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***Private and Public Food Safety Control Mechanisms:
Interdependence and Effectiveness***

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Abstract: In this paper, we propose new research methods and approaches in the area of food safety economics that would improve the allocation and effectiveness of private and public resources and efforts in ensuring food safety. The focus is on approaches that would build a comprehensive understanding of the interdependence between private and public food safety control mechanisms, including direct regulation by process and performance safety standards, traceability requirements, product liability, and product liability insurance; contribute to the development and analysis of loss control functions related to food safety hazards and to the assessment of the insurability of agricultural producers and food processors from such risks; as well as evaluate the impact of food safety hazards on producers and processors and determine whether and how businesses respond to food safety outbreaks affecting other businesses in the same industry. [EconLit Q130, L110, L150].

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Introduction

The late 1990s and the early 2000s present a striking paradox for the incidence of the failure of food safety control mechanisms in the United States and abroad. Government regulation of food safety increased substantially and included changes in ex ante direct regulation (e.g., the implementation of the mandatory Hazard Analysis Critical Control Point (HACCP) system in the meat and poultry industry) as well as changes in ex post product liability laws. Private mechanisms of food safety control, such as self-regulation, third party certification, and product liability insurance, also developed substantially during this time and now play an important role in the supply of higher quality, safer food. However, the number of food safety incidents, including large-scale outbreaks of livestock microbiological infection and food contamination, in the agricultural and food sectors is on the rise. Thus, the mechanisms of food safety control do not seem to be working very effectively. What are the important shortcomings of these mechanisms? What is their interdependence? Could they be working more in concert? Understanding these factors is crucial for assessing the competitiveness of U.S. agricultural producers and processors as they choose product safety levels and bear the costs associated with these levels; for understanding the benefits and costs of government regulations intended to improve the safety of the food supply; and for evaluating the impact of changing consumer demand for safety on the agricultural and food sectors of the U.S. economy.

The main objective of this paper is to propose new research methods and approaches in the area of food safety economics that would improve the allocation and effectiveness of private and public resources and efforts in ensuring food safety. The focus is on approaches that would build a comprehensive understanding of the interdependence

between private and public food safety control mechanisms; contribute to the development and analysis of loss control functions related to food safety hazards and to the assessment of the insurability of agricultural producers and food processors from such risks; as well as evaluate the impact of food safety hazards on producers and processors and determine whether and how businesses respond to food safety outbreaks affecting other businesses in the same industry.

The overall goal is to propose new theoretical and empirical approaches that would assess the relative strengths and weaknesses of the various private and public food safety control mechanisms in the agricultural and food processing sectors, including direct regulation by performance safety standards, traceability requirements, product liability, and product liability insurance. More specifically, the proposed methods would be used to evaluate recent food safety outbreaks, their economic impacts, and the role of new private and public traceability programs and how these can improve the functioning and the effectiveness of the various food safety control mechanisms, including liability and insurance. Research findings from the studies that would use the new methods could be crucial for agricultural and food safety policy in the United States.

As measured by the number of food safety scares and food safety outbreaks, the effectiveness of food safety controls does not seem presently to be good. The bovine spongiform encephalopathy (BSE) scare in Great Britain, Foot and Mouth Disease (FMD) in several European countries, and the *E. coli* and *Listeria* outbreaks in the U.S. and in Europe raise serious concerns and questions about how to find ways of assuring acceptable levels of safety attributes. There are significant costs to consumers and businesses from food safety risks. In October of 2002, exposures include the *Listeria*

outbreak in turkey that represents the largest meat recall in U.S. history. Pilgrim's Pride Corporation, the second largest U.S. poultry producer, recalled 27 million pounds of turkey and chicken, most of which was sold under the Wampler brand name. About 20 deaths and 120 illnesses were attributed to the outbreak. In July of 2002, ConAgra voluntarily recalled over 18 million pounds of beef that might have been contaminated with *E. coli*. The ConAgra recall was the second largest in U.S. history following the 1997 recall of over 25 million pounds of meat by Hudson Foods.

In this paper, we propose to build on and extend already completed work on the interaction of private and public control mechanisms, and the insurability of risks in livestock production, as well as on survival functions applied to food safety recalls. (Turvey, 2002; Turvey et al., 2002; Salin et al., 2002). A central theme of our analysis is the impact and the role of traceability for safety attributes on the effectiveness of private and public food safety control mechanisms. Economic research on issues of traceability is quite limited so far since these systems have been widely developing only within the last five years. Nevertheless, recent work by Fetter and Caswell (2002), Caswell (2002), and Teisl and Caswell (2002) suggests the key interaction between specification of quality attributes and the control systems necessary to assure that quality. Thus, it is important to incorporate the technology of tracking food safety attributes into analysis of the current and potential effectiveness of different control mechanisms.

Previous Work and Approaches

Significant effort has gone into identifying and evaluating the mechanisms of food safety control in recent years. The vast majority of this work focused on the various approaches to ex ante direct public regulations of food safety and the justification of the

need for such regulation, as well as on the evaluation of their effectiveness, and on the estimation of their costs and benefits (Caswell, 1995; Roberts et al., 1996; Unnevehr and Jensen, 1996; Crutchfield et al., 1997; Mortimore and Wallace 1998; Antle, 1999; Henson and Caswell, 1999). The most common justification of public involvement in food safety is a market failure. Usually, farms and food businesses have better information about the quality and safety of the commodities or products they produce than their customers or consumers. This is a classic ‘lemons’ problem described by Akerloff (1970). Because the firms do not have the ability to credibly signal the higher safety of their products, according to this analysis, unregulated markets will undersupply these attributes. Many argue that public food safety control mechanisms are critical and can lead to the provision of a socially optimal level of safety (Henson and Caswell, 1999). However, the extent to which markets for food safety fail depends on particular aspects of those markets. For example, the market for safe hamburger patties may function more completely for product being supplied to fast food chains than to supermarkets because the chains place much higher emphasis on safety in order to protect their brand names.

Ex ante direct public regulations can take several forms and the degree of intervention can vary from low to high (Henson and Caswell, 1999). Requirements for the provision of information provide an example of less stringent public involvement in food safety control. On the other hand, performance and process standards and requirements of prior approval provide examples of more stringent public involvement. Many researchers conclude that process standards and requirements of prior approval are inefficient from an economic point of view. Therefore, there is some growing support to move toward

less stringent and more efficient public control of food safety through use of performance standards and information provision (Antle, 1995).

Support is also growing for changes in product liability systems that might provide clearer incentives to food producers and manufacturers to supply safer food. The most common justification of product liability laws is that firms will have incentives to produce safer food if they must fully compensate consumers injured by their products. This potential liability represents a portion of firms' expected costs of operation, and firms will take the optimum level of food safety precaution when they attempt to minimize costs (Johnson et al., 1989). Each firm will incur additional costs of food safety precautions up to the point where the marginal costs of implementing the precautions equal the marginal benefits. Benefits from taking precautions depend on the expectations of avoided litigation costs, increased market demand, and higher prices that result from selling a safer product. The expected costs of being sued depend on the probability of paying damages, the potential litigation costs, and negative impacts to the firms' reputation and sales (Caswell and Johnson, 1991).

To date, only a handful of economists working in the food safety area have investigated product liability systems as mechanisms of food safety control (Henson and Northen, 1998; Bredahl and Holleran, 1997; Caswell and Henson, 1997; Hobbs and Kerr, 1992). In one of the few existing studies, Buzby and Frenzen (1999) focus on the U.S. product liability system for food poisoning cases. The authors conclude that current legal incentives to produce safer food are weak, that the information and transaction costs are high for plaintiffs to pursue litigation, and that costly settlements and decisions against other firms in the same industry may provide stronger incentives. Furthermore, the

authors suggest that confidential settlements, health insurance, and product liability insurance distort legal incentives to produce safer food.

Private food safety control mechanisms have received less attention in the literature than public mechanisms. Private mechanisms are typically used in the agricultural production and the food processing sectors. The most common explanation of the private incentive for adopting voluntary food safety control systems (e.g., self-regulation and certification) is the cost of carrying out business transactions or in other words transaction costs (Holleran et al., 1999, Mazzocco, 1996). Transaction costs are linked to uncertainty regarding food safety attributes; the costs vary depending on the level of product differentiation and firm size. Higher transaction costs provide a greater incentive to adopt private food safety control mechanisms. At the same time, adopted safety control systems can directly affect other costs, prices, market access, and business profits.

Private safety control systems can take many forms and include voluntary firm specific international assurance standards (e.g., ISO 9000); national, state, or private organization farm level assurance systems (e.g., Farm Assured British Pigs, organic certification by third parties, “natural” labels indicating non-use of antibiotics in livestock production); and proprietary quality and safety assurance systems (e.g., maintained by large retail food chains). All of the systems rely on documentation of production processes and practices as well as on third party auditing and certification. One of the most internationally recognized private quality and safety assurance systems is the ISO 9000 system. Empirical studies show that businesses adopt such systems based on internal (business driven) and external (customer or regulation driven) incentives (Holleran and Bredahl, 1997). Seddon et al. (1993) find that 56% of the surveyed

businesses were internally motivated in their adoption of the system. The most often cited benefits were to reduce costs and to improve internal operations. On the other hand, 34% of businesses had external motives for the adoption of the system. In contrast to ISO 9000, national safety assurance systems assure customers and consumers that a nation's farm products are safe. These systems have become more common in the European Union (EU) following the outbreak of Mad Cow disease and are intended to provide traceability of raw inputs from the farm to processing and retailing. At the end of the chain, information about the safety assurance system is provided to the consumer in the form of a label. Also, in this case, transaction costs are lower since buyers do not have to search for and collect information about suppliers and do not audit suppliers' production practices very often.

Significance of the Proposed New Approaches

Our paper proposes to expand and extend a line of research developed to address shortcomings in current approaches to analyzing the mechanisms of private and public control (Turvey et al., 2002; Kolstad et al., 1990). It is based on important developments in the theoretical literature on managing risk and uncertainty. This approach provides an effective framework for modeling food safety incidents and the mechanisms designed to prevent them or to mitigate their consequences.

Numerous control mechanisms have developed to ensure the safety of agricultural and food products sold to customers and consumers. Governments get involved through ex ante regulation of information provision, and performance and process standards as well as through ex post product liability rules. In turn, farms and food businesses can also use self-regulation and certification to ensure the supply of safe products. A careful

student of the practice of food safety policy and the economics of food safety literature will quickly notice that the two are in stark contrast with respect to how they deal with the various food safety control mechanisms. Thus, in practice, the mechanisms are most often used jointly to complement each other. On the other hand, theoretical as well as empirical work in the food safety area tends to consider and study these mechanisms separately without recognizing their complementarities and interdependence. Only a few researchers recognize the need for more comprehensive analysis of the interdependence between the mechanisms (Henson and Caswell, 1999; Buzby and Frenzen, 1999; Segerson, 1999; Kolstad et al, 1990; Viscusi, 1989; Shavell, 1984). This is especially crucial considering the expected changes in the Farm Bill that will more closely link private incentives to invest in food safety with public policy incentives (Hooker, 2001).

In this paper, we call for integrated (systems) analyses of public and private food safety control mechanisms, their interdependence and effectiveness. Over the years, as consumer demand for and government regulation of food safety increased, farms' and food businesses' incentives to adopt food safety control systems have been changing as well. These incentives can become even stronger with the enhanced ability to traceback microbiological hazards and foodborne pathogens to their source of introduction into the agricultural or food supply chain. The ability to traceback microbiological hazards and foodborne pathogens provides a very important incentive to create identity preservation and to reward those producers and processors who attempt to assure the safety of their products. With traceability possible, the lemons problem can be solved and the effectiveness of private mechanisms can be improved. Unnevehr (2001) goes even further and recommends linking public income support payments to active private food

safety assurance efforts undertaken by farmers and ranchers. This policy proposal undoubtedly recognizes the public good nature of food safety investments.

The rationale for the proposed new approaches is to provide the methods for the in-depth analysis of the interdependence of private and public food safety mechanisms that will inform discussion of current trends in the incidence of the failure of food safety control mechanisms and their causes. Our ultimate goal is to be able to explain the apparent paradox discussed above that while food safety control increased the number of food safety incidents, and as importantly their scope, is growing. Piecemeal analyses of control mechanisms can help to inform the discussion but are inherently limited in that they focus on one or a couple of factors that influence and determine their effectiveness at any given time. In reality, however, several mechanisms are working and evolving simultaneously and what we see is the outcome of the interaction of these factors.

The most unique and innovative aspect of the proposed approach is that it moves beyond the studies described in the introduction to integrate private and public food safety mechanisms into theoretical modeling and empirical estimation and analysis. Most importantly, this paper is the first in the economics of food safety literature to propose methods that evaluate the role of traceability of food safety attributes, product liability law, and liability insurance as mechanisms of food safety control. In their recent work, Skees et al., (2001) explore the potential role of recall insurance in the food processing sector to improve food safety. The authors argue that recall insurance can motivate earlier recalls and/or adoption of more effective food safety management systems such as HACCP. However, their analysis is descriptive in nature and does not use rigorous methods. In this work, we adopt the view that insurance is a very important and integral

part of the food safety control system. In conjunction with well-designed liability rules and regulations, insurance can provide incentives to supply efficient levels of safety (Turvey, 2002; Turvey et al., 2002; Zeckhauser, 1996; Kolstad et al., 1990; Shavell, 1984, 1987). Liability and insurance are designed to promote equity and spread risk. In addition, they change the incidence of losses, and hence incentives, and they also promote efficient risk decisions. Turvey et al. (2002) show that in the presence of insurance markets protecting food businesses from liability, actions can be taken by insurers or regulatory authorities to ensure that moral hazard (a purposeful decision by management to reduce care in order to either collect insurance directly or to take increased risks in the presence of insurance) and adverse selection (businesses have more information on the probabilities of risk than insurers) do not become part of the management's strategy. These issues are critically important because the consequences of moral hazard and adverse selection in the agricultural and food sector pose a real threat to human and animal health, and in many cases cause deaths.

Our proposed expansion and extension of prior work focuses on three areas: traceability of food safety attributes, insurability of producers and processors for food safety hazards, and other firms' reactions to food recalls in the same industry. The first is to develop approaches that would assess explicitly the impact of the ease of traceability on private incentives to provide safety attributes. This can expand the original work to a more diverse set of control mechanisms to see whether the results of the model can be replicated in the new setting. The second, and very important focus of the proposed approach, is to evaluate the role of insurance in markets for food safety (Turvey, 2002). The motivation for this is that to date models failed to account for the relationship

between safety control mechanisms and insurance. We propose to extend the models and empirical analysis to both production and processing sectors. This approach would allow to draw conclusions for the two very important segments of the food system. Finally, these proposed approaches can specifically assess the impacts of and responses to food safety recalls.

The results obtained from the new approach can be significant in several ways. The results can give a comprehensive picture of the relative strengths and weaknesses of private and public food safety control mechanisms in both the production and processing sectors. This information would be very useful to food producers, processors, and their insurers in analyzing different choices of food safety assurance strategies and the impacts of policy changes. The information is critically important for policy makers as they make decisions related to implementing and supporting more economically efficient and more effective food safety controls. It appears that with the current safety control programs, expected results from these programs have not fully materialized because while the factors they are targeting (e.g., firms' process standards) have an influence on the provision of food safety, this influence is currently diminished by other factors (e.g., a lack of effective traceability systems that diminishes private incentives to adopt safety improvements). Clear understanding of current factors that determine the functioning of the various mechanisms can inform policy choices that rely on enhancement of these factors. Finally, the results could contribute new, more comprehensive theoretical modeling and empirical approaches to risk management in food safety. A key issue is the impact of different levels of effectiveness in traceability systems on the efficient operation of private and public food safety assurance systems.

Theoretical Analysis of the Interdependence between Private and Public Food Safety Control Mechanisms

Our paper focuses on providing new methods to evaluate the inter-relationships between private and public food safety control mechanisms and the role of traceability in improving the functioning and effectiveness of these mechanisms. The proposed theoretical methods make use of models of the relationship between private and public mechanisms, insurability of food producers and processors for food safety hazards, and survival functions for food safety recalls developed by Turvey (2002), Turvey et al. (2002), and Salin et al (2002). To date, we have applied models of interaction of private and public mechanisms and insurability to livestock production, as well as models of survival functions for food safety recalls. This previous research could be deepened and extended through the following framework.

Evaluating the interdependence between private and public food safety control mechanisms requires methodology that would incorporate three major economic issues that are crucial to dealing with food safety incidents. These are: providing protection against food safety incidents, reducing their magnitude, and spreading the risk of whatever losses may result. It is also very important to take into account the fact that the way in which economic agents and society pay for food safety incidents affects incentives for future preventive actions. Thus, if the injuring business is charged much less than the costs that it imposes, its future actions will be too reckless. On the other hand, if it is charged more than the actual damage value, it will be too cautious. This leads to inefficiencies in both instances and society as a whole will sacrifice resources.

The literature on the economics of risk and uncertainty provides the most useful theory and methodology for dealing with the issues discussed above. In theory, the role of mechanisms such as ex ante standard requirements (private or public) is to achieve efficient risk levels. The primary purpose of ex post liability is to promote equity by making the risk imposer pay. The primary role of insurance is to spread risk. In isolation, insurance may weaken incentives to control losses, however, if premiums are adjusted according to the insured's behavior, insurance can promote efficient decisions. In addition, insurance may also be affected by adverse selection and moral hazard as discussed earlier. Adverse selection relates to an insurance market in which asymmetric information persists with the business having greater information about the probabilities of risk than the insurer. Moral hazard represents a purposeful decision by management to reduce care in order to either collect insurance directly or to take increased risks in the presence of insurance.

To obtain models of inter-relationships between ex ante performance standards (private or public), product liability, and product liability insurance, we can extend previously completed work by Turvey et al (2002). The authors utilize a direct expected utility maximization approach for risk averse market participants to evaluate ex ante regulation (a standard of care) of the use of input by producers as a control mechanism against moral hazard. In the model, ex ante regulations are established as covenants to an insurance policy. If the covenants are violated then, ex-post, the insurance provides no payments. The authors show that a joint use of partial insurance coverage with a minimum standard for input use considerably reduces the problem of moral hazard. The authors also argue that these same ex ante regulations would be sufficient to reduce or

eliminate adverse selection. Satisfying both of these criteria is sufficient to support an insurance market for microbiological hazards, food-borne pathogens, and food recalls.

This result is quite appealing, especially to a public insurer who can enforce a minimum standard of input use and reduce the cost of insurance, as well as reduce the amount of subsidy for a public insurance program. This result is also very important for the proposed research project. The U.S. Congress is debating the provision of funds for food safety recall liability insurance that could possibly apply to producers. However, it is not entirely clear whether this type of insurance can apply under crop or revenue insurance available under the Federal Crop Insurance Act (U.S.C. 1501 et seq.). Food safety recalls do not lead immediately to a decrease in production, but can lead to a decrease in revenue, particularly if the insurance mechanism would not provide perfect coverage. The findings from our study will inform the ongoing debate in this area.

We can extend the Turvey et al. model described above to include explicitly the ease of traceability and its role in food safety assurance. With traceback possible, the uncertainty with respect to who pays for losses and how much may largely disappear. In addition, the uncertainty of being fined, found liable, or receive no insurance payment may also largely disappear. We can show that this changes the structure of private incentives for food safety provision. We can also show that the new structure of private incentives in conjunction with government requirements of performance standards can lead to gains in efficiency at various levels including the societal level.

To further evaluate the issue of the insurability of agricultural producers and food processors for food safety risks we can develop and apply loss functions. This analysis of food safety insurance is founded on three important principles: frequency, duration, and

intensity. *Frequency* refers to the likelihood that in any given year a food safety incident (outbreak, recall) will occur in one or more of the firm's business lines. Some diseases occur with greater frequency than others, therefore, a more frequent incidence of possible liability will increase cost of insurance. *Duration* refers to the length of time (e.g. number of days) that a recall is in effect. In the alternative, duration can take on a binary value of 1.0 if the event occurs or zero otherwise. In general, if the liability is based on a duration basis, the longer a pathogen remains in the market, more people will be affected and hence the loss will be greater. The third principle is intensity. *Intensity* refers to the degree of affliction and can be represented as a function of duration. Not all pathogens have the same intensity. A mild pathogen might cause only modest nausea or illness (such as some forms of *E. coli*) resulting in only moderate harm over a fixed period of time, however, a more aggressive pathogen (such as botulism) with high intensity will result in greater harm sooner. The more susceptible people are to a pathogen the greater will be its intensity.

In order for microbiological hazard or food-borne pathogen incidents (food safety recalls) to be insurable the economic loss must be estimable. This requires prior knowledge of the probability of an adverse event happening and the loss associated with the event (as measured by duration and intensity). The rarer the event the more difficult it is to estimate expected economic losses, and in many cases an insurer or re-insurer will require a premium well in excess of the true actuarial loss. Under such circumstances the equilibrium price is more related to the demand and supply rather than actuarial loss estimates.

Related to this issue is the underlying definition of loss. To our knowledge, a loss function related to food safety incidents has yet to be published. However, a loss function presented by Turvey (2002) related to livestock insurance for different kinds of risks can be used to establish the basic principles. These principles can be easily transferred and applied to the case of animal production food safety and safety in the food processing sector.

In Turvey's model, the frequency and intensity of an animal pathogen represent randomness. For example, if a pathogen appears on average only once in five years, but with the exact timing unknown, the event will be given a prior probability of 0.20. Likewise, the duration is a random variable. The duration, for example, can be one day or two weeks, again depending on random factors and other factors such as population medicine and inoculation. The structure of the loss function is displayed in equation (1).

$$V(f, \lambda, \beta) = 1000 f(t) \int \lambda^{(-\beta)} g(\lambda) d\lambda$$

(1)

In (1) the valuation is based upon an indemnified value (\$1,000) although any unit of measurement can be used. The function $f(t)$ represents the probability of occurrence and represents the frequency principle. The symbol λ represents the duration, and its probability distribution function is represented by $g(\lambda)$. In general $g(\lambda)$ will be a negative exponential or gamma type distribution with higher probabilities attached to short durations than long durations. The power function $\lambda^{-\beta}$ captures the intensity. The higher the value of β the greater is the intensity associated with the duration λ . For

example, if $\beta=0$ there is no loss associated with the pathogen. If $\beta=0.5$ the intensity is moderate, but if $\beta=2$ the intensity is high. Essentially, the higher the intensity the faster the \$1,000 value will be driven to zero.

To illustrate how such a loss function works, assume that $f(t) = 0.30$ so that the pathogen arrives on average three out of every ten years. When it arrives it has a mean duration in the herd of 14 days with a standard deviation of 14 days. Assume that $g(\lambda)$ is a gamma distribution with a negative exponential shape so that a short duration has a higher probability of occurring than a long duration. Subtracting the outcome in equation (1) from \$1,000 provides an estimate of expected losses. The indemnity function is therefore used to generate the cost of insurance per \$1,000 of revenue. Using a Monte Carlo approach to loss estimation, Turvey (2002) shows that the cost to the livestock producer per \$1,000 of revenue is \$180 for $\beta=0.5$, \$235 for $\beta=1$ and \$264 for $\beta=2$. The maximum indemnity in all three cases approached \$1,000 asymptotically. Since the frequency variable is a prior probability, the cost of insurance is directly and linearly related to frequency. For example, by dividing the above results by 3, the resulting premiums would represent a frequency of occurrence of 1 in every 10 years rather than 3 in every 10 years.

Of course, the foregoing represents, in a very simple way, the essential elements of pricing livestock insurance. The premium values will differ if a different intensity function is used, if the duration period is changed, or if the frequency changes. However, the results do illustrate several salient points. First, the more frequent is a disease the higher will be the cost of insurance. The longer the duration of a disease, the greater will

be the rate of infection and hence the premiums, and lastly, the susceptibility of the herd to the disease will also lead to increased premiums.

There is also an important policy issue about livestock insurance. It is quite clear that sound population medicine, herd health management, and best management practices will affect all three factors. Frequency will be lower, duration will be shorter, and intensity will be smaller. All three of these factors indicate that mitigation through inoculation or antibiotics will reduce production risks and hence insurance costs. In light of this, consumer perceptions of food safety risks that inhibit, or even laws that prohibit, inoculation can lead to a greater incidence of disease and higher costs to livestock producers. We will investigate these important issues of animal production food safety in the next part of the project.

Returning to the issue of safety in the food processing sector, a corresponding liability also holds. The more frequent a food-borne pathogenic outcome occurs in the food system, the longer it is in the system, and the intensity by which it affects humans contributes to increased losses. As with the livestock example presented above, the regulatory environment under which the food processing sector operates plays an important role in insurance. For example, in the livestock illustration, a regulatory regime that prohibits vaccination against certain diseases such as foot and mouth disease or classical swine fever, can actually increase the losses and hence the premiums to producers, even if the intent of the regulation was to preserve foreign markets or reduce potential hazards in human food consumption.

Likewise, it is possible that certain regulatory regimes within the food system can increase or decrease human risk of food-borne pathogens. For example, irradiated meat,

which is legal in the United States but not approved in many other countries, provides a mechanism to reduce or eliminate *E. coli* in unprocessed meats. It reduces the risk to humans and therefore would concomitantly reduce the liability to food processors. All other things held constant, the insurance costs would be lower for food processing firms utilizing irradiated meat technology in countries where it is approved, versus countries for where it is not.

While large in scope, there does currently exist an insurance market for food safety recalls and other losses to the food system due to animal or human health hazards. However, such insurance is related to either a specific peril, or operates under specific rules of mitigation.

Summary of the New Approach

The proposed approach focuses on developing models to evaluate theoretically and empirically the interdependence between private and public food safety control mechanisms, including product performance standard regulations, traceability of food safety attributes requirements, liability, and insurance. The theoretical models proposed in this can provide a basis for more extensive empirical analysis.

The evaluation of the control mechanisms is important from both competitiveness and policy points of view. For food producers, processors, and insurers the results obtained from these approaches can illuminate the key issues in insurability for microbiological hazards and food-borne pathogens. Proposed methods can lead to better evaluations of incentives to adopt food safety and quality assurance programs. For policy makers, this evaluation can inform regulatory decisions aimed at improving the economic efficiency and effectiveness of food safety programs.

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