Can an Industry Voluntary Agreement on Food Traceability Minimize the Cost of Food Safety Incidents?

David M. McEvoy and Diogo M. Souza-Monteiro*

Paper prepared for the Organized Session on the "Economics of Traceability" at the XIIth Congress of the European Association of Agricultural Economics Association, Gent, Belgium, July 26-29, 2008

* Corresponding author

David M. McEvoy (mcevoydm@appstate.edu) is Assistant Professor at the Economics Department, Appalachian State University, Raley Hall, 416 Howard St., ASU Box 32051, Boone, NC 28608-2051 and Diogo M. Souza Monteiro (D.M.Souza-Monteiro@kent.ac.uk) is Lecturer at the Kent Business School, University of Kent, Wye Campus, Wye, Ashford Kent TN25 5AH, UK

Can an Industry Voluntary Agreement on Food Traceability Minimize the Cost of Food Safety Incidents?

Abstract: In the recent past the United States has had a number of severe food-safety outbreaks in the produce, vegetable and beef industry that greatly disrupted the food system. In all these outbreaks here were severe disruptions on sales that affected the whole industry, and it took an extended period of time to *correctly* locate the source of the outbreak. Traceability can be an effective tool to reduce the impact of food safety incidents my expediting the search for the origin of outbreaks. This paper investigates to what extent an industry-led voluntary agreement for providing traceability can reduce the cost of a food-safety outbreak. We find that a voluntary agreement on traceability can successfully reduce the cost of a food-safety outbreak but will unlikely achieve the optimal social level of traceability because of significant free riding.

Keywords: Traceability, voluntary agreements, food safety

Can an Industry Voluntary Agreement on Food Traceability Minimize the Cost of Food Safety Incidents?

1. Introduction

In the recent past the United States has had a number of severe food-safety outbreaks in the produce, vegetable and beef industry that greatly disrupted the food system. Examples include the 2003 outbreak of the Bovine Spongiform Encephalopathy (or "mad-cow disease") that banned American beef exports to key Asian markets (Goldstein 2003), the 2005 fresh spinach E. coli outbreak which halted spinach sales for California farmers (Calvin 2007), and, most recently, the 2008 *Salmonella* outbreak which had disastrous effects on the lucrative tomato industry after the pathogen was initially traced to tomato farmers (Shin 2008). Weeks later, the source of the outbreak was eventually found to be jalapeño peppers imported from Mexico (Venkataraman 2008).

There are two common features to all of these outbreaks: 1) there were severe disruptions on sales that affected the whole industry, and 2) it took an extended period of time to *correctly* locate the source of the outbreak. Of course these two features are highly linked because the longer it takes to find the source of the problem, the longer consumers and government remain uncertainty about the nature and extent of the problem, which results in larger economic losses. In the short run, economic losses are typically due to food-product bans, product recalls, disposure of contaminated food, public heath impacts and in the long run the economic losses are mainly due consumer's distrust and lost of goodwill. A potential way to decrease the economic costs of food-safety issues is by implementing traceability in food-supply chains. Traceability, as applied to food products, provides detailed product information on product's origins and location, characteristics and production processes that can be used to more easily identify the source of a food safety issue (Pouliot and Sumner 2008).

Traceability was one of the main tools introduced in new food legislation by the European Union (EU) as a response to a similar series of food scares that disrupted European food supply in the late 1990s (European Parliament and Council 2002). Pressure is mounting over the FDA to introduce traceability as a way to expedite the search for the origin of food-safety issues and thus reduce the costs to both consumers and industries (Just-food.com 2008). Although a number of experts suggest that problems in the US food supply are due to shortcomings in the legal system or lack of mandatory regulations, in a recent interview Dr. David Acheson, Associate Commissioner for Food at FDA, remarked that the FDA lacked the authority to mandate traceability systems and urged the industry to voluntarily take the initiative (Venkataraman 2008).

The argument on whether traceability should be an initiative of the industry or government authorities has already been considered in the literature. Golan *et al.* (2004) studied the implementation of traceability systems in the US and concluded it may be inefficient when imposed by governments. Hobbs (2004) argues that the discussion on whether traceability should be a public or private responsibility lies on the eventuality and extent of market failures. In other words, even though traceability may have clear private benefits, such as improving logistics and facilitating procurement, it may also have large public benefits as it can potentially reduce the frequency and/or severity of food-safety outbreaks (Meuwissen *et al.* 2003; Golan *et al.* 2004).

Given that traceability exhibits public good characteristics, its private provision by individual firms will likely be suboptimal; as firms will attempt to benefit from the provision of traceability without bearing the cost of providing it. This point is argued by Havinga (2006) who raises concerns about how effective the private sector may be in delivering controls that coincide with societal goals, given the public good dimension of food safety. Indeed the consequences of inadequate levels of traceability may be very costly, as highlighted by the recent outbreaks in the United States. In short, when traceability provides public benefits, its privately optimal choice may not coincide with what would be the social r event the industry optimum. Thus incentives exist for firms to voluntarily come together to try and jointly increase their provision of traceability. Havinga (2006), in support of voluntary initiatives for providing traceability, argues that coalitions of a limited number of highly organized and fairly homogenous agents can exist whose collective private interest coincides with the public interest, and under certain conditions it may be possible for that coalition to achieve a socially optimal level of traceability.

This study analyzes a model of a voluntary agreement designed to increase the provision of traceability which is used as a tool to mitigate the costs associated with a food-safety outbreak. We adopt the stability concept of a *self-enforcing* agreement in order to determine the equilibrium number of members of a voluntary agreement, the aggregate level of traceability and the resulting cost to the industry of a food-safety outbreak. The goal of this research is to investigate to what extent an industry-led initiative of providing traceability can reduce the cost of a food-safety outbreak. Although the economics literature on the use of voluntary agreements for environmental protection is vast (e.g, Carraro and Siniscalco 1993; Barrett 1994; Khanna and Damon 1999; Alberini and Segerson 2002; Croci 2005; Ulph 2004; Kolstad 2007; Dawson and Segerson 2008; McEvoy and Stranlund 2008a) this paper is the first to apply the framework of a voluntary agreement to traceability systems.

We find that when it is possible for firms to reduce the cost of a food-safety outbreak by cooperatively providing traceability, a voluntary agreement that leads to an increase in the level of traceability will always form. However, the actual number of firms that join the voluntary agreement will depend on the relative cost of providing traceability and the resulting benefit from a reduction in the cost of an outbreak. We find that voluntary agreements will typically garner less than full participation and therefore may not be entirely successful at achieving the socially optimal level of traceability.

2. Background

Traceability systems have the ability to "trace the history, application or location of that which is in consideration" (ISO 2000). Even though this is a very broad definition it does suggest traceability is a tool through which information on origin of products can be registered and shared. Moe (1998) distinguishes internal from chain traceability. The former denotes a system whereby internal information on a firm's production processes is recorded. Chain traceability, on the other hand, tracks a product trough production, transportation, processing and eventually retail involving different firms. In this paper we are interested in chain traceability, and define traceability simply "as sharing information on food's origin, attributes and production processes with the other agents in the market".

While in the early 1990s, traceability started to be implemented in the food industry mainly due to private motives (Gencod EAN France 2001), in the early 2000s both the EU and Japan created public initiatives to make traceability mandatory initially in the beef industry and then, in the EU, for all food sectors (European Parliament and Council 2002; Souza Monteiro and Caswell 2004). Traceability systems have both private and public values. Examples of private benefits of traceability are improved supply chain logistics, consumer's trust, product differentiation or lower recall costs. Some of the public benefits of traceability are better risk management and limit public health impacts of food safety incidents (Meuwissen et al. 2003; Golan et al. 2004; Hobbs 2004). Golan et al. (2004) studied food traceability systems in the US and developed a framework to analyze whether existing private systems deliver an efficient level of traceability and how a regulator may induce the socially optimal level. Golan et al. found that there were different levels of traceability across industries and that each food industry has a specific traceability system. Moreover, although their findings suggest that systems in place were efficient in providing a private level of traceability, it was not possible to assess whether that coincided with the social optimum where both private and public interest should be considered.

Hobbs (2004) analyses the introduction of traceability by an industry, individual firm or a regulator using a game-theory approach. She suggests a taxonomy of traceability systems according to product attributes and information problems, where three types of traceability system for food safety are considered. All these systems, regardless of whether they are an industry or individual's firm initiative, may reduce exposure to 'free-riders' externality costs or liability in the case of an outbreak.

Pouliot and Summer (2008) model the supply of safe food in a two-stage marketing channel, where homogeneous farms sell output to homogenous marketers who in turn sell to consumers. When traceability is not available, firms are anonymous and may free ride on the producers of safer food. Though unsafe food can originate either at the farm or marketer levels, food-safety issues increase in the number of firms in the supply chain and with imperfect traceability systems. In their model traceability is defined as an exogenous probability of identifying a source. Though this work relates to ours in the sense that it investigates the relationship between industry traceability degrees and food safety incidents, we depart from Pouliot and Sumner (2008) in that we only consider a level of firms in the chain and make the choice of traceability endogenous.

Although voluntary agreements are not currently used to increase provision of traceability in food markets, a number of market-led standards recently emerged in the food industry (Fulponi 2006). These standards were initiated at different levels of food supply chains and address both environmental and food safety issues. One example is provided by

EurepGAP, a scheme initially developed by an association of European retailers to harmonize standards imposed by different supermarket chains in their procurement strategies for fruits and vegetables. Recently this was renamed GlobalGAP, and now covers fruit and vegetable, flowers and ornamental, animal production, acquaculture, tea and coffee among and others. The scheme is quickly becoming a universal standard for producers worldwide aiming to get a contract with the increasing number of supermarkets or food service operations that require this standard (GlobalGAP 2008).

Our research relates to both Golan et al. (2004) and Hobbs (2004) in that we focus on an industry-led traceability initiative. Like Hobbs (2004) we investigate the motivations for a firm or an industry to introduce traceability, however we analyze the formation of a voluntary agreement made between firms in order to increase industry-wide provision of traceability. Our analysis addresses one of the fundamental questions in Golan et al. (2004); that is, whether an industry-led traceability system (in our case, a voluntary agreement) can provide the optimal level of traceability.

3. The model

Traceability can be seen as the total amount of information on output origin, production processes and safety attributes a firm is willing to disclose. A reasonable assumption is that the higher the level of traceable information the lower the impact of a food safety hazard. This is because the larger the amount of information available on the location, origin and attributes of a given product at any given time the faster the process of tracking an incident.

In the event of a food safety incident, in the short run firms in the industry will incur economic losses due to recall of products, forsaken sales, disposure of contaminated product and potential compensation to consumers due to health damages. These costs to the industry may be due to market or governmental responses. For example a regulator may issue a penalty on the industry for the societal losses or demand compensation for the cost of searching for the origin of a food safety outbreak and the need to dispose of contaminated foods. Depending on the liability rules prevalent in a country and the ability to held firms accountable for originating a food safety incident, each individual firm may have to internalize a proportion of the total costs of the food safety incident. Of course the faster is the finding of the origin and the more precisely is identified the extent of such incident the lower will be total costs.

Towards a model of choice of traceability in food industries, consider a food industry comprising n homogeneous firms that each make a binary choice whether to provide traceability (i.e., revealed information regarding the production process of a specific food product) in order to minimize their total cost. Let t_i equal one if firm i chooses to offer traceability and zero otherwise and t_{-i} be the sum of traceability provided by all firms other than i, α be the individual cost of providing traceability, π be the probability of a food-safety issue occurring, A be the total cost to the industry of a food-safety issue and $\pi A/n$ is the firm's share of the expected cost of a food-safety issue. While the exact amount or proportion of total costs of food safety may vary from incident to incident and with other factors such as liability rules or the relation of power between firms in food chains, it is reasonable to assume that each firm will be held accountable for the average total industry loss. Individual firms choose t_i to minimize

$$c_i(t_i, t_{-i}) = \alpha t_i + \frac{\pi A}{n}\left[1 - \frac{1}{n}(t_i + t_{-i})\right], \qquad [1]$$

where c_i is firm i's cost function, α, $A > 0$, $0 < \pi \leq 1$, and $\alpha > \pi A / n^2$ so that all firms choose not to provide traceability in a non-cooperative Nash equilibrium. In this baseline situation an individual firm's cost is

$$c_i^b = \pi A / n, \qquad [2]$$

where the superscript *b* indicates a firm's baseline cost function. If all firms in the industry provide traceability (i.e., $t_i + t_{-i} = n$), then using [1] a firm's cost is then

$$c_i^f = \alpha, \qquad [3]$$

where the superscript *f* indicates a firm's cost when all firms in the industry provide traceability.

If $\alpha \leq \pi A/n$ then $c_i^o - c_i^b \leq 0$ when $t_i + t_{-i} = n$ and therefore it is possible for firms to decrease their individual cost (at least weakly) by jointly agreeing to providing traceability. Thus, if $\alpha \leq \pi A/n$ there is an incentive for the industry to try and increase their provision of traceability through a voluntary agreement. From here on we will restrict our analysis to situations in which $\alpha \leq \pi A/n$.

3.1 The voluntary agreement

Following Barrett (2003), we model the formation of a voluntary agreement in three stages. In the first stage the *n* firms decide independently whether to become a member to a voluntary agreement. Let *s* denote the number of members to a voluntary agreement. In the second stage, the *s* agreement members choose their level of traceability to minimize their joint costs. In stage three, the *n* – *s* non-member firms independently make the decision whether to provide traceability given the choices made by the agreement members in stage two. The equilibrium number of members to the agreement is solved by backward induction and hence we begin with stage three.

Let the superscripts *m* and *nm* indicate a member and non-member firm, respectively. The cost function for a non-member firm is

$$c^{nm} = \alpha t^{nm} + \frac{\pi A}{n}\left[1 - \frac{1}{n}(t^{nm} + t_{n-s-1}^{nm} + st^{m})\right], \qquad [4]$$

where t^{nm}_{n-s-1} is the aggregate traceability level of the other $n - s - 1$ non-member firms and st^m is the level of traceability provided by the member firms. Since non-member firms make their traceability decision independently, as before, each non-member minimizes its cost by choosing to not provide traceability in stage three.

In stage two, the s members to the voluntary agreement decide whether to provide traceability by minimizing their joint costs. Given that the $n - s$ non-member firms do not provide traceability in stage three, using [1] the aggregate cost function of the agreement members can be written as $sc^m = \alpha st^m + s\pi A/n\left(1-(1/n)(st^m)\right)$, and when simplified

$$c^m = \alpha t^m + \frac{\pi A}{n}\left[1 - \frac{1}{n}(st^m)\right]. \qquad [5]$$

The cost function of the agreement members is decreasing in s and since $\alpha > \pi A/n^2$ and $\alpha \leq \pi A/n$ there exist coalition sizes that are strictly greater than one and weakly less than n in which the agreement members will minimize their costs by choosing to provide traceability. From [5] it is easily verified that the smallest coalition of members for which providing traceability is cost minimizing is

$$s_{\min} = \min\left\{s \mid c^m(s) \leq c_i^b\right\} = \min\left\{s \mid s \geq n^2\alpha/\pi A\right\}. \qquad [6]$$

If $s \geq n^2\alpha/\pi A$ from the first stage of the game, then the agreement members will minimize their joint costs by each providing traceability in stage two. Otherwise, if $s < n^2\alpha/\pi A$ the members will minimize their costs by choosing not to provide traceability in stage two.

To determine the equilibrium number of firms that join the voluntary agreement in stage one, we adopt the stability concept of a *self-enforcing* agreement often used in the analysis of cartels (D'Aspremont et al. 1983), international environmental agreements (Barrett 1994; Kolstad 2007; McEvoy and Stranlund 2008a), and domestic voluntary agreements (Dawson and Segerson 2008; McEvoy and Stranlund 2008b). Following

D'Aspremont et al. 1983, a voluntary agreement is considered stable if no existing member could benefit by leaving the agreement (*internal stability*) and no non-member could benefit by joining the agreement (*external stability*).

Definition 1: A voluntary agreement consisting of s members is *self-enforcing* if and only if

$$\begin{array}{l} (a)\ c^{m}(s) \leq c^{nm}(s-1) \text{ for } s > s_{\min}, \text{ or } c^{m}(s) \leq c_i^b \text{ for } s = s_{\min} \\ (b)\ c^{nm}(s) \leq c^{m}(s+1). \end{array} \quad [7]$$

Requirement (a) is that the agreement is internally stable in the sense that no member has an incentive to leave a self-enforcing agreement. Requirement (b) is that the agreement is externally stable in the sense that no non-member wishes to join the agreement. The only internally stable agreement size is the one with $s = s_{\min}$ members. To see why, note that for $s >$ $s_{\min}$ [4] and [5] reveal that $c^{m}(s) \leq c^{nm}(s-1)$ implies $\alpha \leq \pi A / n^2$ which violates our assumption that $\alpha > \pi A / n^2$. On the other hand, a voluntary agreement with $s_{\min}$ members is internally stable because if one member of the agreement defected then the remaining members would minimize their costs by not providing traceability. The defector's cost (as well as every other firm's cost) would then be c_i^b, which is weakly less than $c^{m}(s_{\min})$. Finally, a voluntary agreement with $s_{\min}$ members is also externally stable. Using requirement (b) and [4] and [5], $c^{nm}(s) \leq c^{m}(s+1)$ implies $\alpha \geq \pi A / n^2$, which is satisfied because of our assumption $\alpha > \pi A / n^2$. Since an agreement consisting of $s_{\min}$ members is the only internally and externally stable agreement size, it is the equilibrium number of members of a self-enforcing voluntary agreement.

Proposition 1: Let the unique self-enforcing number of members to a voluntary agreement be s^*. Then s^* is the smallest coalition of agreement members necessary for the members to minimize their costs by providing traceability; that is,

$$s^* = s_{\min} = \min\{s \mid s \geq \alpha n^2 / \pi A\}. \qquad [8]$$

The equilibrium number of members of a voluntary agreement is unique, strictly greater than 1, and weakly less than *n*. Note that [8] indicates that participation with a voluntary agreement is increasing in the cost of providing traceability, *α*, and the number of firms and is decreasing in the expected cost of a food-safety issue, *πA*.

4. Discussion and concluding remarks

Traceability can reduce the total cost of a food safety incident by expediting the search for the origin of the problem and the time in which contaminated product is withdrawn from the market. Recent food safety outbreaks in American beef, produce and vegetables industries have shown how the lack of traceability can slow the investigation of the incident and affect most firms in the market, as well as consumers. In many situations, relying on traditional regulatory approaches to increase traceability is difficult. In terms of transactions costs, implementing mandatory traceability systems requires a lengthy legislative process and may create greater ill will between government and industries. Moreover, in some cases the government lacks the authority to require traceability in all food markets. However, it may be possible to rely on the industry to create a traceability system that reduces exposure to losses due to food safety incidents.

Here we propose a model to show that a voluntary agreement between a subset of firms in a food industry for the provision of traceability is feasible and reduces the cost to the industry of food safety outbreaks. In our model traceability is a binary choice that is costly to each firm but, at the aggregate level, reduces the expected total costs of safety incidents. If a firm decides not to provide traceability it will only be exposed to a proportion of the total industry expected cost of a food safety event. As long as the costs of providing traceability are larger than expected proportional costs of an incident to a firm, a rational agent has no incentive to implement traceability. The US has a fairly safe agro-food system and thus firms may perceive a low risk of incurring losses due to food safety hazards which is consistent with our baseline model, where individual firms are reluctant to incur cost to further reduce food safety risks. However, even lower probability events can materialize and in such occasions the consequences are quite extensive and the whole industry can be affected. In this event, the absence of information may further exacerbate the dimension of the problem, and motivate the need to implement traceability. This is what our industry level case reveals, which leads us to the formulation of the voluntary agreement. We show that while having no traceability may be the optimal decision for each firm, it is not the optimum for the industry as a whole. Then we demonstrate that if a group of firms in the industry commits to offer traceability the whole industry is better off in the sense that total expected costs of traceability and food safety incidents are minimized. Our model also suggests that the number of firms joining the coalition increases in the marginal cost of traceability and number of firms in the industry and decreases in the expected losses of the a food safety incident.

The results support claims from both academics and public agency officials for private provision of traceability. However our model has some limitations that caution policy recommendations. First, we assume that each firm faces a proportional expected loss in the event of a food safety incident. Now, in reality this may not be the case because, under strict liability regimes (such as is the case in the US), the firm found responsible for the incident may face most if not all the losses. Also, unless firms can be correctly pinpointed it may be impossible to attribute costs to any particular firm. Second, our results critically rely on firm homogeneity, this is consistent with Havinga (2006) who argues that coalitions depend on the existence of homogenous firm with a common private interest. However, the reality is that the food system comprises highly differentiated firms and is perhaps better characterized by heterogeneity. This may cast doubts into the feasibility of an industry wide coalition for the provision of traceability. Finally, in this model we treat traceability as a binary choice. Nevertheless, as suggested by Pouliot and Summner (2008) there may be degrees of traceability which means that it may be better specified as a continuous variable rather than simply having it or not. In fact, Golan et al. (2004) define traceability in three dimensions: breadth (number of attributes traced); depth (number of layers in food chains involved) and precision (accuracy with each a product is pinpointed to its origin), reinforcing the case for a continuous variable modeling of traceability.

Despite these limitations, that we aim to address in future research, we believe our model and results are an important contribution to the economics of food traceability and have important policy implications. In fact, our research is novel in two fundamental ways: first in our model the choice of traceability is endogenous. Second we apply for the first time a model of self-enforcement, commonly used in the environmental economics literature, to the case of food safety. Furthermore we suggest that food industries may be better of even if only a group of firms collectively decide to have traceability. Our work also raises empirical questions: which would be the minimum number of firms in a coalition that minimizes the costs of a food safety incident? What incentives would have to be created to facilitate the formation of coalitions?

References

Alberini, A. and Segerson, K. (2002) "Assessing Voluntary Programs to Improve Environmental Quality". *Environmental and Resource Economics*, 22: 157-184.

Barrett, S. 1994. "Self-Enforcing International Environmental Agreements." *Oxford Economic Papers* 46(5), 878-94.

Barrett, S., 2003. Environment and Statecraft: The Strategy of Environmental Treaty-Making. Oxford and New York: Oxford University Press.

Calvin, L. (2007) "Outbreak Linked to Spinach Forces Reassessment of Food Safety Practices." *Amber Waves* 5:24-31.

Carraro, C. C. and D. Siniscalco. 1993. "Strategies for the International Protection of the Environment." *Journal of Public Economics* 52(3), 309-28.

Croci, E. 2005. "The Economics of Environmental Voluntary Agreements." The Handbook of Environmental Voluntary Agreements. Edoardo Croci (ed.), Dordrecht and New York: Springer.

D'Aspremont, C.; A. Jacquemin; J. J. Gabszewicz and J. A. Weymark. 1983. "On the Stability of Collusive Price Leadership." *The Canadian Journal of Economics* 16(1): 17-25.

Dawson, N. L. and K. Segerson. 2008. "Voluntary Agreements with Industries: Participation Incentives with Industry-wide Targets." *Land Economics* 84(1), 97-114.

European Parliament and of the Council 2002 "Regulation (EC) No 178/2002, laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety." *Official Journal of the European Communities*, L 31: 1-24.

Fulponi, L., (2006). "Private voluntary standards in the food system: The perspective of major retailers in OECD countries." *Food Policy* 31: 1-13.

Gencod EAN France. (2001). "Traceability in the Supply Chain From Strategy to Practice". April.

GlobalGAP (2008). "What is GlobalGAP?" Available at: http://www.globalgap.org/cms/front_content.php?idcat=2. Assessed 13/08/2008

Golan, E, B. Krissoff, F. Kuchler, K. Nelson, G. Price, and L. Calvin. (2004). "Traceability in the U.S. Food Supply: Economic Theory and Industry Studies." Economic Research Service, U.S. Department of Agriculture, Agricultural Economic Report No. 830. March 2004.

Goldstein, D. (2003) "Cattle Future Fall over Mad Cow". *Oakland Tribune*, December 27.

Havinga, Tetty (2006) "Private Regulation of Food Safety by Supermarkets." *Law and Policy*, 28(4), 515-533.

Hobbs, J. E., (2004) "Information Asymmetry and the Role of Traceability systems". *Agribusiness* 20: 397-415.

International Organization for Standardization [ISO] (2000) ISO 9000:2000 Quality Management Standards.

Just-food.com (2008) US: FDA lobbied for stronger produce traceability. *Just-food, Authoritative and Timely Business Information*, July 4. Available online at: http://www.just-food.com/article.aspx?ID=102998 (assessed on 11/08/2008).

Khanna, M. and L. A. Damon. 1999. "EPA's Voluntary 33/50 Program: Impact on Toxic Releases and Economic Performance of Firms." *Journal of Environmental Economics and Management* 37 (1), 1-25.

Kolstad, C. 2007. "Systematic Uncertainty in Self-Enforcing International Environmental Agreements." *Journal of Environmental Economics and Management* 53(1), 68-79.

McEvoy, D. M. and J. K. Stranlund, 2008a. "Self-Enforcing International Environmental Agreements with Costly Monitoring for Compliance." *Environmental and Resource Economics* Available online at http://dx.doi.org/10.1007/s10640-008-9220-1.

McEvoy, D. M. and J. K. Stranlund, 2008b. "Costly Enforcement with Voluntary Environmental Agreements with Industries." *Appalachian State University Working Paper*.

Meuwissen, M. P. M, A. G. J. Velthuis, H. Hogeveen, and R. B.M. Huirn. (2003). "Traceability and Certification in Meat Supply Chains". *Journal of Agribusiness* 21(2):167-181.

Moe, T. (1998) "Perspectives on Traceability in Food Manufacture." *Food and Science Technology,* 9: 211-214.

Pouliot, S. and Sumner, D. A. (2008) "Traceability, Liability and Incentives for Food Safety and Quality". *American Journal of Agricultural Economics* 90(1): 15-27.

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, Department of Resource Economics, University of Massachusetts Amherst.*

Shin, A. (2008). "Tomatoes still lead the list of suspects in Salmonella probe". *Washington Post*, July 2.

Venkataraman, B. (2008) "As Outbreak Affects 1000, Experts see Flaws in Law". *New York Times*, July 10.

Ulph, A., 2004. "Stable International Environmental Agreements with a Stock Pollutant, Uncertainty and Learning." *Journal of Risk and Uncertainty* 29(1): 53-73.