Food Safety Policies in Case of Economies of Scale in Meat Production: On WTA Compensations for Reduced Stocking, WTP for Antibiotic Reduction and Political Economy Bargaining

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Abstract

This paper offers a novel institutional economics approach for conflict solving in meat industries. We show how to apply a bargaining model in case of: (i) economies of scale and strong competition favouring large scale production as well as high stocking supported by increased antibiotic use, (ii) political power in regulation, and, in contrast, (iii) consumers' requests and WTP for change.

Keywords: political economy bargaining, payments for reducing stocking rate

1 Introduction

Ongoing discussions on the overuse of antibiotics in animal production reveal a problem of market coordination in the meat industry (in Germany see: TAZ, 2013). A pending question is, are bans best, or do we have other policy instruments such as institutional amendments? We will discuss an alternative based on institutional innovation imbedded in bargaining theory (Zusman, 1976). We anticipate political economy aspects, primarily appearing as power and measure power as references in a game, analysing bargaining (Rausser et al 2011). The problem addressed is use of antibiotics as related to stocking density.

2 Concept and framework

It is presumed that there is a trade-off between size, stocking density and antibiotics use in farms. Diagram 1 demonstrates (in absence of or in case of low antibiotics, given a size of the operation) that additional costs accrue because of additional (hygiene) measures. Stocking density of animals matters.

Diagram 1: Farm size and antibiotics

We are not criticising industries; rather see them aiming for low costs, competitiveness and profits for survival and we observe the fact that industries heavily fight for no restrictions. This is a pointer that cost (economies of scale) matter for producer with threat towards competitiveness.

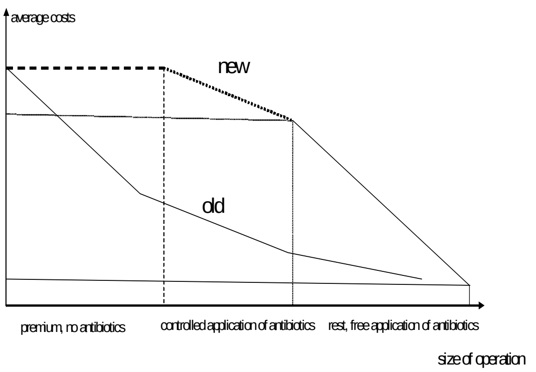
3 Marketing channels and brokerage for antibiotic-free meat

We suggest market segmentation and brokerage. Basically, a consumer could have the choice between three categories of products: (i) un-controlled (rest), (ii) controlled (following negotiated terms on stocking density), and (iii) premium. In fact reduced stocking for health reason (in ii) could be initiated by an agency, as discussed here. Our agency, we call it "Food Safety Agency" FSA (QS, 2013) is given a task. For FSA we assume it "buys in" technology at lowest costs (compensation) to improve the stocking situation in favour of health.

4 Methodological outline for antibiotics and stocking density reduction

We suggest a contracting model for bargaining. Contracting variables are: (i) stocking density reduction, (ii) premium sharing and (iii) fixing compensation rates for health care (costs). To start, production and costs are segmented in three parts (giving economies of scale, see Diagram 2). We distinguish further old and new patterns of economies of scale using the new institutional setup.

Diagram 2: Average costs and economies of scale change



For modelling a producer decides on production categories and delivers to all markets according to options along segmentation. Then the average application rate of antibiotics in relationship to average density "d^a" is determined endogenously by average densities (in segments) and the sizes of the segment.

$$d^a = \varsigma_n d_n + \varsigma_c d_c + [1-\varsigma_n-\varsigma_c]d_r \quad (1)$$

where: d: stocking density, n: no antibiotics (broker), c controlled (agency), r: rest, $\varsigma_{:i}$ production share of rest, c: compensation and n: no-antibiotics

The reduction in stocking density and corresponding antibiotics is the basis for a WTP. Though, government has to decide about the allowed stocking at minimal control of antibiotics (in segment "r"). It determines low cost bounds; the next explanatory equation (2) contains economies of scale driving costs as function of averages:

$$c^a = \varsigma_n c_n + \varsigma_c c_c + [1-\varsigma_n-\varsigma_c]c_r \quad (2)$$

where: c: average costs, n: no antibiotics (brokerage), c controlled (agency), r: rest ; ς: production shares

This specification parallels equation (1). From the two equations (1) and (2) we seek to determine the average costs. We assume a cost function to have a quadratic expression as usually used in supply analysis (i.e. costs increase by production and this is over-proportional: concave), but it also states coefficients of curvature are dependent on stocking. Hereby, economies of scale are covered. It looks as follows:

$$C^a = \gamma_{10}^a q_t + 0.5[\gamma_{10}^a + \gamma_{11}^a]q_t^2 \quad \text{and} \quad \gamma_{11}^a = \gamma_{110}^a + \gamma_{111}^a[1 - r_t / q_t] \quad (3)$$

where additionally: q: production of t: total produce; r: room for animal (space)

$$C^a = \gamma_{10}^a q_t + 0.5[[\gamma_{10}^a + \gamma_{110}^a]q_t^2 + \gamma_{111}^a r_t\, q_t] \quad (4)$$

Equation (4) contains technology and economies of scale as animal density and production. The cost function is based on parameter "r" depicting economies of scale (room) as well marginal and average costs which are subject to production decision. For average costs we can work then with the function (5):

$$c^a = \gamma_{10}^a + 0.5[[\gamma_{10}^a + \gamma_{110}^a]q_t + \gamma_{111}^a r_t] \quad (5)$$

Function (5)'s determination of average costs, in conjunction with equation (2) and equated, gives a dependency on scale technology in the industry such as:

$$\gamma_{10}^a + 0.5[[\gamma_{10}^a + \gamma_{110}^a]q_t + \gamma_{111}^a r_t] = \varsigma_n[c_n^c - c_r]\varsigma_n + \varsigma_c[c_c - c_r]\varsigma_c + 1c_r \quad (6)$$

Further, if (as well since we have constant average costs) we have c_n^c / d_c^c, we get:

$$d_n^c \gamma_{10}^a + 0.5 d_n^c [[\gamma_{10}^a + \gamma_{110}^a] q_t + d_n^c \gamma_{11}^a r_t - d_n^c [c_c - c_r] \varsigma_c + d_n^c c_r = [c_n^c - c_r][[d_c - d_r] \varsigma_c + d_r] - d^a] \quad (7)$$

In fact, equation (7) offers a delineation of average stocking density as dependent on market shares, cost changes and production because its coefficients are settled,

$$d^a = \overset{*}{\gamma}_{10} + \overset{*}{\gamma}_{11} \varsigma_c + \overset{*}{\gamma}_{12} q_t + \overset{*}{\gamma}_{13} + \overset{*}{\gamma}_{14} \{c_c - c_t\} + \overset{*}{\gamma}_{15} c_r + \overset{*}{\gamma}_{16} d_c + \overset{*}{\gamma}_{17} d_r \quad (8)$$

Importantly for the later design of interest functions (i.e. for bargaining) there are the following deliberations: Equation (8) (i) enables us to reduce the number of variables in negotiations; (ii) it limits choices in regard to segments; and (iii) enables us to find an analytical solution. The main choice variable (i.e, variable in the negotiation) is average stocking density d_c of animal population. Then cost increases will be compensated (later). This aspect is important as it is the trigger to change the system.

5 Objective Function of producers for interest specification in negotiations

Here, we work with the case of taking producers in industry as having all three options and negotiating them, simultaneously. A representative objective function is:

$$\Pi = R^n - C^n + R^c - C^c + R^r - C^r \quad (8)$$

where additionally R: revenue: n: no antibiotics (brokerage), c controlled (agency), r: rest

We assume that a selective reduction in economies of scale at enterprise level is feasible. Moreover, for simplification, industry decisions are taken in combination with each other. Then we can write the objective function in terms of average costs and production levels as: $\Pi = R^n - c^n q^n + R^c - c^c q^c + R^r - c^r q^r$ (8')

And inserting of the above cost specification (from equation 3) gives equation (8''):

$$\Pi = R^n - c^n q^n + R^c - [0.5[[\gamma_{10}^c + \gamma_{110}^c] + \gamma_{111}^c 1 / r_0^c [1 - r^c / q^c]]]][q^c]^2 + R^r - c^r q^r \quad (8'')$$

Consecutively, equation (8'') vice versa delivers a profit representation on density d^c:

$$\Pi = R^n - c^n q^n + R^c - 0.5[[\gamma_{10}^{c,*} + \gamma_{110}^{c,*}] + \gamma_{111}^{c,*} d^c]] q^c + R^r - c^r q^r \quad (9)$$

And the objective can be further explained in shares of the market segments

$$\Pi = [p^n + p^c + p^r - [c^n \varsigma^n - 0.5[[\gamma_{10}^c + \gamma_{110}^c] + \gamma_{111}^c d^c]] \varsigma^c - c^r [1 - \varsigma^n - \varsigma^c]] q^t \quad (10)$$

This objective function (10) reduces options for negotiation towards market shares of meat in premium segment ζ_{ci}, stocking density d_{ci}, and share in premium increase ζ_i^n. To complete analysis, a task of a broker (below) is to negotiate share ζ_i^n. Because price increases are shared, finally, the objective can be stated as (11) and prices vary:

$$\Pi_i = [(p_s^n [1 - \nu_i] - c^{n,r}) \varsigma^n + (p^c - c_{10}^c + \gamma_{11}^c d^c) \varsigma^c - p^{r,net}] q^t \quad (11)$$

Again, variables which serve the modelling for negotiation in (11) are: (i) market share of meat ς^n (hence 1-ς^c-ς^r: sold with no use of antibiotics), (ii) stocking density (now as d^c, derive from r^c, and c^c linked to d^c) and (iii) share of controlled produce ς^c (determined by the FSA). Likewise; (iv) there is scope for improved revenue (1-)υ that is dependent on activities of a broker in marketing/promotion. The rest of production (share in production capacity) is implicit and the prices for the rest and compensated are fix (eventually as export).

6 Intermediary remarks on the role of marketing institution for reduction

Design elements for institutions must appear as modified objective functions and bargain design is stated as interest formation in parameters (to be explained). The first issue is: how to include public concern for health, which should become an indirect interest (monetary) of farmers. Second, channel 3 (rest) which produces uncontrolled food is the problem: we must reduce it indirectly through reduced shares in marketing. So how can a broker provide incentives? He is a player in terms of incentives (Zusman, 1989) based on shared premium prices. He ensures (i) that no antibiotics are used, (ii) promotes sales and (iii) offers premiums. The intermediary, FSA, is less effective in controlling antibiotics, but pays. The FSA is needed to calibrate (offer) alternatives at lower level commitments and alternatives in negotiations by giving stable payments.

7 Broker

The broker's objective function (working through retailing), as backed by premium meat, shall comprise (i) costs of promotion, inspection, handling, etc., (ii) market share, and (iii) sharing of the premium. Gains are primarily in term of increased prices boosting revenue, which are shared. A first suggestion is:

$$B = (p_s^n - p_c)\nu_i \left[\textstyle\sum_i \varsigma_i^n q_i^t)\right] - \zeta_b s_b - C_b\left(\textstyle\sum_i \varsigma_i^n q_i^t\right)\varsigma_n^n \qquad (12)$$

where additionally: ν: sharing of price increases, s: search and promotion (costs)
C_b: cost of control by the broker for the purpose of quality assurance (no antibiotics)

To a large extent, the structure of objective function (12) fits that of Zusman (1989). An amendment is control of antibiotics and animal health as transaction costs. In general brokers internalize transaction costs. We assume the broker receives a licence by government by a label approval; then the average application can be accumulated and additional costs are included based on "d^a":

$$B = (p_s^n - p_c)\nu_i \left[\textstyle\sum_i \varsigma_i^n q_i^t)\right] - w_g^n d^a - \zeta_b s_b - C_b\left(\textstyle\sum_i \varsigma_i^n q_i^t\right)\varsigma_n^n \qquad (13)$$

To supplement the approach the premium price is a function of "sensitizing the market" $p_s^n = f_s\,(s_b)$. This sensitizing s is similar to Zusman's (1989) search as task. Yet, negotiations with farmers are on market shares ς^n which shall increase. The issue involved is, that retailers' interests are strengthened, aiming at receiving bigger market shares and non-use of antibiotics or reducing average use.

8 Food Safety (Assurance) Agency

FSA works on behalf of government. It is given money from health care and an association managed by a board (modified QS, 2011). This gives status and can set rules for negotiation. FSA can be considered a bureaucracy licensed by government (Niskannen, 1971 in Diagram 3).

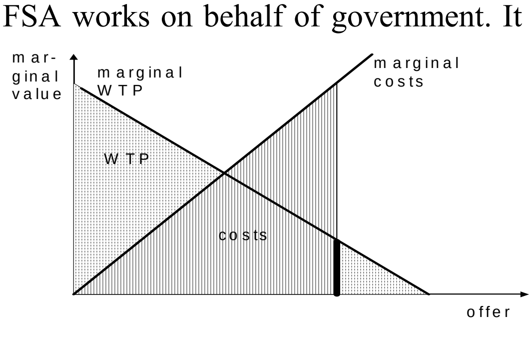


Diagram 3: Bureaucracy Behaviour

FSA makes no profit; rather, revenues shall be equated with costs. The issue and problem for bargaining is given a mathematical outline (14) linking budget maximization and compensation to stocking density. WTP on stocking density change (from current average for the industry) is obtained in equation:

$$WTP = -\theta_{10}^{w}[\sum d_i^a - \sum d_i^r] + 0.5\theta_{11}^{w}[\sum d_i^a - \sum d_i^r]^2 \qquad (14)$$

If the general stocking density reduction is $D=\Sigma d_i$, then along Niskanen (1971) expenditures equal cash receipts. Another way is to summarize changes into transaction costs of the agency $C_A = C_A(D^a,S)$; i.e. both revenues and costs are a function of D and w; and we measure success as reduction of density [D-D_r]) given compensations; all multiplied with w (unit costs); i.e.: D·w. Then R-E:

$$R - E = S_0 D_{b0} + [S_0 - S\ ]D_{b0} + S\ [D_b - D_{b0}] - c_c^a D_i \qquad (15)$$

where additionally: D: average density in the industry
S or s_a: subsidy equivalent for unit costs which can be expressed as average subsidy

is an intermediary objective. Joining the objective function and the constraint, a Lagrange expression (derived as reduction by the willingness to pay, measure for D) can be applied and this is equation (16) for the agency FSA:

$$A = -\theta_{10}^{w}[D_b^a - D_b^r] + 0.5\theta_{11}^{w}[D_b^a - D_b^r]^2 + \lambda[s_{a,0}D_{b0}^r + [s_{a,0} - s_a]D_{b0}^r + s_a[D_b^a - D_{b0}^r] - c_c^a D_b^a] \qquad (16)$$

(FSA's overall objective). For optimization of D and shadow price λ we get:

$$\partial A / \partial D_b^a - \theta_{10}^{w} + \theta_{11}^{w}[D_b^a - D_b^r] + \lambda[s_a - c_c^a] = 0 \qquad (16a)$$

$$\partial A / \partial \lambda = [s_{a,0}D_{b0}^r + 0.5[s_{a,0} - s_a]D_{b0}^r + s_{a,0}[D_b^a - D_{b0}^r] - c_c^a D_b^a] = 0 \qquad (16b)$$

and by solving for variables the shadow price is a function of a reduced form:

$$\lambda = \theta_{10}^* + \theta_{11}^* c_c + \theta_{12}^* s_{a,0} + \theta_{13}^* s_a + \theta_{14}^* D_{b0}^r + \theta_{15}^* D_{b1}^r \qquad (16c)$$

Hereby λ and D are simultaneously optimized (solved) and include the WTP money needed. Inserting them in the initial objective function provides a residual objective function which is ready for bargaining with producers as dependent on parameters set. Finally for the (re-)construction of the FSA’s objective function (bargaining on stocking density) we use (17), where it is necessary to insert average density (see 17):

$$A = -\theta_{10}^*[D_b^a - D_b^r] + 0.5\theta_{11}^*[D_b^a - D_b^r]^2 \qquad (17)$$

Individual reduction request are d_{ci} and market share ζ_{ci}. Hence, things have to be broken down to contributions. Adding them and using a market-wide relationship

$$D_b^a = \gamma_{14}^* \sum_i \{c_{ci} - c_t\} + \gamma_{16}^* \sum_i d_{ci} + \gamma_{10}^* + \gamma_{11}^* \varsigma_{ci} + \gamma_{12}^* Q_t + \gamma_{13}^* + \gamma_{15}^* c_r + \gamma_{17}^* d_r \qquad (7')$$

we can now determine objective functions of FSA for bargaining (18).

$$A = \theta_{10}^*[\gamma_{14}^* \sum_i \{c_{ci} - c_t - s_{ci}\} + \gamma_{16}^* \sum_i d_{ci} + \gamma_{10}^* + \gamma_{11}^* \varsigma_{ci} + \gamma_{1x}^* x_i - D_b^r] +$$
$$0.5\theta_{11}^*[[\gamma_{14}^* \sum_i \{c_{ci} - s_{ci} - c_t\} + \gamma_{16}^* \sum_i d_{ci} + \gamma_{10}^* + \gamma_{11}^* \varsigma_{ci} + \gamma_{1x}^* x_i - D_b^r]^2 \qquad (18)$$

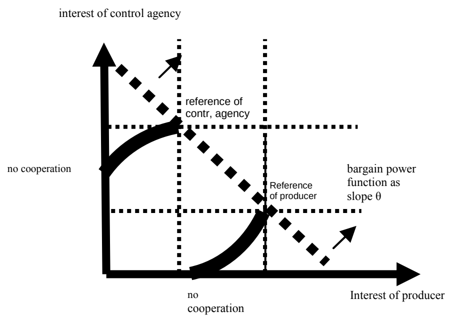
To summarize equation (18) is a function of (i) average costs c_{ci}; (ii) individual reduction request d_{ci} (associated with increase of costs); and (iii) market share ζ_{ci} (determined in negotiations with producers on the basis of delineating the marketing).

At an individual level, FSA addresses c_{ci} as dependent on d_{ci} and looks at changes: $c_{ci} - c_{ci,0} = \gamma_{ci} [d_{ci}-d_{ci,0}]$. Hereby inserting, the problem is reduced to negotiation on $c_{ci}- s_{ci}$. Stocking density d_{ci} and subsidy s_{ci} are linked via anticipated responses of individual producers (bargain partners). There is compensation and the market share is affected, as well as we have additional information on how s_{ci} stimulates ζ_{ci} at given $[\zeta_{ci}-\zeta_{ci.0}]=\gamma_{ci}s_{ci}$. This helps finding solutions. Then the broker's share is ζ_{bi} and the residual market share is ζ_{ir} plus ζ_{ic}. It adds to $(1- \zeta_{ci} - \zeta_{ri})$ which means $\zeta_{bi}+\zeta_r =1-\zeta_{ci}$; i.e. from producers' perspectives there are pressures to contract. Producers negotiate with the brokers and FSA in a quasi-competitive environment for services (low stocking). Variables (parameters in this jargon) are subject to behavioural optimization and bargain.

9 Bargaining as result

Having clarified on interest functions and modes of conduct, a bargaining modelling is feasible (Zusman, 1989). It is based on co-operative game theory (Harsanyi, 1993: explained in Diagram 4). Bargaining is modelled as optimization of interest and offers a power function simultaneously and theoretically. A power indicator λ is the slope.

Diagram 4: Political bargain model and power measurement



In practice, negotiations either with the broker/retailer (for premium meat without antibiotics and sharing) or with the FSA (for compensation for reduced stocking are conducted based on reference points. One can use principal-agent optimization (Furubotn, Richter, 2005) to get corners as reference. They depict alternative trading partners. Hereby, we resume a similarity to Zusman (1989). Power coefficients, derived from corners, exemplify a Nash game and offer coefficients $\Theta_{A,B}$ for "societal welfare" (see: 19):

$$W = [\sum_i \Pi_i] + \theta_B B + \theta_A A \qquad (19)$$

additionally: θ_i: power coefficients of A agency and B broker: The power of producers is $(1- \theta_A- \theta_B$

Finally, result (19), a "societal welfare function", can be optimized (Zusman, 1989) for parameters. Task is to determine references in bargaining as interest.

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