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Traceability, Trade and COOL: Lessons from the EU Meat and Poultry Industry

by

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ABSTRACT

The traditional food supply chain is arranged as a complex array of producers, handlers, processors, manufacturers, distributors and retailers. As the food supply chain grew in complexity over time, little emphasis was placed on preserving information regarding the origin of raw materials and their transformation, often by multiple handlers, into consumer ready products. This paper provides case illustrations of the implementation of information systems for support of traceability in Europe. Emphasis is on the firm level costs and benefits as well as the broader market structure and governance issues inherent in information economics of the firm.

Keywords: *Traceability, Economics of The Firm, Information Systems, Internet, Food Supply Chain*

Introduction

Food safety issues in meat and livestock have come to the forefront in recent years with high profile incidences of contamination by *e. coli*, BSE, dioxin, hormones and antibiotics all contributing to a desire to find ways to improve quality control systems in the meat supply chain. In the U.S., the primary large-scale response has been to implement HACCP programs from slaughter to retail. However, in the case of BSE or hormone and antibiotic residues the need for quality control programs extends farther back to feeding and management practices on the farm or even feed manufacturing. Extending this to include the use of genetically modified feed ingredients; product integrity must be controlled at the crop production stage of the supply chain. As a result, there are increasing calls for meat supply chain traceability initiatives along with identity preservation of genetically modified crop products.

A few recent economic studies have addressed the traceability issue. Liddell and Bailey examine the broader market implications of traceability by ranking the relative development of traceability systems in the U.S. to other competing countries in world markets. They suggest the U.S. lags behind in areas of both food safety and quality control, particularly when compared to European suppliers such as Denmark and the U.K. A recent study by Dickinson and Bailey show that consumers in the U.S. may be willing to pay for traceability and transparency in meat products. Hooker, Nayga and Siebert examine the food safety activities in the beef industry and primarily focus on the results of surveys regarding the ability to implement food safety practices, including traceable supply chains. Most processors in the U.S. and Australia viewed it as feasible, but the particulars of how it might be implemented or the economic costs of implementation are not directly addressed. Bullock, Desquilbet and Nitsi consider the costs of identity preservation and segmentation of grains, but construct their economic results from an economic engineering perspective. Maltsbarger and Kalaitzandonakes take a similar approach with regard to grains and Hobbs develops an economic engineering approach to implementation of traceability in beef processing. In sum all papers focus on either the consumer demand for the attribute of traceability or the physical costs of traceability. However, this paper focuses on the economics of information and information systems as it relates to traceability in the meat supply chain.

Case Study Participants and Methods

Six European organizations employing traceability programs in meat or poultry were chosen for this investigation. The criteria for choosing participants was that they must have an electronic based traceability system which encompassed live animal production through retail sale of meat or poultry products. Primary contacts were made through USDA, FAS offices in the country of the firms and then leads were followed to identify key personnel in the production system. The six participating entities include a poultry production system (Label Rouge/Challans, France); an egg production system (KAT/Wiesengold, Germany), a salmon production system (Intentia/Nutreco, Norway), a veal production system (The VanDrie Group, The Netherlands) a lamb, pork and beef supply chain (Scase-Intentia/Gilde, Norway) and a beef production system in the Scotland (Scotbeef). In examining these systems several supporting organizations were also visited, including the Poultry, Livestock and Meat Board in The Netherlands, several governmental agencies in France, Carrefour supermarkets in France and ASDA supermarkets in the UK. There are several other firms implementing traceability schemes in the E.U. such as Pingo Poultry (Nutreco), Danske Slagterier (Denmark) and Beltrace (Belgium) but which we were unable to gain entry; in some cases due to simple scheduling conflicts. Table 1 provides a summary of the characteristics of the firms included in the case studies. The objectives of the site visits were to document the supply chain production protocols, examine alternative forms of governance structures for supply chain traceability and document methods of electronic traceability. A team of two researchers conducted site visits and typically site visits included one or two day visits to key production facilities (farm, processing and retail). It was also a requirement that the teams were able to meet with key personnel at each stage of the process to interview them regarding their experience. Prior to the site visits participants were asked to compile documentation regarding the operation that might support understanding of their systems. Most were quite willing to do this given that it was consistent with their objective of transparency in their production chain.

Traceability: Production and Information Systems Architecture

The general concept of traceability as implemented by the case study participants included three components – (1) management of the physical supply chain, (2) management of the parallel information system to maintain traceability and (3) organizational structures to manage and implement the production and information systems. This section provides a description of these aspects. For the most part this section is 'fact' base with little discussion of the implications, but sets the stage for the economic issues to be considered.

Physical Production Systems

In all cases, the traceability systems extend from the feed manufacturing process through retail. Also, each case has unique production protocols that support the development of particular consumer product attributes such as organic, group housing, free range or antibiotic free production. All are also clearly focused on the issue of food safety. The production protocols typically stipulate production inputs such as feeds, health treatments, and animal rearing methods (e.g., non-cage, group housing, free-range) and genetics. Production protocols are enforced at all stages of the production process by auditing and production records. Methods for monitoring production included sampling of feces, feed or meat; cross-referencing feed delivery timing and use to correlated production variables such as daily gain; and site visits by auditing firms or certified veterinary or farm management services.

Maintaining traceability through vertical stages requires that firms be organized in a structure conducive to passing products while maintaining their identity. We observed three basic organizational structures. Label Rouge (the most complex) is organized as a cooperative with strong government oversight. At the other end of the spectrum is the VanDrie Group and Nutreco who are completely vertically integrated systems. And in-between, the KAT egg system in Germany represented an independent standards setting group which worked with cooperatives to facilitate production. Gilde Norge is a cooperative structure as well. A later section on governance issues will address the organizational structures more extensively.

In the case of Label Rouge (Figure 1), the French government owns the overall rights to Label Rouge labeling and certification. The Ministry of Agriculture establishes standards and accreditation methods. Quasi-governmental agencies such as Synalaf act as a mediator between the government and the quality groupes which work directly with the farmers as a management advisor. Any group of producers may submit alternative production protocols for approval by the government. This includes a description of the standards and how they will be implemented and enforced through auditing agencies. Auditing agencies are also certified by the government, but are autonomous from either the government or quality groups to avoid conflict of interest. One of the key criteria for approval of standards is that the product must be quantitatively differentiable from other products in the market. Other systems have similar structures of independent auditing agencies, and submission of production protocols by members of the group. However, Label Rouge is the only one that relies heavily on government regulation and control. The others implemented government guidelines in their protocols (e.g., not feeding animal by-products, or animal rearing conditions), but are private enterprises managing their own certification and production protocols. KAT in Germany offers an excellent example of producer cooperative organization that developed cooperative standards, monitoring and enforcement. They purposely avoid government intervention because they are seeking to set EU wide standards which can be implemented in multiple countries and avoid potentially conflicting country specific regulations.

Logistics management in production becomes a key enabler of traceability. Animal supplies, slaughter times and locations, feed deliveries and other aspects are all tightly coordinated because the supply chains are closed. Animals must be identified when they are born, carefully tracked as they are moved between farms and then tracked at slaughter if they are to be identified by the final product. The most intensive points of logistics are at aggregation/dispersion points for inputs (e.g., feed plants with ingredient inputs and packing plants where carcasses are disassembled). Batch integrity quickly becomes an important production management tool by reducing the shear number of observations (e.g., animals, vs. pens, vs. barns vs. farms). The more individual elements (e.g., animals) that are treated identically the greater ease in managing production protocols. Hence, production methods often fit the scale of barns. It's very much analogous to all-in-all-out production management already common in the swine industry. Batch production also reduces the cost of logistics. For example, the VanDrie group veal processing system tracks individual animals through the processing chain to the point where a final retail portion cut at retail could be tracked to an individual animal. This incremental product tracking system required them to reconfigure their entire cut floor and handling system in manufacturing fresh veal cuts. They estimated costs for complete implementation of the information system (scanners, production chain changes, additional employees) in a single veal processing plant at $6.5 million and approximately $24 million dollars to implement it across their feed manufacturing, farms and processing plants. To put this in perspective the VanDrie group consists of two slaughter plants which each slaughter approximately 350,000 head of calves per year, 100 farm operations, three veal fabrication and processing plants (primals are shipped in and converted to case ready) and two milk powder manufacturing plants for feed (~100,000 tons per plant per year). To contrast, Gilde which had recently built a slaughter plant capable of individual cut tracking, estimated the cost of the information system components (i.e., industrial personal computer stations, servers, and software) to be only approximately $150,000 for a single slaughter plant similar in capacity to VanDries' Ekro plant. While these figures are rough estimates, it illustrates the point that the information system requirements are relatively inexpensive, but configuring the production process to maintain traceability to the cut level is quite expensive. Thus, a very important consideration is the economic trade-off inherent in the level of traceability desired (e.g., individual retail ready cuts vs. individual animals, vs. farm, etc.).

Pricing methods are also impacted by the tightly coordinated production systems necessary to support traceability. In all cases prices originated at retail. Retail prices for case ready meat and egg products are transmitted directly from the particular retailer to the processing plants and then printed as part of the labeling information. However, prices to the farm and feed processing are negotiated. In the case of Label Rouge, prices for each participant in the production chain are derived from the retail price and dependent upon current overall commodity conditions. For example, if the cost of feed ingredients increased, farmers were paid a higher payment for the broilers to compensate for a portion of the feed costs. All members of the syndicate, including processors, farmers, feed suppliers and hatcheries, negotiate prices quarterly. Similar arrangements existed for all cooperative forms of organization. However, in the case of integrated firms such as VanDrie, prices received for the final product were allocated through the firm on a cost of production basis. Farmers in this case are contract growers paid a fixed fee for management.

Information Systems

Information systems observed range from relying heavily on paper and personal computers to fully web-integrated traceability systems. However, it is clear that all will evolve to incorporate the Internet because of its inherent merits for creating large and centrally managed databases. There are two key components to the information systems: the computer database applications and the hardware necessary to collect and record data.

One of the first insights gained is that traceability is a subset of total supply chain management and therefore, can be considerably less expensive to implement than a full-scale supply chain management system. This is because only the data on the product attributes itself must be maintained in this information chain. Secondary information such as personnel issues, billing and invoicing, financial planning, ordering, replenishing and forecasting are not central to maintaining traceability, are likely proprietary to the firm, and kept outside the traceability information flow.

Figure 2 shows a schematic of Gilde Norge's information system implemented with assistance from SCASE (hardware development) and Intentia (software development). It is representative of other state of the art systems observed. Figure 2 shows an overall product supply chain, including farms, ingredient suppliers (for simplicity simply feed, but can include seasonings at processing), the retail/distribution stage, consumers and the slaughter and processing plant itself. The vertical members of the supply chain all connect into the traceable information flow via the Internet. Therefore, there is typically a dedicated server which provides the interface and database for the traceability data. Each entity may maintain their own servers for their specific databases and simply allow queries through their firewall or there may be a central system managed by one of the entities on behalf of the participants. The latter is often the case between farms and processors or feed suppliers since few farmers have the information technology access (knowledge or capital) to create an internal information system with Internet capabilities. Underneath the Internet, which allows connectivity between firms, lies each firm's internal information system or enterprise resource planning systems (ERP's). ERP's are simply the platform on which company specific information resides (a prototypical structure is shown in Figure 2). The ERP will locally store all information regarding all activities electronically collected by the firm. The left hand side of the diagram illustrates the structure for Gilde to actually interface the physical data of the product with the digital traceability record. To the extent possible, information is gathered through electronic industrial data terminals. For example, each animal enters the plant with an ear tag printed with a conventional 12-digit barcode. This barcode is the animal's identification number and is cross-tabulated with the truck license plate and farm information which has been manually keyed into a personal computer with a local area network connection. The animal identification number remains with the carcass at all times, through sequential bar-coding. At the processing stages that primals and subsequent cuts are removed, barcode tags are created by printers and attached to each part of the animal as it is removed from the aggregate carcass. The unique barcodes of each cut are also entered into the ERP system. This process continues until the final case ready product is labeled with a barcode (this is in addition to the sale barcode which contains pricing information as well) and can be identified through retail scanning. Only that data which is necessary to assure traceability is accessible by other participants in the chain. This information usually includes the animal identification., the farm on which it was raised, the method of rearing, the feed supplier name and types of treatments (e.g., antibiotic, vaccinations, etc.). This information typically resides on the processors' information system because it serves as the natural aggregation point of data between diverse farms, feed suppliers and stores which are in the product supply chain. This leads to the observation that while retailers were often viewed as instigating or requesting the implementing traceability, it is the processors that played the pivotal role in managing the traceability systems since they are the primary interface between the farm product and the consumer ready product.

A good example of the efficiency of these systems for managing products occurs in the case of feed milling. Navobi, one of the feed suppliers for the VanDrie Group, uses electronic ration balancing for their milk replacer mixing. As a result they are able to uniquely identify all sources and quantities of ingredients in each batch of milk replacer. A subset of this information (ingredient list (not quantities), batch identification number, and microbiological assays) is uploaded to their web server that can be accessed via a password. Subsequent stages in the chain (veal farmers and packers) can examine this information, but cannot access other information which may be proprietary such as the proportion of ingredients used in the formulation, or price of ingredients. The merits of this information system are considerable in that it captures the efficiency of production management systems (ERP's), while enabling efficient transmission of information to upstream and downstream participants in the chain while maintaining security for the entity.

A component equally important for gathering data is hardware necessary to measure and collect the data on products. Weigh scales with data ports, visual carcass grading technologies which enabled capture of key carcass parameters, water monitoring devices for measuring mixing ratios of calf-milk replacer are all examples of data collection devices which greatly enhance the ability to capture production information. These lower the costs of collection by reducing labor requirements and improving accuracy and avoiding the error of human input. At this point, processing plants (feed and meat/egg) have a much higher level of automated data collection hardware than farms. This was particularly true in cases where the farms are mostly independent from the rest of the chain.

In addition to measurement devices, there must be methods to physically identify products. Interestingly, the everyday barcode was still the primary vehicle for labeling products. Two firms (Gilde and VanDrie) had experimented with implantable microchips and radio frequency transmitters (RFID's), but found they are unreliable compared to inexpensive barcodes. The primary problem with implantable chips is that they migrated in the animal so they were difficult to find, and more importantly may have carried a food safety risk in themselves, and RFID's had production line difficulties in getting them to read properly. At farms, much of the information was still captured via human data entry from paper reports, and multiple copies of paper reports are kept on file at other participants' locations or at enabling agencies.

The state of the art systems are real-time and transparent to anyone. In the cases of KAT and VanDrie they have consumer focused websites where the consumer may take the code number from their egg or package of veal, enter it into a website and actually see the farms and production plants where the product originated and a limited set of information on the production protocols, any quality assurance tests which had been done and their results. For an illustration, visit VanDrie's customer website at http://www.vealvision.com.

Firm Level Economic Implications of Traceability

To this point the primary emphasis of the paper has been a description of the traceability systems in place. This is necessary to accomplish the primary objective of defining the economic issues arising from traceability as experienced by our case study participants. Following is a description of the economic implications of these systems as identified by the participants.

Branding, Consumer Demand and Value Added

When case participants were asked why they adopted traceability, the first response in every case was: "consumers demanded to know where their food came from and how it was produced." Historical food safety issues such as dioxin contamination, BSE in cattle, radiation contamination as well as increased demand for organic and non-GMO products or free-range products were all cited as contributing to the consumers' preferences. Mostly these are credence attributes that are only verifiable by assurances of the seller. This is in contrast to physical attributes (e.g., the color of the meat) that are easily observable and verified by the consumer. Table 2 provides examples of prices received for products sold by participants compared to conventional products. Clearly participant products are priced higher than conventional products. However, the value of the credence attributes themselves is typically commingled with the value of the product attribute of traceability per se. So, it is impossible to say how much value consumers actually placed on traceability. However, participants believed that it enabled them to differentiate their products from others making similar product attribute claims, but not including traceability protocols. One participant illustrated this point by quoting Ronald Reagan in regard to nuclear arms reduction as "trust but verify".

In this context, participants clearly viewed traceability as an extension of traditional branding. Traditional branding has two primary benefits: it allows the buyer to capture the value of their particular product by differentiating it to the consumer and it enforces truth telling through a form of "reputational traceability" in the sense the company and it's brand are held accountable for delivering what they say they will deliver – in the present case a safe and wholesome food product containing the credence attributes promised. Electronic traceability also allowed the firms to extend the brand and reputational aspects back through the supply chain to all suppliers who otherwise would be anonymous to the final consumer.

Finally, the limited use of product liability litigation as a form of consumer protection and redress may also explain why traceability has become much more popular in the European countries. This is important for two reasons. One is it certainly adds additional incentive for the brander in the U.S. to maintain product safety and quality even without traceability or face legal and financial penalties. Conversely, the lack of product liability suits makes upstream suppliers less reticent about being identified and more willing to participate in traceability – the concern in the U.S. being that anonymity is good if you're potentially going to be named in a lawsuit.

Food Safety Economics

Traceability has two components in its production economic effects on food safety: (1) it assists in identifying the origin of the food safety problem and (2) it likely reduces the costs of containing a food safety problem if it occurs. Navobi, the calf-milk replacer manufacturer, provided an excellent example of this point. Their veterinary services identified a salmonella problem in routine on-farm testing. They immediately sampled feed batches at the farm. Through traceability databases they were then able to identify all other farms using feed from the same batches and which ingredients and their sources had gone into the suspected feed batches. Therefore, they were also immediately able to go back to plant records to crosscheck feed testing which had occurred prior to its sale. They found that no feed was contaminated and that the salmonella had been introduced by other means on the farm. Without traceability they would have recalled all suspected feed immediately to reduce the risk of cross contamination to other farms, and likely wouldn't have been able to identify as quickly that the contamination had occurred on the farm versus at the manufacturing plant. Had it occurred at the manufacturing plant, they also would have been able to trace the product forward and been able to target farmers that received the feed rather than issue a broader recall. Navobi conducted an ex post assessment of the cost savings from traceability in this circumstance, and estimated in this single instance it saved them over $100,000 in recalls and recovery costs.

Participants suggested that valuation of traceability in a food safety context depends on the following issues: (1) the accuracy of testing and sampling procedures for detecting contamination, (2) the costs of sampling and testing or control (HACCP) procedures, (3) the dispersion of the product once it leaves the control of the firm, (4) the probability of contamination itself, (5) the costs of recall and (6) any potential costs in terms of liability and reputational damage. What traceability likely contributes to these issues is that it reduces the costs of recovering from a food safety outbreak and to some extent may reduce the probability of outbreak by improving information within the process and enabling communication and identification of potential issues more quickly and efficiently among participants. To simplify this logic, think of it as the proverbial “ounce of prevention and a pound of cure”. You can prevent outbreaks and food safety issues through preventative measures such as improved sampling, testing procedures and technologies, or you can reduce the “pounds” or costs of compensating should an incident occur.

Traceability also affected the ability to allocate costs and benefits of value through the supply chain. The current issue with many food safety issues is that the restaurant, grocer or institution which last handles the product before consumption is the initial focal point for identifying the problem and also for resolving it and potentially bearing the liability costs. Similar allocation problems may exist at all stages of the chain. In this case, traceability plays an important role in both allocating costs once an outbreak has occurred, but probably also inherently improves it because firms are more likely to implement control procedures knowing that their probability of being identified and held responsible is much greater.

Management Value of Traceability

Participants also report that traceability often has internal production benefits from improved information and control of production even though traceability has generally been couched as a supply chain management issue driven by consumer demand. In large part this stems from the incorporation of ERP systems at the firm level that inherently improve data collection, as well as analysis, diagnosis and response to potential production problems.

Perhaps Gilde Norge, the Norwegian slaughtering plant, provided the best illustration. In implementing traceability, they incorporated a visual grading system. In this system, the carcass is photographed on the line and a computer program immediately uses the image to construct parameters on the size of the carcass. This information is instantaneously compared to previous carcass yields from similar carcasses already in the database. This information is passed to terminals along the line, which show appropriate cuts to be made in subsequent fabrication to maximize the yields of the carcass. As the carcass is fabricated, data is captured on the actual yields of the fabricated cuts and compared to the predicted values prior to fabrication. This ongoing real-time analysis of carcass cutouts aids in quality control and improves yields. In fact, at the end of each week the workers on the line are evaluated based on the data collected on their cutting efficiency and abilities to meet expected cutout yields with actual yields. They attributed this continuous improvement as adding five to seven percent to their final meat yields.

Similarly, in all cases strict controls on feed use and scheduling of delivery of animals naturally led to improved production management for growth efficiency and certainly enabled benchmarking of farms within the production system as was the case with Label Rouge in Challans. Each grower received a quarterly report of their relative efficiency compared to other growers within the syndicate.

Traceability has a multifaceted economic impact on firms and the supply chain. The key point is that there are potentially real economic cost and management benefits at the firm level at the same time that it improves coordination and allocation of values and costs in the supply chain. Many participants had concluded that the production and management benefits are great enough to warrant traceability adoption even without considering any potential added willingness to pay by consumers – even though as pointed out at the beginning of this discussion they viewed consumer preferences as the primary driver of their original adoption.

Governance and Structural Change Issues

Our case visits also revealed that traceability has implications for the structure of the supply chain and how firms organize. There are two aspects of impacts on governance and structure: (1) the organization and structure of the firms themselves and (2) the organization of the controlling agencies and auditing firms. All participant systems incorporating traceability are very tightly coordinated. The VanDrie group and Nutreco are completely vertically integrated, except for growers which are sometimes contract growers and sometimes owned production units. Gilde and Wiesengold are cooperatives, but growers are tightly organized through contractual membership into the supply chain. Lable Rouge is organized as "syndicates" with feed companies, growers and plants pre-approved for membership, but products within the syndicate can be transferred among alternative members. In all cases the production chains are relatively small scale compared to North American commercial production standards. The key issue with size and structure is the scale compatibility between stages of production which enables traceability. In other words, it generally took a relatively small number of growers to satisfy the demands of processing plants or to absorb the supply of feed plants. The primary scale incompatibilities in the North American supply chain may very well be that processing plants and feed manufacturing plants are of such a scale that it presents coordination problems with the large number of growers needed to manage traceability in the supply chain. The fewer operations which need to be traced the more easily traceability can be implemented. In fact, VanDrie had difficulty coordinating their conventional beef operations for traceability because it required over 500 growers versus the 100 growers who supply their veal operations. One hypothesis is that traceability may have diseconomies of scale in that it is more cost efficient and operationally efficient on a smaller scale than non-traceable commodity production. This observation is clearly dependent on future advances in tracking hardware technologies for measuring traceable attributes.

In the case of Label Rouge and Wiesengold, there are “control agencies”. The control agencies (KAT in the case of Wiesengold and Sylac in the case of Challans/Label Rouge) are responsible for managing records, establishing production protocols and standards, arranging for auditing and maintaining the databases supporting traceability. In other cases, the controls are internal. Auditing agencies are always external to avoid conflict of interest in application of production standards and traceability. Label Rouge also has extensive government involvement in managing the system. The Ministry of Agriculture and the Ministry of Finance have roles in developing and approving standards, establishing labeling requirements, and in preventing fraud. No other system has direct government involvement although government policies on traceability and food safety often influenced their decision to implement traceability or how it was implemented. As an independent controlling agency, KAT offers a good example of how production protocols and participation is managed. The European Poultry, Egg and Game Association developed KAT. It developed the traceability information system and also manages the control processes and data collection. However, outside auditing agencies perform system checks to assure compliance with their protocols. Members such as Wiesengold propose standards (such as feeding, medication, and other production protocols) which distinguish their supply chain. Producer members can then approve or reject these standards. Once approved, all members are audited, including processors, farms and feed suppliers if appropriate. Audits are often done on a monthly, quarterly or annual basis or around production flows of the system such as when animals are ready for slaughter or when new animals are brought into the system. Members pay a fee for the audits and for being members of the control group. Table 3 provides examples of the costs of the auditing and quality control programs for Label Rouge and KAT/Wiesengold. Members who do not comply are removed from the system. This is very important as they recognize their vulnerability to lapses in quality control given their added implication of safety.

It will generally be true that intensive traceability as we observed would require very tightly coordinated supply chains. How this coordination is achieved will also be important. The cooperative forms all recognized two potential problems 1) it is difficult to get membership buy-in to new protocols which may require increased investment since the members were otherwise autonomous 2) the reticence to change may affect their ability to be responsive to changing demands or new innovations. It appears that full integration has merits in both of these instances, where protocols can be updated and enforced at will. Secondly, it is clear that traceability has implications for size compatibility among participants in the supply chain. It appears that very large plants with a large number of suppliers or buyers will have difficulty managing traceability – it's simply a numbers game and as numbers increase logistics and control become more expensive. Information technologies are successful at reducing the costs of managing large numbers of records, but the requirement of control, auditing and verification is still largely a hands-on process which gets more costly as scale increases.

Public Policy and Trade

When this research was originally proposed, we were focused on issues of supply chain efficiency and the role of information systems. As we began scheduling site visits, the outbreak of foot and mouth disease in the UK, the events of September 11, and subsequent anthrax terrorism in the U.S. had a direct bearing on the implications of our research. Traceability affects the ability to contain both natural outbreaks of devastating diseases such as foot and mouth disease, but also on the ability to respond to and contain potential food borne bio-terrorism events. While much of this paper considers the implications on firms, traceability is a public health and policy issue. Since we did not specifically consider the issues of the public costs of disease outbreaks it's difficult to estimate the potential benefits of animal identification and tracking systems but in the case of the UK outbreak of FMD costs to the agriculture and food chain were estimated as $4.8 billion (Countryside Agency). Animal identification and tracking seems to be a minimal set of traceability which would enable quick identification and tracking of all affected animals and minimize the scope of such an outbreak. This is clearly already the objective of the EU animal passport system. Developing national systems on the order of the VanDrie Group's intensity would likely be extremely burdensome from a cost perspective. Similarly, doing nothing likely exposes extreme public health and economic risks.

So far, much of the discussion of trade implications has focused on market (or consumer) aspects e.g., Liddell and Bailey. The argument tends to be that some countries (consumers) have a preference for traceability and the lack of traceability by the U.S. harms its ability to capture those export sales and also reduces the United States' ability to compete with other countries for those importers' (buyers') purchases. In addition, the argument is that consumers may have a preference for products from one or another country and should have the right to know which country products came from. This "right to know" could arguably be left to voluntary traceability requirements. In essence the marketing arguments are completely analogous to those described earlier in this paper for firm level implications relating to branding, consumer preferences, product recall, liability and cost competitiveness.

However, if traceability becomes mandatory, it may have implications for trade agreements. The WTO Sanitary and Phytosanitary Measures (SPS) agreement and Technical Barriers to Trade (TBT) agreement provide complementary guidelines to establish technical requirements for meeting other countries' sanitary and quality standards. Traceability may or may not be classified as a technical barrier if it is not also required of domestic products and if it does not provide a justifiable need for product quality and safety. This is why it is important to understand whether traceability itself improves safety or whether quality assurance standards themselves provide this assurance. A good example of this issue is the EU Commission's proposal for labeling and tracing genetically modified organisms. Clearly the issue is entangled with the validity of the EU's ban on GMO's per se. If GMO's are ruled as being scientifically safe, their ban is unjustified and therefore, traceability required of exporters where GMO's are raised (vs. the EU which is purportedly GMO free) represents a trade barrier by raising the costs of the products which must be segmented, tested and labeled as to their contents. Another example of traceability's potential impact on existing trade restrictions is the EU's ban on U.S. beef due to hormone usage. In this case, the credence attribute of hormone-free beef products may be backed by the traceability program allowing it's acceptance into EU countries versus the ban on all beef products now due to the inability to verify hormone-free products.

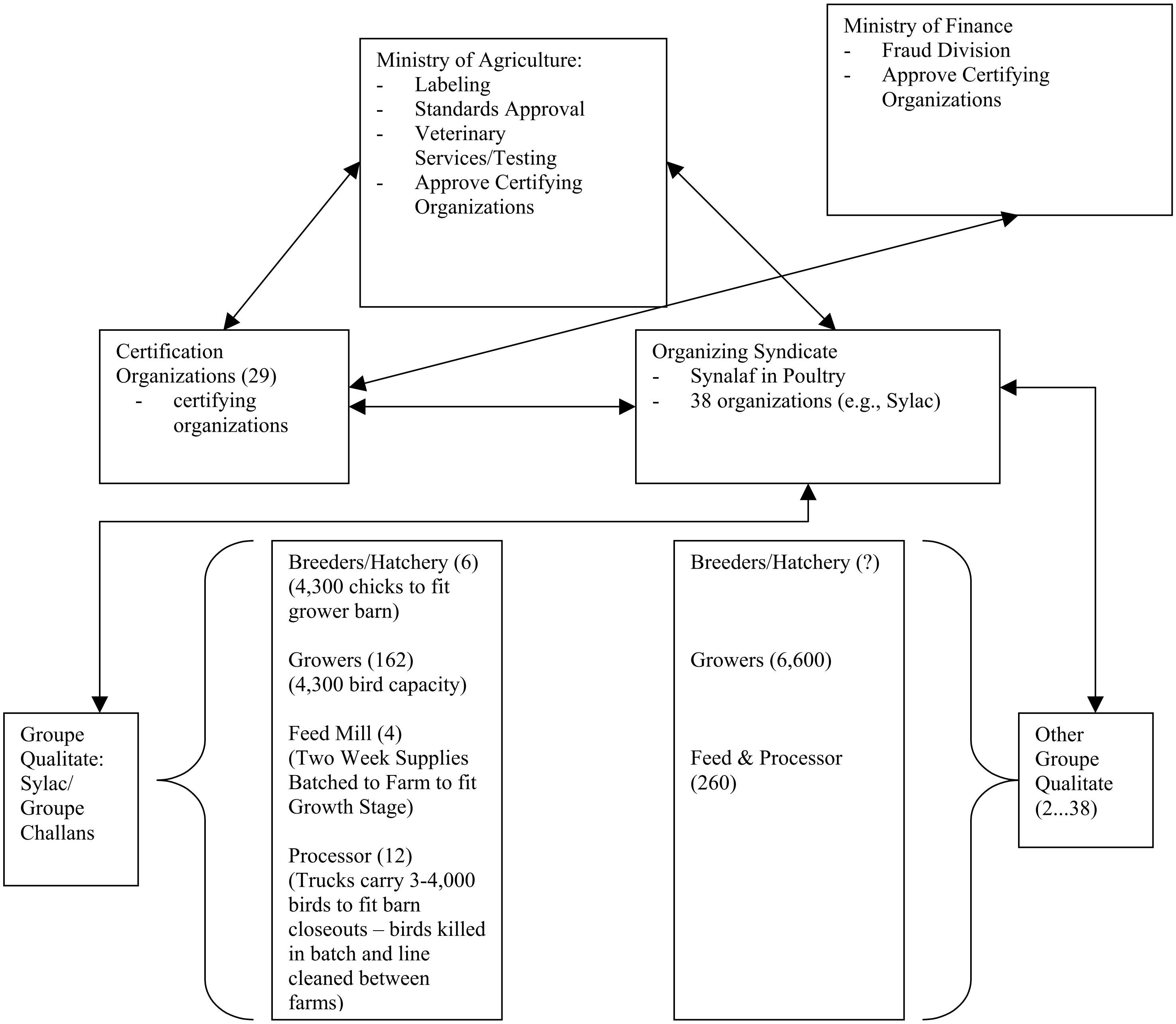
CONCLUSIONS

This paper has raised several issues which require further empirical investigation. However, the data from our visits also provides some guidance for some relatively confident conclusions. First, it is clear that electronic information systems greatly improve the potential for identify preservation, management of the supply chain and firm level management. Second, it is very likely that traceability will lead to more closely coordinated supply chains. Whether these can be cooperatively managed or if vertical ownership is more efficient is an empirical question. Third, traceability can improve the allocation of economic values, but the empirical question is does integration do the same thing and to what extent does integration become more valuable because of traceability and the ability to increase the control of a broader asset base. Fourth, while traceability is commonly considered a consumer demand issue, the greatest direct benefits appear to be from improvements in management and production efficiency. Finally, producers must begin to consider how they can capture and control their own information to improve the value of traceability for their own situation.

Given recent events, a relevant question in the U.S. is one of "how much traceability is *enough* traceability?" For example, without any additional investment in the U.S. meat supply chains, animals likely can be traced from packing plants back to individual finishing farms by using existing business documents such as invoices, shipping or weight tickets and other similar documentation. Lot or batch numbers can also be used to trace most meat products back to plant of origin and even with a reasonable level of confidence to the date they were manufactured and therefore narrow the window of possible sources of contamination. Is that enough? Would we also like to be able to trace the feed batches? Would we also like to know before actual entrance into the meat chain what other farms may have been supplied this feed? This is the central policy and business issue in traceability, particularly when considering food safety issues. How much is enough depends on the costs of tracing products, the potential costs if a contaminating event occurs and the potential costs of recall or discovery if a contaminating event occurs. These costs in turn are affected by the likelihood of a food safety event occurring and also the ability to control this likelihood given quality control strategies (e.g., feed testing at the farm) and the ability to intervene (e.g., irradiating for biological pathogens). This complex set of trade-offs is basically what defines how much is enough. As the U.S. meat industry considers traceability, the European experiences provide excellent insight into alternative information, production and management systems that can be used to achieve a range of desired levels of traceability.

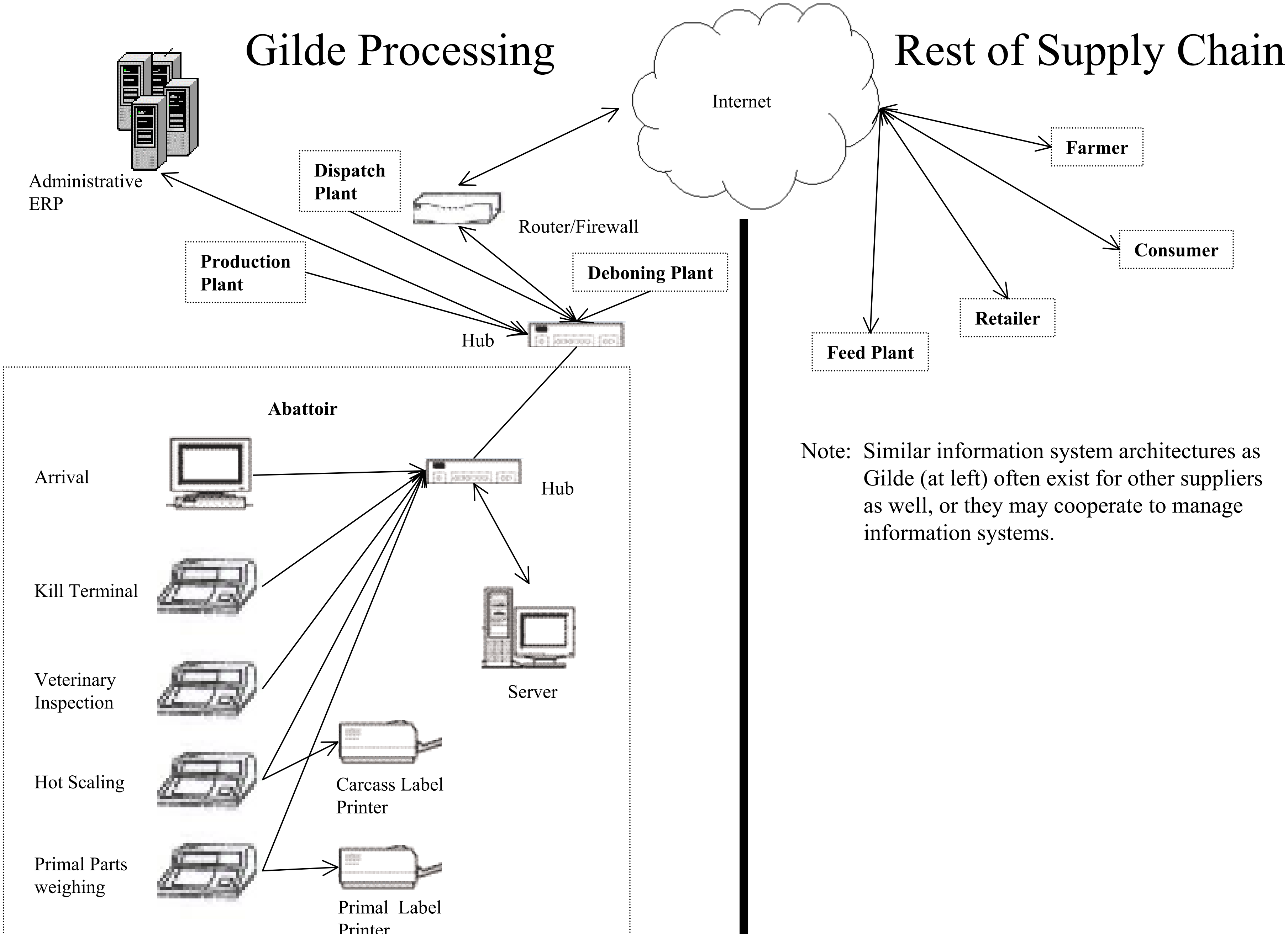
Table 1. Overview of Firms in Case Study

	Challan/ Label Rouge	VanDrie Group	Gilde Norge	Scotbeef	Wiesengold/ KAT	Intentia/ Nutreco
Product	Chicken	Veal	Pork, Lamb, Beef	Beef	Eggs	Salmon
Country	France	Holland	Norway	Scotland	Germany	Norway
Attributes	Free Range, Organic, Genetics	Hormone Free, Group Housed	Hormone Free, Humane Rearing	Hormone Free, Humane Rearing	Free Range, Organic	No specific criteria
Organ-ization Structure	Govt. Authorize 'Syndicate'	Vertically Integrated, Feed/Calf Raising/ Packing	Coop	Independent Contracting	Cooperative KAT is Standards Organization	Vertically Integrated
Quality Assurance	Govt. Audited, Syndicate Controlled Standards	External Audits, Self Imposed Standards	External Audits, Self Imposed Standards	External Audits, Self Imposed Standards	External Audits, Standard Defined by KAT	External Audits, Self Imposed Standards
Info. Systems	PC based Records, Labeling	Internet Based System	Internet Based System	PC Based System	Internet Based System	Internet Based System
Traceable Activities	Feed, Farm, Slaughter, Retail	Feed, Farm, Slaughter, Retail	Farm, Slaughter, Retail	Feed, Farm, Slaughter, Retail	Feed, Farm, Packing, Retail	Feed, Farm, Processing, Retail
Depth of Trace	Individual Bird	Individual Retail Cut	Individual Retail Cut	Individual Animal	Individual Egg	Individual Pond
Method of Tracing	Wing tags, manual reading	Barcode and ear tags	Barcode ear tags	Passports ear tags	Numerical code printed on eggs	Unknown



- Ministry of Agriculture and Ministry of Finance both approve Certifying Organizations.
- Certifying Organizations report to both Ministry of Agriculture and Ministry of Finance.
- Synalaf is a Quality Groupe that oversees all Label Rouge Poultry
- Sylac falls under Synalaf as one particular set of standards for Label Rouge Poultry. There are many other Groupes.
- Synalaf acts as liaison for standards approval and control for producers
- Sylac manages operations of groupe – maintains records, reports to Synalaf on controls, coordinates quality certification (e.g., site visits), and reconciles traceability checkpoints (e.g., feed quantity w/ number of birds fed or chicks delivered and chicks slaughtered.
- Ministry of Agriculture, Certifying Organizations and Sylac/Synalaf all maintain databases of relevant information, but these don't necessarily communicate.

Figure 1. Sample Organizational Structure of Label Rouge



Note: Similar information system architectures as Gilde (at left) often exist for other suppliers as well, or they may cooperate to manage information systems.

Figure 2. Prototypical Information System Architecture

Table 2. Comparative Prices of Quality Assured Products and Conventional Products

Item	Quality Assured Product (organic)	Conventional Product
Weisengold Eggs[a]	$0.30/egg	$0.10/egg
Challan Whole Chickens[b]	$4.50/kg	$2.60/kg
Pork Loins[c]	$12.90/kg	$11.57/kg
Beef Tenderloin[c]	$19.53/kg	$12.45/kg
Carrefour Poultry[c]	$5.51/kg	$4.15/kg

[a]Prices in Koln, Germany. KAT Certified Organic and Free Range Eggs. Conventional eggs had no traceability or quality traits

[b]Prices in Challan, France. Label Rouge organic and free range whole chickens versus conventional whole chickens at retail.

[c]Prices in Carrefour Store, Paris, France. Quality assured products are all organic but not Label Rouge. Conventional products have no quality assured traits.

All prices converted to U.S. dollars using exchange rates corresponding to date of visits.

Table 3. Illustration of Costs of Quality Assurance Programs

Organization	Organization Fees	Auditing Fees	Other Costs
Label Rouge	$0.03/bird	$90/site visit	--
KAT/Wiesengold	$0.02/egg (minimum of $135)	$70/site visit	$60 capital costs per hen, $7,000 printer costs, $0.10/egg direct costs

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