FARM PROGRAMS, PESTICIDE USE, AND SOCIAL COSTS*

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Environmentalists attack agricultural pesticides because of adverse drift effects during application, run-off into streams and persistence in the environment. The Environmental Protection Agency (EPA) has banned DDT and currently is considering cancellation of its registration of mirex, 2,4,5,-T, and dieldrin [4].

Emotionalism rather than economics appears to be guiding environmental groups in their fight against pesticides. As agriculture's pesticide use comes under more and more pressure from the public, U.S. farm programs are likely to come under attack because they may have encouraged farmers to substitute pesticides for cropland. The "farm program" for the past decade has restricted acres planted and supported prices of agricultural products. Acreage controls encourage farmers to substitute variable inputs for limited cropland to take advantage of support prices.

Recently policy makers and researchers are questioning the merits of simultaneously restricting crop acreages and supporting prices; thus encouraging farmers to use pesticides [2, 3, 8]. The objective of this article is to examine three farm programs with respect to pesticide substitution for cropland, environmental quality and social costs. The farm programs analyzed are: a cropland diversion program, a marketing quota without pesticide restrictions and a marketing quota with limits on pesticide use.

PROCEDURE

To analyze the past farm program's role in substituting pesticides for cropland and to estimate effects of alternative farm programs, an aggregate production function for agriculture is useful. From this function the estimated marginal rate of substitution of cropland for pesticides gives an indication of the change in pesticide use for a given change in cropland. Also, estimates of input costs and resource use can be made from such a function.

An aggregate production function is estimated for the 1965-1969 time period. The Cobb-Douglas functional form is used because of its previous use in aggregate economic studies, ease of estimating parameters, and because provision for diminishing factor returns and constant elasticity of factor substitution are reasonably consistent with reality. Cobb-Douglas function parameters can be estimated by factor share, a methodology utilized by Tyner and Tweeten in studying optimum resource allocation for U.S. agriculture [12, 13].

Factor share for an input X_i is the ratio of total expenditures for the input to total value of the output $\frac{(P_{xi} \cdot X_i)}{(P_y \cdot Y)}$. Given competitive equilibrium conditions $(\partial Y/\partial X_i) = (P_{xi}/P_y)$ the right hand side (1) becomes the factor share (F_t) for input X_i

$$(1) \quad \frac{\partial Y}{\partial X_i} \cdot \frac{X_i}{Y} = \frac{P_{xi}}{P_y} \cdot \frac{X_i}{Y} = F_i$$

where:

P_{xi} is the price of factor X_i,
P_y is price of output Y,

after multiplying both sides by the ratio $\frac{X_i}{Y}$. The left

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The author is grateful to Luther Tweeten for his help in developing this paper and for his constructive criticisms of earlier drafts.

*Oklahoma Agricultural Experiment Station Journal Article No. J-2750.

hand side of (1) by definition is the elasticity of production for factor X_i. Since the elasticity of production is the exponential coefficient in a Cobb-Douglas function one can derive the functions coefficients from aggregate expenditure data by factor share.

Equilibrium in the factor market is an implicit assumption to use factor shares to estimate elasticities of production. This assumption is invalid for three agricultural inputs in 1965-1969: pesticide, fertilizer, and labor [5, 6, 7, 11]. An adjustment in factor shares (F_t*) can be made by multiplying F_t by the ratio of the inputs marginal revenue to marginal cost [12] as in (2): $F_i^* = F_i \cdot \frac{\partial Y}{\partial X} \cdot \frac{P_y}{P_{xi}}$.[1] Table 1 contains estimated elasticities of production for the factors in (3) with F_i* or $F_i = b_i$:

$$(3)\quad Y = A X_1^{b_1} X_2^{b_2} \ldots X_9^{b_9}.$$

With the inclusion of pesticides and the exclusion of real estate taxes, the input categories are similar to those used by Tyner and Tweeten [13]. Real estate taxes are a factor in determining the price of real estate and are therefore implicit in the real estate input. The intercept A in equation (3) is estimated by simple regression (assuming a multiplicative error) to be 13.9885 for the 1965-1969 data.

Table 1. ESTIMATED ELASTICITIES OF PRODUCTION FOR AN AGGREGATE AGRICULTURE PRODUCTION FUNCTION, 1965-1969

Input[a]	1965–1969
1. Pesticides (pounds)	.0473
2. Fertilizer and lime (tons)	.1266
3. Feed, Seed, and Livestock ($)	.1322
4. Labor (hours)	.1651
5. Machinery ($)	.1238
6. Real Estate (cropland acres)	.1957
7. Machinery Operating Expenses ($)	.1195
8. Miscellaneous Current Operating Expenses ($)	.0611
9. Crop and Livestock Inventories ($)	.0528
Sum	1.0241

[a]Description of Inputs: Pesticides, domestic sales adjusted for non-farm use [14, 20]; Fertilizer and lime, tons purchased [16]; Feed, seed, and livestock, purchases from non-farm sector adjusted for interfarm sales [17]; Machinery, annual investment (interest and depreciation) [18]; Labor, man hours used for farm work [16]; Real estate, annual investment in land adjusted for farm programs capitalized into land values [18]; Machinery and operating expenses, fuel, repairs and operations [17]; Miscellaneous current operating expenses, less pesticide expenditures [13, 15]; Crop and livestock Inventory, interest on inventory [18].

ANALYSIS OF A CROPLAND DIVERSION FARM PROGRAM

Land diversion farm programs typically support crop prices, so farmers have an incentive to be as productive as possible on the cropland in use. Since pesticides can help make cropland more productive farmers have an incentive to increase pesticide use as cropland is diverted from production. There are several ways to estimate this phenomenon, those used here are: observation of resource substitution along an isoquant, estimated marginal rate of substitution and elasticity of substitution.

From the aggregate function specified above (3) we can estimate the change in pesticide use (along an

[1]This adjustment yields the elasticity of production X_i:

$$F_i^* = \frac{X_i}{Y} \cdot \frac{\partial Y}{\partial X_i}$$

or

$$F_i^* = \frac{\partial Y}{\partial X_i} \cdot \frac{X_i}{Y} = E_{xi}, \text{ the elasticity of production } X_i.$$

isoquant) as available cropland changes. With cropland fixed at different level, the least cost combination of other factors necessary to produce the average 1965-1969 adjusted output was calculated (Table 2). (Adjusted farm output is total cash receipts for all sales adjusted for interfarm transfers and government payments for land diversion.) Estimated pesticide use increases from 1,048.5 to 1,124.8 million pounds as available cropland decreases from 350 to 260 million acres (Table 2). Cropland that would be in use at current prices is 332 million acres and the farm program restricted cropland to an average of 292 million acres [15, 19]. Total input cost decreases as available cropland increases, estimated input costs decreases $454.7 million as available cropland changes from 260 to 350 acres (Table 2).

The marginal rate of substitution of cropland (acres) for pesticides (pounds), estimated from equation (3), is –7.53. Suggesting that pesticide increases –7.53 pounds for each one acre decrease in available cropland to maintain farm output at a specified level. This is a partial explanation of the increase in pesticide use during the past decade. The 1965-1969 cropland diversion, other than the Conservation Reserve, averaged about 40.1 million acres per year [19]. Using this information and the marginal rate of substitution above, it is estimated that acreage restrictions encouraged the use of 300 million pounds more pesticide than in the absence of these restrictions. It should be pointed out that the substitution of pesticides for cropland may not be totally reversible because once adopted farmers continue to use new technology.

Table 2. ESTIMATED LEAST–COST INPUT COMBINATION AND TOTAL INPUT COST TO PRODUCE THE AVERAGE 1965-1969 ADJUSTED FARM OUTPUT WITH CROPLAND FIXED AT DIFFERENT LEVELS[a]

Cropland (mil. Acres)	Pesticides[b] (mil. lb)	Fertilizer[b] (mil. tons)	Livestock Feed, & Seed[b] (mil. $)	Labor on Farms[b] (mil. Hours)	Machinery Investment[b] (mil.$)	Machinery Operating Expenses[b] (mil. $)	Misc. Operating Expenses[b] (mil. $)	Cropland Livestock Inventory[b] (mil. $)	Estimated Total Input Cost[b] (mil. $)
260	1,124.8	84,096	4,369.7	4,547.6	4,092.1	3,949.9	2,019.6	1,745.2	31,432.5
270	1,114.8	83,349	4,330.9	4,507.2	4,055.7	3,914.9	2,001.7	1,729.7	31,345.2
280	1,105.3	82,636	4,293.9	4,468.7	4,021.0	3,881.4	1,984.5	1,714.9	31,268.9
290	1,096.1	81,953	4,258.4	4,431.8	3,987.8	3,849.3	1,968.2	1,700.8	31,202.5
300	1,087.4	81,300	4,224.4	4,396.5	3,956.0	3,818.6	1,952.5	1,687.2	31,145.5
310	1,079.0	80,673	4,191.9	4,362.6	3,925.5	3,789.2	1,937.4	1,674.2	31,097.0
316	1,074.1	80,308	4,172.9	4,342.8	3,907.8	3,772.0	1,928.6	1,666.6	31,097.0
320	1,070.9	80,070	4,160.5	4,329.9	3,896.2	3,760.8	1,922.9	1,661.7	31,055.6
330	1,063.2	79,490	4,130.4	4,298.6	3,867.9	3,737.6	1,908.9	1,649.7	31,023.5
340	1,055.7	78,932	4,101.4	4,268.4	3,840.8	3,707.4	1,895.6	1,638.1	30,997.4
350	1,048.5	78,393	4,073.4	4,239.3	3,814.6	3,682.1	1,882.6	1,626.9	30,977.8

[a]All Resources, except cropland, are variable and are at their least cost optimum.

[b]Estimated from the aggregate function (3) by Factor-Factor II [21]. Factor-Factor II determines the expansion path, total input costs and input use at specified output levels, isoquants if desired, marginal value product and marginal rate of substitution for a Cobb-Douglas function.

The marginal rate of substitution of cropland for insecticides estimated by Headley [6] was –13.24 using 1964 data. His estimate appears quite different than the one above because it is a measure of ounces of insecticides substituted for a one acre change in cropland.

Another measure of the change in pesticide use due to cropland diversion farm programs is the elasticity of substitution of cropland for pesticides, estimated at –4.13. In a free market situation a one percent decrease in available cropland is associated with a 4.13 percent increase in pesticide use. About 12 percent of the available cropland was diverted by the farm programs in 1965-1969 [19]. Interpreting the elasticity of substitution directly, a 12 percent decrease in cropland increases pesticide use about 50 percent or about 288 million pounds (based on average use in 1965-1969).

The costs to society of a cropland diverting farm program are: real costs; government payments and environmental costs. Environmental costs arise from environmental damage caused by pesticides, the cost usually is not reflected in the market place. Since land diversion programs have encouraged pesticide use (as shown above) the programs have increased the possibility of creating environmental costs. Government payments for land diversion are regarded as a transfer payment and as such are not costs to society.

The environmental cost associated with pesticide use is the cost of residue build up on soils and waterways, the loss of animal and human lives, and the cost of pesticide residues in food. Estimates of the costs are not available for a national estimate however some regional and local studies of environmental costs from pesticide use have been made [1, 9]. Edwards [1] estimated that there were environmental costs of $4,590 from using 152,000 pounds of pesticides, in a study of Dade County. Richardson reported that $6,680 of environmental damage in Osage County, Oklahoma resulted from the use of 154,000 pounds of herbicides in 1972, and that about $4,600 of environmental damage in Washita County, Oklahoma resulted from farmers using 32,500 pounds of insecticides [9]. These estimates include only short run costs and do not include long term costs associated with pesticide use.

The cost of environmental damage per pound of pesticide, ranges from $.03 to $.14 based on the values reported by Edwards and Richardson. If this admittedly crude range is used as a national average the 300 million pounds of pesticide engendered by a land diversion program cost society between $9 and $42 million. These estimates are most likely low because they exclude long term environmental costs.

The "real cost" to society of a farm program that diverts cropland is the value of goods and services not produced because of inefficient resource use engendered by the program. Since the least-cost combination of resources is precluded by cropland restrictions "real costs" are created. The difference between input cost when cropland is fixed and when it is variable is an estimate of the "real cost" of restricting cropland.

To estimate the "real cost" to society created by the farm program, the average actual input use in 1965-1969 was compared to the least-cost combination of resources needed to produce the average 1965-1969 adjusted farm output (Table 3). (The average 1965-1969 adjusted farm output is not necessarily the social optimum output but it is used for ease of comparing actual and optimal input use.) The average total input cost in 1965-1969 is $34.93 billion. With all inputs variable the estimated input cost is $31.87 billion (Table 3). The "real cost" to society to fix cropland at an average of 292 million acres a year is about $3.06 billion.

It is interesting to note in Table 3, that pesticide use should be increased 84 percent and fertilizer use should be increased 97 percent to be at a least-cost optimum. This leads one to believe that land diversion programs only hastened agriculture's use of pesticides to a least-cost optimum which would have occurred without land diversion and price supports. Labor use should be decreased about 56 percent. This is larger than the estimate of 35 percent made by Tyner and Tweeten [13]. The additional reduction is most likely due to the increased use of pesticide and fertilizer (Table 3).

Miscellaneous operating expenses should be reduced about 43 percent and real estate (cropland) should be increased about 100 million acres from the average used in 1965-1969 produce the average 1965-1969 output at a minimum input cost (Table 3). Remaining inputs are relatively close to a least-cost optimum level of use.

If input use had been at the least-cost optimum under the past farm program (1965-1969), estimated total input cost would have been about $32.03 billion (Table 4). The "real cost" to society of acreage restrictions in a perfect market is about $161 million per year. The difference between $32.03 billion and the estimated input cost without cropland restrictions is $31.87 billion. The conclusion is that inefficiency arising from acreage restrictions per se are small compared to that from other sources. These other sources include uncertainty of produce and factor prices, lack of knowledge, inertia of past decisions and costs not included in the analysis of adjusting to new economic circumstances.

The estimated total social cost of cropland diversion programs is $3.102 billion or about one percent of the average adjusted agricultural output in 1965-1969. The $3.102 billion is made up of the estimated cost to society of restricting cropland with optimum resource use, $161 million, possible environmental damages from "over-use" of pesticides about $42 million, and other sources of inefficiency. Now let us look at the social costs and pesticide use under alternative farm programs.

ANALYSIS OF A FARM PROGRAM: MARKETING QUOTA WITHOUT PESTICIDE RESTRICTIONS

One alternative farm program is a marketing quota program. For comparison assume the aggregate quota equals the average 1965-1969 adjusted farm output. It has been suggested that by establishing a maximum level of output each farm can sell, the

Table 3. INPUT USE AND COST OF PRODUCING AVERAGE 1965-1969 ADJUSTED FARM OUTPUT WITH AND WITHOUT CROPLAND RESTRICTIONS

Inputs and Input Costs	Actual Input Use 1965–1969 (Cropland Restricted)	Estimated Least-Cost Input Use 1965–1969 (No Cropland Restrictions)[a]
1. Pesticides (pounds)	575,237,800	1,059,220,000
2. Fertilizer (tons)	40,067,400	79,194,500
3. Livestock, Feed & Seed ($)	4,165,200,000	4,115,030,000
4. Labor on Farms (hours)	7,225,000,000	3,568,830,000
5. Machinery Investments ($)	3,898,000,000	3,953,560,000
6. Real Estate (cropland acres)	316,253,000[b]	390,989,000
7. Machinery Operating Expense ($)	3,764,400,000	3,719,710,000
8. Miscellaneous Operating Expense ($)	3,355,600,000	1,901,880,000
9. Cropland Livestock Inventory ($)	1,664,000,000	1,643,520,000
Total Input Cost ($)	34,934,000,000	31,877,500,000

[a]Estimated from the aggregate production function (3) by Factor-Factor II [21].
[b]Includes acres receiving payment for land diversion.

Table 4. LEAST COST COMBINATION OF RESOURCES TO PRODUCE THE AVERAGE 1965-1969 ADJUSTED FARM OUTPUT WITH AND WITHOUT CROPLAND RESTRICTIONS

Inputs and Input Cost	Estimated Optimum Resource Use 1965–1969 Cropland Restricted[a]	Estimated Optimum Resource Use 1965–1969 No Cropland Restrictions[a]
1. Pesticides (lbs.)	1,113,660,000	1,059,220,000
2. Fertilizer (tons)	83,264,400	79,194,500
3. Livestock, Feed & Seed ($)	4,326,510,000	4,115,030,000
4. Labor on Farms (hours)	3,752,240,000	3,568,830,000
5. Machinery Investment ($)	4,051,600,000	3,853,560,000
6. Real Estate (Cropland acres)	316,253,000	390,989,000
7. Machinery Operating Expense ($)	3,910,880,000	3,719,710,000
8. Miscellaneous Operating Expense ($)	1,999,620,000	1,901,880,000
9. Crop and Livestock Inventory ($)	1,727,990,000	1,643,520,000
Total Input Cost ($)	32,038,300,000	31,877,500,000

[a]Estimated from equation (3) by Factor-Factor II [21].

incentive to substitute pesticides for cropland is removed [8]. Under a quota system there are no restrictions on input use, so over time the industry could adjust to a least-cost level of input use. In time the resource use to produce the average 1965-1969 adjusted farm output would approximate the right hand side of Table 3, a free market least-cost combination of inputs to produce the average 1965-1969 adjusted output.

The use of pesticides increases under a marketing quota even though a quota is imposed on farm output. The least-cost level of pesticide use under a marketing quota is about 84 percent greater than the average use in 1965-1969 (Table 3). The reason for the increase is that the estimated marginal benefit (or marginal value product) of pesticides was $2.53 per $1.00 expenditure in 1965-1969. The environmental cost of such an increase in pesticide use is estimated at $67 million using Richardson's [9] estimate and $14 million using Edwards' [1] estimate.

The "real cost" of a marketing quota farm program is zero for there is no restriction on input use. Over time agriculture can adjust to a least-cost combination of resources so the value of goods and services not produced due to inefficient resource use approaches zero.

ANALYSIS OF A FARM PROGRAM: MARKETING QUOTA WITH PESTICIDE RESTRICTION

Recent legislation and publicity indicates that the public generally wants agriculture to use less pesticide instead of more and the above analysis implies that eliminating cropland restrictions and placing a quota on output will not lead farmers to reduce the use of pesticides. A marketing quota with a provision to restrict pesticide use is an alternative farm program that may satisfy some environmental protection groups as well as guarantee farm output at desired levels. Pesticide use can be regulated by fixing a maximum level of use or by imposing an excise tax on use.[2]

Fixing pesticide use is not examined specifically here but results for this alternative are apparent from the subsequent analysis of an excise tax, where the specific use obtained by the excise tax can be interpreted as the "quota" or fixed level of use. An excise tax on pesticides reduces pesticide use as it becomes uneconomical to apply. The excise tax also can be used to internalize possible environmental costs deemed to be associated with pesticide use.

As the price of pesticides (initial price plus excise tax) is increased, use declines and estimated input cost to produce a given output increases. The estimated optimum pesticide use at various levels of taxation (prices) and the respective input cost to produce the average 1965-1969 adjusted output is given in Table 5. With a price of $3.00 per pound, over twice the current price level in 1965-1969 pesticide use is approximately equal to the average used in that period of time. If the price is increased to $4.00 per pound, pesticide use is reduced about 30 percent from the average level of use in 1965-1969 and the total input cost is $33.65 billion. The input cost for the same of output without an excise tax on pesticides is estimated to be $31.87 billion.

The cost to society of restricting pesticides is the difference between the estimated input cost with an excise tax and the estimated input cost without an excise tax. The difference between estimated input costs when pesticides are priced at $1.39 and $4.00 per pound is the cost to society of restricting pesticides 30 percent (Table 5). It costs society an estimated $1.77 billion to restrict pesticides 30 percent. In the short run the cost of restricting pesticide use is a cost to the farmer but over a longer period it is largely passed to consumers in the form of higher priced food and fiber, in the absence of artificial barriers [11, p. 66]. The amount of this increased cost passed to the consumer depends of course, upon the elasticities of demand and supply for both the domestic and foreign markets.

Assuming the public wants to reduce pesticide use to about 40 percent of the average 1965-1969 level, the price would have to be set at $7.00 per pound; the estimated total input cost would be $34.57 billion (Table 5). This represents an added cost to society of $2.70 billion, or $13 for each person in the U.S.A., to restrict pesticide use 40 percent. If pesticides are priced at $10.00 per pound, use is reduced 70 percent or about 400 million pounds. This restriction costs society an estimated $3.30 billion or about $19 per person in the U.S.A.

The increase in total input costs is not a "real cost" to society, if the excise tax is a measure of the difference between private and social cost of pesticides, and resources are being used at the least-cost optimum. If pesticides actually created $2.70 billion in environmental damage their use could

[2] Other work on this area has been done by Lacewell and Masch [8] who examined wheat and grain sorghum production after assuming an excise tax was imposed on 2,4–D. This particular study was done for a five county area in the Texas High Plains.

Table 5. ESTIMATED PESTICIDE USE AND INPUT COST TO PRODUCE THE AVERAGE 1965-1969 ADJUSTED FARM OUTPUT AT VARIOUS PRICES OF PESTICIDES

Price of Pesticides After An Excise Tax ($/lb.)	Pesticide Excise Tax ($/lb.)	Estimated Pesticide Used to Produce the Average Adjusted Output (mil. lbs.)[a]	Pesticide Use as a Percentage of Average 1965-1969 Use (%)	Input Cost To Produce the Average 1965-1969 Output (mil. $)[a]
1.39	0.00	1,059		31,877
1.42	.03	1,050		32,014
2.00	.61	782		32,545
3.00	1.61	534	93	33,187
4.00	2.61	407	70	33,651
5.00	3.61	329	57	34,017
6.00	4.61	278	48	34,319
7.00	5.61	240	42	34,577
8.00	6.61	212	37	34,802
9.00	7.61	189	33	35,002
10.00	8.61	171	29	35,182

[a]Estimated from the aggregate production function (3) by Factor-Factor II [21] with cropland fixed at 330 million acres to simulate the short-run physical supply of cropland. (Three hundred and thirty million acres is the total of acres diverted by farm programs annually (1965-1969) and the average number of acres used in 1965-1969.)

be reduced 40 percent without incurring a real net cost to society (Table 5). If one assumes Edwards' estimate of environmental cost from agricultural use of pesticide in Dade County, Florida is representative of the nation, a social optimum level of pesticide use can be estimated [1]. An excise tax equal to estimated environmental cost reduces pesticide use 29 million pounds and increases input cost about $137 million (Table 5). The added input cost is not a "real net cost" to society if the estimate of environmental costs is accurate. However, if pesticides are less harmful than Edwards estimates them to be, the social optimum is at some level greater than the estimated 1,050 million pounds and a real net cost to society accrues.

If the public wishes to reduce agriculture's use of pesticides below its current use, a tax of $1.60 per pound is necessary. This tax results in the social optimum level of pesticide use and a zero "real net cost" only if pesticides actually cause environmental damage amounting to $1.60 per pound. Even though a marketing quota allows resources to be used at the least-cost optimum, the excise tax to restrict pesticide use must be equal to the environmental damage to insure optimum resource use without "real net costs" to society.

If pesticides do have an environmental cost of over $1.60 per pound and their use is reduced to reach a social optimum, the pesticide industry will experience a cut in sales. The cut in sales may be sufficient to force some plants out of production thus unemploying and forcing relocation of employees. This creates a cost to society however it was not estimated here.

Pesticide is not the only agricultural input that may cause environmental damage; for example, fertilizer may adversely affect the environment. The estimated least-cost optimum level of fertilizer use to produce the average adjusted 1965-1969 farm output is about 39 million tons greater than the average level of use during that same period (Table 3). The estimated marginal rate of substitution of pesticide for fertilizer was –5.36 in 1965-1969, so if pesticides are restricted fertilizer use will increase. The increased use may deteriorate the quality of the environment, for as more and more fertilizer is used, the greater is the possibility of nitrogen and phosphate damage to water supplies, wildlife, and people.

Cropland is another farm input that affects the quality of the environment, and like other inputs, as more is used the greater is the possibility of environmental damage. Based on the least-cost level of cropland presently used, we would need an additional 125 million acres in production to be at this estimated least-cost optimum. The added cropland could come from the 40 million acres diverted annually by the past farm programs, the Conservation Reserve, grasslands, and wooded areas.

As land is taken out of these soil conserving uses and put to more intensive uses the level of soil erosion may increase, and soil erosion is already one of the major agricultural pollutants in the U.S.'s rivers and lakes. The increase in the number of acres farmed also decreases the availability of land for outdoor recreation and wildlife habitat. The shift in land use thus may decrease the aesthetic value for society.

LIMITATIONS

This work is done on an aggregate basis and thus has the problems associated with nonhomogeneity of inputs and outputs. In particular, when pesticides are aggregated, we assume that all (insecticides, herbicides, fungicides, etc.) are equally productive for the nation as a whole. This is not the case – Headley's work shows insecticides are more productive than herbicides. Also, pesticides are more productive in some regions of the nation than in others [6]. This is most likely the case with respect to fertilizer use.

Edwards' [1] estimate of pesticide's environmental cost is made for the 1966-1967 crop year on a single county in Florida. Generalizing this estimate and the two from Richardson's [9] work to the whole nation is a crude extrapolation at best but it is the best estimate presently available. The estimates are probably low because they do not include long run costs of pesticide use.

The average 1965-1969 adjusted agricultural output is used throughout this paper, but in reality the mix of commodities in the aggregate is likely to be different with pesticide use altered. Also, the quality of agriculture's output may be lower because of insect damage in production and storage.

CONCLUSION

Farm programs that divert cropland and support prices encourage the substitution of pesticides for cropland. Because of this the past farm program is potentially responsible for an estimated 300 million pounds of agriculture's current pesticide use. However, agriculture is not at the least-cost optimal level of pesticide use, and land diversion farm programs only hastened agriculture's adjustment to the least-cost optimal level of use.

The past farm program of diverting cropland and supporting prices coupled with other factors such as risk and uncertainty resulted in a nonoptimal input mix constituting an annual cost to society of some $3.102 billion. An alternative, marketing quota farm program is suggested to move agriculture toward a more nearly optimal input mix without real costs to society.

Pesticides are currently used at less than the economic optimum, so a marketing quota farm program will not reduce its use. The least-cost combination of pesticide is about 1,060 million pounds and average use in 1965-1969 was about 575 million pounds.

A marketing quota farm program with an excise tax on pesticides is suggested to encourage resource use at the least-cost optimum and reduce pesticide use. An excise tax equal to the environmental cost of pesticide use internalizes the environmental cost as well as encourages social optimum resource use. If society wanted to reduce pesticide use below the average 1965-1969 level of use a tax of $1.60 per pound would be needed. The added input cost of such a move is $1.31 billion.

The cost to society of restricting pesticides is the increased cost of inputs to produce a given level of output, with a specified reduction in pesticides. For example, to reduce pesticide use 30 percent it costs society an estimated $1.77 billion in added input costs. This added cost is not a "real net cost" if pesticides cause net environmental damage of $2.60 per pound ($2.60 is the estimated excise tax necessary to reduce pesticide use 30 percent).

Farm inputs other than pesticides cause environmental damage. The environmental costs from other farm inputs should be considered in an analysis of the effects of restricting pesticides, as well as the increased input costs engendered by pesticide restrictions.

More research is needed to determine actual environmental costs associated with pesticide use preferrably on a national basis. This would allow better estimates of the benefits to society from restricting pesticides and the estimation of the social optimum level of pesticide use for agriculture.

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