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# **Securing Food Quality in the Danish Broiler Supply Chain - an Economic and Organizational Study**

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# **Securing food quality in the Danish broiler supply chain – an economic and organizational study**

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## **Abstract**

Using the Danish broiler sector and an ongoing food quality project as a case study, the paper provides a discussion of how new food safety and food quality standards might be implemented. In the paper the design of new payment schemes is seen as an important part of the realignment of the poultry supply chain. The basic principles of such a new scheme is outlined and suggestions for a re-design of the incentive structures are discussed. Furthermore economic and organizational issues, related to the structural realignment of the supply chain raised by the development and implementation of a chain-wide HACCP system, are discussed. It is concluded that successful implementation of HACCP principles in a sector as a whole, not only is a matter of describing procedures and formulation of sanitary and safety requirements.

*Keywords:* HACCP, Broilers, Chain perspective, Incentive structures, Payment schemes, Vertical coordination, transaction costs

## **Introduction**

In 2003 a new project has been established in the Danish broiler production with the vision to develop a national food quality system, which should ensure that high quality and safe poultry products are produced at minimum costs in Denmark. Methodologically, the development of a food quality system will take its origin in the principles of Hazard Analysis Critical Control Points (HACCP) that are to be implemented at all stages in the supply chain. The developed quality system is required to have a high flexibility, both internally and externally. Externally in order to react to changing consumer attitudes, public regulation and market conditions. Internal flexibility should ensure that the individual actors have their own managerial autonomy.

The project is managed by the Danish Broiler Association in cooperation with producer groups, Department of Poultry Production – a subdivision under the National Danish Advisory Center, the poultry slaughterhouses Rose Poultry A/S and Danpo A/S, hatcheries, feedstuff companies, stable cleaning companies, Northern Jutland Center of Education, Bureau Veritas Quality International and Danish Research Institute of Food Economics (FOI). In total there are about 30 producers and 20 industry partners directly involved in the project activities.

Using the Danish broiler project as a case study, the aim of the paper is to consider the design of payment schemes and the associated economic and organizational implications of the development of a food quality system, which involve all stakeholders in the broiler supply chain from stable to table.

## **Background**

### *The Danish broiler sector*

With only 300 broiler producers, 2 slaughterhouses and about 136 million broilers slaughtered per year the sector is very small seen from an international perspective. The sector has been undergoing significant structural changes. Within the last 2 years the sector has gone from 4 to 2 slaughterhouses and from 4 to 2 hatcheries and there is now discussion of whether the remaining 2

slaughterhouses, Rose Poultry and Danpo, will be merged or bought by a larger actor within the food industry. The main reason for the speculations regarding further concentration and integration of the poultry sector are due to several years with losses and very low income.

The economic problems are related to the increasingly focus on food safety and quality in the sector. In 1996 an ambitious plan of how to deal with salmonella problems was formulated by the Danish poultry sector in cooperation with The Danish Veterinary and Food Administration. In order to fulfill the plan and achieve salmonella-free products the production process is now based on the following five keystones:

- Day-old chicks must be salmonella-free
- Feed and water must be salmonella-free
- The birds must live in a salmonella free environment
- The whole production/processing chain must be monitored
- Immediate action must be taken if traces of salmonella of any type are identified.

So at the start of the operation, the breeding chain is monitored to ensure that it is free of the pathogens. Parent flocks are tested every second week, hatching eggs being taken only from flocks that prove to be free of salmonella. If salmonella is detected, the flock is killed and any eggs that have been transferred to the hatchery are destroyed. The broiler producers have to abide by a number of stipulations regulating the rearing process. This involves the care of the stock, the water and feed supply, house hygiene, salmonella testing and the delivery of the birds to the slaughter house, as it is vital that the birds are grown in as salmonella-free environment as possible (Dorey, 2002).

As a result of these efforts the prevalence of salmonella in the flocks has declined from 30 per cent in 1995 to a salmonella-prevalence between 1 and 2 per cent in 2002 (The Danish Zoonosis Centre, 2003).

### *HACCP*

Simultaneously with the operation of the salmonella-plan, dealing with high campylobacter prevalence etc; the slaughterhouses have used significant resources in order to secure and document the general food safety and quality. The slaughterhouses are therefore systematically operated by the rules of the HACCP-system, which is widely used in the food industry to prevent food safety hazards and to ensure food quality (Unnevehr, 2000).

In addition to be operated by the HACCP-rules, the slaughterhouses are certified in different ways in order to meet the quality demands of their customers. Examples of these certifications are Danpo A/S being certified by EFSIS (European Food Safety Inspection Service) and to the BRC-standards (British Retail Consortium) (Danpo, 2004).

### *The project*

The efforts spend on the chain-wide salmonella plan; the campylobacter problems and the difficulties of making the sector profitable have initiated the quality project and the vision of developing a national food quality system based on the principles of HACCP.

The documentation and traceability provided by the slaughterhouses are mainly concerning the processing within the slaughterhouse and the actual measurable quality of the final product, whereas the effort regarding issues like food safety, food quality and animal welfare at the hatcheries and at farm level aren't documented in the same systematic way. In other words; formal documentation of what is done to prevent food safety hazards and to ensure product quality and animal welfare are needed for the whole production chain. By making a nation- and chain-wide HACCP-certification, including all stages and every activity in the broiler supply chain, it is the goal to be competitive in the future. By differentiating the Danish broiler products from international standards with respect to food safety and quality, future competitiveness should be achieved not only at the export markets, but also at the domestic markets, which is characterized by increasing imports from countries with lower food

safety standards. The reason is that the production costs are significantly higher in Denmark compared to other exporting countries like Brazil and Thailand.

The main activities of the Danish broiler project will be carried out during the project period 2003-2004, and include formulation of the sanitary and safety requirements concerning broiler producers, cleaning companies etc.; description of a national quality system for broiler producers at the farm level; development of educational programs for quality management towards producers, cleaning technicians etc; seminars with the focus on personal attitudes, responsibilities and teamwork; implementation of HACCP principles in feedstuff companies, primary broiler producers and brooding-houses; and authorization and certification of the broiler producers and stable cleaning companies. The Department of Poultry Production – a subdivision under the National Danish Advisory Center, coordinates these activities.

In addition to the adaptation of HACCP-principles it is a formulated goal to consider how the new standards can be implemented in the existing contracts primarily between producers and slaughterhouses. Thus, the design of new payment schemes is an important part of the realignment of the poultry supply chain. The basic principles of such a new scheme is given in the next section, whereas other economic and organizational issues related to the structural changes of the supply chain are discussed in the sections that follow afterwards.

### **Re-designing incentive structures**

Many of the innovative activities in the Danish broiler project involve issues such as leadership, trust building, sharing of information, communication and negotiations, mutual cooperation and competence development. By adopting a principal-agent model and other theories of industrial organization it is possible to analyze how such intangible mechanisms may increase efficiency and profitability of high quality agricultural supply chains, see e.g. Hennessy et al. (2001).

In order to ensure high flexibility in the quality system, the existing contracts must necessarily be adjusted. Based on analyses of information, risk and incentives the paper therefore presents ideas to a new multi component pricing system between broiler producers and slaughterhouses. The new contractual design should lead to a more optimal behavior, fair cost sharing, and ultimately increase the total profit in the sector (Bogetoft & Olesen, 2002).

We have as mentioned an environment of two principals and around 300 independent agents, each agent having his own characteristics and private information. Based on a simple adverse selection model we will therefore try to illustrate, what is needed of the contract system in order to introduce and maintain a food quality system. In the following food safety is considered as a quality parameter.

#### *The model*

Let's consider two types of broiler agents (producers), type  $\theta_1$ , and a type  $\theta_2$ . The agents' costs are a function of prices on input ( $w$ ), output quality ( $q$ ) and output quantity ( $y$ ) for type  $i$ :  $c_i(y, w_i, q)$ , where  $\partial c_i / \partial q > 0 \wedge \partial^2 c_i / \partial q^2 > 0$ . Type  $\theta_1$  has higher marginal cost of quality for instance due to older production facilities:  $\partial c_1 / \partial q > \partial c_2 / \partial q$ .

The principal's (slaughterhouse's) value of the supplied chickens, the reservation price  $R$ , is a function of the output prices ( $p$ ), the other input prices ( $w_s$ ), the quality ( $q$ ) and the quantity ( $y$ ):  $R(p, w_s, q, y)$ . The reservation price has a positive but decreasing marginal value of quality:  $\partial R / \partial q > 0 \wedge \partial^2 R / \partial q^2 < 0$ . Thus we have a situation as illustrated in figure 1.

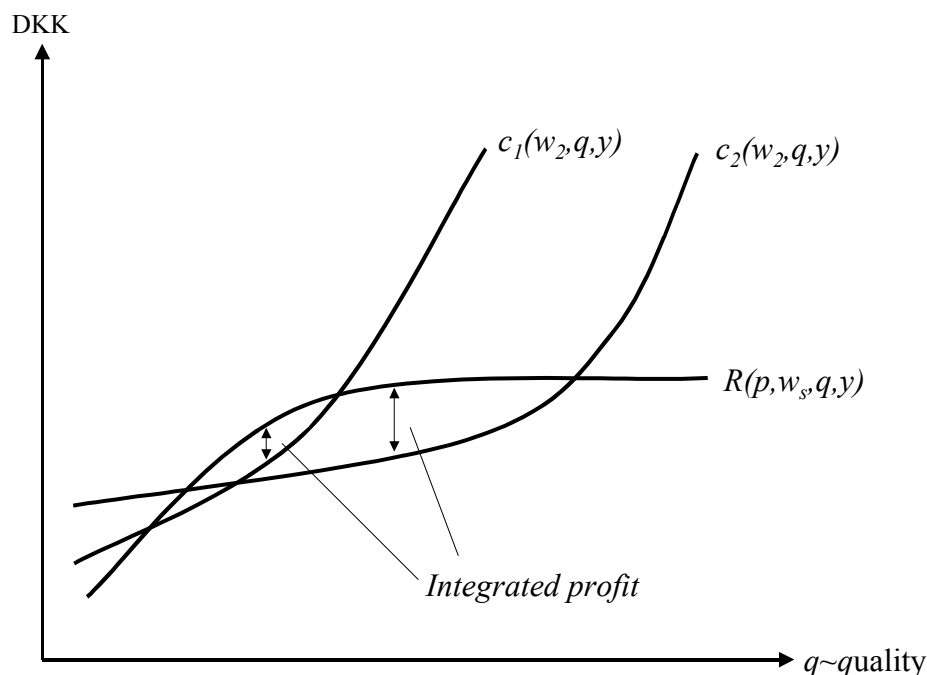


Figure 1. Costs and reservation price for broilers

The “regular” approach for this model is for the principal to maximize his profit under restriction of the agents’ individual rationality constraints (IR) and incentive compatibility constraints (IC). This typically results in a self-selecting equilibrium, where the principal offers two types of contracts; one for low quality and one for high quality. The low quality contract is chosen by the agent with high cost of quality, type  $\theta_1$ , and he only get a payment matching his cost, and so the principal receives all the profit. The high quality contract is to be chosen by the agent with lower cost of quality, type  $\theta_2$ , but the principal have to pay more than the cost, for him to choose that contract (Salanié, 1997). This optimization might result in a situation, where the contract for the low quality, has lower quality than the first-best solution, because it is optimal for the principal to lower the incentive for the type  $\theta_2$  to choose this contract (Tirole, 1988). However it might also be the case, that the cost of avoiding personal arbitrage for type  $\theta_2$  is higher than the benefits for the principal. Depending on the cost functions, the share of type  $\theta_1$  and  $\theta_2$  producers (and all the other possible types), the uncertainty associated with quality and transaction costs in general it therefore might be optimal for the principal only to offer a single contract for a relative low quality.

This might very well be the case for the Danish broiler slaughterhouses. The current contract for both slaughterhouses has more or less the design as shown in Table 1. Our estimate is that more than 80 pct. get all (or almost all) of the quality bonuses, and in reality there is only one quality to choose. Thus it is reasonable to conclude that the principal is not trying to differentiate between agents, and some of the integrated profit is lost.

Both the slaughterhouses and the producers have in recent years had pour profitability, and there seems to be a general understanding of the need for more cooperation. Thus development of a national broiler HACCP-system is an attempt to increase the integrated profit by raising the quality. An appropriate strategy may be to increase the quality for especially the type  $\theta_2$  producers.

Table 1. Average contract for broiler producers\*

Basic Price	4.15	DKK/kg
Contract bonus	0.15	DKK/kg
Special cost compensation**	0.05 - 0.20	DKK/kg
Quality bonus***	0.05 - 0.20	DKK/kg

\* Apart from some additional rules for weight

\*\* Compensation for GMO-free feed, special breeding brands, UK-rules, etc.

\*\*\* Bonus for special procedures, salmonella and Campylobacter free. Note: Danpo A/S has a special bonus in connection with campylobacter that we will comment on later.

### *Quality and uncertainty*

If we are taking a closer look on quality there is a problem with uncertainty, and this might be the reason behind the choice of relative low quality. If we look at the cost function  $c_i(y, w_i, q)$ , you cannot really decide the precise quality you produce. You might decide to try to get a certain quality and use different input e.g. feed, supervision and cleaning according to that, but it is uncertain if you actually get that quality or not. It might be higher or lower. The cost function therefore also has a random part connected to quality:  $c_i(y, w_i, q) + \varepsilon_q$  (Analogous you could use the same reasoning with output,  $y$ ). It is therefore not optimal for an agent to produce a higher quality, if the principal is only paying the expected marginal cost, since the agent then will carry more risk. One solution could be to make the incentives stronger by offering a larger payment, but if this might not be optimal for the principal especially if the margin is small. This uncertainty could therefore as mentioned also be part of the explanation for the absence of higher quality in Danish broiler production.

The slaughterhouses are of course aware of this problem and have already tried some ad-hoc alterations. Danpo A/S have for some years had bonuses for campylobacter free broilers, but even though they recommended some relatively small production adjustments for the producers, only a few producers made these adjustments. Danpo A/S then redesigned the bonus adjustment, so that the production adjustments themselves triggered a bonus, and at the same time this was prerequisite to get the high levels of bonus for campylobacter free broilers. The result was, that almost all producers now have made the adjustments (Holten, 2003).

A possible solution could therefore be to introduce bonuses paid for the direct effort of the agents. Some parameters could easily be measured, while other things are more difficult. Thus for some control points there could be a moral hazard problem, and these effort bonuses can not stand alone. The principal needs some certainty of the actual quality, so the bonuses must also be based on direct measurement of the quality. Our proposal is therefore a contract system with larger proportion of bonuses that is based on a mixture of measurements of the effort and of the direct quality.

In reality there is a whole range of different producers with different marginal cost of quality. To get a common optimal solution, where all the agents are producing their optimal quality, the bonus system must match this range. We imagine a bonus system, where a producer is given points between 0 and 100. 100 points triggers a maximum bonus and e.g. 70 points triggers 70 pct. of the maximum bonus. Table 2 illustrates this system.

The key feature for the suggested bonus system is to give clear signals to the producers of which parameters affects the slaughterhouses' marginal value of the quality. This might not look as different from the current payment scheme as indicated, but the suggested new system will differ from the existing in several ways.

Table 2. Bonus system based on points

<b><u>Measurements of the actual quality</u></b>	
25	<b><i>Zoonosis</i></b> ( <i>Coli, Salmonella, Campylobacter, etc.</i> )
10	<b><i>Meat quality</i></b> ( <i>Pct. fat, PH, etc.</i> )
<b><u>Measurements of the effort</u></b>	
30	<b><i>Hygiene</i></b> ( <i>HACCP, Cleaning procedures, etc.</i> )
25	<b><i>Production facilities</i></b> ( <i>House standard, ventilation, feeding system, etc.</i> )
10	<b><i>Animal welfare</i></b> ( <i>hock singeing, maximum weight per m<sup>2</sup>, etc.</i> )
100	Maximum points

The first step into the new bonus system is to admit and signal the value of different producers producing different quality. This implies the scale with bonus points being made in such a way, that it clearly shows which parameters are valuable to the slaughterhouse and so that it isn't almost every producer that gets maximum points. In fact almost none of the existing producers should be able to achieve the maximum without additional effort. Furthermore this means, contrary to the current payment scheme, that the range of prices given to different producers has to quite large; saying some will be paid less than today and some will be paid more. In order to implement the new system it might be necessary to lower the basic price, so that a larger share of the total payment will come from the bonus system.

### **Economic consequences and organizational requirements**

Implementing a chain-wide quality system by adaptation of intangible mechanisms is expected to incur new types of costs and benefits (Velthuis et al., 2003). In investigating these costs and benefits a qualitative approach is adopted, which is theoretically grounded on transaction costs economics (Williamson, 1985). Thus, by implementing a HACCP system in the whole chain such aspects as asset specificity, uncertainty and opportunistic behavior need to be discussed.

Furthermore, due to the implementation and operation of the adopted HACCP-system organizational requirements and suggestions for "chain-optimization" are discussed as well as the vertical coordination and ownership structure of the sector.

#### *The organization and ownership structure of the broiler sector*

Independent and private owned actors along the production chain characterize the Danish sector. There is only little vertical integration, implying that the producers are individual and privately owned farm-households and the hatcheries and the slaughterhouses are all investor owned firms. On the other side there is a tight vertical coordination along the entire production chain with a very detailed long term scheduling of when day-old chicks are transferred to each rearing house, numbers of days for rearing, exact dates for slaughtering etc.

Aust (1997) investigates the US broiler industry, which, as the Danish broiler sector, mainly is based on contractual cooperation between the producers and the slaughterhouse. In her economic analysis it is revealed that the most important reason for the tight coordination is caused by uncertainty due to asset specificity.

Rhodes (1995) also uses the US broiler industry as an example of an agricultural production where the market is out performed as an efficient regulation mechanism and substituted by hybrids or the hierarchy. The cause is according to Rhodes that Just-In-Time is decisive in modern broiler production where each stage from the brooder to the slaughterhouse operates within the same tight calendar. Any deviation from this time schedule might result in animal welfare problems and higher production costs through the whole chain.



The need for coordination is increasing everywhere just in time is a key issue. Agricultural products such as fluid milk and different kinds of fruits and vegetables are all examples of products that must be delivered to the final consumers in fresh conditions (Boon, 2001). Should this be achieved with perishable products it is necessary to coordinate production and marketing throughout the whole chain. Without coordination a high degree of waste must be expected in some period while it will be impossible to fulfill consumer demands in other periods.

The explanation for the tighter collaboration in the broiler production is not the perish ability of the processed products as the majority of the slaughtered chickens are cooled down and therefore have an extended durability. The need for coordination is rather that the chicken houses are filled and emptied at the same time. Just a few days extra delay either in the brooder or in the stable may reduce the capacity utilization on the farms and in the end in the slaughterhouse. A constant flow of deliveries is necessary to optimize the utilization of the slaughter capacity.

When implementing a chain-wide HACCP-system in order to ensure that high quality and safe poultry products are produced at minimum costs, it is necessary not only to focus on day to day management procedures but also focus on more strategic issues such as at the organization and coordination of the entire production chain. In the project there are excellent opportunities to do so as all stakeholders of the production chain are represented. With this in mind a transaction cost perspective is considered useful, arguing that economic organization is a matter of minimizing the sum of both the production and the transaction costs.

#### *“Chain optimization” - a transaction cost perspective*

Søndergaard & Lund (2002) consider the economic implications of adopting HACCP principles in the whole supply chain of egg production in Denmark. By use of transaction cost economics and other theories of industrial organization they focus on the organizational and contractual consequences for the different agents in the value chain. The analyses indicate that an implementation of HACCP in the entire Danish egg sector do not require a more vertical integrated structure in the sector although the degree of asset specificity will increase slightly and there may be higher risks of hold-up situations. It is concluded that such moral hazards can be minimized by use of neoclassical contracts, which allow for sufficient flexibility.

It is likely to assume that the same conclusions can be reached, when looking at the broiler sector, as the ownership structure of both sectors have some similarities. However, the tight vertical coordination and hereby control of the size of the production in the broiler sector is quite different from the egg sector. Reasons for this different is assumed be the very “tight calendar” as described above.

Due diligence is traditionally expected to increase transaction costs along the supply chain. However, Ziggers (2000) points out that though HACCP is a management tool to control food safety and quality, it also contributes to process improvement and reduces transaction costs, which combined will contribute to competitiveness (Ziggers, 2000).

From our point of view these general expectations of what are the potentials when implementing quality assurance standards, might relatively easy to achieve internally within a single firm. When including all stakeholders of the broiler production chain it is not reasonable to believe that these potentials can be reached easily without increasing the transaction costs.

#### *Make or buy?*

The statement above may lead to the conclusion that we expect vertical integration of the entire chain to be the optimal solution and necessary for a successful HACCP implementation. That is not the case.

Often the imperative of organizational economics as formulated by Williamson (1985) has been viewed primarily as a question of integration of asset ownership or not. Langlois and Robertson (1995)

point out that there are two aspects which to analyze the vertical organization of economics activities. One aspect is the degree of ownership integration; the other is the degree of coordination integration (see figure 2).

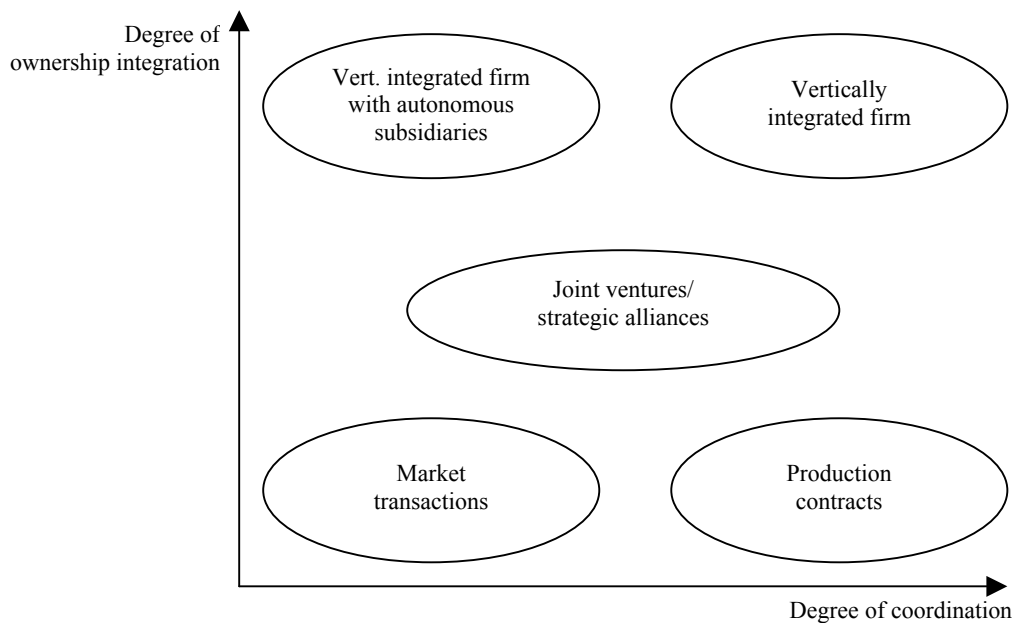


Figure 2. The degree of ownership integration versus coordination integration (Langlois and Robertson, 1995)

We understand the integration problem as a question of how to secure that every actor along the entire production chain has the right incentives; first of all to participate in documenting food safety and food quality, but also to be flexible and willing to move towards future goals set up for the outcome of the production. Solving this problem is not just a matter of vertical integration; it is primarily a matter of the characteristics of the adopted governance structure (Williamson, 1991).

## Conclusions

When adopting HACCP principles in a sector as a whole, it is relevant to ask if there is a risk of excluding actors in some stages of the supply chain? On the other hand it is reasonable to assume that if everyone should be able to participate, the quality standards have to be set on such a low level that there might be no argument for certification at all.

Re-designing the incentive structures as suggested by setting up a new bonus system allows different producers to make different efforts and to produce different quality, and at the same time giving clear signals of what kind of quality and securing of food safety is wanted in the future..

In the Danish project the HACCP-requirements will be developed in such a way that none of the participating stakeholders will be excluded. The argumentation is that the sector is already among the leading countries, when it comes to securing food safety. The goal is therefore primarily to document the existing high food safety standard.

The suggested bonus system offers opportunities to increase or change standards by adjusting the points given to different efforts or measured quality. Hereby a proper use of the bonus system is also to make it clear that some qualities aren't valuable. This may necessarily imply that some producers might be excluded in the future, as they can't produce the wanted quality in a profitable way. The bonus system should also be used to secure an ongoing improvement of food quality; although some

additional quality parameters aren't valuable at the moment, it might be valuable in the long run to add some possible extra bonus points in order to give the best producers incentives to do better. Otherwise it would be even more difficult to obtain a leading market position and be more competitive in the future.

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