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by

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[1] Post-Doctoral Fellow (harun@iastate.edu) and Professor (jdlaw@iastate.edu) , respectively. Both are with the Department of Economics at Iowa State University.

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Practitioner's Abstract: *In the United States (U.S.), there is no uniform traceability regulation across food sector. Food and Drug Administration (FDA) implemented one-step back and one-step forward traceability over the industries under its jurisdiction. U.S. Department of Agriculture (USDA), which oversees meat, poultry and egg production, requires some record keeping as part of food safety regulation. Particularly, a two-part-system has developed; live animal traceability and meat traceability with slaughter and processing plants in between. This paper studies the question of whether (and if so how) meat plants' traceability levels vary with respect to the following factors; product specific (credence versus experience and search attributes, branded versus commodity meat, being exporter), organizational (spot market versus contracting), food safety related, and plant specific (a quality assurance system in place, number of sources, size, capital-labor ratio, etc.).*

Key Words: traceability, food safety, quality assurances, animal ID, RFID.

Introduction

The incidences of bovine spongiform encephalopathy (BSE) and possible introduction of foot and mouth disease (FMD) and other contagious diseases in livestock, the bioterrorism threat, recent high profile food scares and recalls due to *Escherichia coli* 0157 (E. Coli) and *Salmonella* increased interest in the concept of traceability in the United States (U.S.) . The basic idea of traceability is to create and maintain an "information trail" that follows to a certain extent the path taken by a given physical product in its entire production process. At the incident of food safety failure, it assists the response capability by identifying, measuring, and containing the problem, which makes rapid and effective action possible, which in turn may reduce the resulting hazard. Traceability is basically a proactive approach to food safety and quality management as it requires pre-incident investment.

There is no a commonly accepted and one-type-fits-all definition for traceability. The International Standards Organization of standards (ISO 9001: 2000) defines traceability as "the ability to trace the history, application, or location of an entity by means of recorded identifications". Golan, Krissoff, and Kuchler (2004) find this definition quite broad and suggest the following one "record keeping systems that are designed to track the flow of product or product attributes through the production or supply chain". According to Smyth and Phillips (2002), supply chain literature sees traceability as "information system necessary to provide history of products and services from origin to the point of sale". Mennecke, et al. (2006) defines traceability as "the ability to retrieve the history, treatment, and location of the animal that a cut of meat comes from, through a recordkeeping and audit system or registered identification program". Dickinson and Bailey (2002) adopt "ability to track the inputs used to make food products backward to their source at different levels of the marketing chain". The official definition of traceability in European Union (E.U.) is "the ability to trace and follow a food, feed, food-producing animal or substance intended to be or expected to be incorporated into a food or feed, through all stages of production, processing and distribution ." (E.U. General Food Law Reg. EC No. 178/2002). Bailey (2005) finds E.U. definition too detailed for U.S. and suggests the following "the efficient and rapid tracking of physical product and traits from and to critical points of origin or destination in the food chain necessary to achieve specific food safety and/or quality assurance goals." He argues that this alternative definition would allow traceability to be customized by specific industries and firms to meet specific goals for food safety or other types of quality assurances. In this report, we use the word "traceability" in broad sense as the ability to trace and track the flow of product or product attributes through the production or supply chain.

Some aspects of traceability notion also need to be defined. External traceability refers to traceability of product or product attributes through the successive stages of production (e.g. cow-calf producer, auction barn, feedlot, slaughter and processing). Whereas, internal traceability refers to traceability within the plant or productive unit, which may be a part of Hazard Analysis Critical Control Points (HACCP) plans. External traceability may require some degree of internal traceability (Lupin, 2006). Chain traceability refers to traceability throughout the entire food chain. Backward traceability, traceback, or tracing is defined as "the ability to identify the origin of a particular unit and/or batch of product located within the supply chain by reference to records held upstream" (New Zealand Trade and Enterprise, 2006). Forward traceability, traceforward, traceup, or tracking is defined as "the ability to follow the path of a specified unit of a product and/or batch through the supply chain as it moves between organizations toward the final point-of-sale or point-of-service" (New Zealand Trade and Enterprise, 2006).

Traceability is often interchangeably used with the notions; identity preservation, and segregation. Smyth and Phillips (2002) provide a taxonomy of these notions based on their distinct roles in agro-food supply chain. According to these authors, identity preservation (IP) has ex-ante perspective. For example, organic produce obtain premium after credibly claiming that necessary set of measures are taken to preserve the identity of the product (including the source of ingredients) in the chain. IP's main purpose is to extract premiums. Segregation is to prevent commingling of the product for which potential health concerns exist and other products throughout the supply chain. This may include novel varieties of grain and genetically modified (GM) versions. Segregation's focus is to ensure food safety not to extract price premium. The main function of traceability is considered as to identify the source of contamination and thereby help contain and remedy the food safety problem. It implies that that traceability has ex-post perspective. The price premium for traceability can be available for early adopters only in the short term. Liddell and Bailey (2001) further distinguish traceability from transparency, and quality assurances notions. Transparency refer to the public availability of production information at each stage of production and quality assurances refer to practices to ensure food safety and quality, which could be intrinsic such as back fat and curing or extrinsic such as animal welfare and environmental preservation. Hobbs et al. (2005) find that quality assurances are more valuable to consumers than traceability claim by itself. Bundling traceability with quality assurances has the potential to deliver more value.

Based on complexity and variety of traceability systems, Hobbs, et al. (2005) suggest that traceability is not simply a binary variable; present or absent but rather there are degrees of traceability. These degrees or levels can be characterized by referring to the breadth, depth and precision of the maintained information (Golan, et al. 2004). Breadth is the amount of information maintained in the traceability system. It may include contact information (such as mailing address, phone number, fax number, e-mail address) along with production information (such as health records, organic or natural production, etc). Depth refers to how far back or forward in the production chain the traceability is ensured. The product could be traceable to the immediate previous source to the subsequent recipient (one-step backward and one-step forward) as in Food and Drug Administration (FDA) requirements, traceable to processing plant only or traceable further to the feedlot, or traceable all the way to the birth farm. The precision refers to the degree of assurance at which a traceability system can pinpoint the particular item's movement. Precision is determined by the tracking unit such as lot or code with a unique identifier. The smaller is the lot, the more precise is the traceability system.

The tracking unit can be chosen at various levels. For example, Jensen and Hayes (2006) consider three levels: genetic, farm to retail, and batch traceability. Genetic traceability refers to a complete traceability level based on matching particular deoxyribonucleic acid (DNA) in meat to maintained DNA samples from animals and thereby locating the records of the animal. Even though DNA tracing is considered as a hypothetical benchmark in Jensen and Hayes (2006), some of its applications in New Zealand and Australia are reported elsewhere (Tonsor and Schroeder, 2004). Nevertheless, Cunningham and Meghen (2001) argue that DNA identification will not be the primary means for live animal identification in the foreseeable future, yet it can aid the visual or electronic ID systems. Farm to retail traceability is the system which can track the identity of all cuts from a farm through the processing and distribution channels. Jensen and Hayes (2006) argue that this system is very expensive and requires reconfiguration of production, additional capital, and data infrastructure investment. For a typical large scale U.S. plant, the cost of such reconfiguration is reported as eight cents per pound of meat produced. Finally, batch traceability is the traceability from farm up to carcasses without further tracking in the cutting floor. The identities of the source are maintained at the batch level. Jensen and Hayes (2006) argue that this system is relatively inexpensive as it does not require reconfiguring the production line. Within the batch traceability, the more stringent traceability can be obtained by stopping the production and breaking the full day of work into segments (intra-day batches) or by sorting or segregating the inputs and processing the resulting batches.

Furthermore, tracking unit can be chosen by using radio frequency identification (RFID) technology. Mennecke and Townsend (2005) provide case studies for various RFID applications. According to these authors, RFID could be applied at gambrel or further at bin or board level in the fabrication floor. At gambrel identification, the information in live animal's tag is carried through the process of packing plant. Once carcass is hooked, the information in animal's ear tag (RFID or visual tag) along with date and lot number information are read into RFID chip embedded in gambrel. Then, the post-slaughter weight is added to gambrel's RFID chip and general information system. Gambrel RFID system works till the point of separating primal parts. After this point, animal is off the hook and bin-based RFID systems might be useful. In latter, primals are moved to bins and all information accumulated up to date point is passed to RFID chip in the bin. The shortcoming of bin-based systems is that it can track individual animal but in case the cutting board is contaminated, it still requires recall of the entire lot. To avoid this, another method is developed in Australia, which enables individual tracking and individual recall. It is based on moving RFID-embedded cutting boards with information on primal cuts. Boards are sterilized between animals. The value cuts and scrap of individual animal are moved to individual cutters for later separation and packaging. More complex cuts are handled by maintaining the part sequences, which are correlated with the original animal. Information in bins and boards are transferred to general information system and if this information is correlated with the position of packaging conveyor, it may suffice to establish traceability at the individual animal level. Once the product is packaged, a bar code or RFID label is assigned. This is the starting point for the traceability in next segment in the beef chain.

Tracking unit examples can be found in other industries, as well. Pharmaceutical industry experimented to implant RFID technology at item (folder box or bottle) level or container level (bundles, boxes, pallets, cases, etc.) to prevent counterfeit drugs, better call-back control, and better inventory control. In fresh produce industry, container as a tracking unit is critical in case of recall. Grower's container may contain information on the field, day and sometimes even the hour it is harvested (Food Traceability Report, 2001). Depending on the information on the container, the product can be traceable at the level of day, shift or hour of production. In seafood industry, the tracking unit could be pallets, cartons, and units within the cartons (Lupin, 2006).

The objective of this study is to quantify the relationship between the level of traceability adoption and the plants' characteristics, quality and safety practices, and the food safety regulation. Although U.S. slaughter and meat processor plants are surveyed for their adoption of HACCP plans and food safety investments (Ollinger, Moore, and Chandran, 2004; Muth, et al., 2005a; Cates, et al. 2006), their traceability activities are not studied in a straightforward and coherent manner. To this end, a survey including 43 questions which characterize meat plants' traceability level, production process, products, and plant type is prepared. The survey was recently sent to the licensee plants of Iowa Department of Agriculture and Land Stewardship,[2] which covers 192 meat plants including those with national brands and many small or very small plants. Based on the survey responses, an indirect (categorical) measure of traceability and appropriate explanatory variables will be constructed (see Table 3). An ordered logit model along the lines of Hassan, Green and Herath (2006) and Souza-Monteiro and Caswell (2006) will be estimated. The estimated model, then, will be used to test the hypotheses (discussed in Econometric Modeling section) that can convey answers to the questions of interest.

[2] See the website at http://www.agriculture.state.ia.us/meat&poultry.htm for more information.

We are interested in the plant level solution for adopting a level of traceability which is determined by the breadth, depth, and precision of the maintained information. Firms' adoption of traceability system should be similar to typical investment decision. They must be balancing benefits and costs for traceability. As benefits and costs for traceability vary, they develop different traceability levels. Because the relative significance of generic drivers (risk management, differentiation, productivity gains) will differ among industries, individual firms, this will lead to the adoption of various solutions (New Zealand Trade and Enterprise, 2006). Technologies with a clear and immediate benefit are more readily adopted. Whether that is the case in adopting a traceability system is not known. Nevertheless, an analogy to firms' investments decisions on information technology (IT) can be useful. Firms' investment on IT and uncertainty over return in terms of productivity is an ongoing discussion (Lucas, 1999). Even though previous literature found no evidence on the positive impact of information system (IS) spending on output at the aggregate level, Brynjolfsson and Hitt (1996) find firm level evidence on the positive impact of IS spending on productivity with a more current and larger dataset. In a later study, Brynjolfsson and Hitt (2003) find much larger contribution of computerization in the long term compared to short term and explain this with a combination of computerization and complementary organizational investment and innovations which takes time to accrue. They argue that firm level data may be more suitable in capturing intangible benefits associated with computerization to the extent that it is due to firm specific investments, whereas these benefits may be missed at industry level analyses due to aggregation error.

Background

In response to BSE crises in mid 1990s, E.U. mandated a highly stringent level of traceability as defined earlier also known as "farm to fork" or "linear" traceability. Compared to E.U., U.S. traceability system is less stringent and less sophisticated (Souza-Monterio and Caswell, 2004; Jensen and Hayes, 2006). Firstly, there is no uniform traceability regulation across food sector in U.S. FDA mandated Establishment and Maintenance of Records under Bioterrorism Act of 2002 for industries under its jurisdiction. This regulation requires traceability at the level of immediate previous source and immediate subsequent recipient. These requirements do not apply to the industries that are exclusively under U.S. Department of Agriculture's (USDA) jurisdiction which are meat, poultry and egg products.

Particularly, in cattle and beef industry a two-part-system has developed; live animal traceability and meat traceability. Linking these two systems at the stage of slaughter and processing is an ongoing challenge for the industry (Golan, et al. 2004). For live animal tracking, National Animal Identification System (NAIS) is scheduled to be fully implemented in 2009. Currently, only about 10% of the 2 million premises nationwide was registered as of March 2006 as part of implementing NAIS (Brasher, 2006). In E.U. all meat animals arrive to plants with individual animal identification through a passport number with a scanner code. Nevertheless, Jensen and Hayes (2006) claim that farm to retail traceability is very rare in practice even in E.U. although many consumers think that this is the system prevailing in E.U. Instead, batch traceability is the most common traceability system in E.U., yet less common in U.S. On the processing stage, batches are typically larger in U.S. than E.U.

For U.S. meat slaughter and processing plants, traceability is voluntary beyond the record keeping required by food safety regulation (Federal Meat Inspection Act, Wholesome Meat Act, HACCP plans of 1996 and BSE regulations of 2004). A related mandate is country of origin (COOL) regulations (a 2002 Farm Bill provision) which requires appropriate labeling as to the country of origin of product. However, the implementation of mandatory COOL for all covered commodities (beef, pork, lamb, etc.) except wild and farm raised fish and shellfish was postponed on November 2005 until September 2008. COOL requires that firms maintain verifiable record keeping audit trail. Self-certification is not enough, which implies identification and segregation as to the country of origin. Meanwhile, in order to make COOL voluntary, Meat promotion Act of 2005 was proposed. Trade associations such as American Meat Institute (AMI), state processor associations, and some producer associations (National Cattlemen's Beef Association, NCBA) support voluntary COOL. Lusk and Anderson (2004) report that voluntary COOL has not been seen in the market place even though this option is available to plants and some willingness to pay is reported (Loureiro and Umberger, 2004). Some producer associations (R-Calf USA) and consumer groups such as Consumer Federation of America seek mandatory COOL. In line with this, there are some legislative efforts to speed COOL up to September 2007. Perhaps, the issue with COOL will be resolved as part of Farm Bill 2007. Amid this regulatory turmoil, how meat plants are preparing regarding COOL is not known.

The stakeholders on the demand side of food market seek improvements in U.S. traceability system. Consumer representatives such as Consumer Federation of America (CFA) calls for a mandated Animal ID system and a tracking system from slaughterhouse to farm (Consumer Federation of America, 2004).[3] Moreover, in an open letter to FDA Consumers Union called for a comprehensive traceability system from farm to table so that regulators can quickly and easily trace the origin of a given food item.[4] Finally, consumer studies (such as Loureiro and Umberger, 2004) found willingness to pay for traceability even more than country of origin labeling. Nevertheless, the current state of traceability in U.S. is supported by representatives from grain and meat industry for being more efficient than mandatory traceability system in E.U. because of its flexibility to meet a given specific food safety and quality goals (Farm Outlook Report, 2004). U.S. market meat processors think that introducing traceability beyond batch (lot based) level would slow down the throughput (Mennecke and Townsend, 2005). Although lot-based system can control recalls via multiple daily lots (e.g. four lots per shift or two shifts per day) can avoid big recalls, it may not be adequate in providing the source assurance necessary for effective branding (Mennecke and Townsend, 2005). In line with this, some

[3] More information about this organization can be found at http://www.consumerfed.org/ .
[4] More information about this organization can be found at http://www.consumersunion.org/.

segments in meat supply chain voluntarily adopt more stringent traceability systems. For example, Creekstone Farms Premium Beef tracks animals up to the carcasses halved or quartered using gambrel which contains an embedded RFID (Mennecke and Townsend, 2005).[5] There are also emerging businesses providing solutions for a database system to facilitate forward and backward traceability of agriculture products from field to consumer such as VeriPrime Certified Traceable and Scoring Ag.[6]

The previous studies which included traceability questions in their surveys to U.S. meat slaughter and processing plants are reviewed in the following section.

Literature Review

Hooker, Nayga, and Siebert (1999) surveyed a group of slaughter plants in Australia (41 plants) and meat processors in Texas (65 processors) on food safety activities and communication opportunities among different segments in beef supply chain. Among other things, slaughter firms were asked about process modification costs in slaughter floor due to quality assurance activities (mostly due to HACCP). Processors were asked about their customers' food safety demands including traceability of raw materials. In terms of overall average, 56% of customers demanded federal/state inspection, whereas only 4% of customers demanded traceability. The mean percentage of customers demanded traceability increased with the sale size of processors. The mean percentage of customers demanded traceability was 3% for processors with sale size of $1 million to $5 million, and more than 16% for those with sale size of exceeding $5 million. However, for the latter two sale size groups, the percentage of customers demanded traceability varied from 0% to 50%.

Cates, et al. (2006) report based on a national survey of meat and poultry slaughter and processing plants executed by Research Triangle Institute (RTI) on behalf of USDA's Food Safety and Inspection Service (FSIS) in 2004. They surveyed 598 meat and 219 poultry slaughter and processing plants. The survey mainly consisted of questions on the use of food safety practices and technologies and plant characteristics, and included two questions on traceability. In terms of backward traceability, they asked if meat and poultry plants identify and track their products, by production lot, backward to specific animal and bird growers, respectively. In terms of forward traceability, they asked if meat and poultry plants identify and track their products, by production lot, forward to specific buyers (not consumers) of their products. Tables 1 and 2 present a summary the responses. In conclusion, poultry plants adopt more backward and forward traceability than meat counterparts, which could be due to organizational factors as poultry plants are more vertically integrated and have more automated production process (Ollinger, Moore and Chandran 2004; Hennessy, Miranowski and Babcock 2004). As the size of plants

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[5] More information about this company can be found at http://www.creekstonefarmspremiumbeef.com/

[6] More information about these programs can be found at www.veriprime.com and www.ScoringAg.com, respectively.

increase they adopt more forward traceability both in poultry and meat plants. Size is a factor in backward traceability only in poultry plants overall, and large and small plants versus very small plants. Both meat and poultry plants adopt more forward than backward traceability.

Data Sources

Our target sample includes 192 Iowa based federal or state inspected meat plants. They are listed as licensees in the website of Iowa Department of Agriculture and Land Stewardship (IDALS) Meat and Poultry Bureau.[7] The majority of the companies in this sample are small or very small firms, yet there are nationally known large plants, as well. The information on the small and very small plants' traceability activities should be complementary to the research studied the impact of HACCP Rule on small or very small processors (Siebert, Nayga and Hooker, 200l; Antle, 2001; Boland, Peterson-Hoffman and Fox, 2001).

The survey includes 43 questions in total; 16 questions on the plant's traceability activities, 8 questions on the plant's production process, 6 questions on the plant's products, and 13 questions on the plant's characteristics. The survey questions are reviewed by the IDALS bureau and several industry contacts for feedback purposes but no endorsement or responsibility is implied.

Econometric Modeling

In addition to reporting a summary of responses to the survey, we will estimate an ordered logit equation where propensity to adopt a traceability level or category is modeled as a function of firm's characteristics. This is in line with the approach taken in Hassan, Green and Herath (2006) to food safety and quality activities of Canadian meat processors. Also, Souza-Monteiro and Caswell (2006) utilizes a binomial logit model to explain the adoption of traceability at the farm level in Portuguese pear industry, where the choice is over EurepGAP (European Retailers for Good Agricultural Practices) standards versus the mandatory E.U. level. Another approach is provided in Jayasinghe-Mudalige and Spencer (2006). They estimate propensities of the Canadian red meat and poultry processing sector to adopt enhanced food safety controls as a function of firm level characteristics and other factors. They construct a dependent variable (the propensity to implement enhanced food safety controls) in the form of multiplicative and additive indexes based on the responses to their survey and estimate a regression equation using Ordinary Least Squares (OLS) procedure.

The relationship between level of traceability adoption and plant's characteristics is written as

[7] For more information on the plants, see http://www.kellysolutions.com/ia/MeatPoultry/ .

(1) $$T^* = \beta_0 + \sum_{i=1}^{K} X_i \beta_i + \varepsilon \quad ,$$

where T^* is the unobservable dependent variable (traceability level), β_0 is the intercept parameter, X_i for $i = 1,...,K$ are explanatory variables, β_i for $i = 1,...,K$ are the corresponding parameters, and ε is the disturbance term to the equation. The equation (1) can be seen as a reduced form of a structure which describes the traceability decision process of a profit maximizing firm. Souza-Monteiro and Caswell (2006)'s modeling is in line with this approach. Souza-Monteiro and Caswell (2005) consider such a decision problem within a principal agent framework where the customer is principal and the plant is agent. Other structures may include hedonic pricing approach within competitive market equilibrium. This route is taken for the food safety variable in Antle (2000). We concentrate our efforts on the specification of equation (1) without adhering to a particular structure.

Based on the responses to the questions which characterizes the plants' traceability activities (both backward and forward) in terms of breadth, depth, and the precision dimensions in the survey, we will construct an indirect measure for traceability T as levels 1 for low, 2 for medium, and 3 for high. Then,

(2) $$\begin{aligned} T &= 1 \quad \text{if} \quad -\infty \le T^* < \mu_1, \\ &= 2 \quad \text{if} \quad \mu_1 \le T^* < \mu_2, \\ &= 3 \quad \text{if} \quad \mu_2 \le T^* < \infty, \end{aligned}$$

where the bounds μ_1 and μ_2 are parameters to be estimated. Plugging T^* from (1) into (2) and denoting the explanatory variables (intercept term included) and corresponding parameters in matrix form as $\boldsymbol{X}$ and β, respectively yields the following in terms of probabilities

(3) $$\begin{aligned} P(T = 1 \mid \boldsymbol{X}) &= \Lambda(\mu_1 - \boldsymbol{X}\beta) \\ P(T = 2 \mid \boldsymbol{X}) &= \Lambda(\mu_2 - \boldsymbol{X}\beta) - \Lambda(\mu_1 - \boldsymbol{X}\beta), \\ P(T = 3 \mid \boldsymbol{X}) &= 1 - \Lambda(\mu_2 - \boldsymbol{X}\beta), \end{aligned}$$

where $\Lambda = \dfrac{e^z}{1+e^z}$ is the cumulative probability function for logistic distribution with a generic variable z.

Table 2 provides a list of possible variables that can be constructed using survey responses. Based on the estimated parameters of these explanatory variables, the following hypotheses will be tested.

Hypothesis 1: The more credence attributes, as opposed to experience and search attributes in the marketing of meat products include, the more stringent the traceability is for verification purposes.

Hypothesis 2: The branded meat is associated with more stringent traceability than commodity meat for quality control purposes.

Hypothesis 3: Being exporter requires more stringent traceability adoption.

Hypothesis 4: Relying more to spot-market, as opposed to contracting, for supplier base facilitates less stringent traceability.

Hypothesis 5: The level of traceability adopted increases with the risk of food safety failure in meat products.

Hypothesis 6: Having an already a quality assurance system in place such as ISO 9001 (2000), Quality Assurance Systems (QAS) lead to more stringent traceability.

Hypothesis 7: The sizes of firms matter for the level of traceability they adopt.

Hypothesis 8: The more capital intensive plants adopt a more stringent traceability level.

Hypotheses 1), 2), and 3) refer to product specific factors, 4) is for organizational factors, 5) is for food safety related factors, and 6), 7), and 8) are for plant specific factors. We elaborate on these hypotheses in the following:

For hypothesis 1); credence attributes such as claims on geographical origin, animal welfare, humane treatment of animals, no use of antibiotics or growth implants, feed related (naturally fed), genetics (e.g. Angus beef), need to be verified at the farm level in order to be credible (Latvala and Kola, 2003). For experience and search attributes (taste, tenderness, palatability, freshness, appearance, color), consumers are presumed to be able to discern these attributes. If promised quality is not delivered in terms of these attributes, the product may not receive the repeat purchase. Branding can communicate the experience attributes well. Buhr (2003) compares traceability as a means of resolving information asymmetry in the supply chain to traditional means, such as, branding, repeat purchases, third party certification (could be USDA grading or non-profit organizations such as Food Alliance [8]). He argues that branding can be solution for information asymmetry at retail-customer interface but not necessarily at interfaces at upper stream, (such as supplier and processor). The reason given for the latter is that retailers do not have full control over raw materials and quality uncertainty. He suggests that traceability will be preferred more over the traditional means if there are more information asymmetry in the upstream versus downstream process, lower task observability, higher production quality/quantity uncertainty in the upstream suppliers, and higher supervision and/or monitoring costs of tasks and attributes. He also argues that for credence attributes

[8] More information about this organization can be found at http://www.foodalliance.org/ .

and pre-existing vertical production coordination factors, traceability and traditional means can be equally desirable.

For hypothesis 2); Meat brands have recently proliferated as part of efforts for differentiating products and targeting niche markets. Examples for brands include Target's Sutton and Dodge, Oregon Trail Beef, Rancher's Reserve, and Niman Ranch Beef. USDA Agricultural Marketing Service (AMS) defines branded beef product as "those boxed beef that are produced and marketed under a corporate trademark or under one of USDA's meat grading and certification branch certified programs where the basis of brand is the quality, yield, or breed characteristics of the product which are not unique to any one packer and can be produced by anyone in the industry, regardless of the brand (i.e. CAB® or Sterling Silver®)" (Stone, 2004). The packers, fabricators, distributors, and restaurants must be licensed in order to produce or sell products under the latter brands.

Brand can be considered as the implicit contract between customer and the firm. Sustainable profitability from branding requires consistently delivering the promised level of quality. This can be achieved with input and process controls, such as adopting quality assurance systems, and monitoring the compliance with production protocols with suppliers. Antle (2001) considers identity preservation (a close notion to traceability) along with testing, inspection, and process control as quality control instruments. With traceability, the principal firm can better control average quality or variation in quality for specific supplier, and improve its monitoring. For example, Niman Ranch group's nearly 500 suppliers must comply with strict production protocols. This brand's niche is based on the presumption of good taste is mostly determined by good husbandry (all natural feed, avoiding stress on animals, humane treatment, etc) of animals along with breed effects. Furthermore, as seen in recent pet food poisoning incidences, branding may provide a shield against food safety problems to externalize the food safety problems to other brands (Thomsen, Shiptsova, Hamm, 2006) but that requires credible demonstration of a brand's control over its supply chain.

For hypothesis 3); export markets Europe and Japan adopted more stringent and sophisticated traceability systems compared to other countries (Souza-Monterio and Caswell, 2004). In order to qualify to export to Japan, producers should verify age of their animals via Process Verified Programs (PVP) or Quality System Assessment (QSA) Programs, which facilitates traceability of cattle to production records. For European Union, there are specific requirements regarding hormones and feed (non-hormone treated cattle program) that U.S. beef exporters must meet. In meeting the demands of Export markets, because self-certification would not be enough, meat slaughtering and processor plants would need to have a traceability procedure in place to verify the claimed credence attributes.

For hypothesis 4); contracting is used for quantity and quality control, and management of supply chain by retailers or packers. It might specify the production methods, and the type of inputs used. Benefits to producers include financial stability and lower risk. The downside of contracting include less flexibility over production, less price exploration opportunities, and some relationship specific investments that needs to be undertaken. Cost of traceability can be presumed to increase with the number of suppliers and variability over the supply base as in the case of spot-market. Identifying the pre-designated suppliers as in contracting for traceability should be less costly. Also, producers have incentive to do better due diligence to obtain repeat business as contracting facilitate reputation effects better. Muth et al. (2005) report traceability as one of the reasons for adopting alternative marketing arrangements such as marketing agreements and forward contracting. On the other hand, Giraud-Heraud, Hammoudi, and Soler (2005) hypothesizes that implementation of generic standards common to several retailers such as EurepGAP instead of private standard of each individual retailer can herald return back to spot markets instead of contractual relationships or vertical alliances between retailers and producers.

For hypothesis 5); the easier it is to establish liability against the previous segment in the chain in case of food safety failure, the higher the incentive is to establish a more stringent traceability level. This can help to pass at least a part of the cost of food safety failure to other segments (Sumner and Pouliot, 2006). However, the damage to the reputation or brand is typically incurred by the end of supply chain, such as restaurants, or processors (see Stearns, 2004 for two high profile examples). Because, customers often identify the product with the restaurants they are dining. Therefore, franchises and restaurants have strong incentive to implement traceability to the rest of their supply chain. Of course, the influence of these customers is directly related to the significance of their share in a given plant's sales. For example, McDonald's had targeted at least 10% of its U.S. beef purchases to be traceable from farm to table at the end of 2004 and at no distant future all products would be based on animals under animal ID program. Moreover, having an experience of product recall and/or lawsuit for food safety failure in the past may lead to more stringent traceability requirements with the suppliers, and some brand lines or products may have been discontinued by processors. Finally, the riskiness of meat products could also be a factor. Some product categories are more prone to food safety problem than others as found in FSIS-RTI survey of experts' elicitation on the relative riskiness of meat and poultry products (FSIS, 2005).

For hypothesis 6); possible synergies between quality assurance programs and traceability are investigated here. Mora and Menozzi (2005) report that cost of traceability is lower if there are already a quality assurance scheme in place, such as ISO 9001: 2000 standards. Traceability appears to be complementary to quality assurance systems to differentiate products. HACCP and ISO 9001: 2000 require data collection and verification that the necessary actions are taken, and the inputs stage is a critical point under both systems. Pathogen Reduction/HACCP Rule Part 417. 2(a) states that plants must conduct hazard analysis "to determine the food safety hazards reasonably likely to occur before, during and after entry into the establishments". An implication of that is meat slaughtering plants may need more information (such as quality assurance program certification, animal/premise supplier identification, treatment and disease records) on incoming animals for their HACCP plan, which in turn should affect animal producers (FSIS, 2001).

For hypothesis 7); the larger and the more complicated the operations are, the costlier traceability is to satisfy a given safety or quality assurance standard as the total variable cost of traceability increases with the size. On the other hand, average fixed cost of implementing traceability decreases with the number of head processed. Mora and Menozzi (2005) finds that unit cost of the mandatory traceability is higher for medium size firms in Italy. Bailey, Robb, and Checketts (2005) argue that “farm to fork” traceability as in E.U., as opposed to traditional two-part traceability system in U.S., may require plant and line redesigns, new types of line equipment, or fewer people and locations within the plant for disassembling carcasses. At least, under the current batch system, the groups of animals from the same origin can be collected into the same batch and processed at the same time. This gives the small and mid-size firms in advantage over large firms in implementing the traceability in their plants because the individual farms and feedlots can not fill the big scale operations. This necessitates the mixing of cattle from different origins to form batches in large plants, which increases the cost of tracking. Furthermore, Ollinger, Moore and Chandran (2004) speculate that additional compliance costs with HACCP rule could be lower for large firms compared to small firms as large firms would have been more likely to have had to comply with buyer/custommer requirements prior to HACCP rule. Finally, Ollinger, Moore and Chandran (2004) also indicate that small firms tend to produce more specialty products, whereas big firms tend to produce more commodity products. Including both brand and size factors in the regression equation will help distinguish the each factor’s impact.

For hypothesis 8); this is an implication of Hennessy (2005), where he hypothesized that more informed control over inputs may lead to automation and capital intensive production. Capital is known to be less flexible compared to labor to deal with heterogeneity of inputs. Therefore, with better control over input heterogeneity, plants may substitute more capital. However, at least in the short-run, capital can be assumed to be fixed but plant may have flexibility over traceability. Traceability as it increases information flow in inputs, and therefore, the control over inputs, it decreases costly slow downs at the production of more capital intensive plants due to heterogeneity in input, therefore it should be desirable.

Conclusion

This paper outlines our research proposal on the traceability levels of meat slaughter and processing plants in Iowa. It includes the motivation, objective, background, relevant literature, data source, econometric modeling and hypotheses sections. As this paper is written, the surveys have been recently sent. The analysis has to wait until the data becomes available. A final report with the findings will be written in the near future.

This study focuses on the weakest link in the meat supply chain in terms of traceability; meat slaughter and processing plants. The information obtained from this study is expected to shed light on plant level solutions to adopt traceability activities as response to economic incentives and environment. This study is also very much in line with ongoing regulatory proposals. If NAIS is implemented in the near future, the traceability at the live animal stage will improve. Whether that will be matched by slaughter and meat processor plants depends on the economic drivers of traceability levels in the market place. Moreover, synergies are expected between a plant's traceability activities and its preparedness for a possible implementation of mandatory COOL in the very near future per record keeping and verification requirements. Finally, this study may stimulate similar undertakings at other states or at the national level.

Table 1: Meat and Poultry Slaughter and Processing Plants' Backward Traceability Practices (Identifies and tracks its products, by production lot, backward to specific animal/bird growers) [1, 2]

	All Meat	All Poultry	Very Small Meat	Very Small Poultry	Small Meat	Small Poultry	Large Meat	Large Poultry
Number of Plants	598	219	391	27	154	64	53	128
Use the practice now	52.5 %	78.7 %	52.1 %	55.6 %	51.3 %	79.7 %	62.3 %	85.9 %
Expect to begin using the practice within 1 to 3 years	11.6 %	4.3 %	…	…	…	…	…	…
Does not use and does not expect to use the practice within 1 to 3 years	32.4 %	13.5 %	…	…	…	…	…	…
No response/multiple responses/not applicable (write in)	3.5 %	3.6 %	…	…	…	…	…	…

Source: Cates. et al. 2006

[1] "…" indicates no data availability.

[2] Chi-square tests are applied to verify if size is statistically significant factor in adopting the backward traceability practice. The conventional levels of significance are used. For meat plants, size is not found as a factor for both overall and pair-wise bases. For poultry plants, size is found as a factor at the 1% overall, large versus very small plants at the 1%, small versus very small plants at the 5% (with p-value of 0.019), but not for large versus small plants.

Table 2: Meat and Poultry Slaughter and Processing Plants' Forward Traceability Practices (Identifies and tracks its products, by production lot, forward to specific buyers (not consumers) of its products) [1, 2]

	All Meat	All Poultry	Very Small Meat	Very Small Poultry	Small Meat	Small Poultry	Large Meat	Large Poultry
Number of Plants	598	219	391	27	154	64	53	128
Use the practice now	53.5 %	82.6 %	49.0 %	51.9 %	67.5 %	79.7 %	86.8 %	94.5 %
Expect to begin using the practice within 1 to 3 years	11.6 %	3.7 %	…	…	…	…	…	…
Does not use and does not expect to use the practice within 1 to 3 years	32.3 %	10.4 %	…	…	…	…	…	…
No response/multiple responses/not applicable (write in)	3.6 %	3.3 %	…	…	…	…	…	…

Source: Cates. et al. 2006

[1] "…" indicates no data availability.

[2] Chi-square tests are applied to verify if size is statistically significant factor in adopting the forward traceability practice. The conventional levels of significance are used. For both meat and poultry plants, size is found as a factor for both overall and pair-wise bases at the 1% level.

Table 3. Part I: Select variables to be constructed from responses to the traceability survey

	Variable	Description
T_i	Traceability level	Categorical variable which takes 1 for low level, 2 for medium level, and 3 for high level of traceability.
X_1	Type of plant	Dummy variable which take value of 1 for the corresponding category and 0 otherwise. The categories could be slaughter, processor, distributor, other, slaughter and processor, slaughter and distributor, processor and distributor, etc.
X_2	Meat type	Dummy variable which take value of 1 for the corresponding category and 0 otherwise. The main categories could be meat-only versus meat and poultry plants. Meat category could be further divided into sub-categories such as beef-only, pork-only, beef-mixed, pork-mixed, etc depending on the percentages of these meat types within the plant's total annual production.
X_3	Size of plant	Dummy variable which could take value of 1 for the corresponding category and 0 otherwise. The categories are very small, small, medium, and large depending on the size of annual sales.
X_4	Age of plant	Continuous variable indicating the number of years plant has been operating.
X_5	Capital intensity	Dummy variable which takes value of 1 for the corresponding category and 0 otherwise. Categories could be very low, low, medium, high depending on the value of plant's capital versus the number of employees at the plant.
X_6	Market orientation	Dummy variable which take value of 1 for the corresponding category and 0 otherwise. Categories could be intrastate-only, interstate-only, exporter-only, interstate and exporter, etc.
X_7	Concentration of suppliers	Continuous variable indicating the share of top three suppliers in plant's total dollar value of inputs (animal/fresh meat)
X_8	Concentration of customers	Continuous variable indicating the share of top three customers in plant's total sales revenue
X_9	Credence claims	Dummy variable which take value of 1 for the corresponding category and 0 otherwise. Categories could be constructed based on the share of products with credence claims within total annual sales.

Table 3. Part II. Select variables to be constructed from responses to the traceability survey continues.

X_9	Branded product	Dummy variable which takes value of 1 for the corresponding category and 0 otherwise. Categories could be constructed based on the share of branded products within total annual sales.
X_{10}	Plant ownership	Dummy variable which takes value of 1 for the corresponding category and 0 otherwise. Categories could be constructed based on the type of ownership such as if it is independently owned and operated or a branch of corporate company, etc.
X_{11}	Contracting supplier	Dummy variable which takes value of 1 for the corresponding category and 0 otherwise. Categories could be constructed based on the percentage of inputs (live animal/fresh meat) procured using forward contracting or marketing agreements versus cash/spot market.
X_{12}	Contracting customer	Dummy variable which takes value of 1 for the corresponding category and 0 otherwise. Categories could be constructed based on the percentage of sales made using forward contracting or marketing agreements versus cash/spot market.
X_{13}	Customer type	Dummy variable which takes value of 1 for the corresponding category and 0 otherwise. Categories could be constructed based on the percentage of sales coming from restaurants, retailers, wholesalers, etc.
X_{14}	Food safety efforts	Dummy variable which takes value of 1 if plant does tests over and above than what is required in Pathogen Reduction/HACCP Rule.
X_{15}	Product riskiness	Dummy variable which takes value of 1 for the corresponding category and 0 otherwise. Categories could be constructed based on the percentages of meat products with differing food safety risk within the total annual production.
X_{16}	Insurance	Dummy variable which takes value of 1 if plant carry insurance against product recalls and 0 otherwise.
X_{17}	Quality assurances by plant	Dummy variable which takes value of 1 if plant has a quality assurance system (such as QSA, PVP, ISO 9000, etc.) in place and 0 otherwise.
X_{18}	Quality assurances by supplier	Dummy variable which takes value of 1 if plant's suppliers have a quality assurance system (such as QSA, PVP, ISO 9000, etc.) in place and 0 otherwise.

References

Antle, J.M. 2000. “No Such Thing as a Free Safe Lunch: The Cost of Food Safety Regulation in the Meat Industry”. *American Journal of Agricultural Economics* 82(2): 310-22

Antle, J.M. 2001. “Economic Analysis of Food Safety”. Gardner, B.L. and R.C. Gordon, eds. Handbook of agricultural economics. Volume 1B. Marketing, distribution and consumers. Handbooks in Economics, vol. 18. Amsterdam; London and New York: Elsevier Science, North-Holland: 1083-1136.

Bailey . D. 2005. “Benefits and Costs Associated With an Animal Identification System for Cattle in the United States”. Presentation available at http://www.amavoice.com/October05/feature2-oct05.htm .

Bailey, D., J. Robb, and L. Checketts. 2005. “Perspectives on Traceability and BSE Testing in the U. S. Beef Industry.” *Choices* 20(4): 4th Quarter.

Boland, M., D. Peterson-Hoffman, and J.A.S. Fox. 2001. “Post-implementation Costs of HACCP and SSOP's in Great Plains Meat Plants”. *Journal of Food Safety* 21(3): 195-204

Brasher, P. 2006. “ID System Lingers in Limbo”. Des Moines Register. March 12.

Brynjolfsson, E. and L.M. Hitt. 1996. “Paradox Lost? Firm-Level Evidence on the Returns to Information Systems.” *Management Science* 42(4): 541-558.

Brynjolfsson, E. and L. M. Hitt. 2003. “Computing Productivity: Firm-Level Evidence.” *Review of Economics and Statistics* 85(4): 793-808.

Buhr, B. 2003. “Traceability and Information Technology in the Meat Supply Chain: Implications for Firm Organization and Market Structure”. *Journal of Food Distribution Research*. 34(3).

Cates, S.C., Karns, S., Viator, C., & Muth, M.K. 2006. “Food Safety Practices and Technologies Used by U.S. Meat Slaughter Plants: Results of a National Mail Survey.” 93rd Annual International Association for Food Protection Meeting, August 13–16.

Consumer Federation of America. 2004. “A Mandatory Animal Identification System Capable of Tracing All Animals Back to the Farm of Origin Is Essential To Protect Public and Animal Health”. Press release. January 23.

Cunningham, E.P. and C.M. Meghen. 2001. “Biological Identification Systems: Genetic Markers”. *Revue scientifique et technique (International Office of Epizootics*) 20: 491-499.

Farm Foundation. 2004. "Food Traceability & Assurance in the Global Food System." E.G. Jones and D. Bailey, eds. Farm Foundation's Traceability and Assurance Panel Report, Oak Brook, IL, July.

Golan, E., B. Krissoff, F. Kuchler, L.Calvin, K. Nelson, and G. Price. 2004. Traceability in the U.S. Food Supply: Economic Theory and Industry Studies. Agricultural Economic Report Number 830. Economic Research Service, U.S. Department of Agriculture.

Giraud-Heraud, E., H. Hammoudi, and L. Soler. 2005. "Retailer-led Regulation of Food Safety: Back to Spot Markets?". Paper presented at the 11th Conference of the EAAE (European Association of Agricultural Economists) on the Future of Rural Europe in the Global Agro-Food System. Copenhagen, Denmark, August 24-27, 2005.

Food Traceability Report. 2001. "Produce Traceback Investigations Frustrated By Middlemen". FCN Publishing, July.

FSIS. 2001. "The Impact of Pathogen Reduction/HACCP on Food Animal Production Systems." Presentation available online at http://www.fsis.usda.gov/oppde/animalprod/presentations/sld001.htm .

FSIS. 2005. "Relative Risks of Meat and Poultry Products: An Expert Elicitation." Memorandum available online at http://www.fsis.usda.gov/PDF/Elicitation_Memo_092205.pdf .

Hassan Z., R. Green, and D. Herath. 2006. "An Empirical Analysis of the Adoption of Food Safety and Quality Practices in the Canadian Food Processing Industry". Available online at http://www.bepress.com/sjohnson/

Hennessy D., J. A. Miranowski, and B. Babcock. 2004. "Genetic Information in Agricultural Productivity and Product Development". *American Journal of Agricultural Economics* 86 (1): 73-87.

Hennessy, D. A. 2005. "Informed Control Over Inputs and Extent of Industrial Processing". CARD Working Paper #05-WP 398, June 1, 2005.

Hobbs, J.E., D. Bailey, D. L. Dickinson, and M. Haghiri. 2005. "Traceability in the Canadian Red Meat Sector: Do Consumers Care?" *Canadian Journal of Economics* 53: 47-65.

Hooker, N., R.M. Nayga, Jr., and J. Siebert. 1999 "Preserving and Communicating Food Safety Gains." *American Journal of Agricultural Economics* 81:1102-1106.

Jayasinghe-Mudalige, Udith Krishantha & Henson, Spencer. 2006. Economic Incentives for Firms to Implement Enhanced Food Safety Controls: Case of the Canadian Red Meat and Poultry Processing Sector." *Review of Agricultural Economics* 28(4): 494-514.

Jensen H. H. and D. J. Hayes. 2006. "Private Sector Approaches to Secure. Traceability, Transparency and Quality. Assurance in Food Chains". Paper presented in the IATRC Summer Symposium "Food Regulation and Trade: Institutional Framework, Concepts of Analysis and Empirical Evidence". Bonn, Germany, May 28-30, 2006. Available online at www.agp.uni-bonn.de/iatrc/iatrc_program/Session%204/Jensen_Hayes.pdf . Accessed on December 19, 2006.

Latvala, T. and J. Kola. 2003. "Impact of Information on the Demand for Credence Characteristics." *International Food and Agribusiness Management Review* 5(2).

Lucas, H. C. 1999. "Information Technology and the Productivity Paradox: Assessing the Value of Investing in IT." New York: Oxford: Oxford University Press.

Lupin, H. 2006. "Traceability". The Document Presented for Discussion at the Committee On Fisheries, Sub-Committee On Fish Trade (COFI:FT), Tenth Session, Santiago de Compostela, Spain, May 30-June 02.

Mennecke B. and A. Townsend. 2005. "Radio Frequency Identification Tagging as a Mechanism of Creating a Viable Producer's Brand in the Cattle Industry." MATRIC Research Paper 05-MRP 8. Midwest Agribusiness Trade Research and Information Center, May.

Mennecke, B., A. Townsed, D. J. Hayes, and S. Lonergan. 2006. "A Study of the Factors that Influence Consumer Attitudes Toward Beef Products Using the Conjoint Market Analysis Tool." Iowa State University, CARD Research Paper 06-WP 425. August.

Mora C. and D. Menozzi. 2005. "Vertical Contractual Relations in the Italian Beef Supply Chain." *Agribusiness* 21(2): 213-235, April.

Muth, M. K., R. Beach, S. Karns, C. Viator. 2005a. Economic Impact Analysis: BSE Rulemaking. Report prepared for the U.S. Department of Agriculture, Food Safety and Inspection Service, March. Available online at http://www.aamp.com/foodsafety/documents/BSE-EconomicImpactAnalysis-2005.pdf .

Muth, M.K., Brester, G., Del Roccili, J., Koontz, S., Martin, B. 2005b. "Spot and Alternative Marketing Arrangements in the Livestock and Meat Industries: Interim Report." July. Report prepared for the U.S. Department of Agriculture, Grain Inspection, Packers and Stockyards Administration.

New Zealand Trade and Enterprise. 2006. Traceability a Platform for Product Knowledge and Value. A Report for New Zealand Trade and Enterprise, June.

Ollinger, M., D. Moore, and R. Chandran. 2004. "Meat and Poultry Plants' Food Safety Investments: Survey Findings". U.S. Department of Agriculture, Economic Research Service, Technical Bulletin 1911.

Siebert J.W., R. M. Nayga Jr. and N. Hooker. 2000. "Dimensions of Food Safety Risk Mitigation Strategies Adopted by Meat Processors: The Case of HACCP". World Food and Agribusiness Forum International Food and Agribusiness Management Association.

Smyth S. and P. W. B. Phillips. 2002. "Product Differentiation Alternatives: Identity Preservation, Segregation, and Traceability." *AgBioForum* 5(2): 30-42.

Souza-Monteiro, D. M. and J. A. Caswell. 2004. "The Economics of Implementing Traceability in Beef Supply Chains: Trends in Major Producing and Trading Countries". Working paper no. 2004-6. Available online at http://www.umass.edu/resec/workingpapers .

Souza-Monteiro, D. M. and J. A. Caswell. 2005. "The Economics of Traceability for Multi-Ingredient Products: A Network Approach". Paper presented at the 2005 Annual Meeting of the American Agricultural Economics Association.

Souza-Monteiro, D. M. and J. A. Caswell. 2006. "Traceability Adoption at the Farm Level: An Empirical Analysis of the Portuguese Pear Industry". Paper presented at 2006 Annual Meeting of American Agricultural Economics Association, July 23-26, Long Beach, California. Available online at http://agecon.lib.umn.edu/cgi-bin/index.pl .

Stearns, D. 2004. "An E. coli O157:H7 Outbreak at a Chain Restaurant: A Case Study on How Easily Legal Liability Can Spread to a Franchisor." Law Journal Newsletters' Franchising Business and Law Alert, February.

Stone, K. 2004. "Comprehensive Boxed Beef. Cutout: Data, Analysis and Comments." Live Stock Information Center. Available online at www.ag.ndsu.nodak.edu/aginfo/lsmkt/docs/ac071304.pdf .

Sumner D. A. and S. Pouliot. 2006. "Traceability, Liability and Incentives for Food Safety and Quality". Paper presented at 2006 Annual Meeting of American Agricultural Economics Association, July 23-26, Long Beach, California.

Thomsen M. R., R. Shiptsova, and S. J. Hamm 2006. "Sales Responses to Recalls for Listeria monocytogenes: Evidence from Branded Ready-to-Eat Meats." *Review of Agricultural Economics* 28(4), Winter.

Tonsor G. T. and T. C. Schroeder. 2004. "Australia's Livestock Identification Systems: Implications for United States Programs". Available online at http://www.agmanager.info/events/risk_profit/2004/Schroeder.pdf .