Measuring Benefits and Costs *

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INTRODUCTION

Before one considers the ways to measure benefits and costs, it is essential to know precisely what causes the benefits and costs. It would be possible to measure the benefits and costs of a particular tolerance level. Actually, what should be measured are the differences in effects between alternative tolerance levels, including no restriction at all. The findings of such an analysis would tell the decisionmaker whether the benefits of moving to the given tolerance level exceeded the costs, but it would not tell whether that was the best tolerance level. It is possible that either higher or lower tolerance levels would increase the net benefits to society. The economic approach to setting tolerance levels requires consideration of several alternative levels and the changes in benefits and costs as one moves from one level to the next. The economic decision criterion is to lower the tolerance level so long as the additional benefits exceed the additional costs. When the costs of further restriction are greater than the benefits of such restriction, the efficient tolerance level has been found (assuming that benefits and costs exhibit continuous relationships to tolerance levels that are at all points either concave or convex to the origin). Thus, the initial step in the analysis is to choose a likely tolerance level and examine the consequences of moving from the status quo (no restriction) to the selected tolerance level

Benefits

The benefits to be evaluated are defined as the reduction in hazards to human health. This definition follows directly from the concern of the Food, Drug, and Cosmetic Act and the activities of FDA. Any effects on the health of animals or plants, except as they become food and thus affect the health of humans, is not considered in this report. This is not to say that economic analysis is incapable of considering other values associated with animal and plant life. Rather, it is to limit discussion to those aspects most germane to the decision under consideration.

The measurement of human health and the determination of a relationship between a particular contaminant in food and subsequent human health impairment must be made in biological, medical, and physical science terms. For example, the conclusion that daily consumption of food containing x parts per million (ppm) of a given substance over a period of 3 years or longer will result in a 50-percent loss of function of the arms and hands is a medical and biological science conclusion. Until a determination of the health consequences is made, very little can be done toward comparing benefits and costs of regulation,

Health hazards from exposure to food contaminants may be stated in various ways depending on the health effects of the substance and on the state of knowledge about those effects. The hazard from a substance that increases mortality in the exposed population could be stated as the number of premature deaths per year. If illness requiring time-off from regular activity results from a certain exposure level, the hazard to the population might be stated as the number of person-days lost to illness per year. When it is not certain that exposure will cause a particular consequence, but that the likelihood is increased, probabilities may be attached to the outcomes. The hazard from exposure would then be stated that some percentage of the exposed population would die prematurely or would lose a specified number of days from normal activity due to illness, This method of stating hazard is encountered with cancer risks due to smoking tobacco.

*Excerpt from OTA Working Paper entitled "Priority Setting of Toxic Substances for Guiding Monitoring Programs. A complete copy of the paper can be obtained from the National Technical Information Service. (See app. J.)

In many instances the substance in question may not have been studied for health effects or it may have been developed so recently that long-term effects of chronic exposure are uncertain. It may, therefore, be impossible to calculate probabilities, let alone specify the numbers of people affected, This does not mean the matter is of no concern. Based on the chemical structure of the substance, scientists may believe that the long-run consequences may be very serious. In such cases a precise probability cannot be attached to a specific event occurring, It cannot even be said with certainty that a health hazard exists. What can be said is that a serious health risk may be present and the consequences of that risk are so grave that society may wish to avoid whatever risk may result. While this type of statement of the health hazard is more difficult to use in a benefit-cost analysis, it is not impossible.

No matter how the hazard is stated, the first task in economic analysis is to convert the hazard statement into units of measurement that are comparable with the statements of costs to be developed later. Many (although not all) of the costs associated with those decisions are measured in monetary units—dollars. Likewise, at least some of the most important benefits to be achieved from restricting exposure to health risks are also measured in dollars. The most fruitful way to proceed, then, is to assemble the appropriate monetary measures and make conversion into monetary terms wherever possible for those effects not so measured.

Cash Cost Approach

One of the simplest ways to measure the cost of illness and at least part of the cost of premature death is to add up the expenditures made for treatment or burial and other out-of-pocket costs, These costs can be obtained in a straightforward manner and summed for the number of individuals that will be affected at the tolerance level being evaluated,

Even though the procedure does not involve complex calculation, this approach does involve decisions and judgments about the appropriate costs to us. Medical service costs vary greatly between procedures and between locations, It would be advisable, therefore, to obtain medical costs for the specific types of procedures required and for the part of the country where affected individuals would likely reside, In some cases where the contaminated food would likely be consumed nationwide, a weighted average cost of the appropriate medical service could suffice. . . Where the contaminated food is consumed in particular regions of the country, e.g., catfish, the health effects would likely be concentrated in those regions also and the appropriate treatment costs should relate to the same regions.

While the cash cost approach is relatively simple to calculate, it ignores some of the true costs to society from an untimely death or an illness. One of the most obvious omissions is the failure to account for an individual's contribution to economic output, had sickness or early death not intervened. This weakness is corrected with the forgone-earnings approach.

Forgone-Earnings Approach

Generally, the forgone-earnings approach uses the discounted value of the future stream of earnings as the appropriate estimate for the cost of an untimely death, and thus, the appropriate estimate of the value of a life saved from a premature death. While it is clear that if an individual had not died or become ill in a particular year he would have continued to be productive for a number of years, it is not immediately obvious whether the correct measure to use is gross earnings or net earnings.

Those who support the use of gross earnings argue that what is of interest to society is lost production, and an individual's contribution to that production is measured by his or her earnings stream. Thus, the loss to society is the discounted present value of the stream of annual earnings weighted by the probability that the individual will be alive and well enough to earn that year's income. This approach is best suited to the analysis of illness rather than death and has been used to study the loss to society from mental illness, syphilis, and illness of all kinds collectively,

Those who prefer to use net earnings argue that, in the case of death, society may lose the production of the decedent, but it also no longer has to supply goods for the decedent's consumption. Death releases resources to the rest of society for their use. Thus, the appropriate measure of loss to society is the discounted present value to the stream of differences between an individual's expected income in each year and that individual's consumption during the same period. Each annual net earnings would be weighted by the probability of the individual surviving to that year. With this method of calculating, the cost to society of a death could be negative (or a benefit) if the individual consumes more than he or she produces.

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Retired and unemployed individuals are likely to have such negative life valuations.

The possibility of a negative value for a life has led to several criticisms of the approach. Some individuals produce products that are not marketed, but are none-the-less, real and valuable, The largest single example is the output of housewives. Other objections have been raised to the conclusion that the unemployed and retired are of no value. It must be admitted, however, that these latter objections appear to confuse the economic value of an individual with an ethical value of a human life, It is clear that the forgone-earnings approach examines only one portion of an individual's contribution to society—the contribution to those things measured in the net national product (NNP). If the goal of society is the maximization of NNP, then assessing the costs or benefits of a health-impacting project according to the forgone-earnings approach can be rationalized. If society holds other goals as well, then the use of forgone earnings is merely an expedient approximation.

Willingness-to-Pay Approach

The most telling argument against the previously discussed evaluation techniques is that they are conceptually incorrect for use in benefit-cost analysis. They are directed to find the answers to questions like "What is my life worth to other people like my heirs and society in general?" The conceptually correct question to ask is "How much would I pay to avoid a small probability of my death or illness?" Approaches that answer this question are consistent with other measures of societal welfare since they estimate the aggregate consumer surplus involved in the reduction in mortality or morbidity rates.

What has come to be known as the "willingness-to-pay'" approach has received extensive treatment in recent economic literature. A review of much of the theoretical literature and the discussion of some technical points related to a person's willingness to pay for small changes in mortality rate may be found in Epp, et al. (ch. 4), That review will not be repeated here, but rather, the remainder of this section will be addressed to reviewing techniques for determining an individual's willingness to pay. Two approaches have theoretical validity: compensation for risk-taking and questionnaires of willingness to pay.

Compensation for risk-taking as a technique for estimating the loss in consumer surplus due to increased risk of death, illness, or injury, has the advantage of being observable to the marketplace. If an individual agrees to undertake a hazardous occupation which increases his probability of death in exchange for a given sum of money, that sum can be used as an estimate of his willingness to pay for safety, Thaler and Rosen used data that measures the relative riskiness of jobs to estimate the tradeoff between wages and risk. Thirty-seven broadly defined job classifications shown to be actuarially riskier than the average occupation were matched against a cross-sectional earnings survey. The results showed that individuals in the risky occupations received increased compensation of about $200 per year (1967 dollars) for jobs where the risk of death was 1 in 1,000 greater than the average.

This estimate may be conservative when applied to the general population. The occupations surveyed in the Thaler and Rosen study are approximately five times riskier than the average U.S. occupation. People who take these jobs have different reservation prices for risk than individuals who pick less risky jobs. The derived estimate of compensation required to offset greater risk is, therefore, an extremely conservative approximation of aggregate willingness to be compensated. A further rationale for believing this estimate to be conservative is that the riskiness of these jobs can in some measure be affected by the individual employee. He or she is to some degree in control of the personal risk level within the context of the risk level of the occupation. If the individual is not able to affect his or her personal risk exposure, it is quite likely that they would need to be compensated to a greater extent to undertake the unwanted risk.

The other technique for assessing willingness to pay is the questionnaire method. A representative sample of individuals are asked how much they would be willing to pay to achieve a specified change in a particular condition. For the problem of environmental contamination of food, the question would most likely be directed toward the willingness to pay for a reduction in the probability of suffering specific health effects, such as speech impairment and nerve sensations from exposure to methylmercury. Questionnaire design ranges from direct questions about dollar amounts for a specific risk change to a series of questions about items related to the specific risk change of interest from which the analyst can infer an answer to the "what would you pay?" question,

While the willingness-to-pay approach is asking the conceptually correct question, it has serious difficulties in application, because the items of interest are going to be consumed in equal amounts by everyone and no one can be excluded from consuming the item if it is provided for anyone. For example, a reduction in the risk of lung disorders due to reduced sulfur dioxide levels in the air will be available to everyone in the area regardless of their preferences or payment, If it is provided for one person, it is impossible to exclude others. The communal consumption aspect of this large class of similar goods and services provides an incentive for people to misrepresent their true preferences when asked, For instance, if a person believes he will be required to pay some amount in proportion to his answer yet there is a high probability the good will be provided whether or not he contributes and if it is provided, he will be able to enjoy it, then it is rational for him to respond that he is unwilling to pay anything for it, even if he knows he really would pay some amount, if necessary. On the other hand, if an individual knows that someone else will pay for the good if it is found to be valued highly will find it rational to grossly overstate its value to him. Thus, the incentive to be a free rider makes it difficult to accurately measure the value to society of an improvement in food safety.

In spite of the difficulties associated with empirical measurement of willingness to pay, several studies have been done and have reported some success with various methods of presenting the question to the respondents. Randall, et al. (1974) used pictures of the powerplant at Fruitland, N. Mex., at various levels of smoke emission to elicit responses from residents and tourists as to the amount they would pay (in the form of a sales tax increase) to move from a less preferred view to the respondent's preferred view. The technique was used in a similar fashion to examine questions about a powerplant location in southern Utah (Brookshire, et al.) and about reclamation of stripmined land in Kentucky (Randall, et al., 1978). A modification of the technique was used by Mann, et al. to determine willingness to pay for small changes in human mortality. Their study found that people are able to comprehend risk changes of the order of 10^{-6}. Although the risk premiums stated in the Mann, et al. study were substantially different from those' found by Thaler and Rosen, the study indicated that individuals were able to answer the type of question posed, and that with improvements in the survey instrument, the willingness-to-pay questionnaire may be a workable approach.

COSTS

The costs associated with establishing a particular tolerance level are the loss of social welfare resulting from the reduction in supply because some otherwise useful food products can no longer be sold for consumption. The reductions in consumer and producer surplus, which are discussed in detail in this section, account for the economic value of resources, such as labor and production capital, which may no longer be employed in producing the food product being considered, It is possible, however, that some resources may not have any alternative employment, In such case the tolerance level may cause these resources to be unemployed. While this lack of alternative employment is not strictly an economic cost, it is clearly a consequence that a decisionmaker may wish to consider. Therefore, other effects (some might wish to call them costs) of the decision are examined in the following section entitled "Distributional Effects. "

The starting point for assessing the costs of moving to a particular tolerance level is the physical product that will be affected. The results of the monitoring program and various special test procedures can tell what proportion of various food products from any specified area will not meet the tolerance level. The task of the economic analysis is to evaluate the impact of such a reduction in the supply of that food product.

When analyzing the effects of a tolerance level that removes some food products from the market, there are two major alternative methods. These two are what have been called the alternative cost method and the opportunity cost method. Either of these methods may employ models of the affected industry, but as will be shown in the following sections, the opportunity cost method requires more sophisticated models and delivers a more comprehensive description of likely effects.

Alternative Cost Approach

With the alternative cost method, the analyst examines the additional cost necessary to achieve a given objective using the next best alternative method to the one under study. Applying this to the PCB contamination of lake trout in Lake Superior, for example, would require that the analyst examine the next best method for producing 164,000 lbs of lake trout that did not exceed 2 ppm of PCB to replace that amount from Lake Superior which does exceed 2 ppm of PCB. This approach requires that there be some alternative method available which will achieve the same level of output in order that the costs of the two alternative ways of producing the output can be compared.

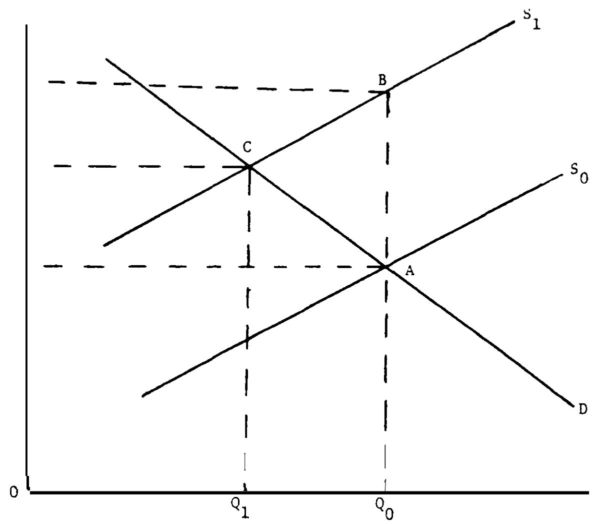
If there are several alternative methods available for producing a "replacement" amount of production, the alternative cost approach requires not only that the cost of total replacement with each method be examined, but that combinations of methods be considered also. To properly evaluate the alternative cost figure, the analyst must know the costs of various amounts of product from each alternative method. To continue with the PCB contamination of lake trout example, the analyst must consider not only the cost of 164,000 additional lbs of lake trout with less than 2 ppm of PCB from each of the other Great Lakes (and any other large sources), but the costs of various increments of production, such as 10,000 lbs. from each source. The least cost combination of increments would be found by starting with the least costly way of obtaining 10,000 additional lbs and adding to that the next least costly way of getting 10,000 more lbs until a total of 164,000 lbs are accounted for.

Opportunity Cost Approach

With the opportunity cost method the analyst examines the additional cost necessary to achieve a new market equilibrium amount of a food product which reflects the likely higher price and, therefore, lower consumption of consumers. Since restricting the supply of a food product from previous sources means a shift to higher cost alternative sources, we can use our knowledge of markets and people's preferences for the food product to estimate their adjustment to the restriction, This gives a different estimate of costs due to restriction than does the alternative cost method which assumes no change in the amount of the food product consumed.

A simplified partial analysis of the difference between the alternative cost method and the opportunity cost method is presented with the use of figure E-1. The decision to establish a tolerance level such that some portion of the product currently offered for sale may no longer be sold is shown by the shift in the supply curve. Curve S_0 represents the industry supply curve prior to the change in tolerance level, while curve S_1 represents supply under the higher cost next best alternative method of production which does not violate the new tolerance level. The alternative cost method examines the increase in cost of obtaining the initial equilibrium quantity, Q_0. This increase in cost is represented by the area ABP_1P_0. The opportunity cost method, on the other hand, recognizes that a new equilibrium price and quantity will emerge after the shift in supply. Quantity will shift to Q_1 and price to P_2. Comparing the new equilibrium with the old, the analyst using the opportunity cost method observes that the consumer surplus has been reduced by an amount equal to area ACP_2P_0 in figure E-1. This reduction in well-being is clearly less than the one calculated with the alternative cost method. Because the opportunity cost method recognizes changes in production and consumption, it is the preferred method. The alternative cost method tends to overstate the cost of more restrictive tolerance levels.

Figure E-1 .—Analysis of a Shift in Supply



The above diagrammatic analysis presents the essential features of the budgeting approach to the opportunity cost method. This is discussed in more detail below. Another approach, modeling, carries the above analysis further to show changes in the market for factors of production as well as other product markets, While this method cannot employ graphic analysis due to the complexity of relationships, the mathematical modeling techniques described below permit a much more comprehensive analysis of likely effects of a change in tolerance level.

As was noted above, the opportunity cost approach measures effects of a change in tolerance level as the change in consumer surplus in the economy. There is abundant literature discussing the problems of estimating consumer surplus; some authors even question the value of the concept in many empirical contexts. For this exercise, however, it seems appropriate that consumer surplus be used. The ultimate consumer of the contaminated food products should provide the basis for evaluation. This becomes particularly crucial where ramifications of the production shift may include a variety of products, not just the contaminated product. Consumer surplus becomes the common denominator allowing comparison among a variety of production effects. In practice, the opportunity cost approach may employ either of two methods: budgeting or modeling.

Budgeting

With budgeting the analyst acknowledges that production shifts are likely for the contaminated product. This technique uses data on inputs used in the production of a product to calculate the costs of producing a particular amount of that product, assuming that other commodities will be produced in the same amounts and at the same prices as with the status quo. The budgeting approach is a more limited and restricted approach than the modeling one, but for some circumstances may prove advantageous.

Modeling

The second and more complete method of applying the opportunity cost approach is through the use of production models. With this method, mathematical models of the relevant portion of the economy are employed to trace the shifts in supply curves and the changes in the amount and price of various commodities and factors which result from the restriction on the use of a contaminated product. If these models are specified to include geographic areas and the various alternative production activities which take place in each of these areas, they are able to project changes in the location of production of particular crops and changes in the use of various production factors in each region of the country. This more realistically describes the likely reactions to the change in tolerance level and permits the calculation of a more accurate estimate of the change in consumer welfare resulting from the action level decision.

Comparison of Approaches

The alternative cost and opportunity cost approaches are not equally adapted to handling all problems—each has several advantages and disadvantages. The alternative cost approach has the advantage of using data that is more easily obtained and not requiring extensive development of mathematical models prior to the analysis. Since the alternative cost approach compares the status quo with the next best alternative, subject to the change in tolerance level, the only additional data needed beyond present production techniques is an estimate of how the same amount of product could be produced under the best alternative available with the new tolerance level. This data can frequently be obtained from experts in the production of the food under consideration.

The major disadvantage of the alternative cost approach is that it is conceptually erroneous. Our knowledge of economic adjustments to changing production conditions recognizes that adjustments will be made in the enterprise combinations and in factor combinations for producing a particular food product. If a significant portion of the total production is removed from use or a specific location is no longer capable of producing a safe food product, the ensuing production adjustments will not be limited to factors of production, but may also include changing the foods produced or the location of production. The amount consumed of the food for which a new tolerance level is being established will probably adjust to changes in the cost of obtaining the food in a safe form (within tolerance levels). The alternative cost approach ignores all of this knowledge by assuming that the food in question, using the next best alternative, will be produced at the same level as before.

The conceptual error leads to a second error—the overstatement of the costs associated with the tolerance level, Because this approach ignores the adjustments in the amount of a food product produced, it leads the analyst to a cost figure that is greater than the one that would actually result. As production costs increase it is likely that the quantity produced will decrease. Thus, the alternative cost approach has the analyst multiply a higher cost per unit by more units than would actually be produced. This leads to an erroneous calculation of the change in consumer surplus and to the overstatement of the cost of setting tolerance at a particular level.

The major advantage of the opportunity cost approach is conceptual: it allows the analyst to see the adjustments that the economy is likely to make in response to changing production costs as a new tolerance level removes some of the product from the market. Where agricultural products are involved, the use of an econometric model of the agricultural sector facilitates the analysis of changing comparative advantage and the resulting production pattern, This gives a more accurate indication of the ultimate cost of making the tolerance level decision,

The use of models can also facilitate distributional analysis if those models have spatial (regional) variables introduced into them. Through the use of regional supply and demand models, the analyst is able to estimate not only the market equilibrium supply and demand adjustments, but also the regional production adjustments in response to the overall market changes. It is thus possible to note changes in the regional location of production and to estimate the impact of these changes on various income and social groups that are distributed differently in the various regions of the country. Thus, the models that are used for the opportunity cost approach can facilitate a more detailed and sophisticated analysis of the effects of a change in the tolerance level. The reasons for examining distributional effects as well as a brief description of some ways these may be done are included in the next section of this paper.

The major disadvantage of the opportunity cost approach is that it requires a very large amount of data. Production costs, outputs, factor requirements, factor prices, and a variety of other bits of information are required for each alternative food production activity in each region including alternative ways of producing the food under consideration. Even if the supply equations and activities are limited to those most likely to enter into the solution, the requirements are formidable for most agricultural and fishery commodities. The demand side also requires regional consideration with specification of the demand for each of the commodities included in the supply side of the model. Careful attention must be given to the inclusion of complements and substitutes so that the model will give a reasonable approximation of actual market adjustments.

A second disadvantage of the opportunity cost approach is that the models developed for analyzing production and market shifts are usually short-run and static, This means that these models must be revised periodically in order to include new developments in factor prices, product prices, and production technology. Thus, the models are expensive to maintain. They are also expensive to create in the first place. Most models require a great deal of prior research on the technical relationships in production and specification of the factors related to consumption. While much of this work has been done for agricultural commodities, it is recognized that the material is frequently inexact and often the models are out of date, It would be necessary, therefore, to undertake some rather expensive research in order to incorporate the opportunity cost approach for a commodity that did not already have substantial prior work. This is likely to be the case for seafoods, freshwater fish, and certain agricultural products produced in a few local areas.

Obviously, the detailed knowledge of production relationships and therefore the expense is reduced if one uses the budgeting method rather than the modeling method in the opportunity cost approach, Budgets usually involve a partial analysis of the adjustments and therefore do not require the development of production relationships for commodities not closely related to the commodity under consideration, Even so, the budgeting approach requires more information than the alternative cost approach because of the consideration of production changes. It is unlikely that the budgeting approach can be used for a regionalization analysis that involves more than a very few regions. Thus, the lesser cost produces less information.

Since the two approaches, alternative cost and opportunity cost, differ in the amount of data that they require and in the cost of acquiring and processing the data, it is necessary for an analyst to choose between these two methods. Several points should be considered when making a selection of the most appropriate analytical method.

Demand Elasticity

If the product for which the tolerance level decision is being made has a very inelastic demand,[1] it may be appropriate to use the alternative cost approach. With a very inelastic demand, it is likely that the assumption of producing the same quantity regardless of cost is a reasonably close approximation to reality, Thus, the disadvantages enumerated above for the alternative cost approach are of less significance for many agricul-

[1] Inelastic demand means that the percentage change in quantity demand as the price of a good changes is smaller than the percentage change in price. Perfectly inelastic demand describes the case where there is no change in the quantity demanded when the price changes.

tural products, such as certain vegetables, sugar, and cereals for human consumption, as well as for fish.

Information Availability

Since the opportunity cost approach requires a great deal of information about production relationships, not only for the commodity under consideration but for alternative commodities, it is helpful to have these relationships previously developed. Much of this information is so time consuming to develop that it would be virtually impossible to create a research program that could give results in time to be useful for any action level decision if a great deal of groundwork had not been laid prior to that research effort. If no information is available concerning production of the product in question or the alternative product that might be produced or consumed, it is likely that the alternative cost approach would be adopted. This approach requires less data and the material that it requires probably can be produced in time to be useful in making a tolerance level decision.

Complexity of Interrelationships

If a product is produced in many areas with a large variety of production alternatives, both with regard to factors of production and to alternative products, one needs to use an opportunity cost approach. In such a situation the interrelationships are so complex that it is difficult to judge from observation of the data the likely combination that will result from a tolerance level decision. Under these conditions it is very desirable to use the opportunity cost approach if at all possible.

Availability y of Mathematical Models

The stage of development of the mathematical programing models for a particular product or sector of the economy is an important consideration in choosing a method. If programing models are fairly well-developed for most of the important alternative commodities as well as the commodity under consideration, it may be possible to modify the existing work relatively inexpensively to obtain the information needed for the tolerance level decision, For example, a great deal of work has been done with the feed grain-food grain sectors of American agriculture. Less work has been done on the livestock sectors, although there are some models that incorporate feed grains and livestock and some models include the dairy subsector. If the decision to be made involves food or food grains, serious consideration should be given to using the opportunity cost approach and some of the models that have been developed, with whatever modification seems appropriate. On the other hand, there has been very little modeling that includes specialty crops, such as specific fruits and vegetables, into a general agricultural model. It would be expensive and of dubious value to develop a programing model for a tolerance level decision involving those crops.

. It is readily apparent that the key assumption of the alternative cost approach—no change in the quantity of product produced after restricting the amount of a particular contaminant that may be present—is not realistic in most cases and can lead to substantial error in estimating the social costs of a decision. It is the opinion of the author that the alternative cost approach is appropriate only in those cases where an alternative source of the product is available at virtually the same effective price or where alternative production techniques are available at no increase in per unit cost of production and which would involve not more than negligible shifts in the location of production. These are very restrictive conditions. For most tolerance level decisions involving major agricultural products these conditions do not hold and the opportunity cost approach is strongly advised.

DISTRIBUTION EFFECTS

The previous two sections have outlined considerations and methods for determining the benefits and costs of a change in tolerance level for a particular contaminant in a specific food product. From an economic perspective and a society-as-a-whole viewpoint, these sections cover the economic analysis of welfare changes. There are, however, related areas of concern which may be crucial to the social acceptability of a decision and for which economic analysis can be useful. Of major interest here is the analysis of how a decision impacts on various groups within society. Even though a decision may produce an improvement in welfare for the whole of society, there may be particular groups for which welfare is reduced. Such distribution effects may be due to the benefits and costs being shared differently by different income groups or by different regions of the country, There may also be concern about how the consequences of the decision affect the environment in various locations or its effect of esthetic considerations. Each of these points is reviewed briefly in this section.

The analysis of benefits and costs may show greater addition to benefits from a particular tolerance level change than the addition to costs; thus, a desirable decision, The consequences of that decision may not, however, be desirable for all affected parties, It is, therefore, important in some cases to examine the distribution of benefits and costs among social and economic groups.

For example, the decision to set a very restrictive tolerance level on a particular contaminant in fish may mean that fishing in certain bodies of water is no longer possible. That may have a very slight effect on consumers, since they can easily switch to fish from other areas. The fishermen who lose their employment may, however, have much lower incomes than the average consumer and may have few or no alternative sources of employment. In this case the benefits in health hazard avoided by a large number of people may greatly exceed the costs of idled resources in fishing and thus, the decision is appropriate. It is well for a decisionmaker to realize, however, that the major portion of the costs will be borne by people of much below average incomes with few alternatives to mitigate the losses.

Another decision may involve restriction of contaminant levels in a food eaten primarily by a specific ethnic or racial minority whose members have low incomes, The producers of this food may have several alternative products they can produce and the consumers may also find substitutes readily available. In this case the costs are slight and a low-income minority receives substantial health benefits.

Most of the data needed to describe the distribution of effects among income groups is available from the analysis of benefits and costs. In some cases it is not clear which income or social group is affected, but the analyst can usually determine this at the time he collects the data on effects. Thus, it is important that benefit-cost analysts be alert for information about the incidence of effects as they collect their data. What may be relatively easy to determine while the original source is being contacted may be time-consuming and difficult to find out at a later point in the analysis. The presentation of distributive impacts would probably be in narrative form rather than a quantitative analysis. The important point is to include this additional information for the decisionmaker so that the fullest possible knowledge of impacts is available when the decision is made.

The interregional differences in the impact of benefits and costs may also be of interest to the decisionmaker. Frequently the alternative source of product to replace that which is contaminated above the new tolerance level will be in a different area. Where a particular stream or valley produces contaminated food, the production may shift only a few miles to a nearby river or valley. Then the impact on the economy of a particular community may be slight. In other cases, a widespread area, such as a large estuary or part of a State, may be contaminated and production will shift to a completely different part of the country, Interregional differences may arise from products which are produced in one area, but consumed in another, For example, most of the winter head lettuce eaten in the United States is grown in the Imperial Valley of California, yet only a minuscule portion of the crop is consumed there. If a tolerance level for some contaminant made it impossible to sell Imperial Valley lettuce, almost all of the cost would be borne by that small part of California while the health hazard reduction would be shared throughout the rest of the country.

The data for constructing the regional impacts of a tolerance level decision can be found most easily in mathematical programing analyses under the opportunity cost approach. Not all programing models have regional specifications, but most agricultural models do, Careful review of budgeting results by experts on the production and marketing of the foods in question can also reveal some of the regional impacts or can call attention to the likely importance of regional differences. Further regional analysis can be performed if desired. The alternative cost approach does not provide much data on regional impacts. Here again, however, a careful review of the results by a knowledgeable analyst can suggest the likelihood of regional shifts that warrant further analysis with finer detail on regional specification.

The fact that a particular decision will severely harm a particular region or social group does not necessarily imply that the decision should be avoided. If the society-wide analysis of benefits and costs suggests a net gain from the decision, there is good reason to go ahead. The analysis of the distribution of effects may serve to point out the need for special programs to assist those harmed adjust to the decision. For example, regional impact analysis may point out the need for a retraining program for unemployed workers in a particular region far enough in advance that the program can be ready to go when the tolerance level decision takes effect.

The analysis of impacts on various regions and social groups can provide the starting point for analysis of the sociological and psychological impacts of the tolerance level decision. In some, perhaps many, cases the effect on a particular community or group of people may have serious consequences for social structure, organizational stability, and even the mental health of the affected people. Such a possibility was pointed out and briefly discussed by O'Mara and Reynolds (pp. 61-66) in their analysis of restricting fishing in the James River of Virginia due to kepone contamination. Since the present report is directed toward economic analysis, the techniques of sociological analysis will not be discussed here. Some of the analyses likely to be used are briefly outlined in Epp, et al. (pp. 134-138).

Another area of potential concern is the impact of a tolerance level decision on the environment or on the esthetic properties of a region. It is possible that a tolerance level decision may cause production to shift to an area where environmental damage would increase.

For example, prohibiting the sale of milk from one area may cause production to concentrate in another, leading to increased wastes from dairy farm holding pens and milk-processing plants. What may have been an acceptable load on the environment previously may become excessive. Analysts should be alert to the possible environmental and esthetic impacts of decisions. In some cases these effects can be measured in monetary terms and compared with benefits and costs. In other cases, the effects must remain in biological terms, but described in such a way as to make them useful in a tolerance level decision. The use of environmental food chain models and impact matrices has been suggested by the author with respect to pesticide decisions (Epp, et al., chs. 5 and 6) and the interested reader is referred to that discussion for greater detail, Not all tolerance level decisions will involve a significant environmental effect, but the procedure of analysis should include a notation to check for such effects and an analytical protocol for use when needed.

ALTERNATIVE TOLERANCE LEVELS

The sections on benefits, costs, and distribution effects have described how an analysis might be conducted of a particular decision to change the tolerance level from one point to another. For example, one decision might move from no restriction to prohibiting the sale of a particular food with 5 ppm or more of a specific contaminant. If benefits exceed costs and distributional as well as other effects are not overwhelming, then the move to a 5-ppm tolerance is efficient. That does not say that 5 ppm is the most efficient tolerance level. There may be some other level, say 2 ppm, that would produce even greater net benefits. The proper use of economic methods requires that consideration be given to the likely changes in benefits and costs if the tolerance level were changed a little either way. If it seems possible that net benefits would increase significantly by moving to a different tolerance level, then a detailed analysis as described above should be made of the change from the originally proposed tolerance level (5 ppm in the example) to the new level (2 ppm).

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