Staff Paper

**THE THEORETICAL BENEFITS OF
FOOD SAFETY POLICIES: A
TOTAL ECONOMIC VALUE FRAMEWORK**

Eileen O. van Ravenswaay and John P. Hoehn

July 6, 1996 **No. 96-72**

Department of Agricultural Economics
MICHIGAN STATE UNIVERSITY
East Lansing, Michigan

The Theoretical Benefits of Food Safety Policies: A Total Economic Value Framework*

by

Eileen O. van Ravenswaay
and
John P. Hoehn *

Staff Paper #96-72

July 6, 1996

* van Ravenswaay and Hoehn are Professors in the Department of Agricultural Economics, Michigan State University.

The Theoretical Benefits of Food Safety Policies: A Total Economic Value Framework

This paper examines consumer benefits from food safety policy. The main objective is to develop a model that integrates important insights from the literature on consumers' responses to food safety. We consider four consumer responses: product avoidance, brand switching, averting behavior, and mitigation. We suggest how these responses are affected by consumers' knowledge of marginal product contamination, the effect of averting on marginal product contamination, the health effects of total exposure to contaminants, and the mitigation expense associated with these health effects.

Section one examines tasks that a comprehensive model should accomplish in estimating the consumer benefits of food safety policy. Section two describes key insights from the literature and how we use them to model consumer response. Section three describes the model and implications for valuing a food safety improvement. Section four illustrates how the integrative model affects the analysis and measurement of consumer benefits from food safety policy. The final section summarizes major themes.

What Theory Should Address

A theoretical framework for evaluating the consumer benefits from food safety policies should help us predict which policies consumers would prefer if they were as knowledgeable as experts. This function is necessary to ensure that policy information provided by economic analysis reflects consumers' true interests.

Second, the theory should enable us to describe what real, albeit uninformed, consumers would do under various policy scenarios. This task is crucial to accurately inferring what empirical measures of benefits reveal about how consumers would value policy change if they had expert information. For example, suppose contingent valuation methods were used to develop a measure of consumer willingness to pay for a food safety improvement. Respondents' perceptions of the policy scenario and its consequences will influence their valuation. When these perceptions depart from how an informed expert would evaluate the scenario, these differences must be controlled for by careful design of data collection instruments or by accounting for these differences in estimating statistical models. The same is true for any benefit measures based on actual consumer choices, such as hedonic or travel cost estimates.

Finally, theory should enable us to analyze a full range of relevant policy scenarios. There area four kinds of food safety policies: labeling, public announcements, educational programs, and risk reduction services (i.e., process and performance standards). Each of these policy options affect consumers' choices differently. Product labels may affect how much of a product is consumed (e.g., reduced fish consumption), which brands are bought (e.g., organic), and how products are used (e.g., cleaning or cooking methods). These choices affect subsequent use of medical services to alleviate illness. Risk reduction services relieve consumers of these choices, but affect subsequent mitigation actions. Thus, theory should account for different ways consumers respond to food hazards.

Previous Literature

Previous literature has identified four ways consumers could respond to food hazards. They include product avoidance (Choi and Jensen, Eom 1994, Falconi and Roe, van Ravenswaay and Hoehn 1991b, Weaver), brand-switching (Choi and Jensen, Hammitt, van Ravenswaay and Hoehn 1991a, Weaver), averting (Eom 1995, Weaver), and mitigating actions (Weaver). Averting actions include cleaning or cooking to reduce contaminants in food. Product avoidance involves reducing purchases of foods associated with a contaminant. Brand-switching involves selection of a close substitute which differs in the amount of the contaminant and related quality factors (e.g., pest damage). Mitigation involves treatment of illness from food contaminants. Our model includes all these types of consumer responses to food contaminants.

Weaver's model allows product avoidance and brand-switching, but combines averting and mitigation expenses. Our model separates averting and mitigation because consumers may make tradeoffs between them, thus affecting consumer valuations.

Eom's (1995) model allows averting actions which reduce the probability of health problems, and Weaver's model allows averting actions which reduce total exposure to a contaminant. We define averting as actions that reduce the marginal product contamination level. This approach enables us to more clearly separate product avoidance and averting actions, as well as forms of consumer knowledge related to these actions.

The Choi and Jensen, Hammitt, and Weaver models allow brand-switching, but brands are assumed to differ only in terms of the contamination level and price. However, when contamination levels change, other product attributes may change (van Ravenswaay and Hoehn 1991a). For example, reduced pesticide residues may increase pest damage or price. Thus, consumers may "pay" for reduced contamination by accepting lower quality rather than a higher price. Our model allows tradeoffs among attributes as well as price.

Each of the possible consumer responses to food contamination depends on consumers' knowledge of marginal product contamination levels, the effect of averting on marginal product contamination levels, the health effect of total exposure to the contaminant, and the cost of mitigating these health effects. Our model specifically shows how. Like the Choi and Jensen, Eom (1994, 1995), and Falconi and Roe models, we allow for uncertainty about the health effect of total exposure to a food borne contaminant. This is important because, even when the consumer possesses the same health effects knowledge as experts, this knowledge is usually probabilistic.

In the Choi and Jensen model, health effects are limited to mortality. In the Eom and Falconi and Roe models, health effects are limited to morbidity. However, a food contaminant increases the probability of death because of the occurrence of illness. Following Berger et al., we allow mortality to depend on morbidity. This is important because mitigation expenses depend on both relieving illness and improving survival odds.

The Model

A two period Lancaster model is developed in this section. In the first period, the individual earns income, avoids and averts exposure to food contaminants through purchases of market goods, consumes attributes of market goods and food brands, and saves income for the second period. In the second period, the individual experiences the health effects from her choices in period one and undertakes activities to mitigate them. The consumer's problem is to maximize constrained utility over the two periods.

More formally, in the first period, the individual earns income, y, consumes market goods, $\mathbf{q} = (q_1,\ldots q_J)$, and saves s for second period expenditures. The market goods include food brands and averting inputs used to reduce exposure to contaminants in food brands. The jth market good has a vector of attributes $(a_{1j},...a_{Ij})$. The total amount of the ith attribute consumed as a result of purchasing q_j units of the jth market good is $a_{ij}q_j$. The total amount of the ith attribute consumed from the purchase of all J goods is

$$(1) \qquad A_i = \sum_{j=1}^{J} a_{ij}\, q_j$$

The marginal contamination level in the jth good is a_{ij}. Total contamination in q_j units of the jth good is $a_{Ij}q_j$. When fully informed, the consumer is able to observe how food brands vary in terms of the marginal product characteristic. She may calculate how her total exposure to a food contaminant varies with brand selection.

Let **A** represent the vector $\mathbf{A} = (A_1,...,A_i,...,A_I)$, where total exposure to a contaminant is represented by A_I. Total exposure has no effect on utility in the first period, but on health consequences in the second period. First period utility is:

$$(2) \qquad u_1 = u_1(A_1,...,A_{I-1})$$

Assume that the consumer knows how to avert exposure to contamination. In other words, she knows the proportion of the marginal product contamination level that can be removed before consumption of a food, q_j. We represent this removal process $r(\mathbf{q})$, where $0 \leq r(\mathbf{q}) \leq 1$ and $\mathbf{q}$ are market inputs such as soap and water. Thus, total exposure after averting and food consumption is

$$(3) \qquad A_I' = A_I\,[1-r(\mathbf{q})]$$

In the second period, the individual consumes savings from the first period, experiences a health status (h), and a probability of survival, π, which is a function of health status expressed as $\pi(h)$. Second period utility is:

(4) $u_2 = u_2(h,s)\pi(h)$

Assume that the individual knows exactly how health status depends on consumption and averting in the first period as well as mitigation (m) undertaken in the second period. Thus, $h = h(A_I', m)$. Substituting into (4), the second period problem is to maximize second period utility,

(5) $u_2 = u_2(h(A_I', m), s-m)\pi(h(A_I', m)),$

by selecting m where A_I' and s are fixed by actions in the first period. Solving the maximization problem yields m^* and an indirect utility function:

(6) $u_2 = v_2(h(A_I', m^*), s-m^*)\pi(h(A_I', m^*))$

The first period maximization problem is:

(7) $\max \quad u_1(A_1,\ldots,A_{I-1}) + v_2(h(A_I', m^*), s-m^*)\pi(h(A_I', m^*))$

s.t. $y = s + \mathbf{pq}$

$A_I' = A_I[1-r(\mathbf{q})]$

by selecting **q** and s where $\mathbf{p} = (p_1,\ldots,p_J)$ are the prices of the market goods. Solving (7) and expressing in terms of indirect utility yields:

(8) $u = v_1(\mathbf{A},y,\mathbf{p}) + v_2(h(A_I', m^*), s-m^*)\pi(h(A_I', m^*))$

Suppose that a food safety policy reduced the marginal product contamination level on food j. The level of compensation that offsets a small change da_{Ij} is obtained by totally differentiating (8) conditional on the level of averting $(1-r^*)$ and product avoidance and brand-switching (q_j^*):

(9) $dy/da_{Ij} = -[(\partial v_2/\partial h)(\partial h/\partial A_I')q_j^*(1-r^*)\pi]/(\partial v_1/\partial y)$

$- [v_2(\partial \pi/\partial h)(\partial h/\partial A_I')q_j^*(1-r^*)]/(\partial v_1/\partial y)$

The first term on the right-hand side of (9) represents the morbidity effect of a small exogenous change in marginal product contamination. The second term is the mortality impact. Note that these effects depend on chosen levels of avoiding and averting.

Implications for Research on the Benefits of Food Safety Policies

Analysis of the consumer benefits involves comparing welfare with and without the policy. This comparison involves characterizing the choice set a consumer faces with the policy to the one faced without the policy. The objective is to find the amount of income that leaves the consumer indifferent between having or not having the policy.

The model above attempts to more fully characterize the relevant dimensions of that choice set than previous models have done. Thus, when this model is applied, we should have a different analysis of the "with" and "without" policy scenarios than we would otherwise. It should also change how we collect data to obtain empirical estimates of what consumers are willing to pay for, or willing to accept to forego, policy change.

Analysis of the "With Policy" Scenario

Recall that we want to evaluate the "with policy" scenario from the perspective of the informed consumer. One of the advantages of the model is that it permits us to more precisely define exactly what we mean by "informed" and "uninformed." There are four "health knowledge" dimensions of the choice set: the marginal product contamination levels in different foods and food brands (a_{ij}), how averting actions reduce the contamination level ($r(\mathbf{q})$), the health effects of total exposure (h), and the health effects of mitigation combined with total exposure ($\pi(h(A_I', m))$). Each of these "health knowledge" dimensions can be specified to correspond with that of experts.

Also recall that we want to be able to evaluate the full range of policy alternatives including labeling, public announcements, education programs, and risk reduction services. An advantage of the model is that it permits us to characterize the choice set associated with each of these different types of policies. If, for example, we did not include all the "health knowledge" dimensions, we would not be able to evaluate many of the possible forms of product labeling, public announcements, or education programs.

Analysis of the "Without Policy" Scenario

In estimating consumer welfare without the policy, we need to be able to estimate the extent of the market failure occurring without the policy. To do this, we need to make realistic assumptions about the state of consumers' "health knowledge."

In some cases, we might assume the consumer is completely ignorant of all the "health knowledge" dimensions, and thus is unable to undertake averting or avoiding actions. In this case, a consumer would choose consumption as if there were no contaminant present and were faced with a lower price. However, although the consumer acts in this case as if the exogenously determined marginal product contamination is zero, we know that it is nonzero without the policy. Thus, we can predict the welfare difference between knowledgeable and unknowledgeable states.

In other cases, it may be more realistic to assume the consumer is not completely ignorant and is able to undertake some averting or avoiding activities. In still other cases, it might be more realistic to assume consumers have erroneous "health knowledge." One of the advantages of the model we have developed is that it allows these types of market failure scenarios to be specified. The following example of an incorrectly estimated welfare loss from market failure illustrates why this feature of the model is important.

Suppose that government investigation reveals that 9,000 Americans die annually due to salmonellosis. This is a baseline assessment of health effects to which government action could be compared. Say a public program is developed to reduce the number of deaths by half. In the most simple analysis, the economic benefits would be estimated by multiplying the 4,500 prevented deaths by an average value of a "statistical-life" for which a number of reasonable estimates exist (Viscusi). However, suppose the government did nothing at all but report the health effects information on salmonella? Should we assume that the 9,000 salmonellosis deaths would continue unabated unless public action is taken? Empirical evidence suggests that health effects information has value to consumers, will be transmitted to them through a variety of sources, and will affect consumption behavior (van Ravenswaay and Hoehn 1991b, Johnson). In other words, once health effects information is publicly available, it can no longer be assumed that only government action will result in prevention. Individuals may undertake any number of avoiding, brand switching, and averting actions (e.g., reducing chicken consumption, switching to well-known brands, and cooking chicken thoroughly). Therefore, assuming no erroneous health effects, product characteristics, brand, or averting information is available to consumers, the simple analysis would overestimate the benefits of the government program to control salmonellosis because it assumes illness is greater than in fact it would be once consumers have the health effects information. It is conceivable the consumers' avoiding, brand-switching, and averting activities could be just as effective in preventing salmonellosis deaths, in which case, the value of the government program would be the prevention costs saved by consumers, not the value of the deaths prevented.

We describe this particular example because, in doing "with and without" analysis, both policy scenarios should be cast in terms of what we would expect the *future* would be with and without the policy. Once the health effects are known, the future without the policy will not be the same as past without the policy. We may over- or under-estimate benefits by assuming the future without the policy will be the same as the past.

Now consider that the extent and type of avoiding and averting activities by consumers can have major impacts on food producers. For example, if consumers reduce chicken consumption, producer surplus falls in poultry markets. Similarly, activities like cooking chicken more thoroughly or specially washing utensils raise the cost of chicken consumption to consumers, and, thus, may also have some negative effects on poultry demand. If the government program eliminated the avoiding and averting activities by consumers, poultry producers benefit from increased sales. This producer benefit of government action is omitted when we incorrectly assume the baseline health effects estimate is the one associated with no preventative activities by consumers. Moreover, this producer benefit can take on significant proportions under a world trade scenario. When consumers can avoid salmonella in chicken by switching "brands" in terms of the country from which imports are acquired, producers pay a heavy price unless a government program to control the salmonella is established.

Empirical Estimation of Consumer Benefits

Empirical measures of the consumer benefits of food safety regulations could include cost of illness, contingent valuation methods, hedonics, averting expenditures, and travel costs. The model above has implications for determining the applicability of each of these methods under different policy scenarios and assumptions about the "with" and "without" policy states. Because of space considerations, we discuss only two methods.

Cost of illness studies (e.g., Roberts) generally include estimates of the opportunity cost of lost labor time and mitigation expenses. As the model developed above shows, when measures are already being taken by consumers to reduce exposure or the methods taken are ineffective, cost of illness methods will incorrectly estimate consumer benefits when a policy change involves saving of avoiding and averting costs.

Contingent valuation methods ask respondents to directly value a policy scenario. However, the way they value it will depend on their knowledge about marginal product contamination, methods for reducing contamination, health effects of total exposure, mitigation costs, and prices with and without the policy scenario. Furthermore, respondents will vary in terms of underlying illness rates. Although we can describe scenarios and provide information about some of these variables, we cannot be certain that respondents will take the information at face value. Moreover, respondents may ascribe other consequences to their food purchases such as improved environmental quality, animal welfare, or worker safety, and thus evaluate the characteristics of goods differently than experts. This is especially likely if consumers associate the policy scenario with changes in production practices that have well-known external effects. Respondents may also value a government program because it reduces illness among others today and in the future. Empirical evidence suggests that some of these values could be important. For example, Eom 1994, Buzby et al., van Ravenswaay and Hoehn 1991a find willingness to pay for reduced pesticide residues is only partially explained by perceived risk reduction.

Conclusion

The literature on food safety has identified at least four different ways that consumers may respond to food safety problems. The model developed in this paper suggests one way of encompassing each of these possible responses. We show how these responses affect the analysis of the benefits of food safety policy.

The model provides a way for specifying how consumer response depends on a least four different types of knowledge. This specification makes it possible to analyze a broader range of food safety policies including policies that provide different types of information as well as policies that reduce exposure to food contaminants. This specification also enables us to characterize market failures in terms of how consumers' knowledge differs from that of experts. It also helps to show how we may improve the accuracy of empirical estimates of the benefits of food safety policy by accounting or controlling for consumers' knowledge states.

The model could be extended by including multiple time periods, the individual's discount rate, the time cost of averting and mitigation, and uncertainty about other types of knowledge than just health effects.

References

Berger, M.C., G.C. Blomquist, D. Kenkel, G.S. Tolley. "Valuing Changes in Health Risks: A Comparison of Alternative Measures." *S. Econ. J.* 53(April 1987):967-984.

Buzby, J.C., J.R. Skees, and R.C. Ready. "Using Contingent Valuation to Value Food Safety: A Case Study of Grapefruit and Pesticide Residue." *Valuing Food Safety and Nutrition*. J. Caswell, ed. Boulder CO: Westview Press, 1995.

Choi E.K. and H.H. Jensen. "Modeling the Effect of Risk on Food Demand and the Implications for Regulation," *Economics of Food Safety*. J. Caswell, ed. NY: Elsevier, 1991.

Falconi, C. and T. Roe. "A Model of the Demand and Supply of the Health Effects of Food Substances,"*Economics of Food Safety*. J. Caswell, ed. NY: Elsevier, 1991.

Eom, Y.S. "Pesticide Residues and Consumer Valuation of Food Safety." *Amer. J. Agr. Econ.* (August 1994):760-771.

Eom, Y.S. "Self-Protection, Risk Information, and Ex Ante Values of Food Safety and Nutrition." *Valuing Food Safety and Nutrition*. J. Caswell, ed. Boulder CO: Westview Press, 1995.

Hammitt, J.D. "Consumer Willingness to Pay to Avoid Pesticide Residues." *Statistica Sinica*. 3(July 1993):351-366.

Johnson, F.R. "Economic Cost of Misinforming About Risk: The EDB Scare and the Media." *J. of Risk Anal.* 8(June 1988):261-269.

Roberts, Tanya. "Human Illness Cost of Food borne Bacteria." *Amer. J. Agr.*

Econ. 71(May 1989):468-474.

van Ravenswaay, E.O. and Hoehn J.P. "Contingent Valuation and Food Safety: The Case of Pesticide Residues in Food." Staff Paper No. 91-13, Dept. of Ag. Econ., Michigan State University, April 1991.

van Ravenswaay, E.O. and J.P. Hoehn. "The Impact of Health Risk Information on Food Demand: A Case Study of Alar and Apples," *Economics of Food Safety*. J. Caswell, ed. NY: Elsevier, 1991.

Viscusi, W.K. "The Value of Risks to Life and Health." *J. Econ. Lit.* 31(December 1993):1912-1949.

Weaver, R.D. "Mitigation, Product Substitution, and Consumer Valuation of Undesirable Food Borne Effects," *Valuing Food Safety and Nutrition*. J. Caswell, ed. Boulder CO: Westview Press, 1995.