied and the objective function increases.

Now we can say more about the possible monotonicities in the activities level. We already excluded one of the four possible cases, case *iv*), because of lemma 2.1. We can now show that two other cases, *i*) and *ii*), are not optimal.

It is never optimal for the producer organization to offer menus characterized by condition *i*) and *ii*).

Proof: See Appendix 2.

[10] In the standard setting there are in fact other problems that require budget balance (see, for example, Fudenberg and Tirole, 1991, ch. 7).

[11] With a different timing in the game, the group could first offer a payment schedule to members, whom would then decide the output to provide.

In other words, the optimal menu entails specialization, i.e., hillside producers specialize in quality and valley producers specialize in producing quantity.

Note that IC_V is above IC_H because of truth-telling and the assumption (A1). In other words, the payment for the Hilly type, y^H, derived from the IC_V, is no less than the y^H derived from IC_H (see Appendix 3). In addition, notice that both IC constraints are either below (case i/a), or above the bisector (case i/b). Then the first step of the problem can be represented like in figure 2.

Also notice that only two constraints may be simultaneously binding, one being the budget constraint. The other could be any one of the remaining four, the PC_is and IC_is. But we can show that it is not optimal to have either one of the majority's constraints binding.

At the optimum, neither of the constraints for the majority's type, PC_V or IC_V, will be binding.

Proof. See Appendix 4.

Remember that the majority cares about her own, i.e., type V's, welfare. From figure 2, notice that for a given activity level the solution of the first step is either at A, when the PC_H intersects the BC below A, and then the incentive compatible constraint IC_H is binding; or at the intersection between PC_H and the budget constraint BC, when the PC_H intersects the BC above A but within the feasible region between A and B, i.e., the participation constraint for the minority PC_H is binding.[12] In the next section we consider the solutions of the problem when the incentive constraint is binding, while in the section that follows we consider the binding participation constraint case.

3.1 Binding H's incentive-compatibility constraints

The first case we consider is at point A, where the budget constraint and the quality-efficient producer's incentive compatibility constraint, IC_H, are binding. In this case, the PO has to avoid that the quality-efficient in the minority "poses" as a quantity-efficient type. We then have the following:

$$\begin{aligned} c^H(q^H, s^H) - c^H(q^V, s^V) + y^V &= y^H, \\ p(Q, S)Q - F - n_H y^H &= n_V y^V, \end{aligned}$$

[12] Another possibility would be to have no feasible solutions, which would correspond to PC_H intersecting the BC above B.

from which we obtain the following payments for the two types:

$$\begin{aligned} y^V &= \frac{p(Q,S)Q - F}{n} - \frac{n_H}{n}[c^H(q^H, s^H) - c^H(q^V, s^V)], \\ y^H &= y^V + c^H(q^H, s^H) - c^H(q^V, s^V). \end{aligned}$$

As this latter equation shows, the payment for the quality-efficient type (H) in the minority makes her just indifferent between her payment scheme and the one intended for the quantity-efficient (V) should she, the quality-efficient type, pose as quantity-efficient.[13]

In the second step, the problem is the choice of the optimal quantity and quality levels. By defining an auxiliary variable $\alpha \geq 0$ such that $q^V = q^H + \alpha$ and $\beta \geq 0$ such that $s^H = s^V + \beta$, we take into account the conditions of Lemma 2.1 and reduce the problem to an unconstrained nonlinear program. We then need to maximize the following:

$$\max_{q^H, \alpha, s^V, \beta} \quad y^V - c^V(q^V, s^V), \tag{7}$$

$$\begin{aligned} y^V &= \frac{p(Q,S)Q - F}{n} - \frac{n_H}{n}[c^H(q^H, s^H) - c^H(q^V, s^V)], \\ Q &= \sum_{i=V}^{H} n_i q^i; \quad S = S(n_i, s^i, q^i); \quad q^V = q^H + \alpha; \quad s^H = s^V + \beta. \end{aligned}$$

We obtain the following first order conditions respectively for q^H, α, s^V and β:

$$\begin{aligned} [p_Q(\cdot) + \frac{p_S(\cdot)}{n}[\frac{\partial S}{\partial q^H} + \frac{\partial S}{\partial q^V}]]Q + p(Q,S) - \frac{n_H}{n}[c_q^{qH}(q^H) - c_q^{qH}(q^V)] - c_q^{qV}(q^V) &\leq 0, \\ q^H &\geq 0, \end{aligned}$$

$$\begin{aligned} [p_Q(\cdot)n_V + p_S(\cdot)\frac{\partial S}{\partial q^V}]\frac{Q}{n} + p(Q,S)]\frac{n_V}{n} + c_q^{qH}(q^V)\frac{n_H}{n} - c_q^{qV}(q^V) &\leq 0, \\ \alpha &\geq 0, \end{aligned}$$

$$\frac{p_S(\cdot)Q}{n}[\frac{\partial S}{\partial s^H} + \frac{\partial S}{\partial s^V}] - \frac{n_H}{n}[c_s^{sH}(s^H) - c_s^{sH}(s^V)] - c_s^{sV}(s^V) \leq 0,$$

[13] Note that whether $y^H > y^V$ or not depends on technology conditions, that is on whether $c^H(q^H, s^H) > c^H(q^V, s^V)$ or not. See the discussion of case i/a) and i/b) in Lemma 2.1.

$$
\begin{aligned}
s^V &\geq 0, \\
\frac{p_S(\cdot)Q}{n}\frac{\partial S}{\partial s^H} - c_s^{sH}(s^H)\frac{n_H}{n} &\leq 0, \\
\beta &\geq 0,
\end{aligned}
$$

where $p_Q(\cdot)$ and $p_S(\cdot)$ are the first derivatives of the inverse demand function with respect to Q and S, while $c_q(\cdot)$ and $c_s(\cdot)$ are the first derivatives of the cost function with respect to q and s. Let us assume that we have interior solutions for q and s. With regard to the auxiliary variables, we can have different possibilities.

- No bunching

Let us start with the case in which we can assume interior solutions for both auxiliary variables,[14] i.e., $\alpha > 0$ and $\beta > 0$. After some manipulations we obtain the following solutions:

$$
\begin{aligned}
[p_Q(\cdot) + \frac{p_S(\cdot)}{n}[\frac{\partial S}{\partial q^H} + \frac{\partial S}{\partial q^V}]]Q + p(Q,S) &= c_q^{qV}(q^V) + \frac{n_H}{n}[c_q^{qH}(q^H) - c_q^{qH}(q^V)], \qquad (8) \\
[p_Q(\cdot) + \frac{p_S(\cdot)}{n_H}\frac{\partial S}{\partial q^H}]Q + p(Q,S) &= c_q^{qH}(q^H), \\
\frac{p_S(\cdot)Q}{n}[\frac{\partial S}{\partial s^H} + \frac{\partial S}{\partial s^V}] &= c_s^{sV}(s^V) + \frac{n_H}{n}[c_s^{sH}(s^H) - c_s^{sH}(s^V)], \\
\frac{p_S(\cdot)Q}{n_H}\frac{\partial S}{\partial s^H} &= c_s^{sH}(s^H).
\end{aligned}
$$

With interior solutions, that is with separation of the different types for both activities, the optimal pricing mechanism requires quality-efficient types producing quantity and quality up to the point at which their marginal cost equals the marginal price the PO receives from the sale of the commodity. In other words, minority types are not distorted compared to what they would be producing in a constrained first-best world.[15] At the same time, quantity-efficient types in the majority

[14]See Appendix 6 for a proof that we can not have bunching for both variables, that is, confirming a result originally due to Guesnerie and Seade, that there is no bunching of types.

[15]We are referring to a regulating Agency who sets up a collective brand, has perfect observability (and verifiability) of quality and quantity, no information on individual producers technology, and an utilitarian social welfare function with unitary weights for each type of producers. In other words, consumer's welfare would not be taken into account. This is a situation which may be relevant when exports are a high proportion of production, or when the regulator is captured by producers. See Appendix 5 for more details on this problem.

produce more of the activity at which they are relatively good at, i.e., quantity, and less of what they are relatively inefficient at, i.e., quality.

Indeed, for the choice of quantity, remembering that $q^V > q^H$ and the Assumption 1, we have that the term in the bracket is negative, i.e., $[c_q^{qH}(q^H) - c_q^{qH}(q^V)] < 0$, which implies that $p_q(\cdot) < c_q^{qV}(q^V)$ and so the majority types overproduce quantity. For the choice of quality, $s^H > s^V$ and hence $[c_s^{sH}(s^H) - c_s^{sH}(s^V)] > 0$, which implies that $p_s(\cdot) > c_s^{sV}(s^V)$, i.e., the majority type under produces quality.

- Bunching over quality

Now suppose we have partial bunching over quality, that is we assume that $\beta = 0$ such that $s^V = s^H$, but $\alpha > 0$. In this case the optimal solutions are the following:

$$\begin{aligned}
[p_Q(\cdot) + \frac{p_S(\cdot)}{n}[\frac{\partial S}{\partial q^H} + \frac{\partial S}{\partial q^V}]]Q + p(Q,S) &= c_q^{qV}(q^V) + \frac{n_H}{n}[c_q^{qH}(q^H) - c_q^{qH}(q^V)], \\
[p_Q(\cdot) + \frac{p_S(\cdot)}{n_H}\frac{\partial S}{\partial q^H}]Q + p(Q,S) &= c_q^{qH}(q^H), \\
\frac{p_S(\cdot)Q}{n}[\frac{\partial S}{\partial s^H} + \frac{\partial S}{\partial s^V}] &= c_s^{sV}(s^V) + \frac{n_H}{n}[c_s^{sH}(s^H) - c_s^{sH}(s^V)], \\
\frac{p_S(\cdot)Q}{n_H}\frac{\partial S}{\partial s^H} &< c_s^{sH}(s^H).
\end{aligned} \tag{9}$$

Note that the term into the bracket in the third equation, $[c_s^{sH}(s^H) - c_s^{sH}(s^V)]$, is equal to zero since $s^V = s^H$. With partial bunching on quality, the optimal menu of contracts requires the quantity-efficient types producing quality up to the point at which their marginal cost equals the marginal revenue the PO receives from the sale of the commodity. In other words, majority types are still distorted with respect to quantity, as in the previous case, but not with respect to quality. The minority's type, on the other hand, is not distorted with respect to quantity, as in the previous case with no-bunching, but now she is producing the same level of quality like the majority's type, that is underproducing quality.

- Bunching over quantity

Now suppose instead we assume that $\alpha = 0$ such that $q^V = q^H$, but $\beta > 0$, that is partial bunching over quantity. In this case the optimal solutions are the following:

$$[p_Q(\cdot) + \frac{p_S(\cdot)}{n}[\frac{\partial S}{\partial q^H} + \frac{\partial S}{\partial q^V}]]Q + p(Q,S) = c_q^{qV}(q^V) + \frac{n_H}{n}[c_q^{qH}(q^H) - c_q^{qH}(q^V)], \tag{10}$$

$$
\begin{aligned}
[p_Q(\cdot) + \frac{p_S(\cdot)}{n_H}\frac{\partial S}{\partial q^H}]Q + p(Q,S) &> c_q^{qH}(q^H), \\
\frac{p_S(\cdot)Q}{n}[\frac{\partial S}{\partial s^H} + \frac{\partial S}{\partial s^V}] &= c_s^{sV}(s^V) + \frac{n_H}{n}[c_s^{sH}(s^H) - c_s^{sH}(s^V)], \\
\frac{p_S(\cdot)Q}{n_H}\frac{\partial S}{\partial s^H} &= c_s^{sH}(s^H).
\end{aligned}
$$

Note that the term into the bracket in the first equation, $[c_q^{qH}(q^H) - c_q^{qH}(q^V)]$, is equal to zero since $q^V = q^H$. With partial bunching on quantity, the optimal menu of contracts now requires the quantity-efficient types producing quality in an undistorted fashion, but still underproducing, i.e., distorting, quality. The minority's type is not distorted with respect to quality, but she is overproducing quantity, since her level is equal to that of the majority type, the quantity-efficient.

To summarize, when quantity-efficient types have the majority, the group proposes two contracts so that it leaves the minority types just indifferent between the two. The majority takes advantage of its position, and leaves the minority a rent just above reservation utility, which is the least to be still incentive compatible. With no bunching, the majority can "extract" most surplus from the minority when this latter produces at the efficient level, i.e., with no distortions. In order to make the contract incentive compatible, the majority distorts its own optimal choices, forcing itself to produce more of the activity at which it is relatively more efficient, i.e., quantity, and less of what the minority is relatively less efficient at, i.e., quality. In this fashion, the contract of the majority becomes less appealing to the minority's type.

When the costs of separating between the differet types are relatively high, arguably because the cost differences in producing quality (or quantity) are small, it is better for the group to buch together over quality (quantity), that is not to discriminate between types over quality. Indeed, with distortions the total surplus to be split may be lower, so it may be better for the group to have the two types bunched, that is producing the same quantity (quality) level, determined by the marginal condition for the the majority's type, which corresponds to overproducing (underproducing) for the minority's type. At the same time, it is better to separate over the activity at which the producers are rather different, i.e., quality (quantity), by making the majority's type underproducing (overproducing) it.

We can now state another result that shows how the group with a quantity efficient majority produces overall more quantity and less quality than the constrained first-best.

When the minority's incentive compatibility constraint is binding, the Producers' Organization with a quantity-efficient majority overall produces a higher quantity and lower quality levels than the constrained first-best.

Proof: See Appendix 7.

The intuition for this result is that the type in the majority overproduces quantity (underproduce quality) in order to make her contract less appealing to the minority. This latter is not distorted with respect to the first best, but since her marginal benefit is smaller (greater), given the greater quantity (smaller quality) for the production of the majority's type, she in fact produces less quantity (more quality). In other words, for the individual producers quantity (and quality) is a strategic substitute with respect to the quantity (quality) produced by the other type. This is equivalent to quantity (and quality) spreading, and given that the inverse demand function for the group is convex in quantity (concave in quality), it results in an overall decrease in quantity (increase in average quality).

The group produces more quantity but at a lower average quality level, since the majority of producers is relatively inefficient at providing quality. In this way they maximize their profits and have the quality-efficient members still making some positive profits in order to make the remuneration scheme incentive-compatible. A policy that could implement this optimal mechanism would pay a relatively high price to low-quality products and would have a relatively low premium for high-quality ones. Using from the jargon in the literature, one can say that the group would offer a menu of relatively low-powered contracts for quality. This would explain those situations in which some groups are unable to take advantage of the quality potential of their production.[16]

[16]For example, the case of Soave, one of the most known italian white wines. It is well known among practitioners that the wine produced by the local cooperative, one of the biggest wine cooperative in Europe, is of relatively low quality. It is not unusual though to listen to some members that would rather prefer the cooperative to better remunerate higher quality grapes and sell higher quality wine. While these members are located in quality-fortunate production areas, the majority of producers belonging to the cooperative is located in the fertile region, where higher yields but lower quality potential is the norm. Indeed, more often than not the cooperative has been producing an excess supply of wine of relatively low quality, preferring to sell to retailers big volumes for low prices.

3.2 Binding V's participation constraint

When the participation constraint for the minority (PC_H) intersects the budget constraint in the feasible region between A and B, the relevant constraints that are binding are the budget constraint BC and the quality-efficient producer‘s participation constraint or PC_H. While in the previous section we show the case in which the management had to avoid the minority from mimicking the majority's type, now the PO has to induce the quality-efficient in the minority to participate in the group. We then have the following:

$$\begin{aligned} c^H(q^H, s^H) &= y^H + u^H, \\ p(Q,S)Q - F - n_H y^H &= n_V y^V, \end{aligned}$$

from which we obtain the following payments for the two types:

$$\begin{aligned} y^V &= \frac{p(Q,S)Q - F - n_H c^H(q^H, s^H)}{n_V}, \\ y^H &= c^H(q^H, s^H) + u^H. \end{aligned}$$

The payment for the quality-efficient type (H) makes her just indifferent between participating in the group or staying outside of the group. In this case, since there is no incentive-compatibility problem given that those constraints are not binding, in the second step we do not have to take into account the monotonicities presented in the lemma above and each type picks what is efficient for her. That is to say, the problem to maximize is the following (unconstrained) one:

$$\max_{q^i, s^i} \quad \frac{p(Q,S)Q - F - n_H c^H(q^H, s^H)}{n_V} - c^V(q^V, s^V), \tag{11}$$

$$Q = \sum_{i=V}^{H} n_i q^i; \quad S = S(n_i, s^i, q^i).$$

Assuming interior solutions for both variables and after some manipulations we obtain the following solutions:

$$\begin{aligned} [p_Q(\cdot) + \frac{p_S(\cdot)}{n_V}\frac{\partial S}{\partial q^V}]Q + p(Q,S) &= c_q^{qV}(q^V), \qquad (12) \\ \frac{p_S(\cdot)Q}{n_V}\frac{\partial S}{\partial s^V} &= c_s^{sV}(s^V), \\ [p_Q(\cdot) + \frac{p_S(\cdot)}{n_H}\frac{\partial S}{\partial q^H}]Q + p(Q,S) &= c_q^{qH}(q^H), \\ \frac{p_S(\cdot)Q}{n_H}\frac{\partial S}{\partial s^H} &= c_s^{sH}(s^H). \end{aligned}$$

The optimal pricing mechanism in this case requires both quality-efficient and quantity-efficient types producing quantity and quality up to the point at which their marginal cost equals the marginal revenue the PO receives from the sale of the commodity.[17] In other words, both minority and majority types would not be distorted compared to a hypothetical constrained first-best, both in the choice of quantity and quality.

To summarize, when quantity-efficient producers are the majority, the optimal menu of contract for the group may be designed to leave the minority producers at their reservation utility. Minority producers, under these parameter conditions for demand and technology, are not "tempted" to mimic the majority's type. Hence activity levels, given that there are no problems of incentive-compatibility, are not distorted and such that the marginal cost is equal to the marginal revenue for an additional marginal increment of quality and quantity for each type.

3.3 Which constraint is binding

In this section we establish for what technology and demand parameter values we can expect the rationality constraint for the minority's type to intersect the budget constraint either above or below A. In addition, we consider when there are no feasible solutions to the problem, i.e., the PC_H cuts the BC above B (figure 2). First, suppose that each type is producing the first-best, i.e., the non-distorted, quantity and quality level. Consider now an incentive-compatible payment, i.e., suppose that in the first stage of the problem the constraints that are binding are the BC and the IC_H. The optimal payment for the quality-efficient type is then the following:

$$y_A^H = \frac{p(Q,S)Q - F}{n} + \frac{n_V}{n}[c^H(q^H, s^H) - c^H(q^V, s^V)],$$

and call it y_A^H. Now consider the payment consistent with the rationality constraint of the minority type, i.e., when the minority type

[17]Note that the marginal revenue for the quantity choice has three components, instead of the usual two that a firm with monopoly power would have. Indeed, since the average quality provided by the group is a function of the quantity produced by each type, the extra term takes into account how a change in quantity would affect the average quality, i.e., $\frac{p_S(\cdot)}{n_i}\frac{\partial S}{\partial q^i}Q$.

gets $y^H = c^H(q^H, s^H) + u^H$. We can form the following inequality:

$$y_A^H = \frac{p(Q,S)Q - F}{n} + \frac{n_V}{n}[c^H(q^H, s^H) - c^H(q^V, s^V)] \geq c^H(q^H, s^H) + u^H. \tag{13}$$

When this inequality is satisfied it is indeed feasible, actually better, for the group to leave some rents to the minority type's producers. If violated, it is better for the group to drive the minority's types to their reservation utility. The term on the left of the inequality can be interpreted as the size of the opportunity to be taken by the group via the collective action - which is a function of the demand parameters - minus the costs of doing it. These latter depend on the fixed cost component, spread among all the producers, and on the differences between the two types. The differences are indeed important: once weighted by the relative number of the quality-efficient producers, they enter into determining the incentive-compatible payment for the minority‘s type (eq. **??**). The term on the right of the inequality is the payment for the minority‘s type when his rationality constraint is binding, and is affected by outside opportunities.

This inequality says that when there are enough opportunities to be taken by the group, i.e., the surplus creation is relatively high, it is optimal for the majority to leave some rents above the reservation utility to the minority‘s producers. But when there are not big opportunities to be taken, the group is relatively heterogenous in terms of cost differences and relative number of producers, or there are good outside opportunities for the minority's type, it is optimal for the majority to leave the minority‘s producers just at their reservation utility in order to increase the group's welfare. Which also translates in no distortions in the activity levels.

Now let us consider when it is never feasible for a quantity-efficient majority to form a group in the first place. This may happen when the minority type's incentive constraint is satisfied but the participation constraint cuts the BC above point B in figure 2. Again, consider first-best activity levels. At this point, the payment schedule makes the majority producers, the quality-efficient type, indifferent between her contract and the one designed for the minority type. that is, $y^V - c^V(q^V, s^V) = y^H - c^V(q^H, s^H)$, with the first-best output levels. From the budget constraint we have that $y^V = \frac{p(Q,S)Q - F - n_H y^H}{n_V}$, which can be substituted in the previous equation to obtain the following:

$$y_B^H = \frac{p(Q,S)Q - F}{n} + \frac{n_V}{n}[c^V(q^H, s^H) - c^V(q^V, s^V)].$$

Call this y_B^H. Now consider the payment for the quality-efficient type corresponding to the same output level but when the rationality constraint is binding. The minority type's producers get $y^H = c^H(q^H, s^H) + u^H$, and we can form the following inequality:

$$y_B^H = \frac{p(Q,S)Q - F}{n} + \frac{n_V}{n}[c^V(q^H, s^H) - c^V(q^V, s^V)] \geq c^H(q^H, s^H) + u^H. \tag{14}$$

When this inequality is satisfied the group may form, otherwise it can not. Note that y_B^H and y_A^H differ only in their cost term inside the brackets, which is bigger (in absolute value) for y_B^H. because of truth-telling (see appendix 3). This leads us to consider the following cases.

- *Case a*: $y_B^H > y_A^H > c^H(q^H, s^H) + u^H$. For these demand and technology parameter values, the most favorable for the group, the group may form and the minority receives some rents.

- *Case b*: $y_B^H > c^H(q^H, s^H) + u^H \geq y_A^H$. In this case the group still forms but it does not leave rents to the minority's types.

- *Case c*: $c^H(q^H, s^H) + u^H \geq y_B^H > y_A^H$. Given these parameter values, the opportunity to be taken via the collective action is too small, the producers are too heterogenous, the fixed costs too high, or the outside opportunities too high for the group to form.

Appendix 1. Proof of Lemma 2.1.

Consider the incentive compatibility constraints for both types:

$$\begin{aligned} y^V - c^{qV}(q^V) - c^{sV}(s^V) &\geq y^H - c^{qV}(q^H) - c^{sV}(s^H), \\ y^H - c^{qH}(q^H) - c^{sH}(s^H) &\geq y^V - c^{qH}(q^V) - c^{sH}(s^V). \end{aligned} \tag{15}$$

Combining the two expressions we have the following:

$$c^{qH}(q^V) - c^{qH}(q^H) + c^{sH}(s^V) - c^{sH}(s^H) \geq y^V - y^H \geq c^{qV}(q^V) - c^{qV}(q^H) + c^{sV}(s^V) - c^{sV}(s^H).$$

With the use of the fundamental theorem of calculus, this in turn implies:

$$\int_{q^H}^{q^V} [c_q^{qH}(q) - c_q^{qV}(q)]dq \geq y^V - y^H \geq \int_{s^H}^{s^V} [c_s^{sV}(s) - c_s^{sH}(s)]ds, \tag{16}$$

where $c_q^{qi}(q)$ and $c_s^{si}(s)$, $i = V, H$, represent the derivatives of the cost function with respect to q and s.

Suppose that the left-hand side (LHS) of the inequality is non-positive, i.e., $q^V \leq q^H$. Then to be incentive-compatible it must be that the right-hand side (RHS) is non-positive too, i.e., $s^V \leq s^H$ and thus $y^H \geq y^V$ (case i)).

Analogously, suppose the RHS is non-negative, that is $s^V \geq s^H$: to ensure incentive-compatibility the LHS must be non-negative, i.e., $q^V \geq q^H$ and thus $y^H \leq y^V$ (case ii)).

Consider case i), with $q^V \geq q^H$ and $s^H \leq s^V$. The LHS is non-negative, and the RHS is non-positive, and thus the inequality is satisfied. Now consider the payments. Let $y^V \geq y^H$. From IC_V we obtain

$$c^V(q^V, s^V) \geq c^V(q^H, s^H),$$

which by using the fundamental theorem of calculus becomes

$$\int_{q^H}^{q^V} c_q^{qV}(q)dq \geq \int_{s^V}^{s^H} c_s^{sV}(s)ds,$$

i.e., for type V the relative cost increase over the relevant quantity range is greater than the cost increase over the quality range. Analogously, from IC_H we obtain

$$c^H(q^V, s^V) \geq c^H(q^H, s^H),$$

which becomes

$$\int_{q^H}^{q^V} c_q^{qH}(q)dq \geq \int_{s^V}^{s^H} c_s^{sH}(s)ds,$$

i.e., also for type H the relative cost increase over the relevant quantity range is greater than the cost increase over the quality range. So when quantity is relatively more costly to produce for both types, the payment for the type producing more of it has to be no lower, i.e., $y^V \geq y^H$ (case iii/a). In a similar fashion one can derive that when quality is relatively more costly, i.e., $c^i(q^H, s^H) \geq c^i(q^V, s^V)$, $i = V, H$, then $y^H \geq y^V$ (case iii/b).

To conclude, suppose that case (iv) holds, and $q^V \leq q^H$ and $s^V \geq s^H$. Given Assumption 1, the left-hand side of (16) is non-positive and the right-hand side non-negative and thus it is not incentive compatible.

Appendix 2. The optimal menu.

Suppose that the optimal menu of contracts is characterized by case *ii*), with $q^V \geq q^H$ and $s^V \geq s^H$ and call it the *old menu*. We want to show that it is possible to construct a new menu that increases the objective function with all the constraints still satisfied. Let us then consider a *new menu* $\tilde{q}^V = q^V, \tilde{q}^H = q^H, \tilde{s}^V = s^H$ and $\tilde{s}^H = s^V$, i.e., the hillside type now produces the quality level that was intended for valley producers in the old menu and the valley type produces the hillside quality level.

With the new menu, costs for the hilly type are no lower than before, i.e., $c^H(q^H, s^H) \leq c^H(\tilde{q}^H, \tilde{s}^H)$, since $\tilde{s}^H \geq s^H$. For the valley type, costs are no higher with the new menu: $c^V(q^V, s^V) \geq c^V(\tilde{q}^V, \tilde{s}^V)$, since $\tilde{s}^V \leq s^V$.

Now define the cost change over the quality range for both types, $\Delta c^V(s) = c^{sV}(s^V) - c^{sV}(\tilde{s}^V)$ and $\Delta c^H(s) = c^{sH}(\tilde{s}^H) - c^{sH}(s^H)$ so that they are both non-negative. Note that because of Assumption 1, i.e., $c_s^{sV} > c_s^{sH}$, the following is true:

$$\Delta c^V(s) \geq \Delta c^H(s),$$

that is to say, in absolute terms the cost increase over the quality range for the hillside type is lower than the cost decrease for the valley type.

With the new menu, suppose you offer a payment such that $\tilde{y}^H = y^H + \Delta c^H(s)$ and $\tilde{y}^V = y^V - \Delta c^H(s)$, i.e., increase the payment for hillside types and decreases payments for valley types for the same amount, equal to the hilly type's cost increase. It is easy to show that with the new menu all constraints are satisfied. For example, suppose that the PC_H is satisfied with the old menu, i.e., $y^H - c^H(q^H, s^H) \geq u^H$. With the new menu $\tilde{y}^H$, $\tilde{q}^H$, $\tilde{s}^H$, the left-hand side of the PC_H becomes: $\tilde{y}^H - c^H(\tilde{q}^H, \tilde{s}^H)$, which becomes $y^H + c^{sH}(\tilde{s}^H) - c^{sH}(s^H) - c^{qH}(\tilde{q}^H) - c^{sH}(\tilde{s}^H)$, since $\tilde{y}^H = y^H + \Delta c^H(s)$ and by the definition of $\Delta c^H(s)$. After simplifying, we get $y^H - c^{sH}(s^H) - c^{qH}(\tilde{q}^H)$, and the PC_H is still satisfied since $q^H = \tilde{q}^H$. In a similar fashion, one can show that the other participation constraint, PC_V, anf both IC_is, are satisfied with the new menu.

In addition, the objective function with the new menu increases,i.e., $\tilde{\pi}^V = \tilde{y}^H - c^H(\tilde{q}^H, \tilde{s}^H) \geq y^V - c^V(q^V, s^V) = \pi^V$. Indeed, note that the previous expression is equal to $\tilde{\pi}^V - \pi^V = y^V - c^{sH}(\tilde{s}^H) + c^{sH}(s^H) - c^{qV}(\tilde{q}^V) - c^{sV}(\tilde{s}^V) - y^V + c^V(q^V) + c^V(s^V)$, which after some simplification reduces to $\Delta c^V(s) - \Delta c^H(s)$ which is non-negative since $\Delta c^V(s) \geq \Delta c^H(s)$ because of Assumption 1. To conclude, with the new menu the profits for the majority's type would increase and hence the contract consistent with case *ii*) is not optimal.

The proof for case *i*), i.e., $q^H \geq q^V$ and $s^H \geq s^V$, is similar. Consider the new menu $\widetilde{q}^V = q^H, \widetilde{q}^H = q^V, \widetilde{s}^V = s^V$ and $\widetilde{s}^H = s^H$, i.e., the hillside type produces the quantity level that was intended for valley producers in the old menu and the valley type produces the hillside quantity level. With the new menu, the costs for the hilly type are no higher than before, i.e., $c^H(q^H, s^H) \geq c^H(\widetilde{q}^H, \widetilde{s}^H)$, since $\widetilde{q}^H \leq q^H$. For the valley type costs are no lower: $c^V(q^V, s^V) \leq c^V(\widetilde{q}^V, \widetilde{s}^V)$, since $\widetilde{q}^V \geq q^V$.

Now let us define the cost change over the quantity range as $\Delta c^V(q) = c^{qV}(\widetilde{q}^V) - c^{qV}(q^V)$ and $\Delta c^H(q) = c^{qH}(q^H) - c^{qH}(\widetilde{q}^H)$, which can be ranked in the following fashion because of Assumption 1, i.e., $c_q^{qV} < c_q^{qH}$:

$$\Delta c^V(q) \leq \Delta c^H(q),$$

or, in absolute terms the cost decrease for the hillside type is higher than the cost increase for the valley type.

Now, let us offer a payment scheme such that $\widetilde{y}^H = y^H - \Delta c^H(q)$ and $\widetilde{y}^V = y^V + \Delta c^H(q)$, i.e., it decreases the payment for hillside types and increases payments for valley types for the same amount equal to the hilliside type cost decrease, $\Delta c^H(q)$. One can easily show that both incentive-compatible constraints are satisfied because the decrease in payment is just compensated by the cost decrease for the hillside type, and the payment increase ($\Delta c^H(q)$) more than compensate the cost increase for the valley type. This is also true for both types' participation constraint. In addition, the objective function, i.e., type V profits, increases because the decrease in costs more than compensate the increase in payment. To conclude, this shows that also the contract consistent with case *i*) is not optimal.

Appendix 3. On the relative position of the incentive compatible constraints.

From eq. (4) note the following:

$$\begin{aligned} y^H &= y^V + c^V(q^H, s^H) - c^V(q^V, s^V) \qquad from \quad IC_V, \\ y^H &= y^V + c^H(q^H, s^H) - c^H(q^V, s^V) \qquad from \quad IC_H. \end{aligned}$$

Now let $c^V(q^H, s^H) - c^V(q^V, s^V) = A$ and $c^H(q^H, s^H) - c^H(q^V, s^V) = B$. In case *iii*) we have that $A \geq B$ because of assumption (A1). That is to say, the IC_V lies above the IC_H. Indeed, rearranging terms and using the fundamental theorem of calculus, we get back to inequality (16) in Appendix 1. Intuitively, we compare the total costs of picking the efficient levels of activities of each type to its costs of producing at the levels that would be efficient for the other type. In addition, if $c^i(q^V, s^V) \geq c^i(q^H, s^H)$, $i = V, H$, and hence $y^V \geq y^H$ (case iii/a), then both IC_V and IC_H are below the bisector (figure 2a). Otherwise, if $c^i(q^H, s^H) \geq c^i(q^V, s^V)$, $i = V, H$, and $y^H \geq y^V$ (case iii/b), then both IC_V and IC_H are above the bisector (figure 2b).

Appendix 4. Not binding constraints for the majority's type.

Since the BC is binding, the payment of the majority's type is the following:

$$y^V = \frac{p(Q, S)Q - F - n_H y^H}{n},$$

and hence the objective function for the group becomes the following:

$$\pi^V = \frac{p(Q, S)Q - F - n_H y^H}{n} - c^V(q^V, s^V).$$

a) Suppose that PC_V is binding, i.e., $y^V = c^V(q^V, s^V) + u^V$. One could increase y^V and reduce y^H by the same small amount. The other constraints would still be satisfied and the objective function, π^V, would increase. Hence it is not optimal to have a binding PC_V.

b) Suppose now that IC_V is binding, i.e., $y^V - c^V(q^V, s^V) = y^H - c^V(q^H, s^H)$. In the same fashion, one could increase y^V and reduce y^H by the same small amount. The other constraints would still be fine, while the objective function would increase. Hence it is not optimal to have a binding IC_V.

Appendix 5. The regulator's problem (constrained first-best).

In this section we find the solution of the same output provision problem faced by a regulator, for example the case of an Agency who sets up a collective brand, has perfect observability (and verifiability) of quality and quantity, no information on individual producers' technology, and an utilitarian social welfare function with unitary weights for producers. In this case the program for the optimal design of a contract can be formulated in the following way:

$$(PO) \qquad \max_{y^i, q^i, s^i} \left\{ \sum_{i=V}^{H} n_i [\, y^i - c^i(q^i, s^i)] \right\}$$

$$\begin{array}{rrcl}
s.t. \quad (IC_V) & y^V - c^V(q^V, s^V) & \geq & y^H - c^V(q^H, s^H), \\
(IC_H) & y^H - c^H(q^H, s^H) & \geq & y^V - c^H(q^V, s^V), \\
(PC_i) & y^i - c^i(q^i, s^i) & \geq & \underline{u}^i, \\
(BC) & p(Q,S)Q - \sum_{i=V}^{H} n_i y^i & \geq & F, \quad i = V, H.
\end{array}$$

The regulator would like to maximize producers' profits, given her informational constraints (IC_i) and the voluntary participation of individual producers (PC_i), through market rules that do not require public money but that would be self-financed by producers (BC). This problem can be decomposed in two steps:

$$\max_{q^i, s^i} \left\{ \max_{y^i} \left\{ \sum_{i=V}^{H} n_i \, y^i \,|\, IC_i, PC_i, BC \right\} - \sum_{i=V}^{H} n_i \; c^i(q^i, s^i) \right\}.$$

As already said, we assume that the program aims at enhancing agricultural income without discriminating between different producers. We may then reasonably argue that neither of the IC_i constraints need to hold. In addition, let us assume that demand and technology conditions allow to create enough surplus through the collective brand program and hence we may argue that the PC_V is to the left of B (fig. 2), and PC_H is below point A, i.e., both participation constraints are not binding. Given these assumptions, there exists infinite solutions to the first step of the problem, i.e., there are many surplus distribution possibilities, and all must be on the budget constraint in the feasible region between points A and B. The solution of the first step can then be derived from the budget constraint equation and is equal to $\sum_{i=V}^{H} n_i \, y^i = p(Q,S)Q - F$. The second step of the maximization problem becomes then the following:

$$\max_{q^i, s^i} \left\{ p(Q,S)Q - F - \sum_{i=V}^{H} n_i \; c^i(q^i, s^i) \right\}.$$

We obtain the following first order conditions respectively for q^H and q^V:

$$\begin{array}{rcl}
[p_Q(Q,S)n_H + p_S(Q,S)\dfrac{\partial S}{\partial q^H}]\, Q + p(Q,S)\, n_H - n_H \, c_q^{qH}(q^H) & \leq & 0, \\
q^H & \geq & 0, \\
[p_Q(Q,S)n_V + p_S(Q,S)\dfrac{\partial S}{\partial q^V}]\, Q + p(Q,S)\, n_V - n_V \, c_q^{qV}(q^V) & \leq & 0, \\
q^V & \geq & 0,
\end{array}$$

where $p_Q(\cdot)$ and $c_q^i(\cdot)$ are the first derivatives with respect to Q and q. For s^V and s^H the first order conditions are the following:

$$\begin{aligned}
p_S(Q,S)Q\,\frac{\partial S}{\partial s^V} - n_V\, c_s^{sV}(s^V) &\leq 0,\\
s^V &\geq 0,\\
p_S(Q,S)Q\,\frac{\partial S}{\partial s^H} - n_H\, c_s^{sH}(s^H) &\leq 0,\\
s^H &\geq 0,
\end{aligned}$$

where $p_S(\cdot)$ and $c_s(\cdot)$ are the first derivatives with respect to S and s.

After some manipulations and assuming interior solutions for both variables, we obtain the following solutions:

$$\begin{aligned}
[p_Q(Q,S) + \frac{p_S(Q,S)}{n_V}\frac{\partial S}{\partial q^V}]Q + p(Q,S) &= c_q^{qV}(q^V), \qquad (17)\\
\frac{p_S(Q,S)Q}{n_V}\frac{\partial S}{\partial s^V} &= c_s^{sV}(s^V),\\
[p_Q(Q,S) + \frac{p_S(Q,S)}{n_H}\frac{\partial S}{\partial q^H}]Q + p(Q,S) &= c_q^{qH}(q^H),\\
\frac{p_S(Q,S)Q}{n_H}\frac{\partial S}{\partial s^H} &= c_s^{sH}(s^H).
\end{aligned}$$

In the case of a regulator with no redistribution concerns and when demand and technology conditions allow the creation of enough surplus through the program, the optimal mechanism requires both types to produce quantity and quality up to the point at which the marginal cost equals the marginal revenue received from the sale of the commodity under the common program.

Appendix 6. The no-total bunching proof.

To show that there is no bunching for both activities simultaneously we use a proof by contradiction following Chambers (1997). Let us start from the first order conditions of the problem of eq. (7), and use the fact that $\frac{n_V}{n} + \frac{n_H}{n} = 1$ to obtain the following:

$$\left[\left[p_Q(\cdot) + \frac{p_S(\cdot)}{n}[\frac{\partial S}{\partial q^H} + \frac{\partial S}{\partial q^V}]\right] Q + p(Q,S) - c_q^{qV}(q^V)\right] \frac{n_V}{n} +$$

$$\left[\left[p_Q(\cdot) + \frac{p_S(\cdot)}{n}[\frac{\partial S}{\partial q^H} + \frac{\partial S}{\partial q^V}]\right] Q + p(Q,S) - c_q^{qV}(q^V)\right] \frac{n_H}{n} -$$

$$-\frac{n_H}{n}[c_q^{qH}(q^H) - c_q^{qH}(q^V)] \leq 0, \quad q^H \geq 0,$$

$$\left[\left[p_Q(\cdot) + \frac{p_S(\cdot)}{n_V}\frac{\partial S}{\partial q^V}\right] Q + p(Q,S) - c_q^{qV}(q^V)\right] \frac{n_V}{n} +$$

$$\left[c_q^{qH}(q^V) - c_q^{qV}(q^V)\right] \frac{n_H}{n} \leq 0, \quad \alpha \geq 0,$$

$$\begin{aligned}
\frac{p_S(\cdot)Q}{n}[\frac{\partial S}{\partial s^H} + \frac{\partial S}{\partial s^V}] - \frac{n_H}{n}[c_s^{sH}(s^H) - c_s^{sH}(s^V)] - c_s^{sV}(s^V) &\leq 0, \\
s^V &\geq 0, \\
\frac{p_S(\cdot)Q}{n}\frac{\partial S}{\partial s^H} - c_s^{sH}(s^H)\frac{n_H}{n} &\leq 0, \\
\beta &\geq 0,
\end{aligned}$$

where $p_Q(\cdot)$ and $p_S(\cdot)$ are the first derivatives of the inverse demand function with respect to Q and S, while $c_q^{qi}(\cdot)$ and $c_s^{si}(\cdot)$ are the first derivative of the cost function with respect to q and s.

To have total bunching means that we have $\alpha = 0$, i.e., $q^V = q^H = q$, and $\beta = 0$, or $s^V = s^H = s$. The first order condition for α becomes the following:

$$\left[\left[p_Q(\cdot) + \frac{p_S(\cdot)}{n_V}\frac{\partial S}{\partial q^V}\right] Q + p(Q,S) - c_q^{qV}(q^V)\right] \frac{n_V}{n} < [c_q^{qV}(q^V) - c_q^{qH}(q^V)]\frac{n_H}{n}.$$

Note that the term on the right hand side of the inequality is < 0, because of the *Across Types Ranking* assumption, which implies that also the term on the left hand side is less than zero, i.e., $\left[\left[p_Q(\cdot) + \frac{p_S(\cdot)}{n_V}\frac{\partial S}{\partial q^V}\right] Q + p(Q,S) - c_q^{qV}(q^V)\right] < 0$.

Adding the inequality derived from the first order conditions for α to the first order conditions for q^H reported above, and remembering that $q_V = q_H = q$, lead to the following inequality: $\left[p_Q(\cdot) + \frac{p_S(\cdot)}{n_H}\frac{\partial S}{\partial q^H}] Q + p(Q,S) - c_q^{qH}(q^H)\right] > 0$. Thus we get the two following inequalities:

$$\begin{aligned}
p_q(\cdot)Q + p(Q,S) + \frac{p_S(\cdot)\,Q}{n_H}\frac{\partial S}{\partial q^H} - c_q^{qH}(q) &> 0, \\
p_q(\cdot)Q + p(Q,S) + \frac{p_S(\cdot)\,Q}{n_V}\frac{\partial S}{\partial q^V} - c_q^{qV}(q) &< 0.
\end{aligned} \tag{18}$$

The first order condition for β is the following:

$$\frac{p_S(\cdot)Q}{n_H}\frac{\partial S}{\partial s^H} < c_s^{sH}(s^H).$$

If we now add this inequality to the first order conditions for s^V and remembering that $s_V = s_H = s$, lead to the following: $\frac{p_S(\cdot)Q}{n_V}\frac{\partial S}{\partial s^V} > c_s^{sV}(s^V)$. Thus we get the two following inequalities:

$$\begin{aligned} \frac{p_S(\cdot)Q}{n_H}\frac{\partial S}{\partial s^H} &< c_s^{sH}(s^H), \\ \frac{p_S(\cdot)Q}{n_V}\frac{\partial S}{\partial s^V} &> c_s^{sV}(s^V). \end{aligned} \tag{19}$$

Eqs. (18) and (19) are in contradiction since $c_q^{qH}(q) > c_q^{qV}(q)$ and $c_s^{sV}(s) > c_s^{sH}(s)$ because of the *Across Types Ranking* assumption.

Appendix 7. Proof of proposition 3.4.

The proof is in two steps, first showing the spreading for individual producers and then the aggregate result. It is in part based on a proof suggested by Chambers (1997). Respectively from the first and second conditions of the constrained first-best (eq. 17) the following can be derived:

$$\left.\frac{dq^V}{dq^H}\right|_H =, \tag{20}$$

$$\left.\frac{dq^V}{dq^H}\right|_V =, \tag{21}$$

which represent the slope of the curves H and V drawn in fig. 3, and which are straight lines only for exposition convenience.

Note that the intersection between the two curves is above the bisector because of the lemma (2.1). They are downward sloping because the quantity produced by each type is a strategic substitute for the quantity produced by the other type. Curve H cuts curve V from above. In addition, the curves cross only once because of the single-crossing property.

The points lying on the curves satisfy the conditions of the constrained first-best, and at the point denoted by the coordinates q^{*V} and q^{*H}, where the two curves cross, these conditions are satisfied simultaneously. On the points below the curves, the marginal revenue in greater than the marginal cost, while on the points above the curves the marginal cost is higher than the marginal revenue. To be consistent with the terms involving the choice of quantity q in eq.(**??**), a solution must be on curve H but above curve V since $\frac{\partial p(Q,S)Q}{\partial q^V} < c_q^V(q^V, s^V)$, with the first term of the inequality being the marginal revenue, like for example point A. It is easily seen that a quantity combination for the two producer types consistent with eq. (**??**) would then imply the quantity-efficient type V to produce more quantity, i.e., $q^V > q^{*V}$ and the quality-efficient type to produce less quantity than the first-best $q^H < q^{*H}$. Using Lemma 1, we can infer that eq. (**??**) implies a spreading of quantity provision, i.e., $q^V > q^{*V} > q^{*H} > q^H$.

The quantity spreading, together with eq. (**??**) and the convexity of the cost functions lead to the following: $\frac{\partial p(Q,S)Q}{\partial q^H} = c_q^H(q^H, s^H) < c_q^H(q^{*H}, s^H) = \frac{\partial p(Q^*,S)Q^*}{\partial q^H}$, where $Q^* = \sum_{i=V}^H n_i q^{*i}$, which implies that $\frac{\partial p(Q,S)Q}{\partial q^H} < \frac{\partial p(Q^*,S)Q^*}{\partial q^H}$. Since the price function is strictly convex in quantity, we can infer that $Q = \sum_{i=V}^H n_i q^i > Q^* = \sum_{i=V}^H n_i q^{*i}$ or that the aggregate quantity provided by the group, when the majority is of quantity-efficient producers, is higher than the constrained first-best.

We can prove that the average quality is lower in an analogous fashion. In figure 3, label the vertical axis with s^H, the horizontal with s^V and switch label between the two curves H and V. To be consistent with the terms involving the choice of s in eq.(**??**), a solution must be again on curve H but now below curve V, since $\frac{\partial p(Q,S)Q}{\partial s^V} > c_s^V(q^V, s^V)$, like for example point B. In this case, a quality combination for the two types consistent with eq. (**??**) implies the quality-efficient type H to produce more quality, i.e., $s^H > s^{*H}$ and the quantity-efficient type to produce less quality than the first-best $s^V < s^{*V}$, i.e., we can infer that eq. (**??**) implies a spreading of quality provision such that $s^H > s^{*H} > s^{*V} > s^V$.

Taken together with the quality spreading, eq. (**??**) and the convexity of the cost functions lead to the following: $\frac{\partial p(Q,S)Q}{\partial s^H} = c_s^H(q^H, s^H) > c_s^H(q^H, s^{*H}) = \frac{\partial p(Q,S^*)Q}{\partial s^H}$, where $S^* = S(n_i, q^i, s^{*i})$, which implies that $\frac{\partial p(Q,S)Q}{\partial s^H} > \frac{\partial p(Q,S^*)Q}{\partial s^H}$. Since the price function is strictly concave in quality, we can infer that $S^* = S(n_i, q^i, s^{*i}) > S = S(n_i, q^i, s^i)$ or that the average quality provided by the group, when the majority is of quantity-efficient producers, is lower than the constrained first-best.

References.

Bockstael, N. The Welfare Implications on Minimum Quality Standards. American Journal of Agricultural Economics. 1984; 466-471.

—. Economic Efficiency Issues of Grading and Minimum Quality Standards. In Kilmer, R. L. and Armbruster, W. J. (Eds.). Economic Efficiency in Agricultural and Food Marketing. Iowa University Press, 1987.

Bourgeon, J.-M. and Coestier, B. Private vs. Public Product Labeling. Working paper, THEMA Paris. 1996.

Canali, G. and Boccaletti, S., The Antitrust Policy in Italy: Learning from some Food Cases", presented at the 6th Joint Conference on Food, Agriculture and the Environment, Minneapolis, MN, August 31, 1998.

Chambers, R. G. Information, Incentives, and the Design of Agricultural Policies. In Gardner, B. L. and Rausser, G. (Eds.), Handbook of Agricultural Economics, forthcoming.

Chambers, R. G. and Weiss, M. D. Revisiting Minimum-Quality Standards. Economics Letters. 1992; 40(2):197-201.

Chiang, S. and Masson, R. T. Domestic Industrial Structure and Export Quality. International Economic Review. 1988; 29(2):261-270.

Fletcher, A. Theories of Self-Regulation. Unpublished Ph.D. Dissertation, Nuffield College, Oxford. 1993.

Gehrig, T. and Jost, P. J. Quacks, Lemons, and Self Regulation: A Welfare Analysis. Journal of Regulatory Economics. 1995; 7:309-325.

Gobbo, F. and Cazzola, C. La Politica Italiana della Concorrenza nell'Industria Agroalimentare. Rivista Di Economia Agraria. 1996; LI(3):379-404.

Grossman, S. J. and Hart, O. D. An Analysis of the Principal-Agent Problem. Econometrica. 1983; 51 (1): 7- 45.

Guesnerie, R. and Seade, J. Nonlinear Pricing in a Finite Economy. Journal of Public Economics. 1982; 17:157-179.

Jesse, E. V. Economic Efficiency and Marketing Orders. In Kilmer, R. L. and Armbruster, W. J. (Eds.). Economic Efficiency in Agricultural and Food Marketing. Iowa University Press, 1987.

Leland, H. E. Quacks, Lemons, and Licensing: A Theory of Minimum Quality Standards. Journal of Political Economy; v87(6) Dec. 1979: 1328-46.

Lewis, T. R.; Feenstra, R., and Ware, R. Eliminating Price Supports. A Political Economy Perspective. Journal of Public Economics. 1989; 40:159-185.

Myerson, R. B. Incentive Compatibility and the Bargaining Problem. Econometrica. 1979; 47:61-74.

Sexton, R. J. The Formation of Cooperatives: A Game Theoretic Approach with Implications for Cooperative Finance, Decision Making, and Stability. American Journal of Agricultural Economics. 1986; 68:214-225.

Shaked, A. and Sutton, J. The Self-Regulating Profession. Review of Economic Studies. 1981; XLVIII:217-234.

Shepard, L. Cartelization of the California-Arizona Orange Industry, 1934-1981. The Journal of Law and Economics. 1986; 29:83-123.

Tirole, J. The Theory of Industrial Organization. MIT Press, 1988.

U.S.D.A. - U.S. Department of Agriculture. A Review of Federal Marketing Orders for Fruits, Vegetables, and Specialty Crops: Economic Efficiency and Welfare Implications. Washington D.C., Agricultural Marketing Service. 1981.

Vercammen, J.; Fulton, M., and Hyde, C. Nonlinear Pricing Schemes for Agricultural Cooperatives. American Journal of Agricultural Economics. 1996; 78:572-584.

Weymark, J. A Reduced-Form Optimal Income Tax Problem. Journal of Public Economics. 1986; 30:199-217.