ECONOMIC IMPACTS OF REDUCED PESTICIDE USE IN THE UNITED STATES: MEASUREMENT OF COSTS AND BENEFITS

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ABSTRACT

ECONOMIC IMPACTS OF REDUCED PESTICIDE USE IN THE UNITED STATES: MEASUREMENT OF COSTS AND BENEFITS

Ronald D. Knutson

Regulation of pesticides in the United States is based almost entirely on the direct effects on health and environment. The countervailing risks in terms of the health and environmental effects of the pesticide alternatives as well as the economic effects on farmers, rural communities, nutrition, food security, developing countries, and foreign constituencies could be so large that they outweigh the direct effects.

Knutson analyzes the results of three studies of the countervailing risks of reduced pesticide use that were conducted by the Agricultural and Food Policy Center at Texas A&M University. The methodology for the three studies is reviewed and critiqued. It is concluded that the current "worst first" pesticide policy has serious shortcomings and needs to be reevaluated. Studies of the effects of eliminating broader groups of pesticides need to be undertaken.

ECONOMIC IMPACTS OF REDUCED PESTICIDE USE IN THE UNITED STATES: MEASUREMENT OF COSTS AND BENEFITS

Ronald D. Knutson

The issues being discussed in this workshop are important both economically and environmentally. A policy of our Environmental Protection Agency (EPA) is that of "worst first" (Finkel and Golding). The question is whether pesticides are one of our "worst" problems. Then, the issue becomes which pesticides are the worst of the worst. The test for registration of pesticides under our recently enacted Food Quality Protection Act of 1996 (FQPA) is "a reasonable certainty no harm will result- - - from any action." This would appear to be a broad test. One of the issues involves how "harm" is defined.

- EPA and its environmental interest allies prefer to define the "harm" occurring from pesticides as the direct health effects measured by increases in the risk of diseases such as cancer and neurological disorders with an emphasis on providing an extra measure of protection for infants and children. The targeted pesticides under this definition are those having the greatest risk of "harm," as defined.
- If "harm" is measured considering the impact of alternative substitutes, the degree of "harm" may differ. A recent study by Gray and Hammitt (1999), in the Harvard Center for Risk Analysis and School of Public Health, suggests that the risks of substitute chemicals and of environmentally-induced natural toxins in plants may be as great as the

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pesticides being banned. If this is the case, there would be no positive health benefits associated with banning pesticides.

- A third level of economic risks results in reduced food production, higher production costs, increased food prices, and higher levels of malnutrition. While developed economies may choose to ignore such issues, as is arguably the case for EPA and some US environmental interest groups, the potential adverse consequences for the poor and globally for food security are no different than the controversy surrounding genetically modified organisms (GMO) that currently is being played out between the United States, the European Union, and Japan. This third level of unintended economic and nutritional consequences of banning pesticides receives little or no consideration in the current US regulatory strategy and debate.

Overview of Studies Conducted

The Agricultural and Food Policy Center at Texas A&M University and Bob Taylor at Auburn University have been studying the economic impacts of reduced pesticide use for over a decade. The basic approach has been to evaluate the effects of eliminating groups of pesticides on a cross-section of crops. Sequentially, these studies have included:

- 1990: A consulting study by Knutson, Taylor, Penson, and Smith of the economic impacts of eliminating insecticides, fungicides, herbicides, and no pesticides on field crops.
- 1993: A consulting study by Knutson, Hall, Smith, Cotner, and Miller of the impacts on yields and costs of eliminating and reducing by 50 percent pesticide applications on a

cross-section of 9 fruit and vegetable crops representing 83 percent of the value of US production.

- 1999: A Texas A&M University study by Knutson, Smith, and Taylor on the economic impacts of eliminating organophosphate and carbamate pesticide applications on seven field crops and seven fruits and vegetables. The unique feature of this study is that it was paired up by the American Farm Bureau Federation (the largest US farm organization) with the previously cited study by Gray and Hammitt (1999) of the health effects of organophosphates and carbamates. The results of this Harvard study have not yet been published. However, some insight is provided by recently presented testimony before the US Congress–to be discussed subsequently.

Methodology

The following sequential steps are common to these three studies:

1. The chemical use scenarios to be analyzed must be carefully defined to obtain a comparable set of impact estimates. In other words, what pesticides are to be eliminated?
2. The commodities studied were selected to represent a cross-section of all major field crops, fruits, and vegetables. That is, wheat was used as a proxy for barley and oats, peaches for stone fruits, and oranges for citrus fruits. This procedure facilitated the use of large sector models to quantify the aggregate economic impacts.
3. Estimates of the impacts of each chemical use scenario on yields per hectare were made on a regional basis by a plant scientist selected based on his/her experience with the specific crop being studied. The plant scientists were instructed to establish a baseline set of

production/management practices. Then, changes in these practices and related yields were specified by the plant scientist for each chemical use scenario. Estimates were made on a regional basis for major production areas and then weighted to aggregate to the national estimates. The plant scientists were urged to utilize the expertise of other scientists and related publications from each production region. Scientists found that while there were several field trial studies of the consequences of eliminating individual pesticides, few–if any–estimates existed of the impacts of removing pesticide combinations. As a result, some of the most respected scientists, who spent most of their careers studying a very limited number of pests, did not feel qualified to make these group pesticide reduction estimates. Therefore, the scientists engaged to make the estimates tended to be generalists who worked directly with farmers advising on pest control strategies. Integrated pest management (IPM) scientists were commonly utilized for this purpose in the 1999 study because of their broad training and experience. One of the issues confronted by the plant scientists involved whether it was possible to add up the yield effects of the individual pesticides being eliminated to derive the group effects. It was found that additivity was not a common strategy. However, some group estimates appeared to be greater than additive while most were less.

4. An agricultural economist, typically a farm management specialist, applied input cost estimates to the alternative management practices specified by the plant scientist for each chemical use scenario. It was found that these scientists worked best as a team if they were employed by the same university and had previously worked together. In other words, many had been engaged previously in multi-disciplinary research and/or farm

advising activities. Once the economist's work was done, the change in variable cost per unit of production could be calculated. It is important to note that while both yields and costs per hectare declined for all chemical use reduction scenarios, yields fell proportionately more than costs–meaning that unit costs rose. Therefore, comparisons of costs are only meaningful if put on a per unit of output basis. Thus, farmers employing non-traditional farming techniques (organic, etc.) who indicate that their costs declined when they switched from commercial production are probably talking about cost per hectare rather than per unit of output.

5. Changes in variable costs are crucial because they are used by economists to determine shifts in the supply functions contained in sector econometric models. The use of such models is important because the percentage reduction in yield should not be confused with the percent change in production. Nor should the percent increase in variable cost be confused with the magnitude of reduction in net farm incomes. The combination of yield and cost changes generates an upward supply curve shift which, in combination with an assumed constant demand schedule, generates a price increase. This price increase offsets a portion of the income effects of the yield reduction. In addition, the relative magnitude of yield and cost changes across crops influences not only what crops will be grown but where they will be grown. The only means of capturing these complexities is through the use of quantitative sector models. The quantitative sector models utilized in our studies were developed by Penson and Taylor (1990), maintained by Taylor (1993), and augmented by Taylor to include fruits and vegetables (1995 and 1999). These two models can be briefly described as follows:

- AGSIM is an econometric simulation model that is based on a large set of statistically-estimated demand and supply equations for major agricultural commodities. The model is capable of estimating how US farmers will adjust their acreages between commodities when relative prices and profitability change as a result of farm program, pesticide, or other policy changes. Changes in economic variables such as production, prices, domestic demand, exports, imports, and incomes are computed by comparing the results from a policy scenario with reduced pesticide use with a baseline simulation of current farm and environmental policies and production practices. Therefore, the only policy change relates to pesticide use.

  The result is the ability to isolate the economic impacts of the specified change in pesticide policy on producers and consumers. The traditional method of welfare analysis (which is based on the concept of economic surplus) is used to compute the sum of changes in producer surplus (net farm income) plus changes to all consumer surpluses (domestic and foreign).

- The fruit and vegetable simulation model, although conceptually similar to AGSIM, is more rudimentary. For each commodity, it includes a supply equation, a domestic demand equation, an import supply equation, and a farm-to-retail price transmission equation. With a supply curve shift indicated by the percent change in variable cost, the simulation model solves for a new market-clearing farm price, quantity supplied, quantity consumed, quantity imported, and quantity exported. These then are compared to the baseline to determine the aggregate impacts of a proposed change in pesticide policy on the fruit and vegetable sector of US agriculture.

Three other models used in one or more of the three studies merit mentioning because they give a more complete picture of the effects of pesticide regulation:

- Our forte in AFPC is analyses of the farm level impacts of policy changes. This is done through the use of a farm level policy simulator (FLIPSIM) developed by Richardson and Nixon (1986) and maintained in AFPC. This model has been utilized in increasingly analytic stochastic forms since 1981. Output from the sector models in terms of prices and inflation rates for the baseline and the pesticide reduction scenario provides the input to the FLIPSIM model on which approximately 100 US representative farms are simulated (Richardson, Smith, Knutson and Outlaw, 1991). These farms, which produce field crops and/or livestock, are developed as consensus operations by panels of 5-7 actual producers in major US producing regions. Discussing with legislators the effects on the farms of panel members who elected them is very effective. Farm level modeling is much more difficult in fruits and vegetables than for field crops. Fruits are multiple-year crops, and the adverse effects of pesticide use reduction increase over time. These effects are difficult to track. Vegetables are multiple-cropped within the year. This makes an already complex farm level model almost unmanageable.

  It is important to note that AFPC analysts have been working with Folkhard Isermyer at the Institute of Farm Economics, Federal Agricultural Research Center (FAL) to develop representative farm capabilities comparable to those of AFPC. FAL has made remarkable progress in duplicating AFPC's farm level methodology. An important next step involves the development of an EU baseline.

- While AGSIM estimates impacts on the agriculture sector, there are broader economic impacts from pesticide use reduction that extend to the general economy. For example, reduced production and exports mean fewer jobs in rural communities for performing marketing and storage functions. Reduced exports mean less economic activity for the transportation system and at the ports. These general economic effects were estimated utilizing a US input-output model named IMPLAN. Triggers for these general economic effects included changes in the volume of production, the cost of production, and in consumer spending on food.
- During the 1990s, Huang (1990) utilized his complete system of US demand for food to estimate the effects of economic factors on the nutrient content of diets. Taylor and Smith (1999) utilized the work of Huang to estimate the impacts of eliminating organophosphates and carbamates on nutrition. That is, higher prices and reduced consumption run counter to USDA's policy of encouraging people to eat more fruits and vegetables. By utilizing Huang's research, it was possible to estimate the magnitude of these effects.

Results

It is difficult to summarize the results of three studies utilizing five different models. Therefore, this presentation will be incomplete and of a summary nature. Those who want greater detail can get it from the references cited, many of which are on AFPC's home page.

Table 1 captures the US yield reductions associated with alternative pesticide use reduction scenarios for the commodities that were common to the three studies. The following observations evolve for these results:

- The broader the group of pesticides eliminated, the greater the yield impacts.
- Fruits and vegetables are more adversely affected by a broad-based reduction in pesticides than are field crops.
- Substantial variability exists among the crops studied for each pesticide reduction scenario.
- Crops most dependent on pesticides include apples, cotton, peanuts, and tomatoes. Wheat, perhaps, is the least pesticide-dependent.
- Areas most dependent on pesticides tend to have long growing seasons with no hard frost and with high humidity. One of the impressive aspects of the results–of great political interest–was the regional analyses of yield and cost effects which were then weighted to obtain the national estimates. There is a saying in the United States that, "all politics are local politics." Thus, localized state estimates are more likely to get the attention of legislators. By analogy with the European Union, country estimates might be expected to get greater attention than EU estimates, and country estimates could be expected to differ dramatically from north to south.
- Risk increases markedly as farmers' alternatives for dealing with pests decline.

Table 2 summarizes the estimated US variable cost increases associated with alternative pesticide use reduction scenarios. The following observations are generated by these results:

- The percentage increases in variable costs are generally larger than the percent reduction in yields, frequently strikingly larger. The result is to magnify the level of impact, particularly with the inelastic supplies and demands that characterize agriculture.
- Broadening the coverage of pesticide elimination has dramatically greater impacts on costs as alternative control methods are taken away.
- The relatively large cost impacts of eliminating herbicides in field crops (1990 study) goes a long way in explaining why "Roundup Ready" GMO varieties have been rapidly adopted by US farmers.
- Generally, the results across the three studies are consistent. The main inconsistencies were between the 1990 cost impacts for no pesticides and fungicides compared with the 1999 study eliminating organophosphates and carbamates.

Table 3 summarizes the estimated reduction in production resulting from pesticide elimination for the 1990 and 1999 studies. Comparable estimates are not available for the 1993 fruit and vegetable study. The following observations are generated by these results:

- Except for cotton, the production decreases are less than the yield decreases (compare Tables 1 and 3). This means that more land was brought into production, and the land was farmed more intensively utilizing other inputs–such as commercial fertilizer.
- Production decreases in crops such as rice and cotton for the 1990 study were sufficiently large that, in some areas, the infrastructure for production and marketing could be severely threatened. Even under the 1999 study, the infrastructure for producing and marketing cotton and rice could be threatened in some regions.

Table 4 summarizes the estimated price increases associated with pesticide elimination for the 1990 and 1999 studies. The following observations are generated from these results:

- The percentage increase in price was generally larger than the percentage decrease in production (compare Tables 3 and 4). This reflects the inelastic demand that generally exists for farm products.
- Price increases of this magnitude would be expected to raise the level of net income for those crop producers who were able to survive the transition. On the other hand, livestock, poultry, and dairy producers' net income would decline with higher feed prices.
- Exports would also be expected to tumble from the higher prices with the largest declines being in those commodities where foreign competition is intense, such as cotton and rice. US exports of major grains were estimated to decline by 15 percent, reflecting the strong position of the US in world corn markets. On the other hand, cotton exports fall by 46 percent.
- Imports of fruits and vegetables increase. If the countries of origin for these imports do not effectively regulate pesticide use, the effect of increased imports would be to partially offset any positive health benefits from reduced pesticide use.

Additional observations from one or more of these studies include:

- Negative economic effects on US consumers in terms of higher prices are approximately twice as large as the positive net income effects to major crop producers.
- The negative overall net economic surplus (globally) was generally about three times as large as the net income benefits to major crop producers.

- Utilizing the IMPLAN model, the overall US GDP loss in the 1999 study was almost three times as large as the net economic surplus to the farm sector analysis.

Health Effects

Absent the final report by Gray and Hammitt, comprehensive discussion of the health effects is premature. However, the findings of Taylor and Smith regarding nutrition impacts, combined with the Congressional testimony by Gray, lead to the following observations that should give pause to health advocates opposing pesticide use:

- Reduced production and higher prices of fruits and vegetables leads to reduced consumption which, in turn, reduces the intake of almost all vitamins and minerals. The cancer-reducing benefits of fruits and vegetables would correspondingly decrease. On the other hand, fat intake also decreases.
- According to Gray, it is possible that the offsetting or countervailing risks from banning organophosphates and carbamates will offset any positive effects that such a ban might have. Substitute pesticides have their own toxicity profile, plants produce natural toxins to protect themselves, and changes in diet may have a mixture of positive and negative effects.
- Perhaps most important, it would be a serious mistake for developed countries to make decisions regarding pesticide use reduction without considering the effects on the poor, resource allocation, and on food security.

These analyses of the health effects of pesticide use reduction suggest that there is a need to consider a broader set of risks than is utilized by EPA. Its risk cup analysis only considers the

direct effects of the target pesticide on health. To capture these additional or countervailing risks requires a much broader approach to pesticide policy.

Research Implications

The emphasis in this workshop, as I understand, was to be on methodological issues. In other words, what objective information do policy makers need to be provided in order to make an informed–yet still political–decision on pesticide regulation? How do we assure that this information is balanced and objective? At the risk of repeating what has already been written, the following observations appear to be appropriate, based on AFPC experience:

- The goals of policies and regulators need to be clearly set forth. Goals provide considerable direction for all who are affected by pesticide regulation. For example, the motivation for the 50 percent pesticide use reduction scenario in the 1993 study was based on an internal rumor that EPA's goal was to reduce pesticide use by 50 percent by year 2000. When the study was released, EPA analysts criticized the 50 percent option for being as unrealistic as complete elimination. Yet, subsequently, the 50 percent goal surfaced for active discussion as EPA policy.
- A central issue related to goals involves whether economic effects on farmers, rural communities, nutrition, food security, developing countries, and other foreign constituencies are relevant to pesticide policy. Are pesticide use decisions to be based only on the direct effects on health and the environment, or are the countervailing risks also important? These are issues that need serious attention by policy makers.
- In the US, decisions are made one pesticide at a time–targeting the worst first. Little consideration is given to what happens to the use of less effective substitutes or to what

happens when a group of pesticides is eliminated. The emphasis on individual pesticides means that group analyses are largely ignored. Our research has been extensively criticized (Ayer and Conklin) for, among other things, not being based on sound science. The estimates of reduced yields are, at best, informed judgment calls. The reason for the absence of broader-based field trials lies in the regulatory process itself. In addition, there are no incentives for analyzing the countervailing risks.

Studies done with chemical company support are inherently suspect. This reputation may not have been earned but, in any event, it is very real. Objectively perceived analyses require public sector support.

There is a learning curve associated with studies of this type. As a result, fostering centers of excellence such as exists under the leadership of Professor Zilberman at the University of California at Berkeley make sense. AFPC's analyses have evolved over the three studies. There are now some benchmarks against which we can compare. There are also some inconsistencies in results to which attention can be given.

Our ability to model the economic impacts of changes in policy have improved tremendously. They increasingly point to the need for interdisciplinary interaction, particularly in the health and environmental arenas. Scientific disciplinary societies do a very poor job of rewarding interdisciplinary work, as is the case of academic disciplinary departments and peer review processes for both proposals and scientific journals. Government funding agencies can break down these rigidities, but only if they are overtly pursued. It will not happen naturally or by evolution. Peer review committees must be made interdisciplinary.

- The cutting edge in research would appear to involve the interaction among the economic, nutritional, and health effects of reduced pesticide use. These effects need to be pursued on the basis of national, multinational, and global policies. Making national decisions regarding pesticide use based on only national effects is as erroneous as making decisions on the basis of single pesticide effects (worst first).
- Finally, at the risk of beating a dead horse, the interactions between pesticide and GMO decisions need to be recognized and researched. In addition, this research needs to be approached on a multi-country basis within the European Union. While there is a need for central leadership in these types of analyses, multi-country involvement is very important.

Table 1. Impacts of alternative chemical use policy scenarios on the estimated percent yield reduction for three studies, in different time periods, utilizing the same methodology.

Crop	1990			1993		1999
	No pesticides	No herbicides	No insecticides and no fungicides	No pesticides	50% reduction	No organophosphates and no carbamates
	---------- percent reduction in yield ----------					
Corn	32	30	5			4
Cotton	39	17	26			14
Peanuts	78	29	66			9
Rice	57	53	16			8
Soybeans	37	35	3			5
Wheat	24	23	4			1
Apples				100	43	38
Carrots						7
Grapes				89	57	9
Lettuce				67	47	
Onions				64	48	
Oranges				55	28	3
Peaches				81	59	2
Potatoes				57	27	3
Tomatoes				77	38	15

Table 2. Impacts of alternative chemical use policy scenarios on the estimated percent variable cost increase for three studies, in different time periods, utilizing the same methodology.

Crop	1990			1993		1999
	No pesticides	No herbicides	No insecticides and no fungicides	No pesticides	50% reduction	No organophosphates and no carbamates
	---------- percent increase in variable costs ----------					
Corn	5	8	0			5
Cotton	46	32	3			22
Peanuts	146	69	100			7
Rice	78	80	8			8
Soybeans	16	16	1			9
Wheat	33	33	0			1
Apples				No production	49	66
Carrots						4
Grapes				2,982	113	3
Lettuce				85	42	
Onions				82	42	
Oranges				40	35	2
Peaches				196	58	3
Potatoes				125	74	7
Tomatoes				113	40	13

Table 3. Impacts of alternative chemical use policy scenarios on the estimated percent reduction in US production for two different time periods, utilizing the same methodology.		
Crop	1990	1999
	---------- percent reduction in production ----------	
	No pesticides	No organophosphates and no carbamates
Corn	-18	-3
Cotton	-30	-9
Peanuts	-17	-4
Rice	-40	-1
Soybeans	-25	-3
Wheat	- 8	-1
Apples		-4
Carrots		-1
Grapes		-2
Oranges		-1
Peaches		-1
Potatoes		-1
Tomatoes		-2

Table 4. Impacts of alternative chemical use policy scenarios on the estimated percent price increase for two different time periods, utilizing the same methodology.		
Crop	1990	1999
	---------- percent increase in price ----------	
	No pesticides	No organophosphates and no carbamates
Corn	38	10
Cotton	34	23
Peanuts	147	1
Rice	83	3
Soybeans	101	15
Wheat	6	2
Apples		6
Carrots		1
Grapes		1
Oranges		1
Peaches		1
Potatoes		1
Tomatoes		3

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