

Private Sector Approaches to Secure Traceability, Transparency and Quality Assurance in Food Chains

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Abstract

The nature of food production leads to failures to provide safe food and assure quality in the food system. Many of the problems of securing food safety and quality are systemic in nature. Hennessy, Roosen and Jensen (2003) identify four types of systemic conditions that give rise to problems related to assuring quality in food systems: connectedness of the system; difficulties in conveying signals on product attributes or production processes, or mistrust of information; asymmetric information and lack of incentive for preserving food quality; and inflexibilities in adapting the food system or process to changes in the production environment. Innovations in information technology, improved traceability systems and institutional design in the private sector have been developed to address problems of interconnectedness. This paper considers the nature of systematic risk in the provision of food quality and implications for alternative systems for securing traceability, transparency and quality assurance in food chains. An example of various systems of preserving and tracing food quality attributes in meats illustrates tradeoffs between use of feasible technologies and the value of benefits inherent in quality assurance systems.

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1 Introduction

The nature of food production leads to failures to provide safe food and assure quality in the food system. Product from many producers is routinely commingled prior to sale. Trade also introduces new sources of risk in the food supply through more varied sources and easier transfer of food borne hazards and plant and animal diseases. Because agriculture is a competitive industry, individual producers have little incentive to innovate or take care to assure quality attributes since, at least historically, they face competition on price alone. In this environment, farmers do not benefit individually from efforts to protect quality. And, processors who purchase commingled farm product ingredients or face limited ability to preserve quality attributes find it difficult to develop and protect a brand that can command premium in the market.

At the same time, today consumers demand better identification and transparency on food quality attributes and traceability, transparency and quality assurance have taken on greater importance. The increase in demand for traceability and assurance of product attributes stems from consumer concern about food safety, rising consumer income, new information on the safety and quality attributes of food and their role in health promotion, and greater trade in food products among other changes. At higher levels of income, consumers demand relatively higher levels of enhanced attributes associated with food qualities, nutrition, health promotion, and support for causes (Kinsey). What is less well understood is whether consumers are willing to pay for those attributes. Dickinson, Hobbs and Bailey (2003) found that US and Canadian consumers were willing to pay for traceability but would pay more if traceability was bundled with quality attributes such as assurance of animal welfare practices and food safety. Gellynck and colleagues (2005), in a study of Belgian consumers, found traceability on process attributes such as production methods, to be of greatest interest to specific market segments (especially those with negative perception of meat quality). These results and growing evidence in the market suggest demand for product differentiation, with associated premiums, exist in some market segments and are likely to grow in domestic and international markets.

Private markets often fail to provide adequate food safety or quality because information costs are high, detection often very difficult, and the nature of the contamination or protection of quality attributes is complex. Underlying many of the food safety and quality failures is the existence of externalities, or costs not borne by those whose actions create them. Externalities tend to arise when strong dependencies govern relationships between economic agents, and when the production environment is not sufficiently well understood to allow market-based solutions (Hennessy, Roosen

and Jensen 2003). Food supply chains are characterized by strong dependencies between agent decisions. Microbial agents are widespread, can lead to significant hazards, are often difficult to detect, and can re-enter the food supply chain, even after control at earlier stages. Intrinsic product characteristics such as method of production (organic or not, or animal friendly production environment) are inherently difficult (impossible) to measure and require assurance or systems that allow documentation and traceback on production methods. When firms are not able to fully capture the returns from incorporating costly controls of product hazards or production methods, they lack the incentive to implement methods to assure product that meets the higher quality standards of differentiated product, or to provide the degree of control to contain problems that may pose safety or health hazards in the product.

Faced with these conditions, private certification (both self and third party), related contracting schemes, and quality control systems have become important methods of quality assurance in food marketing and trade. Traceability is obtained through systems of records and certifications that let product be traced to its origins. Although technologies and processes for assuring traceable inputs and ingredients exist and are being developed, the incentives for private sector adoption of traceability and quality assurance systems depend on market returns from their use. The paper begins with discussion of the systemic risk in food production and implications for approaches to secure traceability and assure quality in the food system. By exploring the nature of systemic risk it is possible to gain a better understanding of alternative approaches used in the private sector. Traceability systems in use in the European Union (EU) and the US illustrate the private sector approaches. Although more widely used in the EU, technologies for traceability are in use in both regions. Consumer preferences, cost structure and regulatory environment dictate different use.

2 Why Food Systems Fail

The underlying reasons for why food systems fail to protect product quality are often attributed to systemic risks, or the risk that a system fails to perform because of the ways in which its components interact. A typology of risks developed by Hennessy and colleagues (2003) provides a useful classification for better understanding about how the different types of interactions contribute to the problem of assuring product quality in the agricultural and food system, and approaches for managing and controlling the risk. Table 1 provides a listing of four types of causes of systemic risk, their consequences and possible management or policy implications. More than one cause may apply at one time. The first three causes of systemic risk relate to system dependencies such as might occur with commingling.

The first cause (system typology) stems from the basic way the food production system is interconnected. The second cause (mistrust of information) stems from incentives problems and the mistrust on the signals of product attributes. The third cause (asymmetric information) also relates to the problem of information and incentives, although in this case firms act optimally, but the information that they have is imperfect and thus may lead to reduced incentives for preserving quality. Firms do not take the level of care they would have provided with better information. The final cause of risk is due less to the system interactions as to inflexibilities in the food system that limit its ability to adapt to or handle change. We use examples of each to illustrate that the nature of the cause of the risk in the system. The distinctions among the causes of systemic failures highlight the nature of public and private sector approaches to reduce the risk of failures. The following section draws from Hennessy, Roosen and Jensen (2003).

2.1 A. Systemic topology

Food quality failures often stem from problems that are systemic in nature. The systemic failures occur in production systems characterized by interconnected stages in production and inputs, and this interconnectivity gives rise to the technological potential to fail. Figure 1 illustrates the nature of failure in the system in the case when the cause of a failure is not known. The figure is a node diagram of the system, with the three retailer nodes to the right. Arrows indicate the direction of product flow. Suppose that there are three retailers (or restaurants) that source from two providers. The arrows indicate the direction of product flow. Retailer $r1$ sources from provider $p1$ only, retailer $r3$ sources from provider $p2$ only, while retailer $r2$ sources from both $p1$ and $p2$. The retailers also provide some of their own inputs.

If an illness or food quality problem arises at $r1$, then without any information on the source of the problem, nodes $r1$, $r2$, and $p1$ will have to close for quality audits. In contrast, if problems were detected at node $r2$, then the whole system would have to close down for audit. Node $r2$ is the node most strongly connected among all the nodes in the system, and the systemic risk associated with a problem that becomes evident there is most severe. When the cause is known (specifically, failure in nodes $r1$, $r2$, $r3$, $p1$ or $p2$) the loss may be smaller (and never larger) than when the cause is unknown. If $r1$ fails and the problem is known to be internal (that is, inputs from $p1$ are not involved), then the output from $r2$ is not lost. However, when mixing occurs, such as would be the case if $p1$ fails, then output from both $r1$ and $r2$ will be lost. The loss of output from both $r1$ and $r2$ is the same result as occurs when there is a failure at $r1$ but the cause is not known. These results indicate the role of mixing even when the cause of failure is known.

Policies that reduce problems of mixing or commingling include improving traceability, closing the system and improving the management of information.

2.2 Mistrust in communication and information

A second cause of systemic risk is due to lack of trust in the source of information or the process. Conveying information through brand name or labels are methods that firms use to communicate product quality. Through the brand name, firms attempt to build consumer trust and reputation, and invest resources to protect the brand image. Commodity promotion boards also invest resources to build trust in their commodity. The association of product with brand, promotion or even country of origin can pose problems in the marketplace, though, when there is a product failure.

From the public perspective, assurance of product attributes or quality by standards, regulation or food code is designed to facilitate marketing functions and protect consumer health. If consumers lose confidence in the source of information, as occurred in the BSE crisis in the U.K. in the mid 1990s, the loss of confidence and mistrust may not only cause losses in the market for the product market at risk, but may spill over to losses for other food product and assurances. Having lost confidence once over beef products, the consumer may be less inclined to trust information on poultry products with assurance from the same government agency.

Policies that reduce mistrust include improved or mandated testing and certification programs, mandated product labeling, and improved communication in the food system (i.e., method and speed of product recall).

2.3 Asymmetric information and coordination failures

A third cause of systemic risk can be attributed to a lack of information on product quality that leads to incentives problems in the decisions of participants in the food processing chain. Without incentives to do so, producers, processors or other handlers may fail to create or protect product qualities in their production or process. If processors do not reward producers with premiums for certain qualities in live animals, producers lack incentive to take better care in raising the animals or to keep track of production processes (e.g., use of antibiotics). Or, processors, knowing that they will not be rewarded for the identified qualities in meat products, have little incentive to maintain records on these products and reward the producers of live animals. Improved testing methods, traceability systems and other means of product quality verification, or improved contract (institutional) structures serve to better coordinate information and improve incentives for preserving quality attributes.

Policies and approaches to improve information include programs for traceability, improved testing, contracting mechanisms and vertically integrated systems.

2.4 Failures in technologies

A fourth cause of systemic risk can be attributed to failures in the production process or in system technologies to adapt to change. An example might be a meat production and supply chain built around small, multi-specie processing facilities. Such a system was well suited to meat production and processing that entailed limited animal transport and provided services to local production. With increased food safety standards and regulations, the costs and technology required for processing in these multi-specie processing plants become prohibitive. The infrastructure required to support improved food safety and quality levels has now led to a shift of meat processing to larger facilities (for this and other reasons). Failures in technology can also be limited through improvements in emergency planning and preparedness.

In summary, understanding the source or cause of the food system failure can indicate the types of policies or approaches that can be used to assure the food safety or quality of the product. The typology suggested is quite general. The particular response, mix of private innovation or public involvement depends on the degree of failure, technology, and policy environment. Approaches used in the United States in many cases differ from those used in the EU, even for similar products. However, in both cases strong private incentives to reduce the system failures exist. Differences may arise because of different regulatory requirements and /or because of different rewards or costs associated with the methods used to reduce systemic risk. Firms are likely to invest in methods and processes that add value to product or reduce their costs. The next section clarifies the concept of traceability and quality assurance systems to reduce system failures. The examples used in the rest of the paper focus on animal and meat production and processing systems. The results could be applied to other food sectors and products.

3 Private Sector Approaches

The appearance of BSE (bovine spongiform encephalopathy) in Europe in the mid 1990s and other outbreaks of meat contamination with *E. coli* O157:H7 led to rising public concern about food safety and quality. The response in Europe and in the US was to strengthen both public and private systems of food safety and quality controls through the use of a “scientific basis” to food safety control and risk assessment framework. A major difference in approach, though, was the EU placing emphasis on the need to identify responsibility for food safety throughout the food chain and to implement traceability to assure monitoring as required to protect the safety of materials and inputs (European Communities White Paper on Food Safety, Commission of the EC 2000). Companies, themselves, are responsible for monitoring their food safety, although final authority lies with the national authorities (Bunte 2000). Consumers in the EU mistrusted assurance from the public sector and demanded product traceability and quality assurance.

In addition to reasons of assuring food safety in products, consumers, especially those in the EU demanded quality assurance on extrinsic characteristics such as the use of production practices that adhere to methods to protect animal welfare, environmental issues, or other credence characteristics. Traceability systems developed in Europe in advance of those in the US to address both food safety concerns and quality assurance.

3.1 Definitions

As defined by the ISO 9000:2000 guidelines, traceability is the ability “to trace the history, application or location of that which is under consideration” (ISO, 2000) and this may include the origin of the inputs used to make the food product, the processing history, or distribution of the product (Golan et al. 2004). The definition of traceability can be quite broad and include elements of transparency and quality assurance. Transparency refers to the provision of information on procedures and practices used to produce a product throughout the marketing chain (Liddell and Bailey 2001). And, quality assurance includes the use of practices that ensure food safety, meeting grading and other measurement standards, and mechanisms for product recall (Liddell and Bailey 2001). Quality assurance may include assurances on intrinsic product characteristics (carcass leanness, salt content, ingredients) and extrinsic qualities that may affect the value of the product, such as method of production (organic, under animal welfare guidelines) or ingredients used or not used. Assurance of extrinsic product characteristics may establish credence characteristics that would not be possible for consumers to observe directly.

3.2 Public and Private Certification

In a recent study of the pork market, Liddell and Bailey (2001) found relatively high levels of public certification for food safety across a set of selected countries (including the U.S., U.K., Denmark, Canada, Australia/New Zealand, and Japan). However, private certification (determined by aggressive inspections on food safety and other food production aspects, ban on ingredients, and adherence to animal protection laws) was strongest in the European countries and weakest in the U.S. and Japan. They also score pork market traceability, transparency and quality assurance across the six country markets and find the US and Canada to rank with the lowest levels. They argue the low ranking of the U.S. pork system is because the US has placed emphasis on the marketing chain from the processor level forward and placed little effort, compared to the pork industries in other countries, to develop assurances concerning inputs and processes used throughout the system.

It is important to keep in mind, however, that the extent of traceability and quality assurance in all cases except where mandated will depend on market mechanisms. Traceability is a concept that needs to be evaluated relative to a specific objective (Golan et al. 2004). The depth, breadth and precision of a traceability system will depend on need for tracking the required information. Differences among systems in place both within the EU and the US reflect different objectives. It may be that to a large

extent, the lack of private or public certification found in the US and Canadian markets is due not to lack of capacity to provide traceability, but reflects instead differences in industry and product characteristics. For example, US consumer confidence in public assurance about the safety of the food supply (Christensen et al. 2003) may lead to lower levels of consumer demand (and willingness to pay a premium) for the traceability systems. That is, U.S. industry systems may not provide the same degree of private sector traceability as in the European systems, not for institutional reasons but because the incentives are not there.

4 Traceability and tracking systems for meats

The mixing of meat from a number of farm sources at the packer, processing or intermediary levels illustrates both the interconnectivity in inputs and stages of production, and incentive problems. As discussed in section 2, the problem of mixing and commingling of ingredients is technical. It is not caused by lack of expertise of producers, but by the difficulty in tracing ingredient, meat cuts from live animal sold to slaughter to the retail level (where final consumption and value is achieved). Introducing or improving traceability in the production and processing system, or investing in information management are methods for reducing the interconnectedness of the system, limiting risk in the food system, and protecting differentiated food products or undetectable quality attributes.

A recent study of identification and traceability for the U.S. pork industry investigates the technical and economic aspects of traceability systems for meats in the U.S. and Europe (Geiger and Hayes 2003). What is particularly useful about looking closely at traceability systems in practice in Europe is that it becomes apparent that the term “traceability” can have many different meanings depending on the purposes for traceability and requirements for quality assurance. By expanding the view of traceability systems to include batch traceability, the benefits of traceability can often be achieved in the system at a much lower cost.

Today, most fresh meat that is sold in the EU contains a product code that appears to allow the consumer the opportunity to trace the meat back to the originating animal or farm. A driving force behind the system was the outbreak of BSE in the United Kingdom. As a result of regulations put into place in the 1990s to increase food safety through tracing ingredients, almost all retail meat that is sold in the EU contains a code that in theory allows the consumer to find the farm of origin. Replication in the US may be more costly in the US and may be of less value to the majority of US consumers.

4.1 Types of traceability

It is useful to distinguish three types of traceability systems that differ by degree of product identity specificity (Geiger and Hayes 2003). The first method involves complete traceability through the

collection of DNA swabs from each animal or other testing methods to match specific animal to product. In theory, any problem identified in a particular piece of meat would be full traceable through matching the meat DNA to the record of source animal. Most collected samples would never be used for matching, but the possibility of such a match would provide an incentive to producers and processors to take care and adjust their behavior. We term this system **hypothetical traceability**.

A second method is traced through a system that maintains the identity of all cuts from the farm through the cutting and distribution system. It is very expensive and essentially requires new construction and extensive capital investment and data infrastructure. It is very rare in the EU although many consumers think that this is the system in place for beef and pork. We refer to this system as **farm to retail traceability**.

The most common type of traceability in the EU involves traceability from the farm to carcass. The life history of the animal is tracked for each carcass or primal cut, but the ability to trace the animal parts through the cutting floor is lost. Instead, the meat is cut and processed in batches. The final retail product can be traced to a particular batch in the processing plant. This type of system is relatively inexpensive, especially if the batches are large. Processors can achieve additional segregation or identification of product by only purchasing live animals or carcasses that meet certain criteria and then cut the meat from the carcass in different locations. In this way, market forces may dictate the additional traceability that can be added from farm to retail. This type of system is termed **batch traceability**.

4.2 Implementation of traceability in the EU and US

Although there are cases of traceable systems that rely on DNA sampling, this type of system is relatively rare. The potential costs to producers can be quite large were a problem to be identified. Also, producers may not benefit directly from such a system because it is not tied to animal characteristics rewarded in the meat system. The threat and disincentive may drive poor producers from business. More common are farm to retail traceability systems and batch traceability systems.

Farm to retail traceability systems rely on preserving animal identity through slaughter and processing. This is made possible in the EU because almost all meat animals slaughtered in the EU arrive at plants with individual animal identification through a passport number with scanner code. Other methods, including tattoos on hogs, may be used to track animals and provide producers feedback on prices and carcass yield characteristics. When animals arrive at the slaughterhouse, the animal id number is scanned into an electronic system. Then, the system keeps track of the carcass. When the meat is cut, pieces from one carcass are placed in a container and the container includes identification of the animal. The container (and hence carcass that contributed meat to the container) is then tracked until

final cut. When the meat cut is placed into a vacuum bag, a scanned tag is printed automatically and placed in the bag with the meat. The result is product with carcass identification. Figure 2 illustrates the process of sending a live animal to slaughter/processing and identifying product to the carcass or animal level as the retail product (i.e., carcass ID). Geiger and Hayes (2003) estimate the cost of such a system for pork for converting an EU plant to such a system involved a 50% increase in fixed costs per animal and a 20% increase in variable costs per animal. For a typical large scale U.S. pork plant, implementing a farm to retail traceability system in the US would likely mean \$10.22 per animal or \$4.00 per hundred pounds. This would be equivalent to about \$0.08 per pound for retail meat.

The batch traceability system is more commonly used in the EU. This system separates the packing system into two production processes. In the first process the animal's identity is maintained through to the carcass. Then, in the second process, the majority of the carcasses are cut and processed without further attempt to maintain traceability to the carcass. Batch identification can be maintained on the final product by assigning a batch number to all output for that day. Trace-back to carcass would be achieved to the set of carcasses in the entire batch. Such a system is similar to processes used in modern plants in the U.S. except that batches are typically larger in the US. It is possible to achieve smaller batches by subdividing a day's slaughter through a break in the cutting line. In a Danish plant we visited, the shift typically began with hogs destined for a niche market such as the U.K., and ended with a second niche market such as the organic sector. Thus, in this one day, three different batches were slaughtered and processed with only a very small disruption of the line. Large US plants practice versions of this by contracting with buyers for pigs processing on certain days of the week, or in specific shifts in the plant.

The advantage of the batch system is that market forces determine the optimal size of the batch. If recalls are too expensive because the batch is large then it makes sense to reduce the batch size. Also, if a customer wishes to purchase only carcasses with specific attributes they can do so and cut and process these carcasses elsewhere. An example would be all carcasses produced under an animal welfare friendly system could be pulled out of the cooler and shipped to another location for further processing. The benefits of batch traceability include production efficiency and reduced costs of recall. The costs of batch traceability include the cost of animal identification, the cost of tracing the animal through the slaughter line and the costs involved of maintaining animal specific records. There are additional costs associated with inefficiencies associated with breaks in the cutting line as required. These costs would depend on the number of breaks and do not require major restructuring of plants.

Under a broad definition of batch to include one full day of processing, some US plants could claim batch traceability. The optimal size batch would be found by comparing the costs associated with a possible recall, or the premium from batch-identified product, to the costs associated with stopping the

cutting line for smaller batches. Geiger and Hayes report that the costs of batch traceability are relatively small and the process offers some advantages in the market. US packers would adopt smaller batch sizes when it would make economic sense to do so.

In the US system, traceability from the processor to retailer for meat products is practiced widely in order to meet requirements for food safety and recall. However, mixing of live animals prior to slaughter and in processing does occur in some markets. Feeder or finished animals may be commingled through buying stations. Ground meat may come from many different animal/farm sources. Problems that occur from the farm, or in handling of a single animal, can easily spread through the food product in the plant. Although batch testing may detect some food safety problems or raise alerts on product quality, testing of product at different marketing stages is often difficult. Incentive problems occur because it is difficult for packers to reward farmers for care-taking, and farmers have no incentive to take additional care in production or transport to reduce the likelihood of problems at the packer level; nor do packers that sell product to intermediaries that commingle beef from several sources have market incentive to adopt technologies that reduce pathogens in the plant source. The recent case of BSE in the state of Alabama discovered in mid-March 2006 illustrates how the trace-back can break down. That traceback investigation concluded after two months with no success in identifying the older cow's origin. The animal was traced to related animals through five sale barns and 36 farms (Schuff 2006).

5 Summary and Concluding Remarks

While information problems in markets arise, they do so in a variety of forms. Commingling of animals and product, loss of consumer confidence because consumers do not trust the system, or market information problems that lead to lack of incentive, and reward, for quality attributes are evidence of systematic risk in the food system. Several approaches to improving information in the system can be used to address the specific problems in the production system. These include improved traceability and methods of quality assurance on product attributes, improved incentives for preserving quality, and closing systems to reduce commingling. The point of looking at differences in the European and US systems for meat products was to identify and highlight the fact that existing systems have proven to be relatively flexible in meeting demand in the markets.

Although farm to retail traceability systems are possible, they are not widely used – either in the EU or in the US – because consumers are not willing to pay the premium required for a system that would allow tracing meat to animal of origin. Much more common today are batch traceability systems that allow traceability back to the batch of animals that entered the packing facility. This type of traceability system is commercially viable in the EU and less often practiced in the US. Some US

firms can implement a form of batch traceability, and identifying all carcasses in a batch but without specific contracting or assurances, tracing carcass to farm is limited. The issue of batch sizes plays a key role in the costs associated with batch traceability. There may be possibilities for producer incentives and cooperation with packers to match animal delivery and batch sizes to take advantage of timing and processing efficiencies in the plant.

Geiger and Hayes (2003) report on one firm in the Netherlands that provided veal to a specialized market with consumers willing to pay for assured animal product identification. In the future there may be more demand for retail to farm traceability systems, especially if consumers in the US lose confidence in the current food safety system of controls. Recently McDonalds' Corporation announced that it planned to have 10% of its US beef purchases traceable from farm to table by the end of the year in order to assure consumers about food safety. John Hayes, their senior director of U.S. supply said: "We believe it's an essential component of consumer confidence that when an issue develops, within a 48-hour time period...we get the message to the consumer that we can contain the problem, we know where the animal came from, we're ready to deal with any of the ramifications of whatever that issue might be." (Reuters, May 17, 2006). Of course, McDonalds' brings significant buying power to the market.

The private sector has a wide range of systems in place for traceability and quality assurance. Because of increased consumer demand, as well as the increased ability to control production processes with new information technologies, private firms have incorporated increased traceability into their production processes. It may be that once a system is in place, it is less costly to assure multiple attributes, or take advantage of complementarities in production with caretaking on selected product attributes (Goodhue and Rausser 1999). Traceability systems are one way firms can better manage product flow and quality, and take advantage of consumer preferences for quality attributes.

For any plant or producer, market incentives play a large role in decisions about the type of assurance and control systems to put in place. Consumers' willingness to pay a premium for quality assurance or traceability of product is required for firms to use more costly production processes that support traceability systems. The perceived major differences in traceability systems between the US and EU may be due in large part to different consumer preferences for assurance of product attributes and traceability. Other factors, such as slower line speeds and smaller processing units also play a role in determining the relative costs of implementing batch traceability systems.

International livestock and meat markets are in a slow transition from commodity markets to differentiated markets. Increased interest on the part of consumers for assurance on extrinsic quality characteristics and competition in international markets are likely to encourage greater development of

traceability systems in the US. For larger plants, this might be achieved through increased flexibility in stopping production to create intra-day batches or investment in other logistics to process segregated batches. Or, smaller processing plants may find they have competitive advantage in processing for niche animal suppliers. Greater flexibility in processing and in marketing arrangements are two methods that support the development and use of traceability systems.

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Table 1 Taxonomy of systemic risks in food production

Causes of Systemic Risk	Consequences	Potential Policy Implications
<p>A. <u>System topology</u></p> <p><i>i.</i> Consequences are known but cause is not</p> <p><i>ii.</i> Cause is known, but mixing occurs</p>	<ul style="list-style-type: none"> * Losses spread through much of the system 	<ul style="list-style-type: none"> Reduce interconnectedness by * improving traceability * closing of system * investing in information management, audit infrastructure, and research on the nature of the problem
<p>B. <u>Mistrust in communication</u></p> <p><i>i.</i> Mistrust of the sender</p> <p><i>ii.</i> Mistrust of the process</p>	<ul style="list-style-type: none"> * Uninformed consumers * Private branding * Crisis, consumer panic, and market disruption 	<ul style="list-style-type: none"> * Improve communication paths and speed (HACCP, quality audits, emergency preparedness, etc.) * Facilitate market in third party testing * Mandate labeling * Implement truth in advertisement * Develop efficient procedures for redressing torts and assigning liability * Improve perceived impartiality and efficiency in government policy and oversight * Develop effective risk-based regulation, with separated assessment, management, and communications functions
<p>C. <u>Asymmetric information leading to coordination failure and distorted incentives</u></p>	<ul style="list-style-type: none"> * Underprovision of care in protecting food quality * Underprovision of information 	<ul style="list-style-type: none"> * Improve testing, traceability and verification methods (reduce coordination costs) * Rationalize production systems * Do not impede contract production * Encourage cooperation to establish longer-term supply relations * Promote trade in foods * Foster vertical integration for food quality control * Improve sanitation infrastructure * Promote leadership activities
<p>D. <u>Failure to develop state-conditioned technologies</u></p> <p><i>i.</i> Narrow technology development platform</p> <p><i>ii.</i> Overload</p>	<ul style="list-style-type: none"> * System performance may deteriorate in the event of a state that the platform cannot readily adapt to * System performance varies as deterministic states change 	<ul style="list-style-type: none"> * Encourage storage and seed banks * Develop emergency planning procedures * Provide subsidies for research agenda that would broaden technology options * Adapt regulations to deterministic states of nature * Contemplate mechanisms to promote radical technical innovations

Source: Hennessy, Roosen and Jensen (2003)

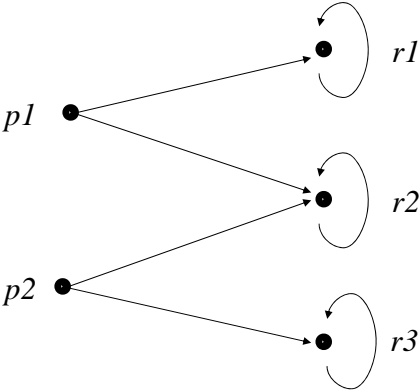


Figure 1 Node diagram of retailers and providers

(from Hennessy, Roosen and Jensen 2003)

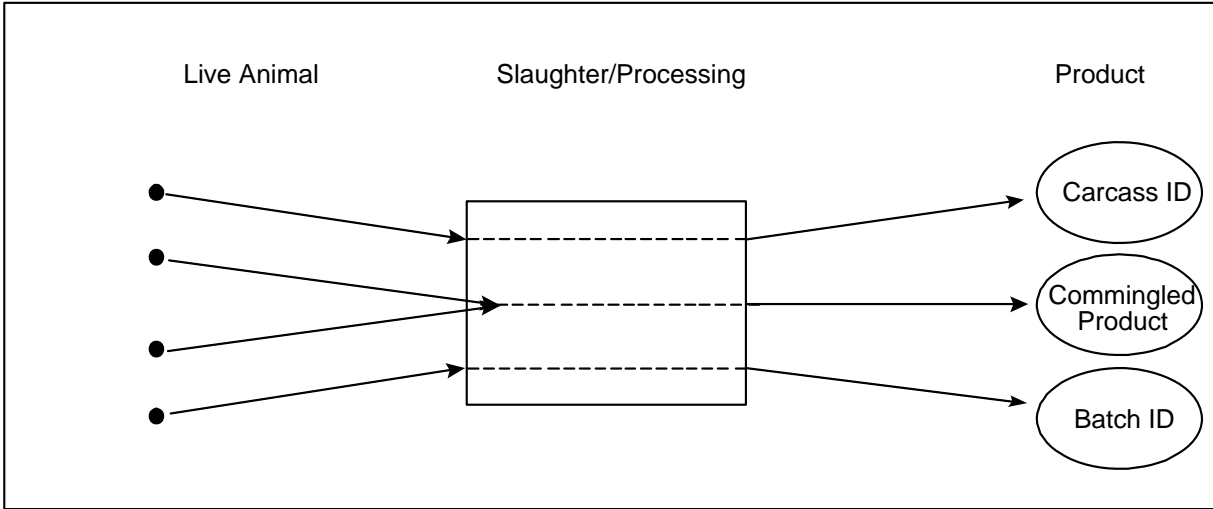


Figure 2 Alternative processing control and traceability of product in meat processing