Invited Presentation

Issues in Risk/Benefit Evaluation for Pesticide Registration

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The Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) and its amendments and related legislation currently require that applicants for registration or reregistration of a pesticide demonstrate to the U.S. Environmental Protection Agency (EPA) that there is not "any unreasonable risk to man or the environment, taking into account the economic, social, and environmental costs and benefits of use of the pesticide." Present benefit evaluation guidelines call for consideration of effects on users, nonusers, consumers, GNP, and employment. Minimum guidelines call for a partial budgeting analysis and, if output effects of eliminating the pesticide appear large, a more sophisticated analysis using neoclassical multimarket economic-surplus concepts.

Risk considerations for registration or cancellation can typically be divided into the scientific disciplines of residue chemistry, environmental fate, ecological effects, nondietary exposure (occupational and residential exposure), and toxicology. A conservative bias in estimating risks is widely acknowledged. Indirect health risks, such as increased dietary risks resulting from higher food prices, are not considered in the risk analysis. Risks and benefits are analyzed independently, and risks are given in nonmonetary terms, while impacts on user benefits (and costs) and impacts on consumers, taxpayers, producers who do not use the pesticide in question, and other sectors of the economy are usually stated in monetary terms.

The EPA Administrator (or a designated Assistant Administrator) is delegated responsibility of judging whether risks to man and/or the environment are outweighed by benefits. According to pesticide legislation and relevant court rulings, pesticide decisions must err on the side of public safety. The Delaney Amendment (to the Food, Drug and Cosmetics Act), which calls for "zero risk," also adds legal confusion to the registration and cancellation processes. Applicability of this amendment to pesticides and the definition of exactly what constitutes zero risk seem to be a never-ending legal/scientific/economic debate. A recent court decision has directed the EPA to enforce the "zero risk" mandate under the Delaney Clause, in conflict with FIFRA. Water-quality legislation also overlaps pesticide legislation.

Several issues pertaining to the benefit evaluation connected with pesticide registration/reregistration/cancellation and issues pertaining to weighing risks and benefits are discussed in this article. My intent is to stimulate discussion on these issues, particularly to see if major thrusts of theoretical and empirical research in economics and agricultural economics match up with the issues. I will restrict my remarks to evaluation under existing legislation, because a companion article by Lichtenberg addresses broader pesticide policy issues. I begin with further presentation of my view of the benefit component of current assessments needed for registration or reregistration of a pesticide. My discussion is in the context of agricultural use of pesticides, but most of the discussion also applies to nonagricultural uses of pesticides (25% of total use), which are also regulated by FIFRA.

Current Benefit Assessment

Benefit assessment, as typically practiced, can be thought of as a two-step procedure. The first step is estimation of direct impacts on pesticide users in terms of per acre yields and productions costs (to use a crop pesticide for illustration), while the second step involves partial budgeting and sometimes economic-surplus analyses.

Implicit in yield and cost estimates are assumptions about what alternative pesticides, if any, producers would use. How production practices would change in response to the decision is also estimated. Estimates are presumably made on the basis of all available information, including experimental, field, laboratory, demonstration plot, and Delphi panel data obtained from manufacturers,

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universities, and state and federal agencies. Since there is no formal way of combining quite diverse data, considerable judgment is used in obtaining yield and cost estimates. For many pesticide decisions, yield and cost estimates are separately provided by the chemical manufacturer, the EPA, and the USDA. Uncertainty in estimating direct production impacts on users is well recognized and is usually highlighted by considerable differences between, for example, EPA estimates and manufacturer's estimates of yield and cost effects. Since yield and cost estimates are drawn from the same body of information, differences in estimates can often be attributed to differences in projections about alternative practices and pesticides, and to difficulties in extrapolating from limited experimental and field data to effects on the average user.

Given estimates of yield and cost effects, EPA guidelines call, at a minimum, for a partial budgeting approach to determine effects on pesticide users. Where effects appear large enough to affect prices of commodities produced with the pesticide in question, guidelines further require that the analysis be extended to include consumer and producer surpluses, indirect taxpayer expense (via farm programs), and finally the classical net welfare triangle. An illustration of multimarket surplus evaluation of possible regulatory options can be found in Taylor, Penson, Smith, and Knutson. Guidelines appropriately caution use of large-scale econometric or programming models for aggregate surplus evaluation because results from different models are not always consistent. Use of different economic models, such as interregional linear programming versus econometric simulation, to evaluate the aggregate economic consequences of given cost and yield effects adds considerably to the confusion and uncertainty surrounding registration and cancellation decisions.

Economic effects are an integral part of FIFRA legislation, but are relegated second priority to risk. Economic effects of EPA decisions on the pesticide industry are *not* considered in risk/benefit decisions, as mandated by FIFRA. Where preliminary economic analysis indicates that the regulation might have a significant effect on agricultural production and thus on prices, the analysis is extended to effects on consumers, producers who are nonusers, taxpayers, and GNP. Both the EPA and USDA/ERS have provided multimarket economic-surplus evaluations as input into regulatory and cancellation decisions for several pesticides.

The way in which the EPA Administrator or designated decision maker handles the immense uncertainty about risk factors, widely divergent benefit estimates, media hype, politics, and conflicting federal guidelines and legislation is not apparent from decisions.

Issues

With this as background about evaluation and decision making for registration or re-registration of a pesticide under present legislation, I would like to turn to several broad economic evaluation issues.

Issues are: (1) Can economics contribute directly to better decisions by providing a formal framework or methodology for weighing risks and benefits, rather than relying on judgment of an EPA Administrator; (2) Should evaluations and policy be based on perceptions of reality or on reality as judged by science; (3) Is risk/benefit analysis socially optimal; (4) Is it better to analyze each pesticide separately, allowing for the possibility of later reevaluation, or should we analyze various combinations of pesticide regulatory possibilities; (5) How can we improve incorporation of dynamics into benefit evaluation; and (6) How can we best handle uncertainty about risks and benefits? This is by no means a complete list of relevant issues, but time and other constraints imposed by a symposium dictate that the list be kept manageable.

What Is the Appropriate Methodology for Weighing Risks and Benefits?

When I first became involved in aggregate economic evaluation of pesticide issues, discussions seemed to be dominated by noneconomists estimating "pest losses" as percentage yield loss times acreage times price, which is the value of losses *not* allowing for supply and demand adjustments that would undoubtedly occur without pest losses. This figure was sometimes inflated by adding producers' expenditures to control the pests in question. Such a calculation, which produced incredibly large and impressive economic-impact numbers, obviously has no relevance to welfare economics or to decision making.

Incorporation of evaluation concepts like economic surplus from neoclassical welfare economics into mid-1970s guidelines for pesticide registration represented a dramatic improvement in the quality and relevance of economic information provided as input into pesticide policy decisions. Extensions of neoclassical models to decision making in a stochastic environment (i.e., the expected utility maximization model) to pesticide policy decisions have not met with success, perhaps because of the difficulty of monetizing risk to man and the environment. Thus, from a broad viewpoint of risks and benefits, very incomplete "economic trade-off" estimates are presented to pesticide decision makers. Of course, considering the cost of information, it may be appropriate to settle for incomplete information, especially where effects appear small.

The neoclassical model of behavior, extended to risk and to social welfare, is based on several assumptions that seem to me to be especially inappropriate to social decision making in the case of pesticides. First, there is the notion of the coldly calculating, expected utility (EU) maximizing consumer with perfect information. Although disciplines such as sociology and psychology have long dismissed this model, many economists seem to use it with religious zeal. Further discussion of this issue can be found in Shoemaker, MacCrimmon and Larson, Boland (1981, 1983), Burks, Caldwell, De Alessi, and Buschena and Zilberman.

The mean-variance (EV) model, which seems to have occupied the fancy of our profession for two decades, is not applicable to analyzing pesticide regulatory issues because strongly skewed probability distributions (on the risk side of the ledger) deviate substantially from the assumption of normally distributed random variables necessary to make the EV model a good approximation to the EU model. Appealing to certainty equivalence for monetizing risks, as called for in general Executive Order guidelines for Regulatory Impact Analysis, would appear to result in substantial bias because of highly skewed probability distributions that clearly violate the certainty-equivalent (Simon, Theil) requirements.

Another difficulty involved with applying the classical EU model is that many pesticide policy issues involve cases for which it is impossible to assign "objective" probabilities to risk factors and, furthermore, for which it is quite difficult, if not impossible, to even assign "subjective" probabilities. Thus, even the safety-first model, which has intuitive appeal for this problem, is not operational when probabilities cannot be assigned.

Along with assuming maximization, the EU model is also based on the assumption that the representative consumer believes in the classical notion of probability and that the probability of all possible states of nature can be assigned, at least subjectively. Although not well advertised, there are challenges to the classical notion of probability (see, for example, Burks) that together with challenges to the maximization hypothesis, cast some doubt on the validity of the EU model.

Building on the utility maximization model, neoclassical welfare economics assumes that utility functions are independent, perhaps because assuming otherwise makes the neoclassical social welfare model intractable, except in special cases. I believe that most people, by introspection, will see that the independence assumption is not appropriate. A few deaths or terminal illnesses out of 250 million people in the U.S. does not seem like many or seem to impose a large social cost (compared to other risks and causes of death), unless, of course, the death occurs to a friend or family member. Likewise, negative risk factors do not affect just producers or applicators, but also family, friends, and the immediate social community. Thus, to the extent that utility functions are *inter*dependent, the notion of consumers' surplus obtained by adding surplus for all individuals is not a valid measure of welfare effects.

Viewed at the individual rather than aggregate level, pesticide policy trade-offs often involve infinitesimal (but nonzero) risk versus infinitesimal benefits for most people, and small to significant risk versus large benefits and costs for users. Viewed at the aggregate level, pesticide registration decisions often involve comparing a few expected deaths or development of a few cancers to hundreds of millions of dollars of benefits.

The main point of this rather lengthy diatribe is that neoclassical expected utility maximization and welfare economics based on this concept and associated assumptions may not have much relevance to pesticide policy decisions. Rather than the profession spending tremendous resources on, for example, trying to estimate surplus changes using compensated rather than ordinary demand curves, or on using the latest static, deterministic duality model applied to a stochastic, dynamic problem, perhaps we should redirect our efforts and thinking toward new theoretical models that might give more insight into pesticide regulatory decisions. Using production economics terminology, one could politely say that the profession seems to be well off of the expansion path. (Or, given our current research funding environment, should we call it the "contraction" path?)

Only with more realistic theoretical models, I think, can we provide a framework or method that will assist pesticide policy makers with weighing risks and benefits. Thus, research on how people actually perceive risk and on how they balance infinitesimal, but otherwise unknown, probabilities of catastrophes with more easily assigned benefits might prove enlightening. Additional research on how we can aggregate preferences to account for interdependent values also seems warranted.

Base Evaluations on Perceptions of Reality or Reality as Measured by Science?

Public discussion of pesticide policy is typically charged with so much emotion, media hype, and fear of any chemical with a big name that one can make the case that legislation is based partly on risk "perceptions" that often do not match up with reality. Yet, risk assessments done as input into the registration process appear to be based on "real" risks, to the extent that science can measure risk.

Recent controversy about the chemical Alar used on apples illustrates the reality versus perception problem. Benefit evaluation based on economic factors before, during, and after the 1988 media hype about dangers of Alar would, because of effects of the hype on demand and baseline prices, give different estimates of benefits. Which should be used?

The public seems to be uninformed or poorly informed about both risk and benefit consequences of pesticide use and regulatory action. Consumers rarely have good information on the food price and quality effects connected to pesticide use; similarly, because of the complexities of pest management, including IPM, producers may not have good information on how a proposed pesticide regulatory action would influence farm income. Environmentalists, all of whom seem to believe in the law of ecology that "everything is connected to everything else," do not often seem to acknowledge that this law also applies to the economy and that there are environmental trade-offs as well as economic trade-offs. The issue is greatly complicated by the lack of trust that now exists in society, especially trust of university professors!

Lack of understanding and not knowing who to believe about pesticide issues makes meaningful public discussion of pesticide issues quite difficult. And, because most people are only affected infinitesimally, the transaction costs (De Alessi) needed to sort through the complexities far exceed individual benefits; thus, public debate seems doomed to media hype, claims, and counterclaims that are based on very few facts.

I think that we need to give more thought to whether we should base economic analysis on perceptions of reality (with respect to risk and to economic effects) or on reality (as judged or defined by what we now call science).

Is Risk/Benefit Analysis Socially Optimal?

Although a full cost accounting is not practical for purposes of this article, a rough measure of expenses connected with meeting federal mandates is useful. Annual expenses for benefit assessment by the USDA and EPA are in the $5 million to $10 million range, while pesticide risk assessments would appear to be in the $50 million to $100 million range, annually. EPA registration-related R&D expenditures by pesticide firms are in the range of $250 million annually (Aspelin, Grube, and Kibler, p. 11). Thus, a rough estimate of annual direct private and government expenditures connected with risk/benefit assessment would be $300 million to $500 million. On a per capita basis, the direct cost of risk/benefit assessment is thus less than $2 annually.

From a simple perspective, annual expenditures of less than $2 per capita appear to be cheap "insurance" compared to risks to man and the environment that might be abated by the policy. However, there are more complex issues of (1) whether the registration process poses barriers to development of new pesticides (especially minor-use pesticides), (2) whether existing expenditures were optimally allocated to assessment of risks and benefits, and optimally allocated to different pesticides under consideration, and (3) whether other policy instruments (Lichtenberg) would better achieve social goals.

Expenditures attributable to EPA requirements for a manufacturer to register a pesticide are approximately the same for minor- and major-use pesticides. For the industry as a whole, EPA registration-related expenditures by pesticide firms account for only about 20% of total R&D expenditures, and total only about 3% of pesticide sales. On average, therefore, registration expenses do not seem high. However, registration expenses are about the same for major pesticides as for specialty and minor-use pesticides. Thus, for highly specialized or target-specific pesticides with low anticipated sales, manufacturers will not find it profitable to register minor-use pesticides or will not find it profitable to try to develop new minor-use pesticides. Although not often acknowledged, registration barriers can also increase benefits because fewer alternatives will be on the market and, with imperfectly competitive markets, will increase the price that a manufacturer will receive. Benefits to an individual pesticide can be increased because barriers keep potential alternatives off the market. Definitive empirical analysis of these issues is not possible because of inadequate data.

The EPA recently acknowledged problems arising with extensive and quite expensive risk/benefit assessment with minor-use registration. Whether recent statements by the EPA is just lip service, or whether they will make substantive changes, remains to be seen.

One-by-One Evaluation?

Current legislation leads to evaluation of chemicals on a one-by-one basis, which is a problem that has been well recognized by the EPA, USDA, and many individuals and organizations for two decades; however, there has been little change in legislation or evaluation practices. The problem with registering pesticides on a case-by-case basis is that there may be insignificant benefits to the first pesticide (in a particular use class) evaluated because there are several alternatives on the market. Proceeding sequentially, there are fewer and fewer alternatives on the market, until there is only one pesticide left for registration consideration. Because this is the only pesticide left, benefits of use may outweigh risks, even though this pesticide is less efficacious and much more toxic than those that were previously banned.

The obvious way around this is to simultaneously evaluate combinations of pesticides. However, with this approach, there may be an unworkable number of alternatives, and staff requirements for simultaneously evaluating so many combinations may be suboptimal. The EPA appears to be moving in the direction of evaluating a few combinations of pesticides, rather than relying exclusively on the sequential decisions on single pesticides, and may thus be striking a good balance.

How Can We Best Account for Dynamics and Induced Technological Change?

There are a variety of issues that one can place under a generic heading called dynamics that need to be addressed. One dynamic issue is how to measure the buildup of pesticide resistance that would likely occur with future use of the pesticide. That resistance buildup occurs is well documented in many cases, but how to project future resistance is extremely difficult because the genetic mechanism responsible for resistance in a particular species is often highly complex and difficult to pinpoint (Hueth and Regev, Taylor and Headley).

A second dynamic issue is how to predict differential induced technological change that might occur if use of the pesticide were restricted. Removing a pesticide from use often increases output price and may increase the price of alternative control methods, both of which combine to increase the incentive to develop alternative chemical and nonchemical means of control. That we should consider induced technological change is apparent to most economists, but how to quantify such well enough for aggregate evaluation is not clear.

A third dynamic issue pertains to the discounting of future benefits and costs, and, with long time horizons, intergenerational welfare comparisons. At the present time, the EPA is pressured by the Office of Management and Budget (OMB) to use a real discount rate of about 10%, which places virtually no present value on some of the possible future consequences of pesticide use.

How to Incorporate Tremendous Uncertainty about Risk and Uncertainty into Decisions?

Uncertainty about risk factors, and even uncertainty about benefits of pesticides, is a striking and pervasive feature of pesticide regulatory decisions. Assessment of risks to man and the environment, and establishment of acceptable tolerances or standards is, ironically, based more on guesswork or art than on cold, hard science. Worded another way, risk assessment is on the frontiers of what we call science.

For example, using the same data set on the human health threat posed by dioxins and using practically the same quantitative model, scientists from three federal agencies (CDC, EPA, and FDA) made risk estimates that varied by an order of magnitude (Executive Office of the President, p. 21). (And we thought this problem arose only with econometric analysis of time-series data!).

The lack of scientific agreement on what constitutes risk contributes to the confusion surrounding pesticide regulation. The EPA Administrator typically must make regulatory decisions on the basis of widely varying and even contradictory estimates of risks and of benefits. Combining the worst-case estimate with the best-case benefit estimate might lead to a decision to deny registration for many pesticides, while combining the best-case risk estimate with the worst-case benefit estimate might lead to a decision to allow unrestricted use of all pesticides. I sense that there is a tendency to assume that conflicting risk or benefit estimates "bracket" the likely outcomes and, further, that the truth is midway between the worst-case and best-case information presented to EPA decision makers. This tendency should be investigated, in my opinion.

Transaction costs and other factors (such as knowing how the system works) may lead to an imbalanced set of information on which decisions are based; that is, transaction costs keep parties that would bear infinitesimal (but nonzero) economic costs and benefits (but, importantly, which might aggregate to significant benefits or costs) from conducting thorough studies of the proposed regulatory action. Thus, the information set given to the EPA Administrator may favor large impacts, positive or negative, or favor those groups for which transaction costs are low.

More fundamentally, I don't think decision theory or the neoclassical expected utility maximization theory provides a solid methodological framework for fine-tuning decisions in the face of considerable uncertainty about risks to man and the environment, and about benefits and costs to users and food consumers. Given weakness in our theoretical decision models, are we better off relying on inadequacies of the current system that is undoubtedly influenced by politics and the judgment of a few individuals, or relying on admittedly inadequate theoretical and empirical models?

Conclusions

Just two decades ago, many discussions of pesticide "benefits" were dominated by erroneous calculations, such as implying that the value of pesticides was losses avoided, computed as price times yield loss times acreage. Now, benefit calculations are increasingly based on neoclassical concepts of economic surpluses to producers and consumers, and on consideration of multimarket effects of regulatory decisions. Thus, the quality of economic information submitted to decision makers has improved considerably over the last two or three decades; however, it is not clear that such economic information is actually a serious consideration relative to risks to man and the environment in pesticide regulatory decisions.

Many pesticide regulatory decision options are characterized by infinitesimal, but otherwise unknown, probabilities of risk to man and the environment that must be weighed against sometimes large benefits to users and infinitesimal, but nonzero, benefits and costs (via induced price effects) to consumers of products produced with the chemicals. Decisions often involve irreversibilities, intergenerational transfer of risks and benefits, distribution consequences, and tremendous uncertainty about risks to man and the environment. The challenge to the economics profession, in my opinion, is to develop theoretical models and empirical estimates that shed more light on pesticide decision making than does the neoclassical expected utility maximizing consumer and the welfare economics based on this model.

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