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Improving Food Quality through Institutional Innovations: Using a Free-Rider Approach for Collective Action

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Abstract

This paper applies an innovation from institution economics to agribusiness: profit (cost) sharing as arrangements to promote public good provision. It outlines how a team work approach can be employed to promote food quality. In institutional economics it was recently suggested to use sharing arrangements to overcome the problem of externalities, in particular by using the above mentioned team work approach. Cost sharing as "team work" is analyzed in this paper as a novel institution to improve food quality, then by indirectly creating incentives to overcome the public good character of "quality". It is assumed that consumers recognize industry quality; not individual by firm in case of asymmetric information. We translate a general approach of negative externality to a positive one. (1) We make a reference to the current state of art on how food quality depends on joint efforts of an industry. The aim is to get a better image and discuss the extent to which group efforts are needed to improve quality. (2) We present a mathematical approach on team work for quality. Quality is seen as positive externality and (3) team building is modelled as a likely a process of forming groups sharing efforts in food industries. Finally some remarks are made on how to actively stimulate the needed process of team formation. Also the role of the government is addressed. At the core of the paper we see the argument that *free riding* on quality images can be avoided if collective action prevails. A team is modeled as partnership of producers in which costs for image raising are shared. A prerequisite is that *economies of scale* and jointness in image exist.

Keywords: food quality, team

1. Introduction

There is a huge discussion on means to promote food quality and images (Henson & Reardon, 2005). A central theme is the role of governments and public interventions (e.g. on standards, monitoring, control, etc.: Codron et al, 2005). From a classical viewpoint, the discussion implies using a rigorous approach to show that (1) quality is a common or public good (phenomena: Martinez et al., 2007), that (2) the market does not provide the social optimum and (3) governments have a role to play (Martinez et al., 2007; Narrod et al., 2009). (4) A mechanism should be outlined, which sets incentives for the private sector (Holleran, 1999) to overcome the *free rider problem* in food quality assurance. In this paper we argue that a framing of quality as a common good problem is an eye-opener, yet, on improving institutions governing quality and to throw light on possible new institutional arrangements.

Frequently, the *belief* is that quality is a self-evident criterion of food that can be easily appreciated by consumers (graded) and that market segmentation develops at minimal intervention (just fixing standards for grades). Then, on the basis of *objective* grading that shall work effortlessly (for example see meat in Germany: Sönnichsen et al. 2000), consumers make easily choices. Perhaps that is fine for minimum standards. But do consumers know the industry's potentials to go beyond current standards? Or what happens if the industry does not meet even professed standards, taste is not linked to visible characteristics, and perhaps manipulations can prevail? In the latter case consumers loose trust. For instance the image of the meat industry in the EU has declined over years (especially when BSE was strong in public awareness: Rausser et al., 2011, Chapter. 17). Though we will not go into detail on free riding, further reasons such as the role of media, ignorance, public request for standards, etc. (see on the influence of media: Verbeke et al., 2000), it seems that some food industries (mainly the meat industry) have an image problem that corresponds to low quality image (as compared to thought standards).

Under this condition, rational producers may employ cost minimization strategies (such as the use of low quality feed, minimal maturing times for animals, low hygiene, etc.). This results in even lower quality. There seems to be no mechanism to change behavior; though consumers often express concerns and might pay more if quality improves.

However, vice versa, it is the hypothesis of this paper that the image (quality as public standard) of an industry can be built up if all producers would jointly increase quality, resulting in consumer confidence. Building up quality also means that costs increase, for instance by buying better feed or forage, and this has a price effect. The individual producer is faced with the dilemma that his colleagues may prefer *free riding* and do not contribute to quality, notably as a rent seeking strategy (Nizan, 1991). The costs of individuals without collection action are too high to improve images; and because they fear *free riding*, calculations are biased. So the question is how can one reduce the costs of individuals and assure *team* work in for quality. A suggestion is to share the additional costs that are to be potentially incurred in realizing higher quality (we follow Platteau and Seki, 2000 by reversing their argument of production, output sharing, to cost sharing), and use economies of scale. To frame a cost sharing arrangement, we suggest a re-invention of sharing arrangements such as in resource management (negative externalities: Heintzelman et al., 2008. There the idea is to reduce efforts to reach an optimum). Here we reverse the argument and will work out the economic logic for sharing as mechanism to get a social optimum. This shall be above current quality.

The suggested approach requires that we have to set references for quality as well as to show that additional cost bearing improves quality and revenues. Reference for quality choices in food markets are normally based on two criteria sets: (1) individual benchmarks associated with taste (subjective) and (2) generic criterions linked to image (objective); image can be seen as pre-knowledge to quality beyond preferences. Producers face a situation where prices and quality, which are achievable in a market, are negatively correlated with images of industries. Then efforts of all participants count in image building and up-keeping of standards. On real markets (based on assumptions of imperfect knowledge) instruments of coordination are needed to promote quality as price and quality may not fit (Hanf & Wersebe, 1994).

It is the objective of the paper to give a theoretical outline of a team work to improve quality in a food industry which fails to get better prices (for instance, beef or pork). The sector is perhaps regionally focused and has a *bad* image, to which farmers collectively contribute. We start with a problem statement, then give a model outline and provide derivations of individual and team behavior. Finally some hints for policy and implementation will be given.

2. Problem Statement and Approach

We start with the following ideas to envision the problem: (1) consumers may not be able to reasonably distinguish different produces by simple quality criteria (mostly visual one, if products are bought in markets; consumers even may not see better quality in the market at all) and they have to place trust on food that they purchase; (2) characteristics don't contain full information at visible scales, but images play a role; (3) some characteristics are even hidden; (4) quality and (5) prices remain below expected value and potential levels (Hanf & Wersebe, 1994); but (6) consumers buy food as generic product with low involvement. In this setup, image has a pivotal role; it can be improved as a result of collective action of farmers.

Against this background we introduce the notion of *quality* as a collective standard (image) that is achieved by cost sharing and which can be achieved with economies of scale (campaigns, etc.). Costs beyond minimal costs are associated with others and can be pooled (efforts to improve quality: better fodder, less adds to food, perhaps better husbandry, etc. effect at industry level as image). The sector image matters for prices. In contrast, if an individual producer wants to improve quality he is a marginal contributor. We assume a cost function that includes individual and joint efforts to increase quality. The basic idea is that costs for quality and image advances can be made sharable. Sharing costs means that individual firms can externalize costs (efforts): I.e. "though bearing some costs for others, it pays off". A prerequisite is that *economies of scale* exist in image creating and the image is of joint for the industry.

Yet, to make the approach realistic, standard production costs and cost of quality enhancement must be (made) distinguishable. We refer to costs of market development (image) and quality as those to be shared. If quality is a matter of collective action, it means that revenues of individual firms are determined by joint efforts of all market participants. I.e. price and quality determine revenues on individual and collective levels. Prices are indirectly changeable by collective action (image advances). High quality adds up from individual contributions towards quality advances and finally changes producer revenues. As mentioned above, as assumption we state that one can distinguish costs for quality and ordinary production. The focus of the paper is on min! (quality) costs. Yet, there is a link to be realized between quality and production costs. For us, to produce in bulk is neg. non-linear in quality (in a cost model).

Measures to improve quality are manifold. For instance, in special cases (meat) we can easily presume that better ingredients (feeds) are relevant and they are more expensive as well as we may take the difference in costs as quality effort based. In physical terms, the amount of better fodder in the diet of an animal is an effort "*e*" and this effort can be measured as a change in recognized ingredients. For instance for beef, a higher percentage of grass in the diet of beef cattle, instead of maize, increases the quality of the meat and we can take the grass percentage in feed as *effort*. However, most case can be generalized and we take a cost function approach that is dual of a production function (Sheppard, 1990: see below). Then the quality, as related to joint efforts, follows a non-linear expression (efforts as regressed on quality see below).

Further assumptions are: (1) the marketing for quality (image) advance is collectively organized (for instance labelled as "better" beef from the association, team of farms having a brand name), (2) there is a willingness to pay, and (3) a premium is paid to producers. The problem is that only cost sharing lifts quality if numerous producers participate. Group (team) formation is negotiated. (5) A further assumption is that a team can be formed by making claims to partners to contribute to image. Then (6) producers are capable to reclaim additional efforts (costs) and pool them, i.e. *costs* (in team) depend with whom one share costs for quality improvement (notably only additional costs to production cost matter). Sharing is done according to group composition and membership in teams. The size of a team (group) is not predetermined, rather it must be simulated. Hence a three-layer-decision problem occurs for individuals and groups (see Heintzelmann et al., 2008). The layers are: (1) the level of effort is decided assuming each farmer is a team member; (2) the group or team formation is depicted as voluntary choice to participate and the number of members in each team is *decided* in terms of options to move between team; (3) then the number of teams is derived endogenously. In the subsequent analysis we follow the analytical outline of the above authors, but reverse their argument from output to cost sharing. Further, we add the production (quantity) decision of farmers on operational size, since we have heterogeneous producers and link it to quality

3. Model Outline and Social Optimum

The formal outline starts with a sector approach on defining production, quality, relationships, objective functions and the "social optimum". Based on that (modified: see Heintzelmann et al., 2008) we work with an average cost function which is: unit cost multiplied by effort. (Notify Heintzelman et al. worked with a production function and looked at revenue.) We reverse the argument and state that costs can be shared. In contrast to Heintzelman et al. (2008) who pursues the idea that sharing will reduce effort in favor of the environment, our issue is to increase costs (quality) based on cost sharing (externalizing). Because an option is to share, costs will result in larger cost for groups and this is hoped to get images needed; the team provides scope for higher grading and better prices as well as incentivizes producers at group level to improve on quality. The lure is that participation in the team through economies of scale (costs) will attract firms. In this respect we follow the assessment that a rigorous institution economic problem analysis would deliver the assertion that quality is a *public good* and too "few efforts" might be currently provided, (i.e. to work with positive externality, yet than negative).

A complication (if one works on quality) is the fact that *quantities* and *qualities* are linked and simultaneous decision variables. About cost vs. quality leadership Porter (1985) put this as strategic options. Here, price levels become disposable if quality improves (prices increase with quality: hopefully). A generic problem is that food prices are considered to be low. (The question arises why farmers should invest in quality. Also, quality is mostly obscured by standards that give minor price signals to consumers.) Thus, the modeling should include quantity quality, and price effects guaranteeing that farmers' decisions are paying off later. Hitherto, the complexity of the problem, in order to become policy relevant, has to be increased. On the other hand it is necessary to maintain the core description of the quality enhancing argument.

3.1 Quality Measure and Objectives

Also we need some remarks concerning measurement of quality: quality can be considered an index to which farmers contribute. As part of production, quality can be achieved, for example, by shares of better fodder in the diet of animals (cut of concentrates), outside grazing, longer feeding periods, mobility and health support, good micro-climates in stables, etc. As part of animal health, reduced additives are also relevant. Cuts of many of modern inputs are called efforts. The cuts of individual farmers are summed up to give a total quality index. Indi-vidual actions correlate with efforts at individual and group level.

Subsequently, for simplicity, firstly revenues are described as the product of price multiplied by quantity and quality: P·Q·Y. Quality is given as an index which lifts up average prices and which is associated with a corresponding willingness to pay by consumer for higher quality. Hereby, we assume that there is an anonymous, average market price P; i.e. the average market price level of the sector is not influence-able by the team (rather for any average kind of product the anonymous sector price prevails and the team can only strive for a niche of quality products which gives them a higher price as mark-up and based on image and branding; apparently the practical part is beyond this analysis). Received prices (above average) can be only raised along consumers' willingness to pay for a quality Q which is truly communicated, assured and established: then P·Q is assigned to quantities Y; i.e. those consumers who get good quality accept a higher price P·Q (Rausser et al., 2011: striving for higher quality is limited to segmented markets for quality products and all prices cannot be indirectly lifted).

In a second version we will investigate the situation of a directly (though only partly) influenced market price at a broader range of raising quality of a sector (see below). Though the effect on average price might be relatively small, with spreading of teams it might be possible to improve the image of a whole sector. In that case free-riding problems become more pertinent, teams should serve internalizing them, and the effect (size of price increase) is an empirical problem. However, as long as quality is determined in a competitive and a to-be-assured market, producers have rarely strong power on increasing price. Eventually it can be supposed that several teams form the sector. Only then, if all producers contest, prices increase.

About production costs, as dependent on quantities produced, we refer to the usual curvature of cost functions: being convex. On quality (image, costs) we see economies of scale (concave) and benefits from joint effort. Since we have to infer sizes of teams (shown later) and numbers of teams, we likewise assume that no single firm can establish "quality" for getting better prices (yet, only for a basis image, in a special game, a single firm can form a team). Due to size limitations firms lack the overall capacity to establish *industry quality*. But shared action can make it. So, we model a typical medium sized sector in a competitive food market.

Further assumptions are: (1) we look at a single layer value added chain product. For the moment we do not distinguish producers, processors and retailers. Yet, we see rules and team building on raw material producing farmers and set contracts with processors and retailers. (2) Since it is our intention to discuss an alternative to external standard setting, we abstract from outside treaties, hierarchies. etc.; though it might be still plausible to integrate processing and production as well as other contracts and to focus on decision units: Y and Q, only. (3) The next step is that we want to make the model operational for numerical simulations. For this sake we suggest introducing a linearized version of an objective function which is mathematically treatable. Thence a needed step is to clarify on *quality* for a mathematical outline of efforts and measurements. For this, it is assumed that quality (as index) is linked to effort: $q=\gamma\cdot e$ or at totaled level: $Q=\gamma\cdot E$; next, assuming that weighting of individual quality contributions "q" can occur, it delivers an overall index $Q=\Sigma w_i q_i$, where we assume that $0 < Q < 1$.

3.2 Social Level (Industry) Specification as Well as Quality and Effort Specification

For a further drafting it has to be mentioned that the approach starts at *social* (aggregated) level. The group (team) problem is usually: maximizing the value added (surplus) of a sector composed of producers which form associations (i.e. producers have a common goal). In our case the goal is exploiting quality increases of food (incl. image for a segment of a market which is characterized by produce offering better returns). From putting efforts in quality improvement producers can expect higher revenues and by cost sharing total costs are lower than in individual cases. In fact we have to clarify on quality as a variable entering the objective of a potential group of producers. In equation (1) we specify the revenue as price multiplied by the quality index as value P·Q and Y. Quantity Y and quality Q vary. In this simple version consumers appreciate Q (are willing to pay for quality) and down grade lower quality. Actually in the simple version P·Q is a superficial new pricing. The condition is expressed as:

$$L^s = P\ Q\ Y\ - c_a Q\ F(Q(E), Y) - C(Y) \tag{1}$$

where:
- P: price
- Y: quantity produced
- Q: Quality
- E: Effort
- C_a: average costs for quality
- C: usual production costs

In this specification sector surplus (inverse of production function, i.e. cost function) is defined as the production coefficient function F(…). It is flexible with respect to quality (see (1')).

$$C = \gamma \ E \frac{F(E,Y)}{E} = E \ \frac{[\alpha_{11} E^2 + \alpha_{12} Y \ E \ ]}{E} = E \ [.5\alpha_{11} E \ + \alpha_{12} Y] \tag{1a}$$

where: E: effort

F: inverse of production function

γ: technology with measurement γ=1 to simplify

Furthermore we use a Taylor approximation for the remaining unit costs and get a simplified version (2) as an expression that helps us to apply the analysis of Heintzelman et al. (2008).

$$L^s = P \ [Y_0 \gamma \ E + Q_0 Y] - c_a \gamma \ E \ [.5\alpha_{11} E \ + \alpha_{12} Y] - \alpha_{21} E \ Y \ - .5\alpha_{22} Y^2 \tag{2}$$

In equation (2) we used a specific *Taylor Approximation* for a concave cost function, i.e. made the goal quadratic and resumed that current, minimal quality 'Q_0' (for instance: Q_0=0.1) is already given as well as current output 'Y_0' (serving as benchmarks). These are benchmarks as references: They serve to get an approximation which fits the actual sector cost function (been estimated). Applying the approximation has several justifications: (1) Unlike the usual cost function formulation, we assume a joint effect in increasing quality and quantity on costs; (2) we split the total effect into two branches: ordinary effects (like in any formulation cost functions are separable) and (3) plus α_{21}EY is the joint effect. (Note, for sequential individual optimizations, individual quantities and qualities are of linked character with the team levels.)

Additionally we can supplement the approach with a dependency of sector price P on quality. This expresses that the overall market follows an image that is translated into prices. It is:

$$P \ = \varepsilon_{11} Q - \varepsilon_{11} Y \tag{1b}$$

As said the reliance of the sector price P on Q and Y might be marginal and it is empirical to get ε´s. In vector description (lb') individual efforts are weighted. Efforts give a price increase.

$$P \ = \varepsilon_{11} \gamma_w' e - \varepsilon_{11} Y \tag{1b'}$$

In Equation (1b) a linear approximation is assumed which is reflecting industry "knowledge".

Notice: in case of making a product price dependent on Y and Q the welfare of the industry (producer surplus) is in the focus. Dropping the dependency on Y and assuming Q is entering welfare of consumers, we even could speak of social welfare as market equilibrium, i.e. as if quality is demanded and the demand corresponds to consumer welfare (Rausser et al., 2011).

4. Social (Industry) Optimization

Given the discussion on an objective (goal) function we can start with a derivation of a social optimum (in the sense of getting a collective one: group or team optimum, i.e. for a number of firms cooperating). It is an "as if" optimization and the firm number is endogenous. Still the optimum serves as reference. Taking the derivative to Q or E, respectively, this would provide an optimum of quality that is analog to the optimum given in Heintzelmann et al. (2008):

$$P \ [Y_0 \gamma \ E + Q_0 Y] \ - c_a Y_0 \ F(Q^*, Y_0) - Q^* F^{/}(Q, Y_0 \ ) = 0 \tag{3}$$

Our problem of a social (group) optimum, here also depends on Y: the production level. Hence we must do a double optimization: on Y and Q. We take an explicit instead of implicit function (used by Heintzelman et al., ibid). For function F(Q(E),Y) we assumed a depiction such as F(Q(E),Y) = 0.5α_{11} E^2+ α_{12}Y E (see above) and then, for the first derivatives towards E and Y (we inserted E as cause of Q), we receive:

$$\frac{\partial L}{\partial E} = P \ Y_0 \gamma \ -_a \gamma \ \alpha_{11} E \ - c_a \gamma \ \alpha_{12} Y \ - \gamma \ c_a \alpha_{11} E \ - \gamma \ \alpha_{21} Y \ = 0 \tag{3a}$$

$$\frac{\partial L}{\partial Y} = P \ \gamma \ E_0 - c_a \gamma \ \alpha_{12} E - \alpha_{21} E - \gamma \ \alpha_{22} Y \ = 0 \tag{3b}$$

Solving the second equation for Y

$$Y \ = \alpha_{22}^{-1} [P \ E_0 - [c_a \alpha_{12} + \alpha_{21}] E \ ] \tag{4b}$$

and inserting in the first equation the optimal effort for *social* (team) quality is a solution as:

$$P \;\; Y_0 \;\; - c_a \gamma \;\; \alpha_{11} E \;\;\; + [c_a \alpha_{12} + \alpha_{21}] \alpha_{22}^{-1} [P \;\; E_0 - [c_a \alpha_{12} + \alpha_{21}] E \;\;\; = 0 \tag{4a}$$

Hereby we resumed E_0 and Y_0 already exist as current ones and it is about improving quality. One can build on the reference, as given in a market situation, i.e. without the suggested institutional innovation of a team work. Notably we receive an optimal effort E* from (4a). In this version quality is a sales argument (WTP) and it does not necessarily change usual prices.

The eventual second step (given what has been said already about influence on the whole sector) is to couple the *co-ordination* problem of team work with sector pricing. If, in particular we like to address the total image issue, better quality and reduced quantity may enable higher prices at industry level. The combination of sales promotion by increased quality which is Q (already tackled above) with a handy knowledge on image and price lifting (5) helps here. For this we presented: price dependent on quality Q (above). For an inverse quality-price equation

$$P \;\; = \varepsilon_{11} Q - \varepsilon_{11} Y \tag{5}$$

it enables linking (with the above specification of the optimal quantity). It delineates a further link amid pricing and quality (as well as effort for quality) in equation (6). In (6) we insert E

$$P \;\; = \varepsilon_{11} \gamma_1 E \;\;\; - \varepsilon_{11} \alpha_{22}^{-1} [P \;\; E_0 - [c_a \alpha_{12} + \alpha_{21}] E \tag{6}$$

$$P = [\varepsilon_{11} \alpha_{22}^{-1} E_0 \;\; + 1]_0^{-1} \varepsilon_{11} \gamma_1 \, [E \;\;\; - \varepsilon_{11} \alpha_{22}^{-1} [c_a \alpha_{12} + \alpha_{21}] E \;\;\;] \tag{6'}$$

and this formulation can be inserted into the result for E (using equation 4a), here to get a price effect. Then equation (7) provides us with a residual depiction of effort at team level:

$$\begin{aligned} &Y_0 \, [\varepsilon_{11} \alpha_{22}^{-1} E_0 \; + 1]_0^{-1} \varepsilon_{11} \gamma_1 \, [E \;\; - \varepsilon_{11} \alpha_{22}^{-1} [c_a \alpha_{12} + \alpha_{21}] E \;\;] - c_a \gamma \; \alpha_{11} E \;\; + [c_a \alpha_{12} + \alpha_{21}] \alpha_{22}^{-1} [[\varepsilon_{11} \alpha_{22}^{-1} E_0 \; + 1]_0^{-1} \\ &\varepsilon_{11} \gamma_1 \, [E \;\; - \varepsilon_{11} \alpha_{22}^{-1} [c_a \alpha_{12} + \alpha_{21}] E \;\;] E_0 - [c_a \alpha_{12} + \alpha_{21}] E \;\; = 0 \end{aligned} \tag{7}$$

The *Optimal effort* in (7) gives quality endogenously by reinserting. And (7) can serve as a reference for the team building process which will be discussed next as a game approach.

5. Cost Sharing and Individual Optimum

As been discussed by Heintzelman et al. (ibid) sharing arrangements work as game approaches. Hence, we have to formally express the institution of cost sharing as game. The next step serves to implement the rule of cost sharing mathematically and shows its implications. The idea is to have two layers of sharing: (1) at upper level teams form themselves and share costs; (2) at lower level, in teams, members share costs on equity basis. And (3) shares in costs are determined by the size of the teams. The overall efforts are taken as reference for (i) the group-wise and (ii) the in-group sharing. Then the team members make decision on joining teams. As a result individual objective functions are to be specified such as:

$$L_{ik}^s = p_{ik} [y_{0,ik} \gamma \; e_{ik} + q_{0,1} y_{ik}] - \{ \frac{1}{m_i} [\frac{e_{ik} + E^{-k}}{E}] \} \{ .5 c_a \gamma \; \alpha_{11} E^2 - c_a \gamma \; \alpha_{12} E \; Y \; \} - \alpha_{21.ik} e_{ik} y_{ik} . - 5 \cdot \alpha_{22,ik} y_{ik}^2 \tag{8}$$

and

$$L_{ik}^s = p_{ik} [y_{0,ik} \gamma \; e_{ik} + q_{0,1} y_{ik}] - \{ \frac{1}{m_i} [e_{ik} + E^{-k}] \} \{ .5 c_a \gamma \; \alpha_{11} E \;\; - c_a \gamma \; \alpha_{12} Y \; \} - \alpha_{21,ik} e_{ik} y_{ik} . - 5 \cdot \alpha_{22,ik} y_{ik}^2 \tag{9}$$

The argument for team formation is backward: Though objective function (9) is optimized at a second step after group formation, it serves as an “as-if” condition for the team formation. The outline is reciprocal: first, we optimize function (9) provided a behavioral function exists for each individual team, and second we show how the team formation works. Optimization towards individual rationality is summed up later and number and sizes of groups are derived. For the individual firm, however, activities of the groups (teams) are given (presumably). Firms choose team membership. How it works will be argued later. For the moment we optimize (9), above function, where we see y_i as part of Y, i.e. $Y=\Sigma y_i$, and $Q=\Sigma w_i q_i$ and $E=\Sigma w_i e_i$. The inclusion of a weighting for the quality index can be done by industry knowledge, given to all firms (else, we can work assigning equal weights; weights reflect brand characteristics).

$$\frac{\partial L}{\partial e_{ik}} = p_{ki} y_{0,ik} \gamma - \frac{1}{m_i} \{ 5 c_a \gamma \alpha_{11} [w_{ik} e_{ik} + w^{-ik} E^{-ik}] + c_a \gamma \alpha_{12} [y_{ik} + Y^{-i,k}] \} - \frac{1}{m_i} [e_{ik} + E^{-ik}] .5 \{ c_a \gamma \alpha_{11} w_{ik} \} - \alpha_{21,ik} y_{ik}. = 0 \quad \text{(9a)}$$

$$\frac{\partial L}{\partial y_{ik}} = p_{ik} q_{0,ik} - \{ \frac{1}{m_i} [e_{ki} + E^{-ik}] \} \{ c_a \gamma \alpha_{12} \} - \alpha_{21i,k} e_{ik} - \alpha_{22,ik} y_{ik} = 0 \quad \text{(9b)}$$

The formulations in equations (8) and (9) are comparable to a participation game. In the optimization (9a and b) we only recognize elements of e_{ik} and y_{ik} being controllable by the individual contingent on the group decisions. It means that a producer has only scope about his optimization and can influence his quality related efforts quantities; others (sum of group activities) are given to him; notably, vice versa, as related to joint quality check he brings in his activities recognized by the others. A problem is how to work with different efficacy of efforts. Information and optimization are limited to the knowledge on own technologies.

In the given case calculations can be reduced to the behavioral description towards efforts for quality. For this purpose we solve the second equation for y_{ik} and insert it in the first equation.

$$y_{ik} = \alpha_{22,ik}^{-1} [p_i q_{0,i,k} - \{ \frac{1}{m_i} [e_{ik} + E^{-k}] \} \{ c_a \gamma \alpha_{12} \} - \alpha_{21,ik} e_{ik}] \quad \text{(10b)}$$

Subsequently we use

$$p_{ki} y_{0,ik} \gamma - \frac{1}{m_i} \{ 5 c_a \gamma \alpha_{11} [w_{ik} e_{ik} + w^{-ik} E^{-ik}] \} + \frac{1}{m_i} [e_{ik} + e_i^{-k}] \{ 5 c_a \gamma \alpha_{ik} w_{ik} \} + \frac{1}{m_i} c_a \gamma \alpha_{12} Y^{-i,k} - [\frac{1}{m_i} c_a \gamma \alpha_{12} + \alpha_{21,ik}] y_{ik}.] = 0 \quad \text{(10a)}$$

in order to get

$$p_{ki} y_{0,ik} \gamma - \frac{1}{m_i} \{ c_a \gamma \alpha_{11} [e_{ik} + E^{-k}] \} + \frac{1}{m_i} c_a \gamma \alpha_{12} w_{ik} Y^{-i,k} + \alpha_{22,ik}^{-1} [p_i q_{0,i,k} - \{ \frac{1}{m_i} [e_{ik} + E^{-k}] \} \{ c_a \gamma \alpha_{12} \} - \alpha_{21,ik} e_{ik}] = 0 \quad \text{(10)}$$

In equation (10) “e_{ik}”, the effort of the producer “k” in team “I”, is a function of E^{-ik} and Y^{-ik}, which are the sum of efforts and quantities of the other group members. These efforts are contributions of other team members and reliance is mutual. “m_i” is the size of team members; it prevails as sub-team. In a simple case the weight “w_{ik}” is given by head count, i.e. 1/n, with n farms. Yet, in concentrated industries weights might be different; for instance, given by previous revenue shares. Note the optimization is contingent on the behavior of the any firm (firms). In total it leads to the necessity to individually optimize and do joint optimization.

6 Team Formation and Team Optimization

The crucial thing for a simulation of any team formation (through modeling which shall be based on rational behavior of individuals joining teams sub-groups), is the determination of the number of teams “n”. By this we seek a stable equilibrium. Following this, the sizes “m_i” of the sub-teams can be derived firstly and then secondly the numbers have to fit into the total number N giving n. In Heintzelmann et al. (2008), for instance, the argument is that a sector is presented by the sum of the individual costs/revenues (benefits in our case). For us it is:

$$\sum p_i y_{0,i}^a \gamma_i = p_0 y_0^a N \Leftrightarrow p_0 y_0 = \frac{1}{N} \sum p_i y_{0,i}^a \gamma_i \quad \text{(11)}$$

Note, in equation (11), y^a_o stands for the average production without an incentive scheme promoting quality. As consumer trade-off indirectly quality and quantity, y might be reduced. For clarifying the size of operation a social optimum can be used. We state that the social optimum is given by n groups and N participants. Team optimization follows sequentially. For a group optimization, a differentiation of “e” and “y” in a *team's objective function* is needed:

$$m_i L_{ik}^s = p_i [y_{0,} \gamma e_{ik} + q_0 y_i] m_i - [e_i + E^{-i}] \{ .5 c_a \gamma \alpha_{11} E - c_a \gamma \alpha_{12} Y \} - \alpha_{21,i} e_k y_i - 5 \cdot \alpha_{22,i} y_i^2 \quad \text{(11)}$$

In equation (11) the objective is those of a group (team). We need this objective to specify the number of teams (n) and members (m_i: consecutively) in a team. The next step is to optimize the *behavior* of the team. Note results are similar to the individual optimization; though now it is assumed: the *team as a whole* is optimized. Joint behavior is perceivable as a team formation: *team* is a special subject. For the moment the optimization of the team's objective yields:

$$\frac{\partial m_i L_i^s}{\partial e_i} = m_i\, p_i^a y_{0,i}^a \gamma - c_a \gamma\, \alpha_{11}[e_i + E^{-i}] - c_a \gamma\, \alpha_{11}[y_i + Y^{-i}] - \alpha_{21,i} y_i = 0 \quad \text{(12a)}$$

$$\frac{\partial m_i L_i^s}{\partial y_i} = p_i\, q_{0,1} m_i - e_i c_a \gamma\, \alpha_{11}[e_i + E^{-i}] - \alpha_{21,i} e_i - \alpha_{22} y_i = 0 \quad \text{(12b)}$$

For the result (12a and b) of the optimization of objective (11) it is once more assumed that the group has knowledge on quantity and quality elements (in the cost function for the generation of quality). This is a limitation to the team. (We can perceive it as subject). Yet, solving of (12b) for y; here the quantity produced by the team gives (12b'). It results in:

$$y_i = \alpha_{22}^{-1}[\, p_i\, q_{0,1} m_i - e_i c_a \gamma\, \alpha_{11}[e_i + E^{-i}] - \alpha_{21,i} e_i\,] \quad \text{(12b')}$$

Then the equation (12b') enables us to specify the quality e_i that should prevail at team level:

$$m_i\, p_i^a y_{0,i}^a \gamma - c_a \gamma\, \alpha_{11}[e_i + E^{-i}] - c_a \gamma\, \alpha_{11} Y^{-i} - [\alpha_{21,i} + c_a \gamma\, \alpha_{11}][\alpha_{22}^{-1}[p_i\, q_{0,1} m_i - c_a \gamma\, \alpha_{11}[e_i + E^{-i}] - \alpha_{21,i} e_i] = 0 \quad \text{(12a')}$$

In principle one can establish the effort of a whole team "e_i" for quality. However, on the one hand the determination is based on the size of the group m_i which is not established yet. On the other hand, nevertheless, we know the socially optimal effort of the whole sector and see the rest of the teams' efforts. The next steps will allow us to get the team numbers.

7. Team Numbers and Size

In this section we show how the team size can be modeled. We again follow the argument of Heintzelmann et al. (2008), who have shown that larger groups have smaller do less. Also we indicate how one can derive the total number of teams. As been further argued (Heintzelmann et al., 2008) membership in groups may not differ between teams. Then, there are reference equilibria along the concept of: "no incentives to switch between teams". These are theoretical and empirical arguments and several sub-teams will prevail because of transaction costs.

The theoretical arguments go along the following line: Defined as quality contribution by individual efforts, we have different contributions of producers that, apparently, are distinguishable and producers have a different stake in sector's quality performance. Performance was introduced by a weighted quality index. It means that a team of producers can be of equal size contributing to quality. As we defined Q_i as equal $Q=\gamma E$ and $Q=\Sigma w_i \gamma e_i$, individuals in the group may differ with respect to the efforts offering; yet they control each other. This respectively implies, we cannot maintain equal quality contributions by teams. Then, knowing the socially optimal quality and dividing it by the number of team efforts is core to the analysis.

For the following analysis a theoretical outline is sketched. In this outline the complex mathematical presentation is reduced to equations for which coefficients in front of variables are to be calculated. For instance, if we take the sorted variables m_i,e_i,E_{-1}, and Y_{-1} in equation:

$$[p_i^a y_{0,i}^a \gamma - [\alpha_{21,i} + c_a \gamma\, \alpha_{11}][\alpha_{22}^{-1} p_i\, q_{0,1}]]m_i - [[1 + \alpha_{21,i} c_a \gamma\, \alpha_{11}]c_a \gamma\, \alpha_{11} - \alpha_{22}^{-1} \alpha_{21,i}]e_i - c_a \gamma\, \alpha_{11} Y^{-i} + [c_a \gamma\, \alpha_{11}]E^{-i} = 0 \quad \text{(13')}$$

it is a detailed account of optimality and correspond to a reduced version of joint coefficients:

$$\theta_{10,i} + \theta_{11,i} m_i + \theta_{11,i} e_i + \theta_{13,i} E + \theta_{14,i} Y = 0 \quad \text{(13'')}$$

The coefficients θ_{ii} in equation (13'') can be recalculated from version (13'). We assume that there are only marginal contributions of individuals to E and Y; i.e. it does not make sense to count Y and E as with or without the contribution of a producer under study. Subsequently we can rewrite equation (13'') in a generalized way if we sum up over the number of teams:

$$\sum \theta_{10,i} + \sum \theta_{11,i} m_i + \sum \theta_{11,i} e_i + \sum \theta_{13,i} E + \sum \theta_{14,i} Y = 0 \quad \text{(14)}$$

In this general representation of a sector, as a sum of teams, the number of teams is implicitly contained (Heintzelman et al., 2008). For instance, if we postulate that the averages of the coefficients (i.e. gains of team work are given as higher marginal revenues) are obtainable by

$$\theta^a = \frac{1}{n}\sum \theta_{10,i} \Leftrightarrow n\theta^a = \sum \theta_{10,i} \tag{15'}$$

the sum (in 15') translates into an average coefficient multiplied by the number of teams. This enables us to postulate a slightly modified version of equation (15) which contains n and it is:

$$n\theta_{10}^a + N\theta_{11}^a + E\theta_{11}^a + n\theta_{13}E + n\theta_{14}Y = 0 \tag{15''}$$

From this equation the number of teams is "n" retrievable. Mathematically the equation (15'') can be solved for "n" given coefficients θ, N, E and Y. As a result one gets the number of teams dependent on the number of potential producers "N" and we refer to a calculated social optimal "E" and "Y" (see above). In this theoretical derivation different variants can be discussed (Heintzelman et al., 2008): A special variant is the case of merely solo-producers: in other words only single players (team) work. This implies (if the above equation is solved for "n" which is the number of teams) a recursive calculation of team sizes enables simulations.

8. Determination of Team Size

Having advanced to a determination of number of groups, the final step is to determine (simulate) the number of members in each team (as remaining problem in team formation), which has to be done separately for any sub-team. We work along the given concept using an objective function and generalize the detailed findings for the individual, team and sector level. Remind that the technical outline of determining variables went along the principle that sub-games and optimization of individuals resulted in teams (summing up) and teams' characteristics help to specify the team number. Knowing numbers of teams (15'') the analysis can come back to member behavior in teams and from the membership number we can re-derive the individual behavior. Finally individual behavior (as sum of effort for quality of each producer) delivers a sector's quality. Notify the approach is embedded in methodological individualism and no mysterious "deus-ex-machina" (coercion) is needed for team formation.

According to Heintzelmann et al. (2008) one can state that teams will form along a concept of achievable equilibria of joining and leaving teams. Incentives are: cost sharing opportunities in various teams due to economies of scale for image which is a common and collective benefit. For practical reasons we can assume that the quality (image) is shared and contributed by each team based on own calculi. However the member number in any team m_i is not yet determined. But deliberation (16) helps us to establish the sizes of (representative) teams (given quality index Q based on E). As described above, the crucial matter is that having "n" teams "n" equations of similar type as equation (13") are given. Then, as definition an average effort in team i is e^a_i, a system of "n" equation (16) for determining the m_i's in a system prevail. Here we make a reference to the fact that the sum of all members is N. We add one equation completing the system. In turn it would mean one team member equation has to be canceled.

$$\begin{aligned} \theta_{11,i}m_1 &= \theta_{10,1} + \theta_{11,i}e^a + \theta_{13,1}E + \theta_{14,1}Y \\ \theta_{11,2}m_2 &= \theta_{10,2} + \theta_{11,i}e^a + \theta_{13,2}E + \theta_{14,2}Y \\ &\dots \\ m_1 + m_2 + \dots m_n &= N \end{aligned} \tag{16}$$

A system like (16) would provide us all sizes of sub-teams. Note for decisions to join a team the size is eventually of bigger importance than the costs: Big teams enable producers to externalize; small to control each other. Technically a problem is that the system is over-determined. Over-determination can be avoided if we include a correction measure c_p. This measure can be considered a public intervention toll (incentive) that guarantees that the individual teams will form.

$$\begin{aligned} \theta_{11,i}m_1 + \theta_{15,1}c_p &= \theta_{10,1} + \theta_{11,i}e^a + \theta_{13,1}E + \theta_{14,1}Y \\ \theta_{11,2}m_2 + \theta_{15,2}c_p &= \theta_{10,2} + \theta_{11,i}e^a + \theta_{13,2}E + \theta_{14,2}Y \\ &\dots \\ m_1 + m_2 + \dots m_n &= n \end{aligned} \tag{16'}$$

The measure can be a special (subsidy) taken by government. Once "c_p" is then endogenous.

So far we assumed E and Y are known from social optimum. Another way of solving the problem is to reason for stratifying the problem. For instance we start with two teams and get

$$\begin{aligned} \theta_{11,1}m_1 + \theta_{11,1}e_1^a &= \theta_{10,1} + \theta_{13,1}E^* + \theta_{14,1}Y^* \\ \theta_{11,2}m_2 + \theta_{11,2}e^a &= \theta_{10,2} + \theta_{13,2}E^* + \theta_{14,2}Y^* \\ e_1^a + e_2^a &= E* \\ m_1 + m_2 &= 2 \end{aligned} \tag{16''}$$

which is a system of four equations and four dependent variables (solvable). It implies that a special quality comes out of two teams as simulated. In this case we have assumed that two teams are established first and members, who join them, are the important formation category.

However our previous result was given by "n" groups. So note that further approximations are needed. A way to go ahead is to assume that the number of teams can be approximated by 2^x. Then from the first upper layer of two teams we can descend to the next (lower) layer assuming 4 teams and check for scope of forming. Forming becomes hierarchical. The constraint for a new team is e^a_i or e^a_2. Hence we assume that new teams form from given teams (splitting). It means that for the first sub-teams m_{11}+m_{12}=m^*_1 and e_{11}+e_1=e^*_1 holds. Similar things can happen to team "2" and we can proceed. With a third layers eight teams are established and with four layers, 16 teams are formed, etc. The closest number in layer creation will give an approximation to number of teams (perceivable form the social optimization equation 15).

A special problem, involved in this procedure, is that a pre-selection of membership in a team and its size determination are given. Since we need to establish the averages for coefficients, this might be arbitrary (dependent on subjective team choices). Again we have to approximate and in reality teams of producers may form according to similarity between themselves. The likelihood for grouping in teams (itself) is size. Starting with a fist layer the discrimination of joint productivity is small and large teams form easily. Then we break down to less large and *bigger numbers* in the group of large ones. Note we do not know the behavior of any individual contributing as producer in advance. Though, the idea is to simulate the outcome.

9. Policy Involvement

So far the discussion has been on the institution of sharing as a rule (instrument without direct intervention). Sharing shall be *invented* by a community itself and tested at the level of individuals; and then, hopefully, members voluntarily join the scheme. Even it could include participation constraints. This probably is the ideal establishment of an economist who does not like government interventions; though it may be possible to influence promotion of the rule and establishment of the community by active involvement. Still no standards are needed and the teams monitor themselves. Yet, the role of government or governance as involvement becomes another issue: are sharing schemes independent from governance? What are the measures to promote and can one use subsidies being helpful as stimuli? For the moment we may assume that governments could also take a share in cost. This share or contribution must be specified according to the delivery of Q and its valuation by consumers. Then we receive

$$L^s = P\ [Y_0\,\gamma\ E + Q_0 Y] - c_a\gamma\ [E\ [.5\alpha_{11}E\ + \alpha_{12}Y] - r_a^g Q_a] - \alpha_{21}E\ Y\ - .5\alpha_{22}Y^2 \tag{17}$$

Equation (17) is a new objective. Here r_g is a payment that is provided as a cost refund from government based on achieved quality and also, the government can make a cost-benefit-analysis. r_g can be considered as an incentive scheme to be added to prices (freely). Yet involvements of incentives raise the question of a cost benefit analysis. But this is beyond the current analysis.

10. Scope for Application

As been indicated in the introduction, there are many cases in which the quality of food is considered lower or has declined in the last decade. In particular, consumer concerns have been expressed on minimal standards and they try to raise awareness in campaigns sponsored by consumer councils, etc. As well many industries are currently struggling with bad images (for example for beef see: Fearne et al., 2001; for pork see: Gilg & Batterhill, 1998; and also potatoes and vegetables may allow applications: Willersinn et al., 2015). Additionally we foresee applications in case of scandals (Wales et al., 2006) where trust has to be rebuilt. Especially issues like *quality, trust, consumer confidence, industry responsibility, etc.* (Hartmann et al, 2015) have been high on the agenda, recently. In these cases the institutional framework of sharing efforts might have many requests. Especially since a collective responsibility can be created within teams which might be even include risk bearing, internal control, etc. Uses of rules for sharing efforts and responsibility, perhaps, will be even spontaneously emerging and the presented theory should help to better understand the background and behavioral aspects. This particularly relates to the game theory aspect tackled.

11. Summary

This article was discussing cost sharing as an alternative institution to public intervention for quality improvement in food industries. Cost sharing, as a rule, is introduced as an analogy to benefit sharing in environmental economics. There, benefit sharing is a mean to reduce efforts while cost sharing shall stimulate efforts. In our case we presumed that current efforts are too low in food industries to get socially optimal quality. The paper develops a scheme of team work in order to get higher levels of quality. A mathematical outline was provided on how to specify objective functions for collective and individual actions. Also, it was shown how the number of teams and the membership in each team can be simulated on the basis of behavior.

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