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Technical and economic considerations about traceability and certification in livestock production chains

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Introduction

Food-safety scandals such as the dioxin crisis in the poultry sector, the MPA crisis in the pork sector and the BSE crisis in the beef sector have created or strengthened consumers' belief that food can be unsafe. A major aspect of the scandals was that the contamination was not immediately detected. Furthermore, after detection the exact source of contamination was hard to find within a reasonable time. As a consequence, there was distrust in the safety of the food that was still in the food stores.

In January 2000, the European Commission outlined radical new principles for food safety in its White Paper on Food Safety (*White paper on food safety* 2000), a few months later specified in a proposal for new food-safety hygiene rules (*Health and consumer protection directorate-general, 2000*). These rules state, among others, that food safety is the primary responsibility of food producers. Linked to this, there is an obligation for non-primary food operators to implement HACCP (Hazard Analysis of Critical Control Points) systems and for farmers to implement sector-specific Codes of Good Hygienic Practice. Furthermore, it is stated that all food and food ingredients should be traceable and that proper recall procedures should be in place for food that might present a serious risk for consumers' health.

The food-safety hygiene rules do not mention the need for certification of 'good manufacturing practices'. Still, certification of the type of systems required by the hygiene rules is becoming increasingly important. Figure 1 illustrates the relationship between the food-safety hygiene rules issued by the European Commission and the (accredited) standards used for certification by certification services. The figure shows that (from left to right) the food-safety hygiene rules lead to regulatory standards at country level and, next, to food-safety and hygiene systems and traceability systems at company and chain level. National surveillance and control services monitor whether these systems fulfil the regulatory standards. Besides, the systems can be certified by public or private organisations using (accredited) standards.

This paper focuses on the right-hand side of Figure 1 and more specifically on traceability and certification. The goal of the paper is to analyse the status and perspectives of traceability systems and certification schemes and to review their potential costs and benefits. The following two sections describe purposes, requirements, status and perspectives of traceability systems and certification

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schemes, respectively. Then there is a section discussing potential costs and benefits, followed by a comprising section with the conclusions and an economic research agenda for the field of traceability and certification in livestock production chains.

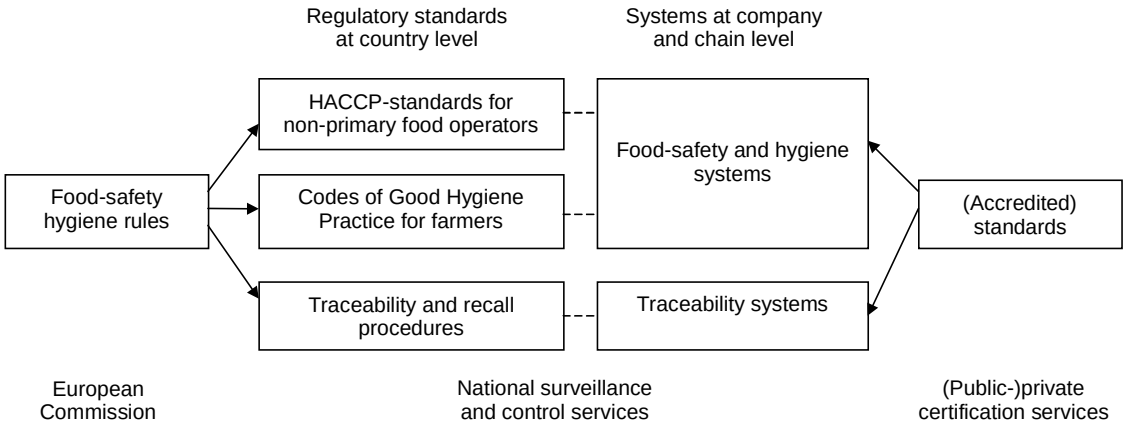

Figure 1: Relationship between the food-safety hygiene rules and (accredited) standards used for certification.

Traceability systems

Definition, purpose and requirements

A traceability system provides a set of data about the location of food and food ingredients along the production chain. Data relate to both the 'where' and 'when' issues. There are various relevant understandings. *Tracing* is the ability to trace food and food ingredients back along the production chain, i.e., from the end user to the producer and even to the suppliers of the producer. Tracing is aimed at finding the history of a product, for example to allocate the source of contamination. *Tracking* refers to the ability to track food and food ingredients forward along the production chain. Tracking can be used to find and recall products that might present a serious risk to consumers' health. *Identity preservation* is the set of measures taken to preserve and communicate the exact identity and source of food and food ingredients to the end user.

Traceability systems can be set up with different purposes in mind. For instance, to increase transparency in the production chain. More transparency is likely to increase consumers' trust in food safety due to the increased amount of information about, among others, production processes, food-safety controls, animals' living conditions and the use of medicines. Increasing transparency is also likely to enhance the actual level of food safety as a result of the improved information flows throughout the chain. Another purpose of implementing a traceability system can be to reduce the risk of liability claims: a proper traceability system is a valuable tool for companies to counterattack liability claims and to recoup claims from other participants in the production chain. Traceability systems can also be developed to improve recall efficiency. With an adequate system, the quality of recalls can be improved, which reduces costs and enhances the image of the production chain. These benefits can also be attributed to traceability systems that enhance the control of livestock epidemics.

For a traceability system to be adequate there are a number of requirements. First of all, all partners within the production chain should be identifiable – also small producers and hobby farmers. The latter is especially important if the traceability system is also used for the control of livestock epidemics (Disney et al. 2001). Secondly, there should be a unique animal identification system (McKean 2001), usually changed into an identification system for batches of animals as soon as the processing level is reached. Thirdly, an adequate traceability system requires a credible and complete (in the sense of what has been agreed on) information transfer along all participants of the production chain.

Current status

Three different types of traceability systems can be distinguished. These are outlined in Figure 2. In system "A", each link in the production chain gets its relevant information about the former link from the former link. The advantage of this type of system is that the amount of information to be communicated remains small, which reduces transaction costs. The disadvantage is that this system is largely based on trust. Each link has to trust the former link on the quantity and quality of the information passed. Furthermore, in case of an emergency, all links need a perfect administration in order to act fast.

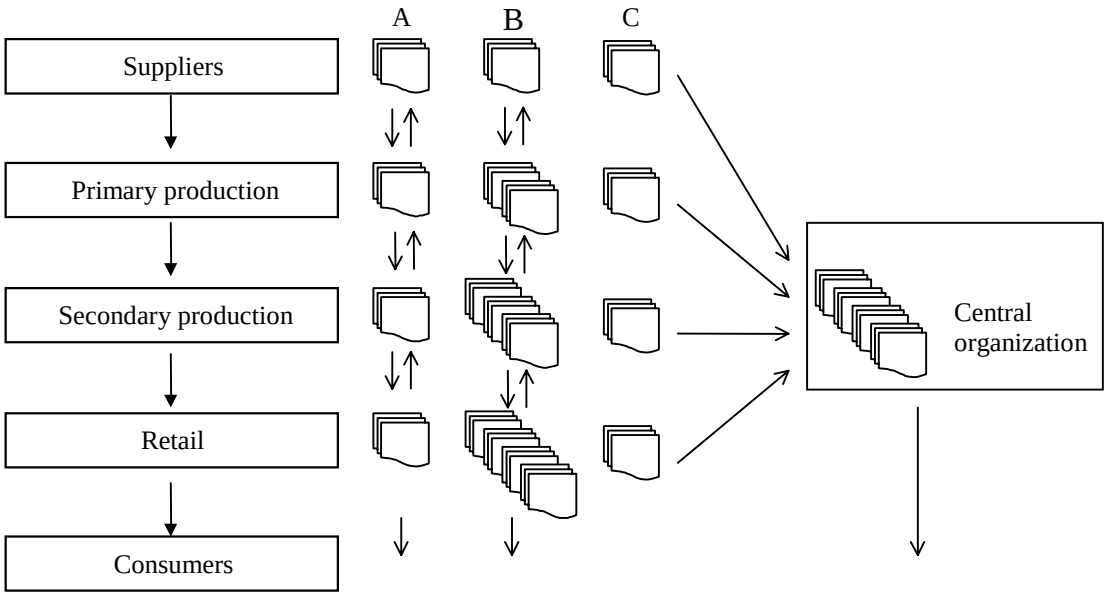

Figure 2: Traceability systems in production chains.

In system "B" each link gets the relevant information about all former links from the former link. With these systems, the speed at which tracking and tracing can be handled is much higher than with systems of type "A". Moreover, because each link in the chain receives all other information, the information can be controlled on completeness. Also the chain's transparency seems larger than with system "A". A disadvantage is that the amount of information to be transferred increases per link.

In the third type, system "C", each link of the production chain provides the relevant information to a separate organisation, which combines the information of all links in the whole production chain. Such organisation can solve the matter of trust. Also, tracking and tracing can in principle be carried out rapidly. Moreover, since the

organisation is dedicated to the system, the danger that the system is not well maintained because of lack of time or other resources is minimised. On the other hand, total costs may be larger.

An example of a traceability system of type "C" can be found in the European beef industry. Due to the BSE crisis, the beef industry put into place a basic version of a traceability system: each package of beef contains information about the country of origin of the animal, the country of growing, the country of slaughtering and the country of butchering. To provide this information, individual countries have identification and registration (I&R) systems in place. In the Netherlands, for instance, each cow receives a unique life number at the moment of birth and two yellow ear tags on which this number is visible. The unique life number is registered at a central database together with some additional information, such as the unique farm code of the farm of birth. When the calf or cow leaves the farm, this has to be registered by both the delivering and the receiving party through the use of an automatic voice-dialling system. In this way, a cow can be traced back and tracked forward at any moment in time. In the UK, the ear tags are combined with a cow passport, which accompanies the cow for its whole life (Pettitt 2001). A same sort of system is also in place for pigs. However, pigs are registered on batch level, using earmarks with a unique farm number.

Future perspectives

In the near future radio-frequency identification devices (RFID) might replace the ear tag system for different types of farm animals. With RFID, the compliance and usability of I&R systems is likely to be improved (Ribó et al. 2001). In the Netherlands, the economic feasibility of RFID systems for cattle, pigs, goats and sheep is under investigation. A further technique – already applied on a small scale – is that of biological markers. Using DNA strains from individual animals it becomes possible to trace back (combined) meat products to the individual animals as long as the DNA structure has not been damaged due to treatment such as heat (Cunningham and Meghen 2001). Immunological identification seems a promising technique to identify batches of smaller animals such as chickens. With this technique animals respond to the treatment with some known protein. An advantage of techniques like immunological identification and the use of DNA is that it is possible to assess the identity of (batches of) animals at any part of the body. Furthermore, the identity of animals cannot be changed by illegal handling by humans.

Besides new techniques to advance traceability systems we also expect some new applications. One of them might be the logistic slaughtering of animals based on historical data about the prevalence of microbiological contamination of the animals or farms, for instance with respect to *Salmonella*. A further additional application includes more detailed assessments of animal-breeding values based on information about the production and offspring of individual animals. Traceability systems may also be used in the future for the inclusion of extra information, for example with respect to the primary production circumstances of animals. Such additional information enhances product differentiation and branding.

Certification

Definition, purpose and requirements

We define certification as follows: certification is the (voluntary) assessment and approval by an (accredited) party on an (accredited) standard. As this definition shows, certification is a very broadly used term. However, it certainly involves an assessment and an approval on some standard. The 'approval of good practice' distinguishes certification from the activities by national surveillance and control services (Figure 1), which do not go any further than only evaluating if implemented systems fulfil the regulatory standards.

Certification is, in general, voluntary. However, there are also cases in which it is 'quasi-voluntary'. For example, if it is a customers' requirement or if there are price disadvantages from not participating in a certification scheme (Payne et al. 1999; Bredahl et al. 2001). Also risk-financing organisations, such as banks and insurance companies, may require some form of certification in their underwriting policy (Bullens, Van Asseldonk and Meuwissen 2002; Skees, Botts and Zeuli 2002). In relation to the certifying party and the standard used for certification, it can be stated that if an accredited standard is used, the certification procedure needs to be carried out by an accredited party (Tanner 2000). All other type of standards can be certified by either accredited parties, (other) third parties, such as product boards and interest groups, or customers (also called 'second parties'). Figure 3 gives an overview of the various certifying and certifiable parties in the livestock production chain. The dotted line linking "accredited party" with "other third party" and "second party" refers to the fact that an accredited party can be employed by any other party to carry out certification audits.

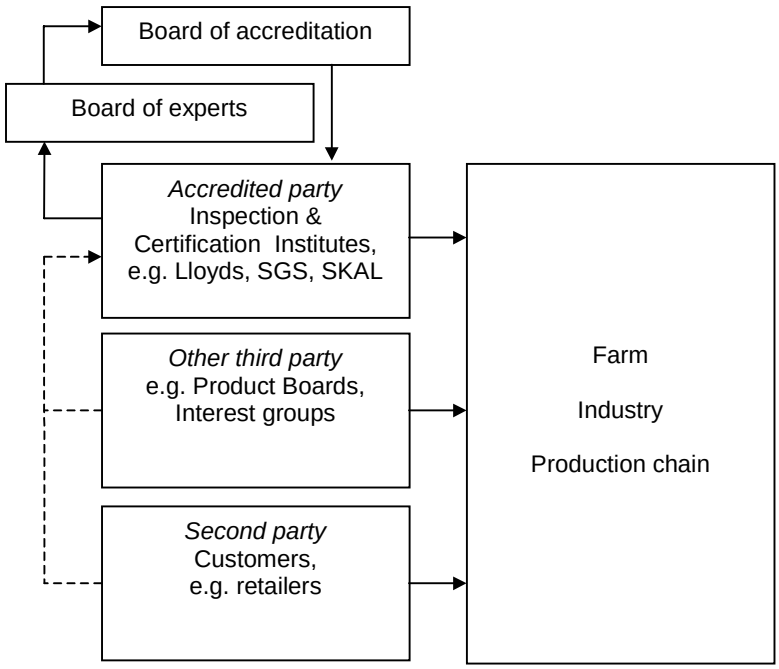

Figure 3: Certifying parties (left) and certifiable parties (right) in livestock production chains.

The purpose of certification is to reach a defined performance and to make this perceptive to stakeholders. Stakeholders may include consumers, other customers, governments, risk-financing parties such as banks and insurance companies, and society as a whole. Also the company itself can be a stakeholder, since certification of food-safety and traceability systems gives organisations a tangible approval of good practice and a tool for due-diligence defence in case of product safety (see for instance (Buzby and Frenzen 1999; Henson and Holt 2000)).

For stakeholders to regard certification as a valuable tool, they must trust the certification scheme as well as the certifying party. Also, there should be regular tests or audits (usually specified in the certification scheme) to verify whether the certified party still reaches the agreed performance level.

Current status

Many certification schemes fit in the context of the food-safety hygiene rules (Figure 1). For each of the certifying parties, Table 1 lists a number of examples.

Table 1: Examples of certification schemes from different certifying parties and, if relevant, underlying ISO guidelines.

Certification schemes by	**ISO guide**
Accredited parties	
BRC (British Retail Consortium)	39 (65?)
SQF-1000 (Safe Quality Food on farm level)	65
SQF-2000 (Safe Quality Food on industry level)	65
EKO (organic)	65
EUREP-GAP (Good Agricultural Practices)	65
Sector-specific Codes of Good Hygiene Practice	65
Identity Preservation	65
Criteria for the assessment of an operational HACCP system*	62
ISO 14001 on environmental issues	62
ISO 9001:2000 on quality	62
OHSAS 18001 on occupational health and safety	62
HALAL (Islamic)	62
Other third parties	
Integrated Chain Control (PVE/IKB) for pigs	-
Chain Control Milk (KKM)	-
Good Manufacturing Practices (GMP)	-
Good Veterinary Practices (GVP)	-
Second parties	
“Ahold-approved organic-pork supplier”	-

*The HACCP-criteria are certifiable under the Dutch Board of Accreditation. A world-wide certification of HACCP is in progress, i.e. ISO22000.

For the certification schemes used by accredited parties, also the ISO (International Organization for Standardization) guideline under which they resort is mentioned. Schemes based on ISO 39 (such as the current version of the scheme from the British Retail Consortium) are inspection schemes, based on a checklist and in principal only valid on the day of inspection. ISO 65-based schemes, such as EKO (a Dutch certificate for organic products), are product-certification schemes in which products as well as processes are tested on specified standards. Certification schemes

based on ISO 62, such as ISO 9001:2000, are system-certification schemes. They use system requirements to evaluate complete management systems. The Dutch Integrated Chain Control (PVE/IKB) and the Chain Control Milk (KKM) are examples of certificates issued by 'other third parties'. An example of a customer-issued certification scheme is the 'Ahold-approved organic-pork supplier'. Most schemes have some requirements with regard to traceability. A scheme specifically focusing on the issue of traceability is Identity Preservation.

Since product- and system-certification schemes do not use straightforward checklists, individual auditors' interpretations become increasingly important with these types of schemes. For instance, in the EKO certification scheme for livestock production it is stated that 'pig-breeding systems should allow sows direct access to the soil (..) except where bad weather or unsuitable soil conditions make housing preferable'. An auditor has to judge whether the housing circumstances at a farm fulfil these requirements. A clearer requirement in the EKO certification scheme is that 'the maximum number of laying hens that can be kept in one group is 3000'. As an example of system certification, the HACCP criteria require 'to identify hazards' and subsequently 'to carry out risk analyses'. Controls by the Board of Accreditation (Figure 3) prevent large interpretation differences between individual auditors.

In Figure 3 it can be noted that also production chains can be certified. However, if a production chain consists of multiple legal entities, as is often the case in livestock production chains, there are only limited opportunities for certification. From a second-party point of view there is a practical limitation of certifying production chains: if a chain consists of multiple entities there is no single addressing point. For 'other third parties' there are in principle no limitations (compare KKM and PVE/IKB), but these certificates are not based on accredited standards. Attaining accredited certification schemes seems to be increasingly important for production chains for reasons of credibility. However, accredited certification schemes based on ISO 62, such as the HACCP criteria and ISO9001:2000, only apply to legal entities. Furthermore, accredited certification for each individual chain participant (either under ISO 62- or ISO 65-based certification schemes) is very costly for production chains in which there are many small enterprises (see for instance (Unnevehr and Jensen 1999; Taylor 2001)). As an alternative, product-market organisations can be set up and certified by an accredited party. This is illustrated in Figure 4.

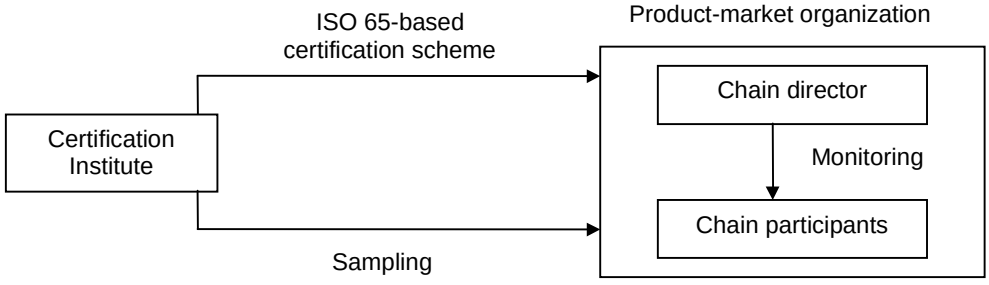

Figure 4: Accredited certification of a product-market organization.

Accredited certification of a product-market organisation has a number of characteristics. Firstly, there is one chain director, for instance a slaughterhouse, product board, or, even possible, a single farmer. Secondly, the certification scheme is issued to the chain director for the full scope of the chain. Thirdly, chain participants are monitored by the chain director and sampled by the certification institute. And fourthly, certificates are restricted to ISO 65-based schemes since these do not require

single legal entities. A rather similar approach to certify farms was described by Mazé, Galan and Papy (Mazé, Galan and Papy 2002) under the term “pyramidal certification systems”.

Future perspectives

Elaborating on current developments, we argue that the importance of certification will further increase. Governments increasingly shift responsibilities to companies under the initial assumption that certified products, processes and systems are in conformity with regulatory standards. In practice, standards used for certification even go beyond the legislative provisions. Certification will also become more important when due diligence becomes increasingly important.

We furthermore expect that the role of retail organisations will increase, leading to standards such as EUREP-GAP (Good Agricultural Practices), introduced by the European retailers’ organisation. Benchmark models such as GFSI (the Global Food-Safety Initiative, set up by the International Food Business Forum) assist in ‘standardising the standards’ so that it remains possible to oversee the increasing number of standards and certification schemes.

Costs and benefits

Table 2 gives an overview of the costs and benefits of food-safety and hygiene systems (FS&H), traceability systems (T&T) and the certification (Cert.) of these systems, from both the industry and consumer perspective. Food-safety and hygiene systems are included here separately in order not to mix the costs and benefits of a system on the one hand and the certification of such a system on the other hand. The table does not distinguish between the various participants of the production chain, or between the various types of systems and certification schemes.

Since most items in Table 2 are fairly straightforward or were already discussed in the previous sections, we focus here on the three aspects: the positive effect on trade, the enhanced license to produce and the price premium. These aspects are mentioned important for food-safety and hygiene systems, as well as traceability systems and certification. The magnitude of the discussed aspects is debatable.

The positive effect on trade is attributed to the fact that food-safety and hygiene systems and traceability systems are an indication of the quality and background of a product for the various (national and international) trading partners involved. Certification further facilitates the communication about the product. The exact size of the trade effect, however, will depend on the extent to which trading partners trust each other’s systems and certificates. There will be fewer problems of trust when international (ISO) standards and accredited certification institutes are involved. Also, the issue of trust can be solved (at extra costs) by in-country inspections or controls at the border (Unnevehr 2000).

With respect to the ‘license to produce’, stating that this license is enhanced by introducing the type of systems and schemes under consideration is probably true. But the question is for how long: as soon as the public is used to the upgraded market, new requirements are likely to be introduced. Discussions on the ‘license to produce’ became actual in countries like Germany and the Netherlands, following the epidemics of BSE, foot-and-mouth disease and classical swine fever.

Table 2: Potential costs and benefits of food-safety and hygiene systems (FS&H), traceability systems (T&T), and certification (Cert.), subdivided into industry and consumers*.

	Costs	Benefits
Industry		
FS&H	– Implementation: development, training, capital purchases – Maintenance: verification and validation, analyses, record keeping, operating processes	– Improved internal efficiency: improved agreements, explicitness about tasks, responsibilities and authorities of employees – Less failure, i.e. recall, closure, scrap and liability costs – Positive effect on trade – Enhanced 'license to produce' – Price premium
T&T	– Implementation: transforming production process, less flexibility, automation, extra storage capacity, production materials, personnel and documentation – Maintenance: audits	– Increased transparency of production chain – Reduced risk of liability claims – More effective recalls – More effective logistics – Enhanced control of livestock epidemics – Positive effect on trade – Enhanced 'license to produce' – Price premium
Cert.	– Implementation – Maintenance: audits	– Lower transaction costs from supplier Identification, contract negotiation, verification and enforcement – Enhanced access to insurance and finance – Effectuated due diligence – Positive effect on trade – Enhanced 'license to produce' – Price premium
Consumers		
FS&H	– Price premium	– Enhanced level of food safety
T&T	– Price premium	– Enhanced level of food safety
Cert.	– Price premium	– Enhanced level of food safety – Lower transaction costs

*Based on, among others: (Caswell and Hooker 1996; Roberts, Buzby and Ollinger 1996); (Bredahl and Holleran 1997); (Crutchfield et al. 1997); (Early and Shepherd 1997; Jensen, Unnevehr and Gomez 1998); (Jensen and Unnevehr 1999); (Golan et al. 2000); (Henson and Holt 2000); (Unnevehr 2000); (Bredahl et al. 2001); (Bullens, Van Asseldonk and Meuwissen 2002).

In relation to consumers paying a price premium for food-safety related systems and certification schemes, there is also uncertainty involved. In general, food safety is perceived as important, in particular in developed countries (Unnevehr 2000). Even more, consumers are generally willing to pay an extra price for safer food (see for

instance (Henson 1996)). However, literature with respect to consumers' interest in the underlying systems resulting in the safer food, becomes less convincing. Walley, Parsons and Bland (Walley, Parsons and Bland 1999) state that it cannot be concluded that consumers are willing to pay for quality assurance. Gellynck and Verbeke (Gellynck and Verbeke 2001) found that traceability is perceived as important, but especially with respect to functional attributes, such as the monitoring of chains and individual chain-participants' responsibility in case of abuses. With regard to certification, Vastola (Vastola 1997) concluded that "consumers' attitude towards certification is twofold: while declaring their willingness to pay a higher price for a certified produce, when faced with the choice among different produces it is economic convenience that matters, not the presence of certification". Blend and Van Ravenswaay (Blend and Van Ravenswaay 1999) also support this conclusion. Literature thus supports our impression that it is not clear-cut whether participants in the livestock production chain receive a price premium for implementing food safety, hygiene and traceability systems and for certifying them.

Besides the debatable magnitude of some specific aspects, a relevant consideration in estimating the size of all costs and benefits listed in Table 2 is the definition of the reference point, or, the 'without project alternative' (Belli et al. 2001). A main aspect in this relates to the type of systems already in place. For instance, additional costs and benefits of implementing a HACCP system can expected to be less if there is already some sector hygiene code in place. Also other characteristics of the livestock production chain, such as the structure of the chain under consideration, will affect the size of costs and benefits (Golan et al. 2000). For instance, in the Netherlands implementing a traceability system in an integrated chain such as the veal chain will be less costly than implementing a similar system in a patchy and dispersed chain such as the dairy-cattle sector. A further relevant aspect is the size of farms and industries involved. Costs are likely to be non-linear, i.e. there is a possible comparative disadvantage for small and medium-size companies, as also denoted by Unnevehr and Jensen (Unnevehr and Jensen 1999) and Taylor (Taylor 2001).

Conclusions and economic research agenda

From our findings we conclude that there are numerous perspectives for traceability systems in livestock production chains and that the importance of certification schemes in these chains is likely to increase further. We furthermore conclude that there is in general much more attention for the more technical issues of traceability and certification than for economic considerations. We therefore would like to recommend that future developments be guided more by economic analyses than by technical prospects. In this respect we propose the following research agenda. The agenda (presented in arbitrary order) covers multiple economic disciplines:

Economic design of traceability systems

Research about traceability systems generally focuses on technical aspects. Additional research is needed to include also important economic aspects. For instance, what is the desired level of detail of a traceability system, i.e., is it efficient to be focused on a system 'as detailed as possible' or is there some break-even point? Relevant questions include whether it is necessary to be able to trace back to individual animals or is tracing back to the herd level also sufficient? Furthermore, is it necessary to track forward to all individual customers who received specific

products, or would it also be adequate to work with day and batch codes so that products can be recalled at a higher level? A further consideration relates to the acceptable level of risk of traceability systems. 'Acceptable level of risk' is a common term in food-safety systems, but apparently not in traceability systems. A relevant question in this respect is whether production chains need to be able to track and recall all products in one way or the other, or whether they could for instance rely on some alert system at the end of the chain.

Distribution of costs and benefits of traceability along the production chain

Transaction costs of traceability systems are likely to increase as one moves along the production chain (Bredahl and Holleran 1997). However, also benefits may increase, for example as a result of increased selling opportunities. A better insight into the distribution of the costs and benefits along the production chain makes it possible to allocate price premiums (if any) accordingly. The relevance to do so was already mentioned by Verbeke (Verbeke 2001).

Optimization of incentives for participating in traceability systems

Although a proper allocation of price premiums along the production chain may be an incentive for most participants of the production chain to participate in traceability systems, this may trigger not every chain participant. This may, for example, be the case with farmers. They face possibly high claims from larger companies further in the chain while they have only limited financial means themselves to counterattack such claims. Incentive problems may especially arise when there is a risk of cross-contamination during processing. Solutions may be found in accredited certification schemes at the farm level, for instance through product-market organisations (as illustrated in Figure 4). Such schemes enhance farmers' opportunities to prove due diligence. A group of farmers that deserve special attention in terms of incentives to participate in traceability systems are hobby farmers. Hobby farmers can considerably influence the introduction and spread of livestock epidemics and the speed at which epidemics can be controlled. They are, however, not participating in certification programs and they are probably not affected by economic incentives such as a lower price for their products if traceability requirements are not fulfilled.

Reconsideration of liability and recall-insurance schemes

The increasing number of product-liability claims and the fact that they are 'moving backwards in the chain' require a reconsideration of liability- and recall-insurance schemes for all participants in the production chain. On the one hand, the need for insurance coverage is reduced because of the increased implementation of the type of systems and certification schemes discussed in this paper. On the other hand, adequate insurance coverage seems to be an increasingly important prerequisite for the long-term continuation of individual farms and companies because of the – small probability but high consequence – risk related to liability claims and recalls. Risk analyses supporting insurance studies are enhanced through the increased amount of traceability and food-safety information that is available.

Communication about food-safety-related systems and certification with consumers

The problem that consumers' willingness to pay for safer food and the implementation of food-safety systems and certification schemes is not straightforward, may be a problem of communication. Key research questions are:

- What information should be presented on the label (e.g., 'HACCP' or 'guaranteed safe', 'from Umbria' or 'fulfills our national standards')?
- Are consumers able to distinguish between various labels?
- Are there alternative ways of communication (see also Frewer (Frewer 2000))?
- What is the interaction with other consumer concerns, such as environmental aspects and animal welfare?
- What market segments can be distinguished? More insight into such questions would improve the communication with consumers about food-safety issues.

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