AGGREGATE ECONOMIC EVALUATION OF THE ELIMINATION OF ORGANOPHOSPHATE AND CARBAMATE PESTICIDES

AFPC Policy Research Report 99-15

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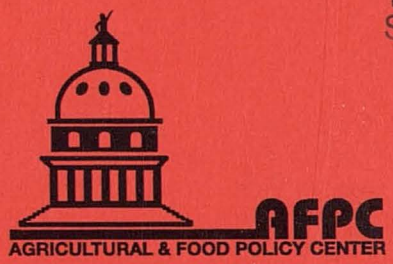

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April 1999

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http://afpc1.tamu.edu/pesticides.htm

Pesticides and registered trade names included in this report are not intended to be a complete listing. The trade names are included merely as some examples of the pesticides. They are not an endorsement of any particular chemical company's product or an indication that any such product is the exclusive trade name used for any particular purpose.

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A set of large-scale quantitative models of the agricultural economy was used to estimate the aggregate economic impacts of eliminating organophosphate and carbamate pesticides. Estimates of the effects of the elimination of organophosphates and carbamates on per-acre crop yields and production costs, which were provided by a team of agricultural scientists and agricultural economists, were used to shock the aggregate models. All aggregate economic effects reported here are averages for the 1999-2002 time period.

Aggregate models used in the analysis include: (1) AGSIM, which is a regionalized econometric simulation model of production, consumption, and export of major agricultural crops and livestock types in the United States (Taylor, 1993), (2) an econometrically based fruit and vegetable model developed as a part of this project, (3) a set of farm level to retail level price transmission elasticities developed as a part of this project, (4) a complete system of retail demand equations for the United States developed by Kuo S. Huang (1993), (5) a complete system of nutrient demand equations, also developed by Huang (1996, 1997), and (6) IMPLAN, a national input/output model of the United States economy including non-agricultural sectors. Each of the models used in the aggregate analysis is briefly discussed below, followed by a presentation of results.

Overview of AGSIM

AGSIM is an econometric-simulation model that is based on a large set of statistically estimated demand and supply equations for agricultural commodities produced in the United States. This model has been peer-reviewed and utilized in many pesticide and other major agricultural policy evaluations (Taylor, 1992).

The model is capable of estimating how farmers will adjust their crop acreages between commodities when relative profitability changes as a result of crop yield and production cost changes as a result of pesticide or other policy. Acreage and yield changes from various scenarios will affect total production of crops, which then affects commodity prices and consumption. The commodity price changes, in turn, affect profitability and cropping patterns in subsequent years. Federal farm program and conservation reserve effects are also incorporated into the model.

AGSIM was designed to estimate changes in the agricultural sector resulting from the implementation of pesticide or other policies. Changes in economic variables are computed by comparing a policy simulation of the model with a baseline simulation of the model. It should be noted that the baseline is not especially critical to estimates of changes in the agricultural sector, except for the case of price support policy. That is, estimates of changes in variables are not very sensitive to the baseline absolute values of variables.

The major outputs from AGSIM are changes in crop acreage, production, price, income, foreign consumer benefits, domestic consumer benefits, and farm program costs. The traditional method of economic welfare analysis (which is based on the concept of economic surplus) of

policy changes is used to compute the sum of changes in producer surplus (net farm income) plus changes to all consumers (changes in consumers surplus) plus any changes in farm program payments (zero under 1996 FAIR Act).

The crop supply component of AGSIM is based on a set of supply equations for each of the USDA ten farm production regions. Crops included in the model are corn, grain sorghum, barley, oats, wheat, soybeans, cotton, hay, peanuts, and rice, with cultivated summer fallow treated as another land use in semi-arid regions. Acreage idled under government programs (primarily annual set-aside and long-term conservation reserve acreage) is also treated as a competing land use in the model.

A set of econometrically estimated equations plus identities comprises the supply component of the model. Sets of equations include: (1) acreage planted to each crop, (2) acreage harvested of each crop, (3) acreage in cultivated summer fallow, (4) acreage in annual set-aside programs, (5) acreage in the conservation reserve program, (6) yield per harvested acre, (7) rate of participation in Federal farm programs by crop, and (8) annual set-aside rates under past farm programs as related to stock levels and thus related to market price. Crop production is defined as the product of acreage harvested and yield per harvested acre. Acreage slippage (with respect to annual set-asides) in farm programs is implicit in the model specification.

Acreage planted is a key behavioral relationship in the supply component of the model. Acreage planted of a particular crop depends on expected per-acre net returns for that crop, expected per-acre net returns for competing crops, and farm program variables. Expected per-acre net returns is defined as the product of expected yield and expected price minus per-acre production costs. Under the 1996 FAIR Act, expected price is defined as market price lagged one crop year, while under past farm programs expected price is defined as the maximum of target price and lagged market price.

Farm program participation rate equations for a particular crop depend on the set-aside rate for that crop, on expected net returns based on lagged market price, and on expected net returns based on the target price (support price). The 1996 Farm Bill eliminates annual set-asides and unlinks income support payments from acreage, price, and other variables. Thus, the baseline in AGSIM for future years reflects a free market, but with transition payments that influence income levels, but not the change in income from pesticide policy or changes in crop acreages.

The crop demand component of the model is based on a set of demand equations for each crop for use categories of (a) net exports, (b) livestock feed, (c) food, fiber, ethanol production, and other domestic uses, (d) ending stocks, and (e) residual use. Each demand component depends on current market price for that commodity and, where relevant, prices of other commodities. Net export equations also depend on real trade-weighted exchange rate indices for the US and for countries that compete on the supply side with the US.

The simulation component of the model finds the set of prices for all commodities endogenous to the model that simultaneously clears all markets in each year over the simulation period. Dynamics are incorporated into the econometric specification and are thus incorporated into the simulation model.

Fruit and Vegetable Simulation Model

An econometrically based simulation model, conceptually similar to AGSIM, was developed for most individual fruit and vegetables and for some fruit and vegetable aggregates. Crop coverage was limited largely by availability of USDA historical supply, utilization, and price data. Economic relationships estimated for each commodity or aggregate are: (a) a supply equation, (b) a domestic demand equation, (c) an import supply equation, (d) an export demand equation, and (e) a farm level to retail level price transmission equation. The estimated econometric relationships were used in the simulation model to solve for the farm level price that cleared the market. The baseline reflected conditions in the 1996 crop year, while the supply equation was shifted on the basis of the estimated change in per-unit production costs attributable to removal of organophosphate and carbamate pesticides. With the supply curve shifted, the simulation model solved for a new market clearing farm level price, quantity supplied, quantity consumed, quantity imported, and quantity exported. These then were compared to the baseline levels to estimate the aggregate impacts on the fruit and vegetable sector of US agriculture.

Econometric relationships for fruit and vegetables are summarized in elasticity form in Table 1. Details on individual econometric relationships are available from Bob Taylor.

Price Transmission Elasticities

Farm to retail price transmission elasticities were estimated for individual crops when adequate data were available. However, data were not available at both the farm level and the retail level for many individual commodities. In such cases, price transmission elasticities for broader groups were assumed to apply for the individual commodities.

Table 2 presents a set of price transmission elasticities for each category of food for which USDA reports farm value and retail cost indices.

Estimation of Price Impacts of the Pesticide Ban

The farm level price and quantity effects were estimated with AGSIM and the fruit and vegetable simulation models. The second column of Table 3 summarizes the effects of the pesticide ban on unit production costs for major field crops, while the next column shows the farm price effects of the ban. Changes in net exports and changes in domestic production of the major crops are also shown in Table 3.

Table 4 shows the estimated effects of the ban on livestock prices. Effects on the livestock sector are attributable to higher feed prices induced by the ban on organophosphate and carbamate pesticides used in the production of major field crops. The price effect on farm-level beef prices is negative because the higher feed prices induce herd liquidation, which increases beef marketings in the short run. Aggregate effects shown in this table, as well as all other economic effects shown in this report, are averages for the 1999-2002 time period. Beef prices would increase after this period of adjustment. Supply adjustments also occur for the other livestock types, but shorter biological lags, compared to beef production, result in higher farm level prices for all livestock types except beef.

The second column of Table 5 presents the estimated effects of the pesticide ban on unit production costs, while the remainder of this table presents resulting aggregate economic effects of the ban on fruit and vegetable farm level prices, exports, imports, and domestic production. In all cases, farm prices increase, exports decline, imports increase, and domestic production and consumption decline. Domestically produced food is lower in pesticide residues than the same food products grown in other countries. Thus, the pesticide ban would indirectly result in an increase in imports, which translates into an increase in some types of pesticide residues in domestically consumed food. Also, since exports are reduced, foreign consumers of fruit and vegetable products might consume food higher in some pesticide residues.

Retail food price effects were then estimated on the basis of relevant price transmission elasticities (Tables 1 and 2) and the estimated farm level price impacts (Tables 3, 4, and 5).

Effects on Domestic Consumption of Nutrients

Time and resource constraints on companion studies, which estimated the yield and costs impacts associated with the elimination of organophosphate and carbamate pesticides, did not permit complete coverage of all agricultural crops that might be affected by the ban. Yet, aggregate economic analysis requires complete coverage of all crops, especially in the context of a complete system of demand equations and a complete system of nutrient consumption elasticities. Without complete coverage, resulting estimates of changes in consumption of individual foods and nutrients, in particular, would be distorted. Rather than have this obvious distortion, unit cost effects or retail price effects for commodities not covered were assumed, based in part on pesticide usage on these other crops and existing literature.

Retail price changes for a complete system of commodities are shown in Table 6. Also shown in this table is the associated change in consumption of each commodity, based on the complete system of demand equations developed by Huang (1993). Using the nutrient component of Huang's system (1996, 1997), Table 7 presents estimates of the effects on nutrient consumption associated with the retail price effects presented in Table 6. As can be seen in Table 7, the pesticide ban results in a decrease in nutrients, except for vitamin A and vitamin B-12. Some of the decreases, such as in fat consumption, would improve health, while other decreases, such as for most vitamins, would have a negative effect on health.

The mixed effects on human health of the nutrient consumption changes shown in Table 7 highlight the complexity of pesticide policy. EPA has a "risk cup" that contains only pesticide residues; results here strongly suggest that EPA should consider all effects on health of possible regulatory policy and not just consider pesticide residues.

Table 8 shows household food spending by income category in 1995. Table 9 shows the estimated changes in food spending by income category that would occur with the pesticide ban.

Aggregate Economic Effects on the Agricultural Economy

Effects on income from domestic agricultural production are shown in Table 10. Net income from production of major crops increases because the price effect induced by the pesticide ban more than offsets lower yield and higher production costs. Net income from production of fruit and vegetable crops decreases, however, because the price effect is not sufficient to offset higher unit production costs. Higher feed prices reduce net livestock income. The net result of the ban on domestic net farm income is a negative $1.8 billion.

Also shown in Table 10 are effects on foreign surplus, which is a mix of foreign consumer surplus and foreign producer income, and effects on domestic consumer surplus. Foreign surplus decreases by $1.3 billion, while domestic consumer surplus declines by $4.9 billion. Net economic surplus decreases by $8.0 billion annually as a result of removal of organophosphate and carbamate pesticides.

Table 11 shows the effects of the ban on income from production of major crops, while Table 12 shows the net income effects for fruit and vegetable crops. Table 13 shows the effects on net income by livestock type.

Indirect and Induced Impacts on the General Economy

Direct changes in the agricultural economy, shown previously, cause indirect and induced changes in the agricultural economy, and especially in the general economy. Direct, indirect, and induced economic impacts of the proposed pesticide bans were modeled using IMPLAN with national data for 1995. Three types of changes were used to trigger the estimated impacts from IMPLAN : (1) changes in the volume of production of food and fiber, (2) changes in the costs of production, and (3) changes in consumer spending caused by the increases in food prices. The production changes included beef (-), hogs (-), poultry and eggs (-), corn (+), sorghum (+), barley (-), wheat (-), oats (-), rice (+), soybeans (-), peanuts (-) cotton (+), hay (-), fruits (+), and vegetables (+). These changes were combined on a weighted average basis into output changes in the IMPLAN sectors: feedlot beef, hogs, poultry and eggs, cotton, food grains, feed grains, hay and pasture, fruits, vegetables, miscellaneous crops, and oil bearing crops. Costs of production were modified by increasing chemical costs 11.65 percent and selected variable costs 0.21 percent in the production functions for each of those sectors listed above plus tree nuts, miscellaneous crops, and greenhouse and nursery products. IMPLAN automatically estimates

induced effects which are a consequence of changes in income due to changes in economic activity, but IMPLAN assumes constant prices, so it is necessary to include changes in final demand for goods and services that would result from consumers facing increased food prices. These changes averaged -0.23 percent on food and –0.21 percent on non-food (see Table 6). Following impact estimation, the results were inflated to 1998 dollars using the IMPLAN sector inflation index.

Table 14 summarizes the direct, indirect, and induced effects of a ban on organophosphate and carbamate pesticides on the United States economy. Gross output in the economy would decline by $17.3 billion annually, and employment would decrease by 209 thousand jobs.

Complete IMPLAN results are available upon request from Bob Taylor.

Table 1. Fruit and vegetable demand, supply, import, and export elasticities.[a]

Food Group	Import Elasticity[a]	Export Elasticity[a]	Domestic Production Elasticity[a]	Domestic Consumption Elasticity[a]	Price Transmission Elasticity[b]
Fruit Juices	1.893	-0.751	0.779	-0.871	1.952
Apple Juice	0.245	-0.836	0.249	-0.237	
Canned Fruit	0.525	-3.737	0.267	-0.400	
Fresh Fruit	0.044	-0.129	0.040	-0.269	
Fresh Vegetables	0.489	-0.785	0.114	-0.452	
Processed Vegetables	0.301	-0.561	0.309	-0.292	
Fresh Apples	0.682	-1.398	0.307	-0.179	0.257
Fresh Oranges	0.866	-0.276	0.099	-0.220	0.232
Fresh Grapes	0.604	-0.053	0.300	-0.946	0.407
Raisins	1.055	-0.720	0.438	-0.374	
Fresh Peaches	1.742	-1.201	1.672	-0.684	
Canned Peaches	1.056	-0.537	0.966	-0.284	
Carrots	0.493	-0.247	0.335	-0.768	0.408
Peanuts	N.A.	∞	0.163[c]	-0.360	
Fresh Tomatoes	0.594	-0.343	0.561	-0.449	0.719
Processed Tomatoes	0.703	-2.927	0.503	-0.182	
Potatoes	0.262	-0.356	0.204	-0.068	0.186

[a]The elasticity is the percentage change in the quantity (imported, exported, or produced domestically) associated with a one percent change in price.

[b]The price transmission elasticity is the percentage change in retail price associated with a one percent change in farm price.

[c]The production elasticity for peanuts is with respect to the world market price of peanuts.

Table 2. Farm value to retail food price transmission elasticities.

Food Group	Elasticity[a]
Market Basket	0.372
Market Basket–for Food Away from Home	0.048
Cereal and Bakery Products	0.165
Dairy Products	0.307
Eggs	0.778
Meat Products	0.523
Poultry	0.572
Fresh Vegetables	0.503
Fresh Fruit	0.787
Processed Fruits & Vegetables	0.226

[a]The elasticity is the percentage change in the real retail cost index associated with a one percent change in the real farm value index.

Table 3. Farm level effects, for major crops, resulting from the elimination of organophosphate and carbamate pesticides.

Commodity	Change in Per-Unit Production Costs (%)	Change in Farm Price (%)	Change in Net Exports (%)	Change in Domestic Production (%)
Corn	5	10.4	-4.7	-3.4
Grain Sorghum	10	18.8	-2.5	-8.7
Barley	1	1.5	-2.7	-1.1
Oats	1	0.6	0.1	-1.6
Wheat	1	2.0	-2.7	-0.8
Soybeans	9	14.7	-11.1	-3.3
Cotton Lint	22	23.0	-0.6	-9.1
All Hay	0	1.4	0.0	0.4
Rice	8	2.6	-0.3	-0.6
Peanuts	7	0.1	-14.4	-4.0

Table 4. Farm level price effects, for livestock, resulting from elimination of organophosphate and carbamate pesticides.

Commodity	Change in Farm Price (%)
Yearling Cattle	-0.4
Cows	-0.5
Calf	-0.4
Hogs	1.2
Broilers	0.8
Turkeys	1.1
Eggs	1.5
Milk	0.1

Table 5. Fruit & vegetable impacts resulting from the elimination of organophosphate and carbamate pesticides.

Commodity	Impact On					
	Unit Production Costs (%)	Farm Price (%)	Exports (%)	Imports (%)	Production (%)	Consumption (%)
Fresh Peaches	3	1.9	-2.3	3.3	-1.8	-1.3
Canned Peaches	3	2.2	-1.2	2.3	-0.8	-0.6
Fresh Tomatoes	13	7.0	-2.9	3.3	-3.2	-2.9
Processed Tomatoes	13	3.4	-10.8	3.8	-1.6	-0.6
Carrots	4	0.4	-0.3	0.6	-1.0	-0.9
Fresh Apples	66	24.3	-34.3	16.8	-12.8	-4.3
Potatoes	7	4.6	-2.3	3.9	-0.5	-0.3
Fresh Oranges	2	0.3	-0.1	0.3	-0.2	-0.1
Fresh Grapes	31	2.6	-0.1	1.6	-3.7	-2.4
Juices	7	2.1	-1.7	4.3	-3.8	-1.9
Other Canned Fruit	7	2.0	-8.0	1.1	-1.3	-0.7
Raisins	3	1.7	-1.3	1.9	-1.0	-0.6
Other Fresh Fruit	7	1.2	-0.2	0.1	-0.2	-0.2
Other Fresh Vegetables	7	0.8	-0.6	0.4	-0.7	-0.4
Other Processed Vegetables	7	3.3	-1.5	0.7	-1.2	-1.0

Table 6. Consumption changes induced by retail price changes.

Consumption Item	Price Change (%)	Consumption Change (%)
Beef & veal	-0.20	0.11
Pork	0.62	-0.50
Chicken	0.50	0.42
Turkey	0.62	0.10
Fresh & frozen fish	0.35	-0.14
Canned & cured fish	0.00	0.62
Eggs	1.18	-0.33
Cheese	0.00	-1.23
Fluid milk	0.03	0.12
Evaporated & dry milk	0.03	0.83
Wheat flour	0.33	-0.10
Rice	0.44	0.06
Potatoes	0.16	-0.87
Butter	0.03	-1.69
Margarine	0.02	1.38
Other fats & oils	2.00	-1.04
Apples	6.24	-1.95
Oranges	0.08	-0.34
Bananas	0.00	1.16
Grapes	1.04	0.37
Grapefruits	0.07	-1.39
Lettuce	0.40	0.05
Tomatoes	5.02	-4.25
Celery	0.40	-1.21
Onions	0.40	0.72
Carrots	0.47	0.54
Fruit juice	4.17	-2.58
Canned tomatoes	0.78	-0.11
Canned peas	0.75	-0.68
Canned fruit cocktail	0.45	-0.11
Peanuts & tree nuts	0.10	0.63
Sugar	0.00	-0.10
Sweeteners	2.00	0.36
Coffee & tea	0.00	-0.37
Ice cream & other frozen dairy	0.03	0.62
Non-Food	0.00	-0.21
Income	-0.11	NA

Table 7. Change in nutrient consumption.

Nutrient	Daily Per Capita Consumption	Change in Daily Consumption (%)
Energy	2005.00	-0.259
Protein	74.00	-0.147
Total fat	74.30	-0.390
Sat. fat	25.40	-0.414
M-unsat.fat	28.50	-0.315
P-unsat.fat	14.60	-0.492
Cholesterol	247.00	-0.202
Carbohydrate	257.90	-0.156
Dietary fiber	15.40	-0.348
Calcium	793.00	-0.264
Iron	15.40	-0.226
Magnesium	264.00	-0.205
Phosphorus	1214.00	-0.201
Potassium	2620.00	-0.350
Sodium	3271.00	-0.651
Zinc	11.10	-0.142
Copper	1.20	-0.447
Manganese	400.00	-0.249
Vitamin A	952.00	0.059
Vitamin C	99.00	-1.410
Thiamin	1.59	-0.298
Riboflavin	1.89	-0.126
Niacin	21.70	-0.132
Pantothenic	10.00	-0.138
Vitamin B-6	1.75	-0.152
Vitamin B-12	4.84	0.019
Folate	256.00	-0.512
Vitamin E	8.00	-0.522

Table 8. Household food spending, 1995.

Item	All	$5-10K	$15-20K	$30-40K
Grain Consumption (base)	454	282	420	479
Vegetables (base)	222	147	213	226
Fruits	245	173	229	236
Milk	311	186	286	320
Meat Consumption (base)	758	512	824	769
Sugar & Sweeteners	119	73	99	112
Fats & Oils	84	59	84	86
Nonalcoholic Beverages	250	155	238	242
Miscellaneous	394	226	324	388
Food Away from Home	1805	558	1148	1803
TOTAL FOOD	4642	2371	3865	4661

Table 9. Change in food spending ($/house/year).

Item	All	$5-10K	$15-20K	$30-40K
Vegetables (base)	0.7	0.4	0.6	0.7
Fruits	3.8	2.7	3.5	3.7
Milk	0.5	0.3	0.4	0.5
Meat Consumption (base)	3.3	2.3	3.6	3.4
Sugar & Sweeteners	0.3	0.2	0.2	0.3
Fats & Oils	0.7	0.5	0.7	0.7
Nonalcoholic Beverages	-0.9	-0.6	-0.9	-0.9
Miscellaneous	-0.9	-0.5	-0.8	-0.9
Food Away from Home	-0.2	-0.0	-0.1	-0.2
TOTAL FOOD	8.4	5.9	8.6	8.5
Change in Expenditure (%)	0.18	0.25	0.22	0.18

Table 10. Aggregate economic effects on the farm sector.

Sub-Sector	Economic Effect (million dollars)
Net Income–Major Crops	2,407.
Net Income–Fruit & Vegetable Crops	-1,666.
Net Livestock Income	-2,589.
Net Farm Income	**-1,848.**
Foreign Surplus	**-1,287.**
Domestic Consumers' Surplus	**-4,851.**
Net Economic Surplus	**-7,986.**

Table 11. Aggregate effects of the elimination of organophosphate and carbamate pesticides on returns for major field crops.

Item	Economic Effect (million dollars)
Returns over Variable Costs for:	
Corn	1,382.
Grain Sorghum	105.
Barley	6.
Oats	0.
Wheat	79.
Soybeans	680.
Cotton	136.
All Hay	159.
Peanuts	-43.
Rice	17.
Non-Land Fixed Costs for Major Crops	113.

Table 12. Aggregate effects of the elimination of organophosphate and carbamate pesticides on net returns for fruit and vegetable crops.

Crop	Economic Effect (million dollars)
Fresh Peaches	-3.
Canned Peaches	-1.
Fresh Tomatoes	-75.
Processed Tomatoes	-58.
Carrots	-14.
Fresh Apples	-889.
Potatoes	-55.
Fresh Oranges	-10.
Fresh Grapes	- 69.
Fruit Juices	-73.
Raisins	-7.
Other Fruit and Vegetable Crops	-122.

Table 13. Aggregate effects of the elimination of organophosphate and carbamate pesticides on net returns for major livestock types.

Livestock Type	Economic Effect (million dollars)
Cow/Calf	-193.
Fed Cattle	-420.
Hogs	-872.
Broilers	-416.
Turkeys	-126.
Eggs	-111.
Sheep	-11.
Dairy	-440.

Table 14. Impacts of elimination of organophosphate and carbamate pesticides on the United States economy.

Aggregate Effect	Direct	Indirect	Induced	Total
Output (million dollars)	-4,126	-2,035	-11,110	**-17,271**
Total Value Added (million dollars)	-2,934	-1,084	-6,405	**-10,423**
Employee Compensation (million dollars)	-1,018	-521	-3,281	**-4,821**
Personal Income (million dollars)	-1,155	-634	-3,743	**-5,542**
Proprietors Income (million dollars)	-136	-113	-471	**-720**
Other Property Income (million dollars)	-1,321	-356	-2,019	**-3,696**
Employment (# jobs)	-58,988	-22,860	-127,034	**-208,882**

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